i-Nord
A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean

Main Report

Contents of the main report:

1. Project Proposal
2. Users and Stakeholders Survey
3. Description of system concepts, including demonstrator
4. Baseline for main project

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TITLE

i-Nord

A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean

Project proposal

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ABSTRACT

The surveillance of the High North ocean areas

KEYWORDS	ENGLISH	NORWEGIAN
GROUP 1	Information technology	Informasjonsteknologi
GROUP 2	Monitoring	Overvåkning
SELECTED BY AUTHOR	High North	Nordområdene

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1 Preface

The following intuitions have participated to the generation of this project proposal as shown in Table 1.

Table 1 Contributor to the *i-Nord* project proposal

Institution	Role	Contact person
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2 Summary

The Norwegian Government consider establishing a sustainable and multidisciplinary project on ocean surveillance in the Barents Sea and Artic ocean henceforth called the ***i-Nord project***. The project it foreseen to be initiated in 2009 and gradually implemented towards a fully functional systems towards 2017. The ***i-Nord*** project proposal is based on the Norwegian Government's High North Strategy.

The main objective of the *i-Nord* project proposal is to:

Implement and operate a comprehensive monitoring, prediction and information system for the High North ocean areas.

The project objective will be obtained through initiating activities in:

- **Maritime safety, security and operations –** focusing on an integrated monitoring and early warning system as day-to-day vessel monitoring, maritime risk assessment, and maritime crises management.
- **Marine environment and climate –** to meet the challenges in anthropogenic activities, its influences on and impacts of the physical environment, along with climate change and associated environmental changes.
- **Marine resources –** to meet the challenges for management of the living marine resources together, with increased focus on implications of human activities and operational management of northern areas, including pollution aspect related to ecosystem functioning,

reflecting applications and requirements, realised and implemented through activities focusing on:

- **System architecture and information management –** for creating and maintaining interoperability infrastructure for both internal and external users of the *i-Nord* system.
- **Communication systems and infrastructure –** for transferring and supporting necessary surveillance information and sensor network data for evolution of the environment and pollution threats.
- **Observation systems and models –** retrieving information from in-situ and remote sensing sources for development of reliable and predictive models.
- **System Coordination and Support -** will secure interoperability between the different systems to be integrated as well as maintaining operational continuity of the services of the *i-Nord*.

These activities are respectively hereafter referred to as the "vertical" and "horizontal" work packages, as shown in Figure 1.

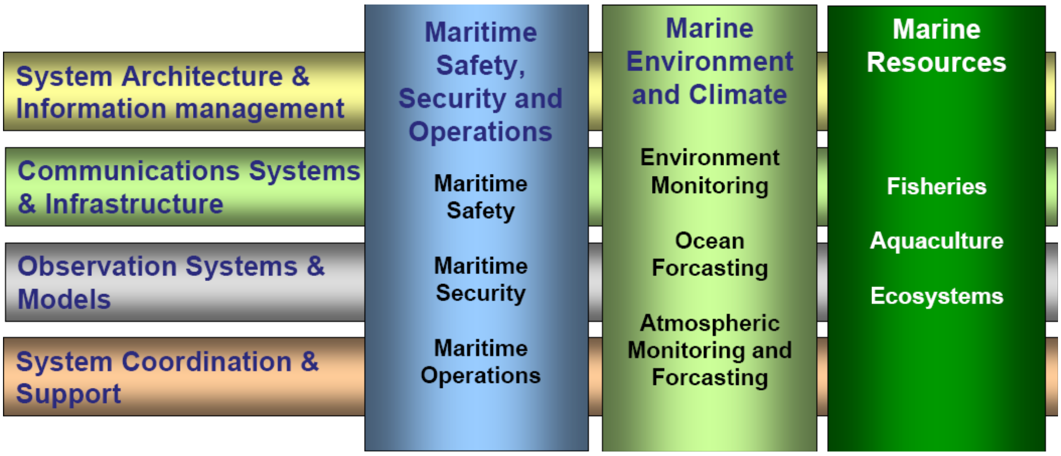

Figure 1 The *i-Nord* project structure

The vertical activities are user and application/service oriented initiatives, whereas the horizontal work packages will answer and implement the technical solutions required for answering the demands put forward from the vertical work packages.

For meeting the overall goal of the *i-Nord* proposal, both extension of on-going research and development of new activities in both industry and research/university communities are proposed, as well as new initiatives leading to new products for the industrial sector.

i-Nord is proposed to be an on-going activity for more than a decade, as detailed in the different work package descriptions. There are also proposed “Fast-Track” activities/services:

- Decision support to the Norwegian Coast Guard
- Iceberg detection and warning
- Oil spill detection and warning
- Harmful algal blooming detection and warning
- Marine ecosystem resource monitoring
- Ocean Space Surveillance (awarded strategic project at SINTEF)
- MyOcean (collaborative and coordinative activities)

demonstrating the initial potential of the *i-Nord* concept. These activities/services will be initiated in phase 1 (2009-2011). The estimated budget of phase 1 and 2 (2012-2013) is shown in Table 2.

Table 2 Proposed budget for *i-Nord* project activities

i-Nord Budget								
Phase	Phase I			Phase II		III	IV	V
Work Package Breakdown	2009	2010	2011	2012	2013	2014	2015	2016
WP 1: Maritime Safety, Security and Operations	5.000	7.000	8.000	8.000	8.000	TBD	TBD	TBD
WP 2: Marine Environment and Climate	4.000	6.000	8.000	8.000	9.000	TBD	TBD	TBD
WP 3: Marine Resources	4.000	6.000	8.000	8.000	9.000	TBD	TBD	TBD
WP 4: System Architecture and Information Mgm.	5.000	10.000	10.000	11.000	11.000	TBD	TBD	TBD
WP 5: Communication Systems og Infrastructure	2.000	4.000	7.000	7.000	7.000	TBD	TBD	TBD
WP 6: Observation Systems and Models	2.500	7.000	10.000	15.000	20.000	TBD	TBD	TBD
WP 7: System Coordination and Support	1.000	2.000	3.000	4.000	6.000	TBD	TBD	TBD
WP 8: Quality Assurance	500	1.000	1.000	1.000	1.000	TBD	TBD	TBD
WP 9: Program Management	3.500	6.500	6.500	6.500	6.500	TBD	TBD	TBD
Total	27.500	49.500	61.500	68.500	77.500			
Accumulated	27.500	77.000	138.500	207.000	284.500			

Table 3 *i-Nord* funding strategy

i - Nord Funding Strategy					
	2009	2010	2011	2012	2013
Norwegian Governmental Funding	27.500	49.500	56.000	60.000	60.000
International Governmental Funding	0	0	5.000	8.500	17.500
Estimated Gross Governmental Funding	27.500	49.500	61.000	68.500	77.500
Framework Program Funding (FP 7)	10.000	10.000	10.000	TBD	TBD
Project Partner Funding	5.900	5.900	5.900	5.800	TBD
Estimated Gross Partner Generated Funding	15.900	15.900	15.900	5.800	0
Gross i-Nord related Funding	43.400	65.400	76.900	74.300	77.500

The *i-Nord* project activities are proposed to be carried out through five phases were:

- **Phase I –** initiates the first "Fast Track" services as well as identifying specifications and requirements for the first prototypes to be developed. This prototype will demonstrate the synergy and value adding services. Plans for future concepts will be made, thus identifying needs for R &D activities as well as infrastructure.
- **Phase II –** Iterative implementation and further system and service integration according to the results and requirements of phase 1. There are also foreseen to be some continued R&D activities from phase 1. Consolidation will be prioritised to obtaining best possible results.
- **Phase III, IV and V** - Consolidation of phase I and II along with further on iterative implementation. Dissemination from the previous phases will be an important issue throughout all phases.

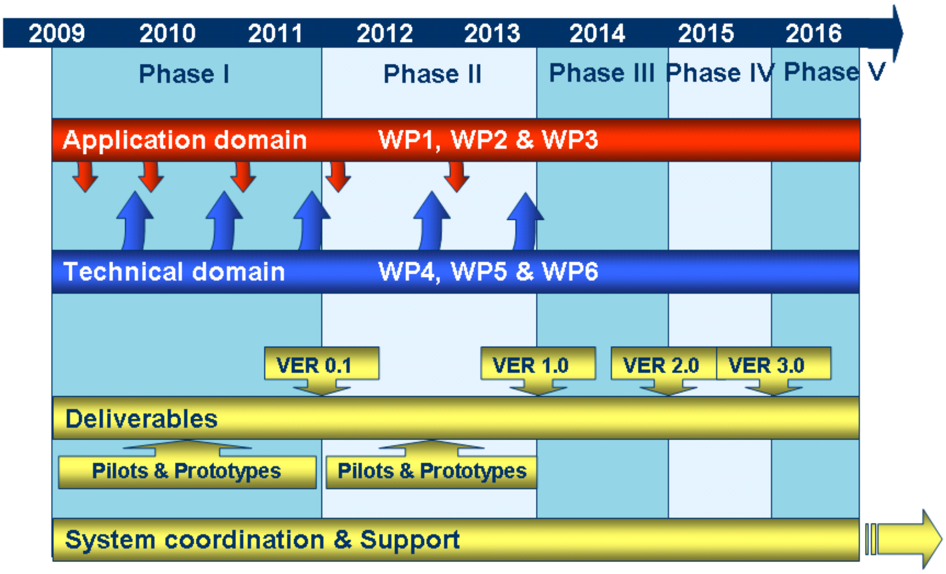

Figure 2 The *i-Nord* proposed project phases

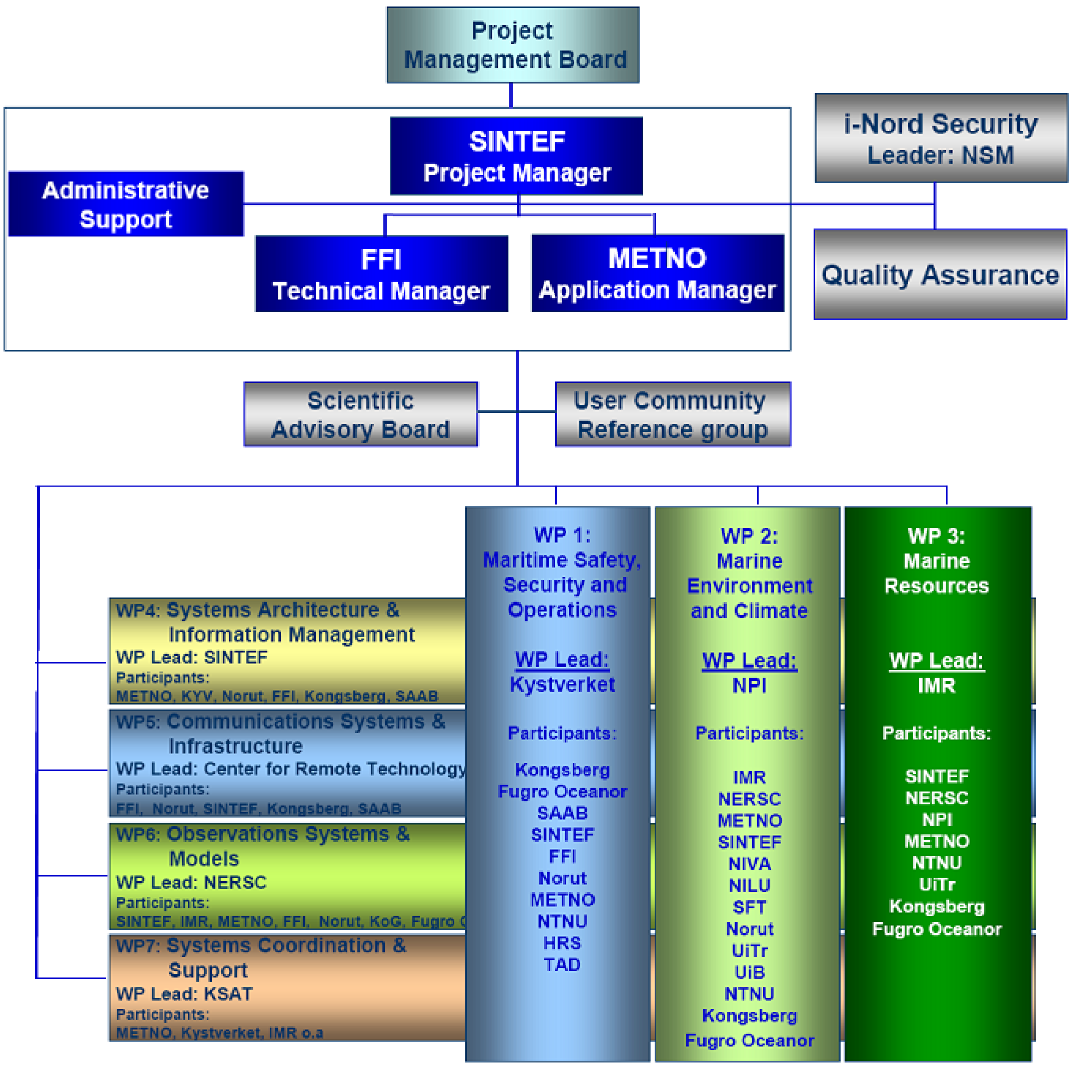

Figure 3 The *i-Nord* project management structure

3 Objective

The Norwegian Government consider establishing a sustainable and multidisciplinary project on ocean surveillance in the Barents Sea and the Arctic. The perspective is to start in 2009 and foreseen to incorporate gradual implementation towards 2017.

The *i-Nord*[1] project is based on the Norwegian Government's High North Strategy[2]. Where the Strategy has a rather wide scope, *i-Nord*´s main objective is to implement and operate a ***comprehensive monitoring, prediction*** **and information system** of the High North ocean areas. This is in order to directly address and maintain Norway's ***ambition of playing a leading role*** in the Barents Sea and Arctic Ocean, including proper advice for sustainable management as well as proactive partnership in the intergovernmental Arctic collaboration.

The goal of *i-Nord* is to become:

> ***The cutting edge surveillance and information system for maritime security, marine environment and marine resources of the Nordic Seas and the Arctic Ocean***

To achieve this we will:

- Establish a holistic infrastructure that integrates existing data sets, products and processing chains with respect to traffic control, pollution (e.g. oil spill) preparedness, ecological assessment and operational meteorological and oceanographic services.
- Establish new services on top of existing services, products and data where needed, including the development of new long-term indicators of the physical, chemical and biological biological states as well as dynamics.
- Improve data collection by comprehensive use of satellite, air-borne, ship-borne, moored and drifting data collection platforms
- Develop and deploy novel sensor systems, sensor technology and containers where observations are missing.
- Support the development of and integrate state of the art numerical models operated on 24/7 basis providing adequate forecasts on ocean, sea ice, meteorological quantities and selected living resources on a daily basis.
- Support the development and integration of a spatially explicit ecosystem model operated on monthly basis to provide adequate and spatially resolved forecasts on ecosystem components and processes
- Support adequate data management and dissemination to provide basis for ocean and atmospheric research and management advice of the Nordic seas and the Arctic Ocean including climate monitoring and assessment.

The main activities that are part of the *i-Nord* concept are shown in Figure 4.

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[1] '*i-Nord*' is the short project name for 'in the High North'.
[2] As of 2008-10-22: http://www.regjeringen.no/en/dep/ud/Documents/Reports-programmes-of-action-and-plans/Action-plans-and-programmes/2006/Strategy-for-the-High-North.html?id=448697

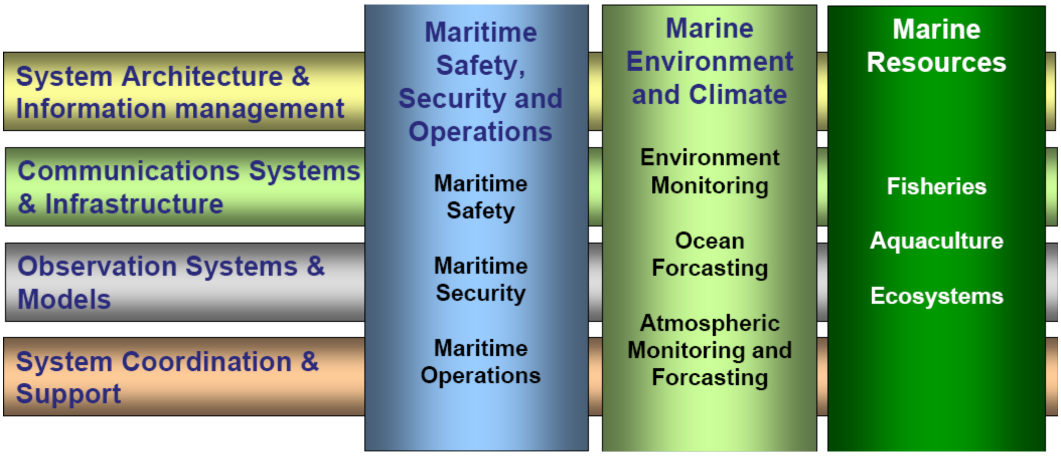


Figure 4 The *i-Nord* concept

The specific objectives for the development of the *i-Nord* system are to:

- Provide reliable nowcast and forecasts on sea ice, wind, waves, current and icing to improve safety for transportation of people and goods and prevent or limit impact of hazards including oil spill and radioactive contamination.
- Provide information (for the past, now and the future) for the benefit of research, management, industry and the general public on important parameters[3].
- Provide public information on a *i-Nord* web portal (similar to yr.no) with links to other relevant web-portals where the data shall be easily and freely accessible.
- Combine AIS messages of ships carrying dangerous loads, weather forecast and the knowledge about sensitive areas for early mobilising of emergency response
- Actively promote rules and regulation with obligation to prior warning of potential risk for accidents associated with planned transport. The objective is to know where all actors are to give preventive as well as curative assistance when problems arise
- Provide a research-based foundation for long-term integrated management and a basis for wealth creation based on marine resources.
- Reinforce Norway's position as the leading nation in sustainable marine ecosystem – related management and research.
- Become a central contributor to the process of generating more knowledge of the marine environment.
- *i-Nord* shall also encourage research and development activities of the marine environment and marine ecosystem at high international quality

The benefits and impacts of *i-Nord* are expected to be:

[3] With important parameters we mean: temperature, salinity, transport/currents, frontal positions, turbulence, vertical mixing depth, stratification, wave height and direction, seabed shear stress, sea ice concentration (including ice edge positions), ice type and thickness, light (in the water column), suspended particulate matter (SPM), upwelling index, oxygen, CO2/pH, nutrients, chlorophyll, algal and zooplankton production and abundance of functional groups, (harmful) algal blooms, river plumes and loads, fish larvae growth, mortality and distribution, pollution transport and dispersion (including oil), fish and mammal distribution.

- Reliable and timely information and services related to environmental and security issues in support of public policy makers' needs for sustainable management of the Barents Sea and the Arctic.
- Dynamic and effective risk assessment to support decisions and crisis management.
- Establishment of adaptive observing systems by systematic use of simulation experiments.
- Effective and professional services to operators in the region including fisheries, ship transport and offshore industry.
- Basis for regulations and negotiations with neighbouring countries.
- Co-ordination of existing activities in the Barents Sea and Arctic.
- Strengthening the position of Norwegian research within all disciplines related to the priority issues of *i-Nord*
- Contribution to Pan Arctic Observing Network.
- Contribution to priority sectors defined by the Arctic Council.
- Support to Norwegian industry in designing and developing observing platforms and delivering systems and services related to *i-Nord*.
- Strengthening of the collaboration between Norwegian Industry and Norwegian research institutes within the scientific areas related to the issues addressed by *i-Nord*

The implementation if *i-Nord* will start with a number of “Fast Track Services” as an early demonstration of the *i-Nord* concept. The choice of these services has been driven by their technical maturity and their uptake by their user communities. The services are:

a. Decision Support Norwegian Coast Guard:
   Provide a best possible common recognized maritime picture for on-site resources, governmental agencies and the Joint Rescue Coordination Centre in search and rescue operations. A common understanding, combined with improved communication between participants and sharing of sensor data (e.g. AIS receivers and radar tracks from vessels in theatre), will improve the overall performance of a search and rescue operation.

b. Iceberg detection and warning:
   Priority services include maritime traffic information and extended ice information services in particular detection of ice bergs, and discrimination between ice bergs and other surface targets.

c. Oil spill detection and warning:
   Priority environment service includes an integrated oil spill detection information, including pollution detection, potential source identification, drift modelling and assessment of impact on environment and selected living resources.

d. Harmful algal blooming detection and warning:
   The potential harmful algal bloom detection and monitoring information should primarily be based on in situ observation and optical satellite data. The information on the environmental impact on aquaculture industry will be provided.

e. Marine Ecosystem Resource Monitoring:

Develop a realistic operational system to realistically quantify fish larval growth and distribution, for early prediction of recruitment and potential mortality from pollution. Support new information to the fisheries management advice process.

f. Ocean Space Surveillance (OSS) (awarded strategic project at SINTEF):
The OSS project targets the interaction between real time sea parameter measurements based upon underwater sensor networks and software modelling tools to improve the quality of the modelling/prediction outcome.

g. MyOcean (collaborative and coordinative activities):
The objective of MyOcean is to define and to set up a concerted and integrated pan-European capacity for Ocean Monitoring and Forecasting.

4 The *i-Nord* concept

The technological approach being used within *i-Nord* shall ensure a sustainable solution that can be gradually developed and updated throughout the project lifetime. It should also acknowledge that *i-Nord* is a system to be built on existing service providers. Thus *i-Nord* should take full advantage of existing production chains and services and provide a facility to exchange data and information more efficient.

The technical approach of *i-Nord* should at any time reflect the priorities of *i-Nord*. The priorities will change in a long term perspective and the plans will be adjusted accordingly. The *i-Nord* organisation will adapt to the-state-of-art technology and changing priorities.

The need for research within *i-Nord* is related to the challenge of optimizing observational systems in concert with model development to provide user oriented products and needs in near to real time.

4.1 Maritime safety, security, and operations

i-Nord shall be an integrated monitoring and early warning system for the Nordic seas and the Arctic waters. The first important area of application for *i-Nord* will be maritime safety, security, and operations, supporting functions as day-to-day vessel monitoring, maritime risk assessment, and maritime crisis management. Barents Sea is an important shipping lane to/from north-western part of Russia. It is expected that this traffic will increase, especially in the long term perspective. The melting of the Polar ice could lead to the possibility of a northern shipping lane between the Atlantic and the Pacific Ocean. The navigation conditions in the area are demanding for ship traffic – icing, drifting ice, fog, high sea, and strong winds. The region's vast natural resources require efficient management, in particular the fisheries and the offshore oil & gas sectors. Furthermore, Norway, as signatory to the Schengen Agreement, has responsibility for border control in these areas, a challenging task in itself.
Increasing human activities in the region will need enhanced vessel traffic monitoring, environmental monitoring and forecasts, and early warning of possibly dangerous situations. The *i-Nord* approach opens for new opportunities:

- improved data collection by development of novel sensor technology and platforms;
- better and easier integration of existing data sets, products and processing chains;
- distribution of navigational and safety information to ships in the area; and
- improved coordination of ships at an emergency scene and Search and Rescue (S&R) assets.

One benefit with this system is that data products that already exist can be made available for a large group of users and be combined with other data products in order to achieve new services, leading to an enhanced maritime situational awareness.
One main information source for monitoring the civilian vessel traffic is Automatic Identification System (AIS). AIS messages, combined with radar information, provide relatively good insight of the ordinary surface vessel traffic in the near shore region (~20 nautical miles). More recently, a national program has also been established to demonstrate deployment of an AIS receiver in low Earth orbit. A micro-satellite is scheduled for launch in 2009, to demonstrate reception of AIS messages over the entire Arctic. This has the potential for extending the AIS operational coverage from coastal to the whole region. Further, International Maritime Organisation (IMO) has introduced the Long Range Identification and Tracking (LRIT) system. From 2009, vessels are required to report their position once every 6 hours. These reports must go to the authorities of their flag states, the authorities of coastal waters they are navigating in, and to port authorities at

their destination. However, the system will predominantly rely on reporting using Inmarsat, which has limited coverage in the Arctic region.

Since the early 1990's, the launch of several Earth observation satellites into near-polar orbits has given Norway the opportunity to make use of such tools for more efficient maritime monitoring and surveillance. Today, Norway is a significant user of satellite radar imagery in particular for fisheries monitoring, oil spill detection, and ice monitoring.
The basic idea of *i-Nord* is to use a system of systems approach, where information from existing data collecting- and observational systems, services, and initiatives are integrated into a common picture. This picture could combine maritime vessel traffic data (e.g. AIS, coastal radar, VMS, LRIT, etc.) maritime information (e.g. resource databases, SafeSeaNet, natural reservations, protected areas, fishery zones) together with environmental information (e.g. meteorological and oceanographic data and forecast, ecological simulations). This will support inter-agency cooperation, and inter-disciplinary data sharing. Furthermore, more sophisticated sensors will produce an overload on the decision makers. *i-Nord* could develop services for decision support and anomaly detection.

4.1.1 Maritime operations

Both during exploration and drilling, prediction of reliable weather forecasts, especially on polar lows, are required. The rapid change in weather and wave conditions associated with these lows have serious impact on offshore operations such as helicopter transport, vessel operations etc. Various operators and contractors have highlighted the difficulties encountered with unpredictable downtime due to local environmental conditions.

Offshore icing is also an operational problem, often in combination with polar lows. This will cause increasing loads on vessel and helicopters and slippery conditions on platforms. Icing can also cause problems on oil and gas terminals. For floating production systems the combination of the directional divergence of wind, waves and currents are determining the orientation of the systems, which is especially important during loading of oils from FPSO Floating. Heavy lifting operations are sensitive to waves, especially long periodic swell. Waves are also required for operations such as loading of oil to shuttle tankers.

Several operations require real-time observations of the vertical current profile. Examples of such operations are exploration drilling, ROV operation and covering of pipeline where stones are lowered from a vessel and the current will cause the dumping material to move away from the pipeline.

Hence, environmental information as ice, wave, wind and current conditions are crucial for the safe execution of maritime operations. *i-Nord* will provide new information distribution facilities to ships in the Arctic areas. Furthermore, *i-Nord* will also improve the quality of navigational information available in the area, by innovative use of existing shipboard systems, such as AIS and ECDIS.

4.1.2 Maritime safety

Maritime safety has always been dependent on getting first line assistance from nearby ships. This has been the guiding principle in the IMO convention SOLAS since its first edition after the Titanic disaster. Crisis management and S&R operations need to be carefully planned, prepared and trained. These operations are often based on inter-agency co-operations. *i-Nord* will improve these capabilities in Arctic waters. A common operational picture will be critical for efficient first line assistance to ship in distress as well as coordination of coastal state supported rescue and mitigation actions.

The Norwegian Coastal Administration (Kystverket), the Norwegian national agency for coastal management, marine safety and communication, has several Vessel Traffic Service (VTS) centres that are responsible for ensuring safe and efficient navigation and protecting the marine environment against undesired events. One example on this is monitoring of the vessel traffic from Russia which often content oil and radioactive matters. Combining maritime and environmental information could be used for risk assessment and early warning of the development of dangerous situations. Part of this information can be made available to ships in the format of standard Maritime Information Overlay (MIO).
i-Nord will also investigate how new operational procedures can be implemented in the Arctic area. This will be dependent on existing international and national legislation (based on the SOLAS convention) and making use of the opportunities the coastal nations have to enforce stricter requirements in certain sea areas. The objective is to get an improved safety in the area, involving all ships, at minimum cost in terms of investments and special training.

4.1.3 Maritime security

Maritime Security focus is on protection of danger and severe loss potentially caused by people with illegal intensions. The *i-Nord* Maritime Security concept is also security in it its widest definition; an information area valuable in combating i.e. illegal fishing as well as trespassing (Schengen Agreement of border control in these areas). *i-Nord* can improve information harvest and information exchange between different governmental agencies with security responsibilities and thereby improve security.

Maritime security is best achieved by blending different maritime security activities into one integrated effort. For example, a more seamless architecture for information exchange between different government agencies and sensors will improve the enforcement of Norwegian fisheries jurisdiction and the overall surveillance capability for this giant area.

i-Nord is targeted as a non-classified system, but will to some extent, interconnect with established monitoring and command & control systems (C2I). Such an interconnection can for example be established by use of a data diode which link two networks with different security levels through a guaranteed one-way connection. A best possible unified presentation of the maritime situation should at all time be provided to the different stakeholders at their level of responsibility and algorithms to detect anomalies and avoid information overload on the decision makers should be part of the *i-Nord* system.

4.2 Marine Environment and Climate

Norway has an ambitious political and economical agenda in the high latitude and Arctic region, leading to increased attention and interests from a wide range of tentative national and international actors (e.g., fisheries, offshore industry, shipping, environmental and climate agencies and bodies). Two main environmental challenges are identified with regards to the implementation of this agenda, namely (1) the increase environmental pressure from anthropogenic activities in the North, and conflict of interest raising from the potential impact of oil and gas activities on the marine environment, both in general terms and on fisheries in particular; and (2) climate change and its impacts on both human activities and the marine systems. Climate change is expected to be stronger in the high latitude and Arctic region, although the natural variability is known to be large.

These environmental challenges require the urgent implementation of a comprehensive and reliable, while cost-effective capability for monitoring and prediction of the state and changes of the high latitude and Arctic marine environment and climate. The main operational products and services that can presently be delivered to users, cover geophysical information including: air and sea temperature, air humidity, wind and waves; concentration, extent, drift and deformation of sea ice; ocean currents and transport pathways; mesoscale ocean variability; properties, distribution and transformation of water masses. This baseline information moreover allows routine production of oil spill detection and tracking, production of environmental indicators as well as generation of physical-based input to water quality, ecosystem and marine resource monitoring such as plankton dynamics, including algae blooms; operational fish larvae drift; transport, distribution of contaminants, their concentration in the marine food-chain and the exposure on plankton and fish larvae.

Maritime pollution e.g. from ships or offshore activities may represent a serious threat to the Arctic environment. It is therefore a need to have a reliable operational pollution detection, monitoring and forecasting system. This system should be capable to detect pollution at sea under all weather and light conditions, identify the likely source of the pollution, predict the temporal evolution, transport, spreading and/or drift, and identify the potential impact e.g. resulting from pollution reaching the beaches. Oil spill detection and monitoring service is likely to be established from integrating the existing satellite and aircraft based detection and monitoring systems with backward and forward numerical drift models, and also by integration with source data and additional non-satellite observations and/or environmental data.

4.2.1 Environmental monitoring

The dynamics of the high latitude seas and Arctic Ocean are characterized by small spatial scales, which are poorly described because of limited in-situ data coverage. This calls for significant challenges and demands regarding monitoring system and modelling capabilities; including validation and data assimilation. The opportunity to utilize new knowledge and data from the growing number of national and international research and application programs, including The International Polar Year (IPY) and its legacy, EC-MyOcean, MD/SFT monitoring programs, must therefore also be systematically incorporated.

In addition the marine ecosystem in the Arctic is considered to be extremely fragile and sensitive to natural and anthropogenic changes of the environment and climate. Changes of temperature, salinity, contaminants and the marine biogeochemistry caused by external disturbances and pressures are therefore expected to have significant consequences and dramatic impact on the range of natural variability of the ecosystem characteristics, and the interactions between the physical, biological and chemical components that shape the ecosystem. This may trigger irreversible processes. As a nation with borders to the Arctic, Norway is therefore faced with an urgent and proactive action to provide better understanding and management of this harsh and remote marine environment. Better understanding and management requires the deployment of interdisciplinary observations and sampling networks that are coincident in space and time, and that can also support model validation and assimilation.

4.2.2 Ocean forecasting

The Arctic Ocean and boundary sub-seas to the south have experienced major shifts in water mass properties, ocean circulation, sea ice coverage, extent, drift and thickness, ice-albedo feedback and ecosystems over the past three decades. Changes in the physical ocean and sea ice environment, in turn, modify ecosystem structure and function, ocean-atmosphere gas exchange, land-sea material transfer, and ultimately the living resources on which local human populations depend.

Marine observations in the Arctic and Barents Sea will use a combination of different techniques and sampling strategies. This is a task to share with all nations in the region at intergovernmental level. At the initial stage the physical and chemical ocean observations should include combined hydrography and tracer sections across the major frontal features of the Arctic Ocean, and observations of fluxes (e.g., volume, heat, salt, and dissolved nutrients) through the straits and gaps that connect the Arctic Ocean with the Atlantic Ocean (Fram Strait, Svalbard-mainland Norway, Greenland-Iceland-Faereo-Shetland gap). Of bio-geo-chemical observations and measurements, photo-synthetically active radiation, organic carbon, major nutrients, alkalinity, standing stock, primary production, contaminants and suspended particulate matter are suggested parameters that will support the operative and scientific communities.

The Arctic Observing Network (AON) represent a resource that should be routinely used by the research community as a base for further exploration and investigation of large-scale marine environment and climate. Equally urgent is the systematic incorporation and application of the new operational information products and services provided by MyOcean.

4.2.3 Atmospheric monitoring and forecasting

The Arctic and the Barents Sea is a hostile and demanding environment in terms of wind, waves, temperatures, heat fluxes, icing, and rapid sea ice deformation. The occurrence of intensive polar lows as dry cold air is advected into open water, tends to increase with a diminishing ice cap. At the same time it is recognized that polar lows are difficult to forecast due to their limited horizontal extent without a dense observing network including satellite, weather radars, in-situ buoys and landbased platforms. Norway has very valuable meteorological stations at Jan Mayen, Bear Island, Hopen and at Svalbard in addition to Station M (Weather ship). These stations along with ship - and satellite remote sensing observations provide valuable information. However compared with the large ocean and sea ice covered area and the phenomena experienced this observation network is marginal and sparse.

Air pollution is an aspect of increasing concern. Transport of air pollution to Arctic from a far distance is inevitable. The quantification and effects are difficult to separate without detailed observations. In order to influence the political agenda and to provide reliable documentation of air pollution to the Arctic it is necessary to increase operational and research based observations.

Environmental and climate change monitoring in the high latitude and Arctic region is very challenging and an expensive region in which to make surface-based and airborne atmospheric measurements. Changes observed in the Arctic can have an impact on the global scale or represent consequences of climatic imbalances induced somewhere else on the globe. It cannot be treated as a single region, and there are significant variations to be expected between Alaska, the Canadian Archipelago, Greenland, Scandinavia, Siberia, and the Arctic Ocean. Therefore, the *i-Nord* represents a Norwegian contribution to an integrated multinational, sustainable and cost effective Arctic atmospheric monitoring program on e.g., pressure, winds, temperature, humidity, precipitation, upper air measurements, surface radiation, ozone, UV, and albedo, as well as a cost-effective network for processing and information services.

4.3 Marine resources

Norway is the second largest exporter of fish and fish products in the world. This is also the second largest export industry in Norway (after oil and gas), and the largest based on renewable resources. It is therefore of utmost importance that these marine resources are managed in a best possible way.

As a part of EUs maritime strategy a Marine Strategy Framework Directive was accepted in June 2008 (2008/56/EC). This directive is a start of a new ecosystem approach to managing marine waters. As a part of the implementation process, new tools for monitoring and managing marine ecosystems will be developed. *i-Nord* will keep updated with the development of the directive and look for synergies.

The existing surveillance system for living marine resources is designed for supporting assessment and management of single populations on an annual basis, often intended for sustainable harvest. This paradigm is now being modified and the new "*Havressursloven*" postulates that management of living marine resources should be performed within an ecosystem approach, secure sustainability and follow the precautionary principle. This poses substantial challenges to the management of living marine resources with regards to demanding a broader perspective on implications of human activities and a more operational management procedure. In the future management advice has to be on ecosystem scales and founded on a much broader data collection and modeling. The *i-Nord* project will support this development.

4.3.1 Fisheries

Northern marine ecosystems are productive and relatively simple, and as a few abundant species dominate at different tropic levels they are highly attractive to fisheries. For instance, the Barents Sea holds the world's largest stocks of cod, capelin and juvenile herring. Management of marine resources is firstly based on the state of the harvested stocks. Further, factors like harvest strategies or habitat protection and socioeconomic issues participate in the decision making. The state and development of the harvested stocks is estimated annually from a combination of data from commercial catches (catch and size/age composition) and scientific surveys. Book keeping (VPA or similar) of catch data tells the stock development history, while survey data inform about present stock situation. Various tuning models combine the two sources of data into a "historically" correct present stock as a fundament for stock and catch prediction. Harvest strategies, harvest control rules and environmental impact assessment may manipulate stock prediction and the quota settings.

One of the challenges in future management will be to maintain or increase the quality of stock estimates and predictions, while at the same time increase monitoring activities on other ecosystem components. The resource surveillance system proposed developed within *i-Nord* will provide spatio-temporally resolved information on how commercial species are associated to the physical (e.g. temperature) and biological environment (e.g. prey, competitors and predators) through the year, and on how such associations influence processes like individual growth, recruitment and natural mortality. Increased understanding of these crucial processes will increase the precision of stock assessment and prediction models and thereby improve fisheries management.

4.3.2 Aquaculture

There is a considerable aquaculture industry in the *i-Nord* area. Changing climate and weather conditions have a considerable impact on the aquaculture industry through effects on individual growth, development and spread of diseases and parasites, as well as risks of erupting cages and fish escape. However, aquacultural activities also influence the environment. Organic materials are released from cages, which may cause oxygen deficiency during decomposition. The release of organic materials and nutrients, and the carrying capacity of the influenced area (i.e., the area's capacity to decompose the organic material without causing oxygen deficiency) is routinely monitored through the MOM system.
The carrying capacity is highly related to water circulation and currents. Future challenges for management of the aquaculture industry is to (1) estimate the carrying capacity of larger areas to identify optimal locations of aquacultural activity, (2) to resolve fine-scale processes which are of tremendous importance for assessing the local effects of aquaculture discharge, and (3) to understand how the organic material and the nutrients is distributed in and affects the marine environment. The development of *i-Nord* will facilitate this process, by providing easy access to

environmental data and modeled circulation patterns. Furthermore will the prediction systems developed within *i-Nord* yield earlier warnings and increased time to prepare for harmful conditions related to oil spill, temperature, current anomalies, waves and algal blooms. The usefulness of *i-Nord* to the aquaculture industry will depend on products with relatively high spatial resolution at the coast and into the fjords.

4.3.3 Ecosystems

Modern sustainable development and management includes a much broader suite of complex issues than single stock assessment and monitoring of aquaculture. The ecosystem approach expands the focus and gives more attention to the function and welfare of the whole system, and the interaction with human activities. Further, the expanding and sometimes conflicting exploitation of the marine environment by marine industries underline the need for a new approach to securing the system welfare and function. Conflicting use of the far north include:

- Area and time conflict between fisheries and petroleum industry
- Disputes among vessel categories in the fishing industry
- Dispute on resources among nations
- Area conflicts between shipping and fisheries
- Area conflicts between various industries and aquaculture
- Conflict between security issues and fisheries
- Conflict between proposed Marine Protected Areas (MPAs) and human use of the sea area.

The expanding use of the marine environment also raises the probability of disasters like oil-spills from tankers or blow-outs from oil installations. Expanding industries may affect the marine habitat and sometimes in a way that has a long term negative effect on the systems productivity of harvestable resources (e.g., destruction of coral reefs). Introduced species is a rising problem and which affect our ecosystem as well as directly affect the aquaculture industry. The interaction between ecosystem function, productivity and the physical environment may sometimes lead to drastic changes in the sustainable harvest which needs attention by the management.

All these new challenges set completely new demands on data, models and ecosystem understanding to support a sustainable area-based management under the ecosystem approach. As part of this development, monitoring programs such as MOSJ ("*Miljøovervåkning Svalbard og Jan Mayen*") and "*Overvåkningsgruppen for Barentshavet*" have been established. These programs typically use spatio-temporally aggregated indicators to evaluate the state of living resources. Practical day-to-day ecosystem-based management will be facilitated by the *i-Nord* initiative by making data and advice from many sectors and parts of the ecosystem available at the same time and place, and at a high spatio-temporal resolution. In the development and follow-up of the integrated management plan for the Lofoten – Barents Sea the need for a coordinated and broadly scoped surveillance and monitoring system has repeatedly been specified. *I-Nord* will fill this need and thereby facilitate the follow-up and revisions of the Lofoten – Barents Sea plan.

A major challenge in the transition from a traditional management to a modern approach is resolution in time and space. To adequately address these challenges, we need to:

- Establish operational spatially explicit ecosystem models
- Establish adequate observational systems to meet the new requirements
- Develop links between models and observations
- Improve efficiency in operational data flow, both within and between the different service providers

- Present this information in a geographic context directly useful for area-based management

In particular there is a need for 2 types of operational models in i-Nord to accommodate requirements within management of marine resources: 1) A spatially explicit ecosystem model (Atlantis), and 2) high resolution 4D mechanistic ocean models for plankton and fish. The Atlantis model was developed for Australian waters and has now been set up in several different ecosystems around the world. The model system is developed with the implementation of the ecosystem management approach in mind and captures the entire ecosystem from the physics to the upper trophic levels. It is regarded as state of the art in marine ecosystem modeling, and relies on bioregionalization of space through subdividing the ecosystem in grid cells that are as homogeneous as possible. The Atlantis model maintains the distributions, abundance, stock structure, age structure and distribution of the different taxa. The level of detail in taxonomic resolution will differ between the different trophic levels and on the level of information available. Atlantis will be fitted to the i-Nord area, linked with databases that store relevant information on physical environment, density and distribution of the different ecosystem components and will continuously maintain the present state of the ecosystem (i.e. distribution of habitats and species, trophic interactions, system structure), at medium (1 month) and long term (1 year) forecasts. There is, however, a need for continuous research to improve the functioning of the Atlantis model.

In addition there is a need for models simulating spatial dynamics at high spatial and temporal resolution (hours and days). Such models are run routinely for plankton, and eggs and fish larvae. The active movement of adult fish has not been addressed to the same degree as drift of larval fish, due to the complex behavioral processes, the great computing power required, poor description of relationships between environment and fish distributions, and lack of methodology. However, computing power is ever increasing and the observation system proposed within the i-Nord framework will generate much fish distribution data which can be assimilated into models of 3D fish stock distribution. Such high resolution models are already operational for cod and herring larvae and run operationally by IMR in cooperation with NMI, and will be expanded to more stocks/species. Furthermore will these models together with more assessment oriented multispecies models, such as Gadget, be used in parameterization of Atlantis. The high resolution models will also be used in relation to catastrophes such as acute oil spills.

To successfully fulfill these objectives of i-Nord requires a sound scientific base, implementation of new observation regimes, operationalizing associated models, and finally validation of applied models. Furthermore, the models will be used to determine the need for observations, while new observations and information may directly affect model efficiency. A major goal within Marine resources is therefore development of a cost efficient observation system that fit hand in glove with the operational models and management requirements.

4.4 System Architecture and Information Management

System Architecture and Information Management are a key enabler to meet the challenging topics addressed in

- Maritime safety, security and operations
- Marine environment and climate
- Marine resources

The *i-Nord* system is expected to contain a huge volume of data and information from many sources. The intention of this activity is to create an interoperability infrastructure that is useful for both internal and external users of the *i-Nord* system. This infrastructure will not duplicate existing infrastructure, but rather interface this. Interfaces to existing and new infrastructures are set up using a service oriented architecture. The services shall address needs within the *i-Nord* priority sectors Maritime Safety, Security and Operations, Marine Environment and Climate and Marine Resources. The System Architecture recognizes and adapts international standards for data and information management where relevant (e.g. INSPIRE, WIS, OGC, etc.).

Additional research and development may be necessary to improve coordination and integration of agencies' Arctic observing activities. Such research and development activities should be orchestrated in partnership with academic community, northern residents, maritime users and other stakeholders.

The *i-Nord* activity will outline an infrastructure that reflects a system-of-systems approach and that is in line with parallel initiatives internationally (e.g. GMES, GEOSS, WIS). The *i-Nord* approach shall also open up for new opportunities:

- Better and easier integration of existing data sets, products and processing chains.
- Improved data collection by development of novel sensor technology and containers as well as adaptive observing system simulation experiments.
- Optional new services on top of existing services, products and data.

A major feature of *i-Nord* is the support of the value chain from collection of raw data, through basic processing to the generation of higher level data sets and products that can be used by decision makers and others. The value chain comprises to a large extent the production chain. In consequence, the most important feature of *i-Nord* is that it can make production chains more effective by offering interoperation and integration of production chains. It offers the opportunity to set up a new type of production chains that are extended into the end user environment. A generic visualisation of the value chain, including the production chain, and support by *i-Nord* is provided in Figure 5.

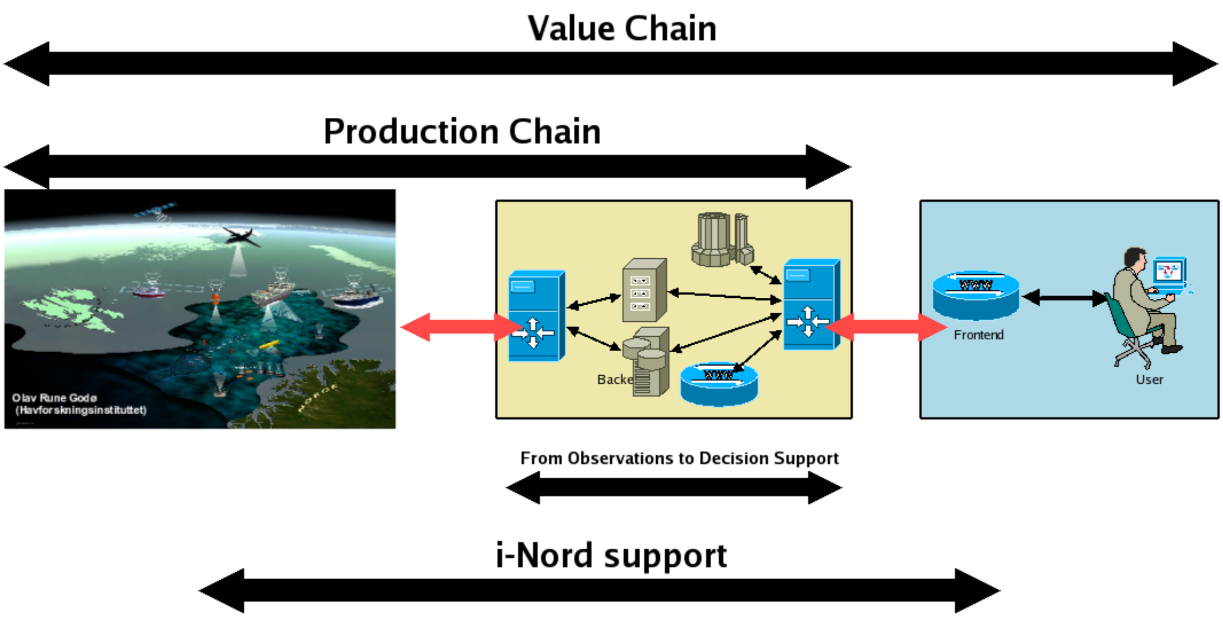


Figure 5 The relationship between value chain and production chains and the support of *i-Nord*

Figure 5 shows the relationship between the value chain and the production chain which is essential to understand the entire *i-Nord* system concept. The *i-Nord* infrastructure supports the production chain with services that improves interoperation (e.g. between institution specific production chains) and integration (e.g. of data). Production chains are subsets value chains, thus *i-Nord* also partly supports value chains. The figure indicates that value chains may extend the scope of *i-Nord* and most of the relevant production chains. This is true because there may be actors whose processes and services that collect and refine data are only indirectly connected to the production chains of the core systems.

The *i-Nord* overall system architecture have two main elements; *front-end services* and *backend services* (Figure 6). The backend services provide access to data and products. The front-end services typically provide User applications that can utilise the information provided by the backend services. Front-end services range from dedicated software applications to functionality served through a web browser (or a machine-machine interface). Users may also be internal to the system. The overall *i-Nord* system architecture is based on Service Oriented Architecture (SOA) principles, where the services are published to a service broker. The service broker maintains the service repository. A service consumer looks up services through the service broker before starting to interact directly with the service in a client-server style.

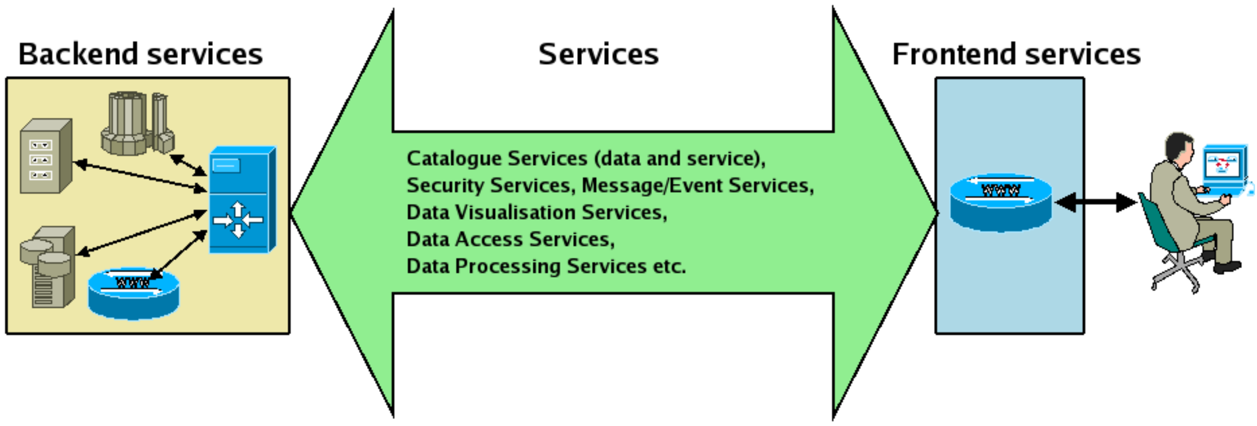


Figure 6 The two main components of the *i-Nord* system. The front-end serves the specific needs of the user, and the backend provides an interface to data and services (graphical, data access and processing services) offered by service providers within the system. The service bus includes the set of services and communication infrastructure that is required to make the system work.

The *i-Nord* requirements are complex and are yet not fully explored. However a generic understanding of the system, following the principles of the conceptual view presented in Figure 4, is provided in Figure 5. Within this the need for open and secure communication (either in a group or bilaterally) is illustrated. Service and data access must be controlled by the appropriate metadata. The *i-Nord* infrastructure should also support peer to peer (P2P) communication. The basic principle of a distributed *i-Nord* system requires a P2P approach. The P2P approach has some issues concerning security, but will also make the system more robust. Furthermore, for some use cases in *i-Nord* it can be important to allow a peer to peer kind of interaction in order to allow autonomous *i-Nord* hosts/actors to communicate real time, for instance in crisis management use cases where events and information preferably should be sent directly between peers.The example shown in Figure 5 will be one of the first use cases to be developed in *i-Nord*.

The *i-Nord* system considers a wide range of security solutions depending on the users and service providers involved and the service required. Internal and external security requirements may vary between the service providers. Security solutions should include, but not be restricted to, IP-address filtering and access by username/password using secure HTTP servers, Public Key Infrastructure (PKI) and Virtual Private Networks (VPN). The solution chosen would depend on the value of the data and information to be handled.

Given the expected complexity and wide range of users as well as the data and information the system is expected to handle the Norwegian National Security Authority (NSM) must be involved throughout the project to avoid any delays due to potential certification of the system at a later time. The first task of the project must be an evaluation of the value of the data and information within the system according to the guidelines issued by NSM. Interoperability is a main issue for *i-Nord* and the evaluation need to focus on separate sources of data and information as well as the integrated approach of *i-Nord*. To keep *i-Nord* as unclassified system specific considerations on the information available within the system may be required. The public Certification Authority for IT Security in Norway (http://www.sertit.no) issues Certificates and Certification Reports. The purpose of the Norwegian Certification Scheme is to cover the needs of government and industry for cost effective evaluation security evaluation and certification of IT systems. The use of the certification scheme is voluntary and the potential requirement for this within *i-Nord* would depend strongly on the evaluation of the value of the data and information within *i-Nord*.

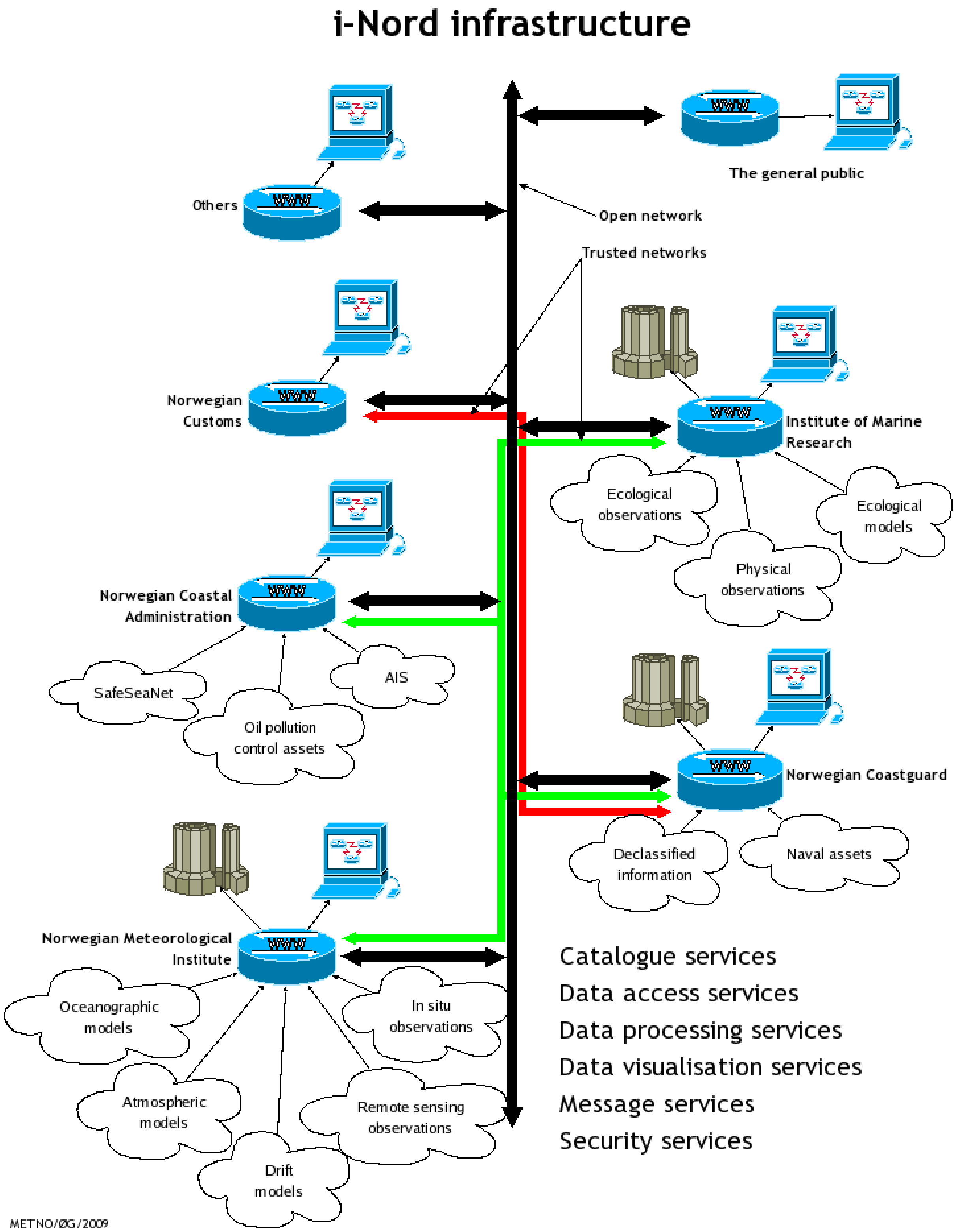


Figure 7 The *i-Nord* infrastructure shall integrate existing data sources, processing resources as well as support secure communication between users. Access to data should be done according to the authorisation level required by the dataset. The example shown relates to Maritime Safety and Security and is by no means a complete illustration for this topic.

4.4.1 Maritime safety, security and operations

The systems of systems approach of *i-Nord* will support maritime safety, security and operations through provision of suitable maritime information views where environmental information is combined with e.g. vessel identification systems and simulation services appropriate for the task undertaken. Specific risk assessment is required when combining the information required to support maritime safety, security and operations as the combination of information needed for this purpose may be of interest to handle the Norwegian National Security Authority.

4.4.2 Marine environment and climate

The interoperability infrastructure of *i-Nord* will integrate existing observation systems and data bases which in the current situation are located in different institutions and with varying online accessibility. Some environmental data as contaminants in biota and sediments sampled during traditional research cruises have long work-up time and analysis time need to be implemented offline. Through this a unified view of the observations and products available in the area is provided. The unified view may be used for real time monitoring, forecasts as well as climate- and pollution studies.

4.4.3 Marine resources

The interoperability infrastructure of *i-Nord* will support resource management through the provision of unified catalogues and standardised interfaces to the information required.

To achieve this goal, an efficient information system is needed, facilitating temporal and spatially resolved information on marine resources. The data infrastructure for traditional resource management is designed for an annual cycle. To meet the requirements in *i-Nord* the infrastructure needs to be improved. The operational models should be updated with new data in near real time, or at least on a time scale comparable to the process that is monitored.

To achieve this, an improved efficiency of the dataflow needs to be developed. This is particularly important for biotic sampling due to the labour intensive sampling procedures. Consequently working up samples needs to be performed at sea or immediately after sampling. For modern observation systems, the challenge relates more to communication systems.

4.5 Communication Systems and Infrastructure

Communication systems are the key enabler for the needed infrastructure to meet the challenging topics addressed in

- Maritime safety, security and operations
- Marine environment and climate
- Marine resources

These topics require several diversified communication solutions with respect to transmission range, bandwidth, update frequency and quality of service (QoS). The needs are not only related to communication in air, but also for underwater installations using either acoustic wireless communication or wired lines, or a combination of both, cooperating all together, as show in Figure 8.

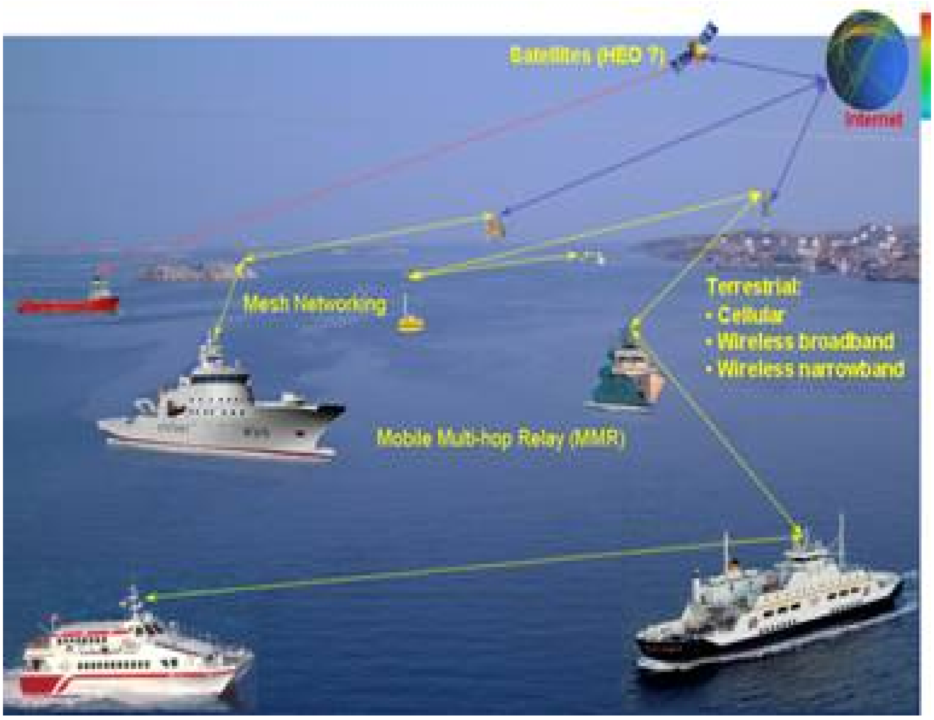


Figure 8 *i-Nord* communication overview

The communication requirements are diversified and quite complicated in the way that information needs to be shared between many parties. Broadband radio communications with data rates up to several Mbps is anticipated to be needed by several activities in vast areas. Lower bandwidth solutions (20-200 kbps) for operational and safety related communication between ships in the area and between ships and shore will also be required.

Systems that requires human processing, e.g. biological sampling, may have organizational bottlenecks more so than technical to meet the *i-Nord* requirements. Underwater systems with range of several kilometers are also of great importance. These infrastructure changes need to be overcome for the *i-Nord* project to be successful.

Extending the coverage and range at sea for both in-use, and novel terrestrial wireless systems will be:

- Cellular
- Wireless broadband
- Wireless narrowband

Finding appropriate satellite communication (SatCom) solutions to complement/supplement the terrestrial systems, mainly beyond their coverage could be:

- LEO: Low Elliptical Orbit
- MEO: Medium Elliptical Orbit
- GEO: Geostationary Orbit
- HEO High Elliptical Orbit

Obtaining seamless and continuous handover and roaming within and between the pertinent systems, in addition to implementing satisfactory reliability, security and integrity. A seamless infrastructure for all activity in the northern and Arctic regions is not possible without new radio solutions for these areas.

Some production chains may require human processing of data. This is especially relevant for environmental or biological sampling that requires laboratory analysis and processing. To update the impact forecast for, e.g. oil-spill impact, field data need to be rapidly processed. This requires communication infrastructures, but also efficient sample processing.

Based on the outcome of the analyses referenced above a set of tentative specifications for a Polar Communication Infrastructure will be proposed and gradually established, and the most crucial parameters of the systems and networks will be resolved.

The *i-Nord* concept set focus on how data and information are shared, visualised and interoperated in a common secure environment between different actors.

The foreseen scenarios where these technologies are necessary are:

- Maritime situation awareness (MSA)
- Crisis management
- Oil and gas leakage monitoring, environmental monitoring of offshore installations
- Vessel monitoring
- Environmental monitoring
- Oceanographic monitoring
- Atmospheric monitoring
- Fisheries and aquaculture
- Ecosystems

4.6 Observation systems and models

Observation systems and numerical models are core elements of an efficient monitoring system. Neither is effective alone, nor cost efficient to operate. An efficient monitoring system must integrate observations and numerical models to achieve the full return of investments in either one. This is the situation whether focusing on real time, near real time or climate applications. Observations are needed to provide the understanding of processes that is needed to set up a proper modelling system and to control the models when running or for validation. Similarly are models needed to define the optimal observation system through observing system sensitivity experiments (OSSE). Finally, to fully exploit the potential of a fully integrated observation system (in situ and remote sensing observations from various sources) and numerical models, assimilation techniques has to be further evaluated along with cost benefit analyses of various observations and numerical models and suites.

In general, monitoring and modelling systems are more mature for atmosphere and ocean dynamics and physics, while they are still at the research and development level for pollution, water quality and ecosystem monitoring and simulations. For instance, there is a strong need to measure pigments, nutrients, contaminants, dissolved gases and other biogeochemical properties in the sea at fine spatial and temporal resolution. Moreover, as the coastal systems reach finer spatial resolution, the need for validation becomes more constrained by lack of data. It is apparent that satellite data alone are not able to make up the deficit of timely observational data needed for most high-resolution coastal systems. Complete satisfactory spatial and temporal coverage of the observing system is therefore not feasible in the near future. It is also necessary to find an optimum, balanced and sustainable observing capacity that can satisfy both environmental and climate monitoring needs. The development and operation of integrated observatories at selected tie-points is considered a viable approach to secure such regular and sustained *in situ* monitoring for environment (inorganic and organic contaminants), resources and climate (physical, biogeochemical) and security (oil spills, red tides, toxic algal blooms).

Sustainable observatories might include atmospheric observations from land based stations, buoys (ocean and sea ice) and ocean observations from moorings, gliders and drifters, repeated hydrographic and water quality (e.g. . Ferrybox-systems, continuous plankton recorder) observations from ferry-lines and regular revisit observations by research vessels or ships of opportunity. Real time or near-real time data flow should be enabled if possible for all in situ observations. Marine safety and operations depend strongly on icing conditions, winds and waves. There is a need to strengthen high resolution (in space and time) observations of currents, waves and precipitation to support needs in this area. This need is both for model input and for validation. To cover this need the number of operating short- and long-range HF radar systems observing waves and current should be increased along with full weather radar coverage along the coast. As one enter closer to shore there is also an urgent requirement for a routine monitoring system of freshwater volume and nutrients discharges from rivers into coastal seas

Optimum performance of the marine monitoring and modelling system will only be achieved when there is an effective two-way integration between the regional-to-local scale observations and models and the basin scale forecasting system. Observations made locally need to be fed back in a timely way to constrain the behaviour of the basin scale model system and thus improve its performance. Data network systems must thus ensure rapid transmission of very high rates of raw data to processing centres and derived products to operational users.

In addition, quantifying and reducing the uncertainty in model simulations is a critical element, in order that society can use the predictions to take informed decisions on mitigation and adaptation strategies. This again points to adequate data coverage and assimilation for combining multivariate data with models to reduce the confidence intervals in the estimates. This presents a major challenge in modeling and prediction, in which quality control of the model fields through regular and consistent validation and inter-comparison against independent observations is mandatory, as is implementation of realistic initial conditions. Moreover, it may include use of multi-model ensemble forecasts.

Currently, we are also seeing a change in emphasis in aspects of climate modeling. Hitherto, focus has been on global centennial predictions, linked to policies for mitigation (in particular reduction of GHG emissions and increased uptake in land carbon sinks by increasing forest cover). In contrast, much greater concern are currently directed towards environmental and climate modeling on regional, annual-to-decadal timescales (ref. next IPCC Assessment Report due in 2010). This changes the picture completely, from one where long-term trends independent of initial conditions are sought to one where initial conditions are crucial. Predicting regional climate change over the next 10-30 years is critically dependent on knowing the current state of the Earth system and monitoring how it evolves in order to keep models on track. This is not only a data issue but requires new methods to assimilate data streams, many of them from satellites, into integrated Earth System models. Essentially, climate models need to be brought closer to the functioning of Numerical Weather Prediction.

Specific challenges and suggested priorities for the purpose of gradually design and optimize a sustainable data and model based monitoring and information system are considered to involve:

- Establishment of an distributed online inventory of existing in-situ data collection programs and activities including data parameters, location, platform details, data policies and the actual data etc through the interoperability infrastructure to be developed.
- Take full advantage of past, existing and planned national and international experience which is relevant for the *i-Nord* area including experience gained within International Polar Year efforts, the Arctic module of MyOcean, Arctic-ROOS, EUMETSAT Ocean and Sea Ice SAF etc.

- Evaluation and cost benefit analyses of in situ and remote sensing observation platforms operating at the sea surface, above (aerial) and below (i.e., the ocean space) with
  - Optimal space and time resolution
  - Optimal list of parameters, indicators
  - Optimal vertical distribution
- Evaluation and cost benefit analyses of relevant existing and potential candidates for operational systems for numerical prediction systems including assimilation of observed data from remote sensing and various in situ platforms.

Currently the main information for traditional fisheries management comes from catch statistics and sampling from commercial fishing vessels and landings, coupled with data from surveys using research vessels, mark-recapture tags or catch per unit effort data (CPUE). The advantage of survey data from research vessels is the possibility to control the design and quality of the sampling, but at the cost of high operating expenses. Table 4 gives an overview of current observation system in traditional resource management. These data can also be used for investigating spatial coverage for single species or species groups, an important aspect of *i-Nord*.

The advantage of biological sampling is the possibility to obtain samples of stomach content, bioptic samples, age and length composition, and age-length keys. These data are important for estimating central ecosystem parameters like trophic interactions, fish condition, spatial distribution etc. However, they are costly need to be manually processed. A good survey design is therefore critical to allocate the resources for biological sampling.

Table 4 Current fishery management observation system

Trawl surveys[b]	Trawl samples from research vessels
Acoustic surveys	Echosounder data from research vessels
Landing statistics/data[b]	Reported landings and biological subsampling
Fishing vessels (biological sampling) [b]	Biological subsampling
Fishing vessels (CPUE)	Catch per unit effort data
Reference fleet[b]	Biological subsampling
Mark-recapture tags[b]	Biomass estimation and biological subsampling
Data recording tags[b]	Behavioural information

[b]Allow for biological samples, including stomack samples, age (otholith reading) and length samples, bioptic sampling (including genetic samples).

Next generation observation system as represented by *i-Nord* must on regular basis supply information on density, composition and biological characteristics with an adequate temporal and spatial resolution. An expansion of present observation system is costwise unrealistic. New sensors, platforms and approaches utilizing adequate models are suggested. The observations will come from a completely new infrastructure although some basic needs associated with annual fish stock assessment will be needed, at least during a transition stage. The system is composed of a set of platforms and sensors communicating in a network as described earlier. The main sensors needed for monitoring ecosystems and marine resources can be summarized:

1. Acoustics. Advanced acoustics gives information on spatial distribution, density and behavior from individuals to high densities of organisms from plankton to whales. Species and size identification is a subject of investigation and might over time reduce the need for biological sampling. These sensors are applicable on most platforms and, when calibrated, they will give comparable information in time and space. They make attractive

complement to traditional observation of the physical and biogeochemical states of the ocean.

2. Biological sampling gears: Remote sensing demand expensive and time consuming sampling for validation. Traditional stock evaluation is based on extensive sampling programs. The gears must be fit to the targeted organisms and thus a suite of gears of different size and operation complexity is needed. Sampling will always be needed but can be minimized in efficient modeling-sampling interactions and by more extensive use of remote sampling techniques like acoustics and satellites.

3. Optical sensors. Camera systems are important in validating remote sensing observation and in mapping of bottom habitat. Lidar is a remote sensing methodology enabling detection and quantification of marine organisms at surface (0-50 m) using laser.

4. Satellite sensors. These sensors can be used to identify large or mesoscale distribution patterns and phenomena related to sea surface temperature, surface geostrophic current, near surface wind and waves, frontal dynamics, ocean color (algal) distribution and sea ice extent, concentration and drift. When this information can be linked to *in situ* observations, e.g. from acoustics or sampling gears, high frequent optical data from voluntary ships, these sensors can be important for developing efficient survey and sampling strategies and detect and quantify ecosystem process of direct impact on marine resources.

Many of the sensors may have different applications when operated from different platforms. In the *i-Nord* infrastructure the main platforms will probably include:

1. Research vessels
2. Vessels of opportunity
3. Cabled system on bottom
4. Buoys, floaters and landers
5. Gliders and AUVs
6. Satellites and Aircrafts
7. Land-based platforms (e.g. HF radar system, weather radar, atmospheric observations)
8. Wireless underwater sensor networks

The various platforms may host a suite of sensors. Also, the technology development reduces size and increase performance on most sensors and thereby makes them available for application in smaller platforms at a reduced price. The ultimate goal is to enable combination of a distributed net of sensors that produce the needed data for operational models. The performance of the *i-Nord* solution is totally dependent of an efficient combination of observations and models. Observations will not only feed the overall spatio temporal models of the main ecosystem component, but also be used to parameterize models describing ecosystem phenomena like migration, feeding etc in relation to environment.

The gradual design, implementation and operation of such an observation and model-based system shall be targeted for the following specific application.

4.6.1 Maritime safety, security and operations

Easy access to improved observations and model products will benefit this community by improving the potential for setting up new services dedicated to specific needs. If better ocean and atmosphere forecasting is achieved margins in various operations may be reduced improving the potential for cost effective operations.

4.6.2 Marine environment and climate

The system of systems approach of *i-Nord* including the interoperability infrastructure will provide a unified view of observations that can be utilised in process studies needed to fully utilise numerical models. These observations can also be used for assimilation within the models and for validation purposes. Sensitivity studies using models and observations will be used to define the optimal and cost effective operational observation system for the area examined. The difference between operational observations and climate observations is in most situations only a matter of time since the observation was made. Main issues for this community are process studies, assimilation techniques and physical parameterisation within a cost benefit analyses context.

4.6.3 Marine resources

Easy access to improved observations and model products will benefit institutions managing marine resources in the area. Simulation services may be established to create scenarios affecting the resources as well as for evaluation of potential.

4.7 System coordination and support

Establishing and maintaining an operational concept of the *i-Nord* project, as well as coordinating the partners in an active *i-Nord* process require a dedicated activity to take responsibility to meet the targets and goal defined of an *i-Nord* system. The intention is primarily to work with distributed services and products provided by the partners involved. However, this may change gradually if new requirements and services are requested during the execution of the project and which are not covered by any of the partner core business and priorities.

In the first phase it is preferable that the activity is hosted by a partner offering 24/7 services.

The core business is to maintain the *i-Nord* system and network offering data and information on two levels. One available to all (public domain) and one restricted and limited distribution where the users are requested to register and log in. This is typically professional users requesting near to real time information, requesting large amount of data or requesting classified information and services. All relevant requests should in principle be answered either by the activity leader directly or by the *i-Nord* management, according to the operational plan of recommendations developed during the project. Some requests may involve the NSM.

5 Work package structure

The project is divided into 9 work packages.

- Application activities
  - WP - 1 Maritime Safety, Security and Operations
  - WP - 2 Marine Environment and Climate
  - WP - 3 Marine Resources

- Technological activities
  - WP - 4 System architecture and information management
  - WP - 5 Communication systems and infrastructure
  - WP - 6 Observation systems and models

- Management activities
  - WP - 7 System coordination and support.
  - WP - 8 Quality Assurance
  - WP - 9 Project Management

The three first work packages reflects the application areas of the *i-Nord* system and the work carried out here is responsible for defining user needs and user requirements, resulting in products and services to be implemented by *i-Nord*. Thus, the connection with *i-Nord* users, potential users and stakeholders are taken care of in these work packages. Also the necessary collaboration with National and International programs and institutes, both on a scientific and operational level, is carried out here.

The user needs and user requirements from the application work packages WP1, WP2 and WP3 are passed over to the work packages WP4, WP5 and WP6 where the actual system design and implementation, both of the main *i-Nord* system and necessary subsystems, are carried out. The gaps between needed and existing infrastructures, observation and communication systems and sensors are identified here and necessary research, development, implementation and integration are planned, initiated and carried out in these work packages.

The last three work packages are aimed at managing the *i-Nord* project and coordinating and supporting the *i-Nord* system as being developed.

Due to the very broad scope and complexity of the project, the project work will be carried out in an incremental and iterative manner in five successive phases. The project is planned to start Q2 2009 and be ended by Q4 2016.

The five phases are:

- **Phase I –** initiates the first "Fast Track" services as well as identifying specifications and requirements for the first prototypes to be developed. This prototype will demonstrate the synergy and value adding services. Simultaneously planning will be worked out for the future concepts, thus identifying needs for R &D activities as well as infrastructure.

- **Phase II** – Iterative implementation and further system and service integration according to the results and requirements of phase 1. There are also foreseen to be some continued R&D activities from phase 1. Consolidation will be prioritised to obtaining best possible results.
- **Phase III, IV and V** - Consolidation of phase I and II along with further on iterative implementation. Dissemination from the previous phases will be an important issue throughout all of these phases.

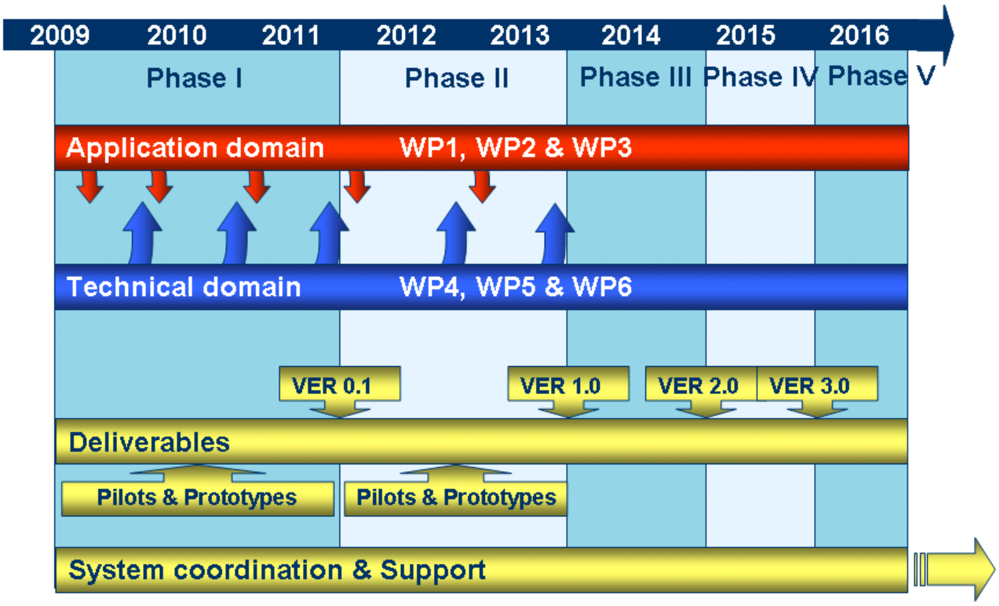


Figure 9 The *i-Nord* proposed project phases

5.1 Work package description

Work package number	1	**Start date or starting event:**	Project kick-off
Work package title	Maritime safety, security, and operations		
Activity type	Application		

Objectives

i-Nord shall be an integrated monitoring and early warning system for Barents sea and the Arctic waters. The first important area of application for *i-Nord* will be maritime safety, security, and operations, supporting functions as day-to-day vessel monitoring, maritime risk assessment, and maritime crisis management. The objective with this work package is to establish user requirements and use cases applicable for *i-Nord* in the maritime domain.

Description of work

The basic idea of *i-Nord* is to use a system of systems approach, where maritime information from existing data collecting- and observational systems, services, and initiatives are integrated. This would lead to enhance maritime situational awareness, supporting inter-agency cooperation, and inter-disciplinary data sharing. Part of this information will also be made available to ships navigating in Arctic waters.

This work package focuses on the maritime domain and will including tasks as:

- Identifying possible end users and stakeholders
- Map existing information sources
- Identifying user information needs
- Identifying new possible data products and services
- Future planning and identification of research activities

The main method used is to establish use cases including relevant scenarios from the maritime domain.
This work package will also investigate how new operational procedures can be implemented in the Arctic area. The objective is to improve safety in the area, involving all ships, at minimum cost in terms of investments and special training.

Phase 1:
During the first phase the requirements from existing users will be documented and used for establishing the first set of core services demonstrating *i-Nord*'s operational capability. Examples of these core services are:

- Integrated oil spill and associated source detection, drift modeling and potential impact service
- Maritime traffic information service, including vessel identity, or unknown status
- Ice information service, including ice map/edge and ice bergs. In particular, detection and discrimination of ice bergs versus ships

Also during the first phase, planning of future concepts and identifying the need for future research will be performed.

Phase 2:
Within phase 2 the results from phase 1 will be further studied along with the identification of new data products and services. Documents from phase 1 will be updated.
New operational procedures gaining from *i-Nord*'s features will be investigated.

Next phases:
During these phases further improvements will be proposed based on feed-back from users and gained from practical experience during earlier phases.

Deliverables

Phase 1:
1. User needs analysis including list of possible end users and stakeholders, identification of existing systems
2. First set of user requirements and use cases for the maritime domain
3. Future planning of new services and research activities

Phase 2:
1. Updated documents from phase 1 according to new findings during phase 2
2. Future perspectives focusing on operational services and procedures

Next phases:
1. Updated documents from phase 2 according to new findings

Work package number	1.1	Start date or starting event:	Project kick-off
Work package title	Maritime Safety, Security and Operations. Iceberg detection and warning		
Activity type	Fast track: Specification and requirement		

Objectives

The specific objectives of this work package are to:

- Apply documented user requirements for specification of the maritime safety, security and operations services to be implemented and delivered via *i-Nord* phased approach.
- During Phase I this activity will focus on services for increased maritime traffic monitoring and control including the Arctic, e.g including service elements:
    - Vessel traffic monitoring (detection, identification, monitoring, routing)
    - Ice berg detection and monitoring
- Discrimination and reporting between ice bergs and other surface targets.

Description of work

The basic idea of *i-Nord* is to use a system of systems approach, where information from existing data collecting- and observational systems, services, and initiatives are integrated into a common maritime picture. This picture could combine maritime vessel traffic data (i.e. satellite imagery, AIS, coastal radar, VMS, LRIT, etc.) maritime information (i.e databases, SafeSeaNet, natural reservations, protected areas, fishery zones) together with environmental information (i.e. meteorological and oceanographic data and forecast). This aggregated information would then be available to the users, leading to enhanced maritime situational awareness, supporting inter-agency cooperation, and inter-disciplinary data sharing. The *i-Nord* approach opens for new opportunities:

- improved data collection by extending existing observation systems as well as development of novel sensor technology and platforms,
- better and easier integration of existing data sets, products and processing chains,
- new services on top of existing services, products and data.

This activity will be initiated shortly after kick-off of the project and will be repeated during each of the phases.

Deliverables

Detailed documentation of the associated users, user needs and user requirements.

Specification of the services to be implemented – specification to be updated per phase.

Work package number	1.2	Start date or starting event:	After deliveries of WP1.1
Work package title	Maritime Safety, Security and Operations. Iceberg detection and warning		
Activity type	Fast track: Implementation		

Objectives

The specific objectives of this work package are to:

- Implement and provide services for maritime safety, security and operations. During Phase I this includes:
    - Vessel traffic monitoring (detection, identification, monitoring, routing)
    - Ice berg detection and monitoring
    - Discrimination and reporting between ice bergs and other surface targets
- Routinely assure the availability of the service information for a Northern area defined in cooperation with the users
- Obtain user feedback on service interactions, and generate requirements for service improvement and for new services.

Description of work

This category services exists and are being provided primarily as individual services by national service providers including KSAT, met.no, Norwegian Coastal Directorate and others. During phase I these elements will be integrated into a more homogenous service concept. This concept shall be capable to provide to the users via an *i-Nord* service interface NRT information on a 24/7 basis on:

- Vessels traffic, including vessel identity, or unknown status
- Ice bergs, identified and discriminated from other targets, temporal berg distribution

The detection and monitoring information should primarily be based on satellite radar images and additional information integrated into a common maritime picture. This picture could combine maritime vessel traffic data (i.e. AIS, coastal radar, VMS, LRIT, etc.) maritime information (i.e databases, SafeSeaNet, natural reservations, protected areas, fishery zones) together with environmental information (i.e. meteorological and oceanographic data and forecast).

By establishing the services during Phase I, the users will get an early experience with the service and the provided information. The users should assess the information and provide feedback on its impact, utility and usefulness, as well as document needs for further improvement and for new services.

These requirements will be provided as input to the technical work packages of *i-Nord*, and the improved and new services should be implemented during the following phases.

Deliverables

Service information according to specifications

Documentation on service performance, utility, and requirements for upgrades and new services.

Work package number	2	Start date or starting event:	Project kick-off
Work package title	Marine environment and climate		
Activity type	Application		

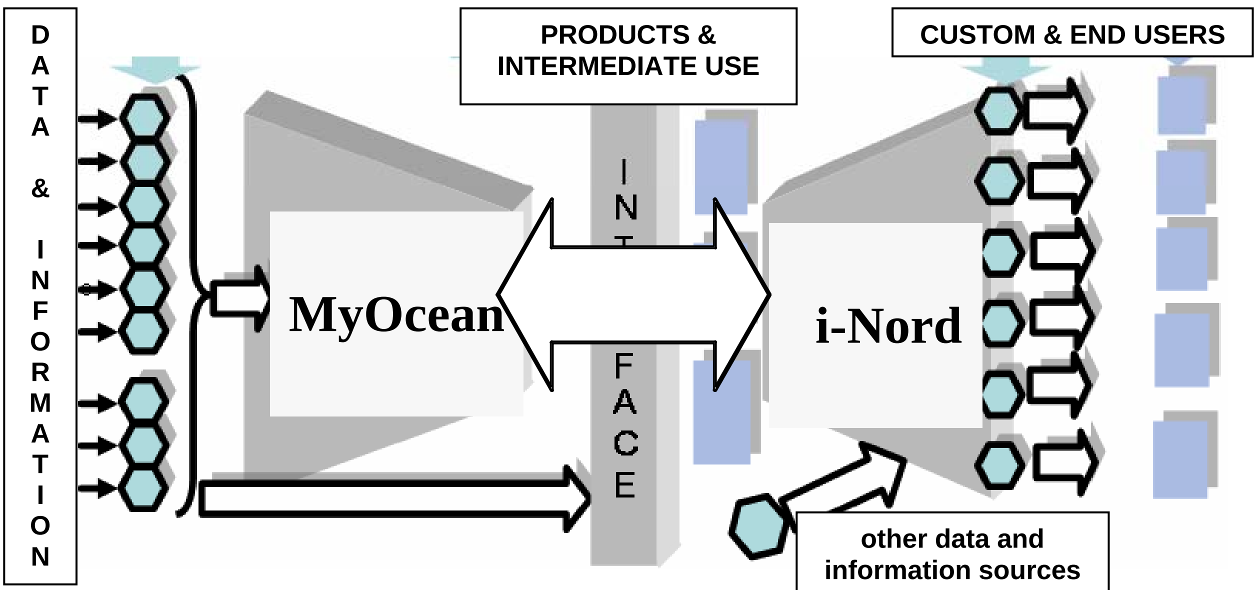
Objectives.

ınage an operative, integrated system for the Arctic environment including atmospheric forecasting, environmental monitoring and ocean forecasting.

Description of work

Phase 1:

- Examine the related data collection programs between the partners and prepare a platform for smooth exchange. Prepare a portal for effective distribution automatically and on demand services.
- Examine Norwegian obligations to data collection initiated by international co-operation like AMAP, Arctic Ocean Network etc.
- Decide for data management standard procedures in consistence with WP 4
- Select and maintain data and products to be available to *i-Nord* Arctic Ocean Portal
- Prepare an assessment based on partners priorities addressing data collection programs at 2-3 years perspective taking account of needs and priorities identified in WP6
- Expand data collection for the open Arctic ocean environment in consistence with OSSE activities undertaken in WP6
- Prepare and establish links to operative numerical forecasting in WP6
- Ensure full utilization benefit of MyOcean and gradually prepare and optimize the two-way link between *i-Nord* and MyOcean as illustrated in the schematic figure.



- Prepare phase 2 in terms of data collection program, research activities, operative infrastructure, share of responsibilities and tasks.

Phase 2:

- Expand the data collection network together with the partners and optimized OSSE executed in WP6.
- Manage and refine procedures for data assembly, exchange and display
- Add new components to numerical forecasting products
- Re-assess plans for next phase.
- As above phase 1

Next phases: As above Phase 1 and 2

Deliverables

Phase 1:

- Report on existing data collection programs, partners priorities and prospects.
- Data assembly of *i-Nord* relevant data to be integrated in the *i-Nord* portal
- Geographical interface to retrieve data and forecasts
- Detailed plan for next phase inn terms of data interface, numerical products etc.
- Weekly ocean magazine at the portal with high lights on last week, specific events, measured data and forecast. Activities.
- Reports on international collaboration and commitments
- Annual workshop

Phase 2:

- Expansion of network. Interface new elements.
- Ocean portal with updated data and information
- Annual work shop
- Reports on future perspectives and priorities.

Next phases:

- Expansion of network. Interface new elements.
- Ocean portal with updated data and information
- Annual work shop
- Reports on future perspectives and priorities

User benefits

- Knowledge-based information and forecasting system that will benefit public and environmental/climate policy implementation and mitigation.
- The users are primarily the intermediate and active partners feeding data and information into the system. Some external users like oil and gas (custom-based) industry will also take advantage of a knowledge-based information and forecasting system. Data collected for operational use will also be available to the research community who will take full advantage of the data management preparation done in the operational phase.

The improved exchange of data between partners will reduce the duplication and increase the multipurpose rating. External users will receive improved weather and ocean forecasts.

Work package number	2.1	**Start date or starting event:**	Project kick-off
Work package title	Maritime Environment and Climate. Oil spill detection and warning.		
Activity type	Fast track: Specification and requirement.		

Objectives

The specific objectives of this work package are to:

- Apply documented user requirements to specify a fully integrated oil spill service to be implemented and delivered via *i-Nord* phased approach.
- This services will include the following elements:
  - Oil spill detection information (time, location, size, potential source (if present), confidence level, impact assessment)
  - Temporal spill drift forecasts
  - Potential environmental impact assessment

Description of work

The oil spill detection service is operationally available today based on satellite and aircraft. In addition, numerical drift models may be invoked by the users upon request. Manual impact assessments can also be done if required.

The activity in this work will assess how the individual oil spill service elements could be integrated in the *i-Nord* context and the complete set of information made available for the users.

This activity will be initiated shortly after kick-off of the project and will be repeated during each of the phases.

Deliverables

Detailed documentation of the associated users, user needs and user requirements.

Specification of the oil spill service to be implemented – specification to be updated per phase.

Work package number	2.2	**Start date or starting event:**	After delivery of WP2.1.
Work package title	Maritime Environment and Climate. Oil spill detection and warning.		
Activity type	Fast track. Implementation.		

Objectives

The specific objectives of this work package are to:

- Implement and a first version integrated oil spill detection service, including:
    - Oil spill detection information (time, location, size, potential source (if present), confidence level, impact assessment)
    - Temporal spill drift forecasts
    - Potential environmental impact assessment
- Routinely assure the availability of the service information for a Northern area defined in cooperation with the users
- Obtain user feedback on service interactions, and generate requirements for service improvement and for new services

Description of work

During Phase I the state-of-the-art service elements will be integrated and the information provided to the relevant users including national pollution control authorities and offshore oil industry. The users will interact with the service and provide feedback which will be used for improvement and further development.

During the following phases the integrated service will be implemented on the *i-Nord* infrastructure, and the results from additional, external service improvements and new developments made available.

The pollution detection and monitoring information should primarily be based on satellite radar images. Information about the potential source will be obtained from direct detection and/or from use of backtracking modelling information, in combination with AIS and installation databases. Forward numerical modelling will be applied for providing information on the pollution temporal drift, and for impact assessment in combination with relevant environmental information e.g. on natural reservations, protected areas, fishery zones etc.

By establishing the services during Phase I, the users will get an early experience with the service and the provided information. The users should assess the information and provide feedback on its impact, utility and usefulness, as well as document needs for further improvement and for new services.

These requirements will be provided as input to the technical work packages of *i-Nord*, and the improved and new services should be implemented during the following phases.

Deliverables

Service pollution information according to specifications, i.e. including:

Oil pollution information:

- Slick location, position and extent
- Time of observation
- Possible source (if present):
    - AIS based vessel identification (when available).
    - Oil rigs, wreck and/or pipeline (if available)
- Confidence assignment (High, Low)
- Country (EEZ) where the spill is located

Additional information:

- Reduced Resolution Image
- Ship detection from satellite image
- Identified ships in the area (if AIS available)
- Predicted (model) wind speed and direction
- EEZ borders
- Offshore installation /pipelines (if available)
- Main ship routes (if available)

Documentation on service performance, utility, and requirements for upgrades and new services.

Work package number	2.3	**Start date or starting event:**	Project kick-off.
Work package title	Maritime Environment and Climate. Harmful algal blooming detection and warning		
Activity type	Fast track activity: Implementation.		

Objectives

The specific objectives of this work package are to:

1. Implement and a first version Harmful Algal Bloom (HAB) activity including:
    - Algal bloom detection information (time, location, size)
    - Algal warning information
2. Routinely assure the availability of the service information for a near coast Northern area.
3. Obtain user feedback on service interactions, and generate requirements for service improvement

Description of work

During Phase I the state-of-the-art service elements will be integrated and the information provided to the relevant users including national and local environmental authorities. The users will interact with the service and provide feedback used for improvement and further development.

During the following phases the integrated service will be implemented on the *i-Nord* infrastructure, and the results from additional, external service improvements and new developments made available.

The potential harmful algal bloom detection and monitoring information should primarily be based on in situ observation and optical satellite- or airborne data. The information on the environmental impact on aquacultures industry will be provided.

By establishing the services during Phase I, the users will get an early experience with the service and the provided information. The users should assess the information and provide feedback on its impact, utility and usefulness, as well as document needs for further improvement and for new services.

These requirements will be provided as input to the technical work packages of *i-Nord*, and the improved and new services should be implemented during the following phases.

Deliverables

HAB information:

1. Location and time of the bloom
2. Algal concentration based on Ships of opportunity data
3. The area covered based on satellite- or airborne data if available
4. Algal identification based on water samples and analyses
5. Assessment of toxicity and the potential harmful effect on fish and human

Documentation on service performance, utility, and requirements for upgrades and new services.

Work package number	3	Start date or starting event:	Project kick-off.
Work package title	Marine resources		
Activity type	Application		

Objectives

- To establish an area based surveillance system of marine resources based on a distributed observational system, real time data flow and operational spatial models that cover the entire ecosystem.
- Establish the surveillance as an integral part of ecosystem based management of marine ecosystems.

Description of work

Phase 1

1. Establish operational spatially explicit ecosystem model
2. Establish operational high resolution 4D mechanistic ocean models for key species of plankton and fish
3. Develop links between models and observations
4. Identify key observational system, in particular for addressing the challenges associated with the increased spatial and temporal resolution. This will be achieved by exploring the model-observation link (previous point), and will be an important input for WP6.
5. Identify operational data flow requirements, both within and between the different service providers, to meet the requirements from the operational models. These requirements will be important guidelines for the development in WP4 and WP5.
6. Present information on marine living resources in a geographic context directly useful for area-based management
7. Research activities for model improvement, including implementation of improved understanding of eco-system processes.
8. Present this information in a geographic context directly useful for area-based management

Phase 2

1. Develop links between operational models and management of marine resources.
2. Implement operational framework for management of marine resources.
3. Implement operational data flows for new observation systems (from WP6).
4. Research activities for model improvement, including implementation of improved understanding of eco-system processes.

Next phases:

- Research activities for model improvement, including implementation of improved understanding of eco-system processes.
- Further iterate the model-observation cycle, where models are used to identify gaps in observations and novel technology provides new opportunities.
- If a promising observation system is identified, implement operational data flow and

coupling to the operational models.

- Continuously searching for potential synergies in combining the information from the ecological models with the information provided from the rest of the *i-Nord* network.

Deliverables

Phase 1

- Established operational Atlantis model for the Barents Sea.
- Established high resolution 4D mechanistic ocean models for key species of plankton and fish species in the Barents Sea.
- Generic procedures for links between the models and different kinds of relevant observations.
- Report describing an adequate observational systems to meet the new requirements
- Implementation of fully operational data flow from observation platforms to land based data bases.

Phase 2

- Report describing links between operational models and management of marine resources.
- Implementation of operational framework for area based management of marine resources.

User benefits

The existing surveillance system for marine resources is designed for supporting assessment and management of single populations on an annual basis for sustainable harvest. This paradigm is now being modified and the new "havressursloven" postulates that management of living marine resources should be performed within an ecosystem approach and in accordance with the precautionary principle. The new challenges we face set completely new demands on data, models and ecosystem understanding to support a sustainable area-based management under the ecosystem approach. Practical day-to-day ecosystem-based management will be facilitated by the *i-Nord* initiative, by making data and advice from many sectors and parts of the ecosystem available at the same time and place. In the development and follow-up of the integrated management plan for the Lofoten – Barents Sea the need for a coordinated and broadly scoped surveillance and monitoring system has repeatedly been specified. *I-Nord* will fill this need and thereby facilitate the follow-up and revisions of the Lofoten – Barents Sea plan.

Work package number	3.1	Start date or starting event:	Project kick-off.
Work package title	Marine resources		
Activity type	Fast track: Marine ecosystem resource monitoring.		

Objectives

- Develop a realistic operational system to quantify fish larval growth and distribution for early prediction of recruitment and potential mortality from pollution.
- Support new information to the fisheries management advice process

Description of work

Phase 1

- Finalize and validate an operational simulation system for distribution of herring and cod larvae from spawning grounds to the Barents Sea.
- Distribute daily operational results on the web.
- Develop an operational system linking larval distributions with potential oil (or other contaminants) distributions and risk assessment of the year class strength.
- Couple zooplankton model with larval drift model to better estimate growth (and mortality) in addition to distribution.
- Improve vertical migration process formulation through detailed field studies from ships and buoys.
- Implement improvements in operational system and new validation
- Define a measurement system necessary to improve accuracy
- Perform and analyze long term simulations to understand and improve predictions of recruitment

Promote the results towards the fisheries management advice process

User benefits

The operational larval drift system will support decisions to be taken during e.g. oil pollution accidents, and may give an early warning on potential negative effects on the year class strength which may have an impact on management advice. This will also support IMR's larval field experiments in real time to optimize the cruise tracks. The long term simulations will be of great interest for understanding recruitment processes, and the potential results may lead to an operational three-year prediction capability of cod recruitment, directly relevant for international management advice.

Work package number	4	Start date or starting event:	Project kick-off.
Work package title	System Architecture and Information management		
Activity type	Technological development		

Objectives

The infrastructure identified, described and implemented within this work package is the glue of the *i-Nord* system. It is what makes the system, without this all sub systems would continue as today and no unified view of a situation is achieved. This work package shall support the needs of the user communities utilising *i-Nord* and must as such be well coordinated with the other work packages of the project.

Description of work

i-Nord will be a distributed system utilising existing infrastructure and in line with international requirements represented by INSPIRE, WIS and GEOSS. All these represent the new generation of systems which all are distributed in nature and utilise Service Oriented Architecture to interface existing infrastructure.

i-Nord shall facilitate mechanisms for sharing data, processing resources and information both in an open environment as well as in a trusted environment. That is, the system shall support both the general public and governmental agencies in need of secure communication and exchange of information and data. All requirements need to be identified along with user communities. It is important to realise that *i-Nord* shall not affect the internal systems of participating entities but interface these. Furthermore, *i-Nord* must comply with international technical requirements represented by INSPIRE, WIS and GEOSS. This implies in short that OGC standards CSW, WMS, WFS, and WCS, and ISO standards ISO19115, ISO19119, and ISO23950 must be supported. Other standards should be supported wherever beneficial for the system, e.g. by the amount of additional data and information that may be available within the system by adding such interfaces.

The main challenge when designing the *i-Nord* system is the variety of sub systems and applications the system shall serve as well as the diversity of the development community. *i-Nord* is linking communities with very different requirements and expectations of the *i-Nord* content and performance. This requires a well documented and endorsed development strategy and tools.

Phase 1:
The development and implementation strategies and tools needs to be identified, documented and endorsed. A risk assessment according to the guidelines issued by the Norwegian National Security Authority (NSM) is required along with an evaluation of the potential need for usage of SERTIT certification scheme. This is important for the strategies, standards and tools adopted within the project.

All functional and technical requirements must be identified, documented and related to specific user communities within or external to the system. All functional requirements must be described using use cases.

The functional and technical requirements must be broken down into a detailed specification which is suitable for implementation. The detailed specification must be unambiguous when used for implementation.

The technology and standards identified has to be implemented and used to integrate existing infrastructure. This is a stepwise task that will be repeated throughout the other phases of the project and requires strong coordination within the project to achieve the functional requirements identified. A specific test plan has to be identified and followed to make sure the implementation comply with the requirements. The test plan should relate directly to functional and technological requirements identified.

The resulting infrastructure shall be demonstrated within the identified areas of *i-Nord*. This will be done in a stepwise manner, area by area and by adding functionality as it is developed.

It is not expected that the implementations of phase 1 will have full functionality nor conform to all standards/specifications, but after phase 1 key components of existing infrastructure should be integrated and available for use within *i-Nord*.

Phase 2:
Within phase 2 the implementations of phase 1 will be further developed along with updates of the implementations with the required protocols and standards as well as new backend and front-end services. All documents must be updated and endorsed.

i-Nord will use known technology and standards wherever possible. When the functional and technological requirements along with the detailed specifications identify tasks that cannot be solved using known technology or standards, research and development is required. This should however preferably be done through existing bodies and by influencing the relevant standards. Research and development in such situations must be closely related to the user requirements whether internal to *i-Nord* or external.

Functional requirements, the detailed design and implementations are revisited and extended aiming towards compliance with the main *i-Nord* standards and protocols.

Next phases:
During these phases the future perspectives of interoperability and dissemination technology is examined and exploited.

Deliverables

Phase 1:

1. Risk assessment document concerning the information contained within *i-Nord* according to guidelines from NSM, first version
2. Development strategy and standards document, first version
3. Functional requirements document, first version
4. Detailed specification document, first version

5. System design document, first version
6. Interoperability implementation and documentation of selected parts of existing systems (backend and front-end services), not necessarily compliant with all system specifications[4]

Phase 2:

1. Updated documents from phase 1 according to the content of *i-Nord* and compliance with standards
2. Updated interoperability implementations and documentations of selected parts of existing systems, compliant with all specifications defined within phase 1, addition of new backend and front end services
3. Future perspectives document focusing on potential technology to be evaluated and possibly implemented in subsequent phases[5]

Next phases:

1. Updated documents from phase 2 according to the foreseen information and services content of *i-Nord*
2. Updated versions of the implementations and addition and documentation of new backend and front-end services

User benefits

Establishing an interoperability infrastructure will have strong benefit for all user communities. If this is designed and implemented appropriately, it will be a cost effective interoperability solution for governmental agencies as well as external users providing a unified role restricted view of the information, observation, products and services available for utilisation. Designed, implemented and managed properly it may help avoiding duplication of efforts and creating a balanced and appropriate observation system for the support tasks undertaken by *i-Nord*. It should be emphasised that the system must be cost effective to achieve support within the service provision community and that the success of the system depends on the service providers.

[4] Due to both maturity of some standards and the effort required to adapt existing systems.
[5] This requires input from the information content work packages of *i-Nord*.

Work package number	5	**Start date or starting event:**	Project kick-off.
Work package title	Communication Systems and Infrastructure		
Activity type	Technological development		

Objectives

The objectives are based on the users needs (transmission rate, bandwidth and quality of service) to provide suitable communication systems and infrastructure for activities in:

- Maritime safety, security and operations
- Marine environment and climate
- Marine resources

In this context, existing infrastructure will be utilised wherever this is possible. New technology will be developed according to a prioritised list worked out in this work package and harmonised with the available funding.

Description of work

Phase 1:

1) Based on the user scenarios, identify user requirements for the different communications systems (transmission range, bandwidth, QoS) :
   a. Sensor networks
   b. Surveillance systems
   c. Crises management systems
2) There will be a lot of interoperating communication systems in *i-Nord*, and it is necessary to identify those who need to share information.
3) A lot of data from various nodes and sensor networks needs to be secured for a safe transfer. Several security mechanisms needs to be identified and proposed built-in in the communication systems and infrastructure.
4) Lacking systems performance and/or improvements needs to identified verified and proposed improvements proposed for the *i-Nord* concept. Proposed new developments will be identified.
5) Prioritise an activity list based on the findings in the previous task.

Phase 2:
The following activities are planed for phase 2:

- Development of prioritised communication systems/subsystems
  - Technical specification
  - Prototype development and testing
  - Re-design of prototype towards product development
- Integration of developed systems
- Evaluation of obtained results from developed systems

Next phases:
The proposed activities for the following phases are:

- Carry out a new scenario study to identify user needs and the related communication systems/subsystems and infrastructure.
- Specification and prioritising of the systems
- Technical specification and development of the final systems
- Test and integration

Deliverables

Phase 1:
Reports will be worked out from each of the activities described above.

Phase 2:
Reports and functional prototype systems will be delivered and demonstrated.

Next phases:
Reports and previously identified will be delivered for a fully operating *i-Nord* communication system and infrastructure.

User benefits

Communication systems and infrastructure is crucial for a success in the *i-Nord* concept. Data from sensor networks/monitoring systems and for handling crises management must be passed on to the right entity. This work package will within the given funding provide trusted technology for data transfer.

Work package number	6	**Start date or starting event:**	Project kick-off.
Work package title	Observation Systems and Models		
Activity type	Technological development		

Objectives

Design and implement an optimum observation- and model-based information system for *i-Nord* tailored to support application dictated by:

- Maritime safety, security and operations
- Marine environment and climate
- Marine resources

Description of work

The observation system has three subsystems:

- Measurements (sensing) sampling and data transmission
- Data management and dissemination
- Data analysis and modelling

This WP will bridge national and international operational observing systems like EUMETSAT, Arctic ROOS, the Arctic component to My Ocean and available observations of the marine ecosystems. It will contribute actively to the Pan Arctic Observing network initiated by US and Canada. It will reflect the overall objectives of *i-Nord* and its stakeholders as well as take full advantage being an active member of the Arctic Community.

Sustainable in-situ and satellite based observations are vital elements to establish and operate *i-Nord*. Observations managed and co-ordinated by *i-Nord* will include fixed buoys and drifters, routinely hydrography and water quality characterisation (e.g. continuous plankton recorder) from research vessels, Ferry boxes (observations from ships of opportunity). All systems delivering data automatically and in near real time. Radar systems at coastal points will provide detailed features and with appropriate area coverage, of surface current, waves and weather. Experiences from similar installations elsewhere in Norway should be examined closely. Such sustainable in-situ observations combined with satellite observations are mandatory for model validation that, in turn, shall be used to define the optimal observation capacity through observing system sensitivity experiments.

WP-6 will actively and continuously keep a dialogue with the stakeholders representing the three main vertical structures of *i-Nord*: WP-1 (maritime safety, security and operations), WP-2(marine environment and climate) and WP-3(marine resources).

Quantifying and reducing the uncertainty in model simulations is also critical in order that society can use the predictions to take informed decisions on mitigation and adaptation strategies regarding a wide range of applications including. The intention is to take full advantage of the existing infrastructure provided by key institutions and together decide for solutions serving their needs optimally. All sorts of formal restrictions preventing open and free share of data and information has to be sorted out and codes for operation decided for

An effective data management reduces uncertainties about quality and provide professional solutions for storage and dissemination. An effective data management will primarily depends on the partners, but *i-Nord* has to adopt a best available standard and actively promote all partners to follow recommended principles of data control, storage and dissemination. An effective data management in *i-Nord* will actively distribute data for operational as well as for research purposes. In this context data delivered from *i-Nord* shall be associated with highest standard available for data management.

The selection of data, regularity and dissemination sequence should reflect *i-Nord* ability to serve all kinds of requests. Of major importance is data input to initialize numerical prediction models. Some of the partners as METNO, IMR, NIVA and NERSC are professional users of data. METNO, IMR and NIVA are active data providers. The four institutes are also are also professional users operating numerical models for atmospheric and ocean prediction. The prognostic value and significance is critical dependent on a regular data input with appropriate resolution in time and space domain. A critical examination of the data input to optimize the data collecting serving the models will be part of WP-6 in phase 1.

Phase 1:

Establish priorities for gradually design and optimization of a sustainable data and model based monitoring and information system:

- Establishment of a distributed online inventory of existing in-situ data collection programs and activities including data parameters, location, platform details and data policies.
- Develop and improve infrastructures for rapid access of key existing observations to *i-Nord* users and others.
- Take full advantage of past, existing and planned national and international experience which is relevant for the *i-Nord* area including experience gained within International Polar Year efforts and its legacy, the Arctic module of MyOcean, Arctic-ROOS, EUMETSAT Ocean and Sea Ice SAF etc.
- Execute a series of observing system simulation experiments (OSSE) in order to identify the major deficiencies in existing observing capacity.
- Use these OSSE results to optimize the design of the in-situ and satellite observing system.
- Evaluation and Cost Benefit Analysis (CBA) of in situ and remote sensing observation platforms operating at the sea surface, above (aerial) and below (i.e., the ocean space) with

- Optimal space and time resolution
- Optimal list of parameters, indicators
- Optimal vertical distribution
- Expand and improve observation network

Phase 2.

- Update new elements to the observation network and examine the partner's priorities for the coming years.
- Refine structure of data management network and distribution system
- Prepare *i-Nord* priority list reflecting the partners individual priorities and *i-Nord* overall objectives and responsibilities
- Prepare detailed budget and implementation plan for observation network for 5 year period
- Prepare detailed budget and operational plan for expanding and improving numerical models for a 5 year period
- Attend international and national workshops in Arctic observations and forecasting services

Deliverables

Phase 1:

- Inventory of relevant operational, national and international data collection program
- Implement necessary infrastructure to provide first generation of *i-Nord* data and information distribution system
- Serving *i-Nord* WEB based portal. Presenting links and operative information from international systems relevant to *i-Nord*.
- Report based on first operational experience and feed back from partners and user community
- Provide regular inventory and statistics of *i-Nord* user community.
- Deliver Cost Benefit Analysis (CBA) of existing observing system and services

Phase 2:

- Expanding the suite of services including data and forecasts products form the Arctic
- Maintain and improve data management activities of the *i-Nord* network. Updated version of the WEB based portal.
- Expand network of user community and service and data providers.
- Updated plan for the optimal observing network of *i-Nord* reflecting latest priorities from user community and service and data providers

- Implement new elements to the data collection program.
- Updated CBA of the existing *i-Nord* observing system
- Plans for next 5 years with budget.
- Publications and presentations of *i-Nord* in national and international conferences

User benefits

The value of an adequate observing system for the Arctic and Barents Sea is multiple. Locally it is a great value to the partners of *i-Nord* to share information and data.

i-Nord provides a forum for effective and professional co-ordination of data collection and numerical operations. It will serve as a platform to seek common and cost effective solutions to data collection and to explore new opportunities. It will attract the new user groups. It will have an impact on safety and security issues in the Arctic and Barents Sea. It will support the professional users/partners of *i-Nord* to meet the new challenges driven by climate changes and increased exploitation of this region.

With *i-Nord* Norway contribute actively to the global programs in ocean and atmospheric observations and prediction in a short and long term perspective.

Work package number	7	**Start date or starting event:**	1
Work package title	System Coordination and Support		
Activity type	Management		

Objectives

The objectives of this work package are:

- Develop plans for integration and deployment of user applications for each phase of the project
- Integrate the main technical components of the *i-Nord* developments of the other WPs according to the plans
- Assess the *i-Nord* system and concepts
- Refine the results based on feedback from the users.
- Gradually, and based on the previous points and the other WPs, develop operational plans which will be the basis for a long-term operation and maintenance for the *i-Nord* system.

Description of work

Establishing and maintaining an operational concept of the *i-Nord* project, as well as coordinating the partners in an active *i-Nord* process require a dedicated activity to take responsibility to meet the targets and goal defined of an *i-Nord* system. The intention is primarily to work with distributed services and products provided by the partners involved. However, this may change gradually if new requirements and services are requested during the execution of the project and which are not covered by any of the partner core business and priorities.

Phase 1:

- Identify the personnel and the roles that will be involved in the System Coordination and Support activity.
- Define the integration and user application scenarios and design them so that they inflict minimum disturbance on the normal operation of the user organizations.
- Define detailed System Coordination and Support plans for the first phase, incl. the evaluation and assessment of the integration and deployment of user applications.
- Execute the application scenario and evaluate and assess according to the defined criteria.
- Define the first version of the Operational Plan of Recommendations to be presented to the PMB, UCRG and SAB. The PMB is asked to assess these recommendations.

Phase 2:

- As above, but with adjustments according to
    - lesson learned, cf. evaluation and assessment report,
    - the plans of this phase, and
    - decision made in PMB and PACB, and recommendation.

Next phases:

- As above.

Finalise the Operational Plan of Recommendations to be approved by the PMB.

Deliverables

Phase 1:

- User application scenarios
- Detailed plans for the whole phase
- Evaluation and Assessment Report, cf. execution of the integration and application scenarios.
- Regular updates and reports, incl. input to Project Activity Report.
- Operational Plan of Recommendations Report (This report id the basis for the PMB to decide on the

Phase 2:

- As above with adjustments

Next phases:

- As above

User benefits

- Reliable and timely information and services related to environmental and security issues in support of public policy makers' needs for sustainable management of the Nordic Seas and the Arctic Ocean.
- Operational plans for support of application such as dynamic and effective risk assessment to support decisions and crisis management.
- Effective and professional services to operators in the region including fisheries, ship transport and offshore industry.
- Basis for regulations and negotiations with neighbouring countries.
- Co-ordination of existing activities in the Nordic Seas and the Arctic Ocean.
- Strengthen the position of Norwegian research of all disciplines related to the priority issues of *i-Nord*
- Norway's contribution to Pan Arctic Observing Network.
- Support to priority sectors defined by Arctic Council.
- Support to Norwegian industry in delivering systems and services related to *i-Nord*.
- To strengthen the collaboration between Norwegian Industry and Norwegian research institutes within the scientific areas related to the issues addressed by *i-Nord*

6 Project management

This project will be carried out by a Consortium of Beneficiaries (Project Partner) from rather different types of organisations. The Beneficiaries vary not only in size and type, but also in terms of the role in and expectations from the project (Research and technology provision, software development tool vendor, system and service development organisation, Domain Content Providers, etc.). This disparate collection of Beneficiaries will pull together to ensure a successful project; the project management and co-ordination structure here described is intended to facilitate this.

The Project Activities are divided into several work packages (WPs). These constitute the main work breakdown structure of the project, grouping the major activities to be carried out. The management structure of the project reflects this work breakdown structure. The overall project management structure with roles and responsibilities is depicted in the following Figure and summarised below.

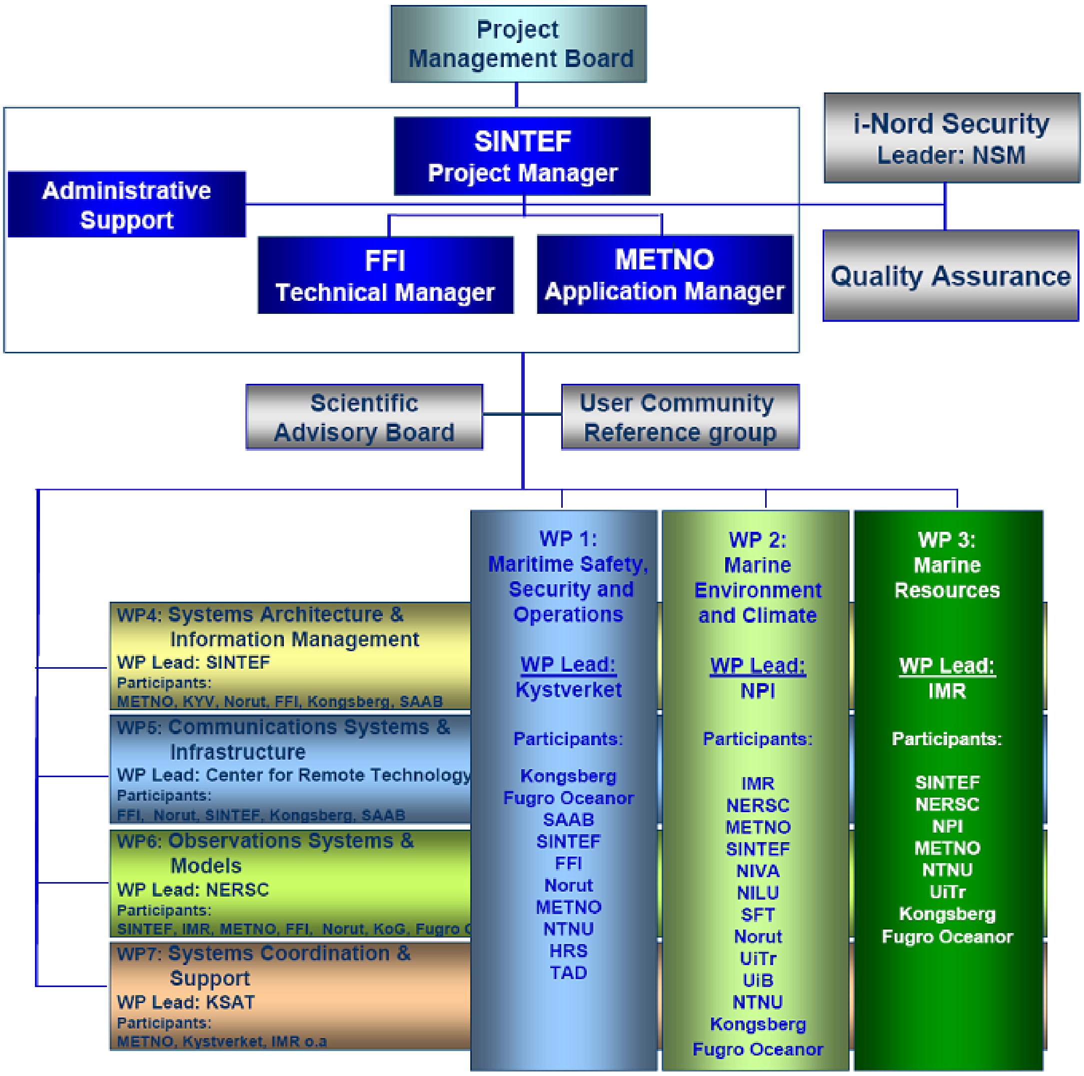


Figure 10 The *i – Nord* project organization and management structure

An overview of the management bodies, their composition and principal responsibilities are shown in the following table.

Table 5 Management structure

Level	Body	Composition	Principal Responsibilities
Project as a whole	Project Management Board	5-8 authorized representatives.	• Strategic decisions. • Resolution of any major conflicts • Overall project governance and management
	Project Activity Coordination	Project Manager, Application Manager, Technical Manager and Work Package Leaders	• Make strategic decisions concerning project co-ordination and direction, • Overall technical management and planning. • Project Risk Management.
	Project Management	Project Manager, administrative support	• Implement decisions of the Project Management Board and Project Activity Coordination • Assist all other management bodies. • Overall day-to-day project management.
Work Package (WP)	WP Leader	One responsible person per WP	Co-ordinate a specific WP, and report on progress of detailed work in the WP.

6.1 Project Management Board

The Project Management Board (PMB) is the formal decision body of the consortium. It is responsible for the overall management of the project. It consists of 5 – 8 members; it is chaired by a representative appointed by the Commissioning Party[6], which also approves the other members of the PMB, including at least include the representative of the Coordinating Partner. The PMB will be delegated the necessary authority to make decisions binding the Project as a whole. The PMB will meet every three months to monitor and direct the progress of the project. Some meetings may be organised as telephone conferences. The tasks of the PMB include:

- Ensure that the progress is maintained according to the Project Plan.
- Review and approve the financial status.
- Review and approve the regular project risk assessment.
- Approve the Project Quality Plan.
- Formally approve the project technical results.
- Approve Quarterly Management Reports
- Provide strategic guidance for the project management related to:
    - Exploitation and commercialisation potential.
    - Intellectual property management.

[6] The Commissioning Party is the Government Body signing the contract on behalf of the Government, i.e., representing it as the Contractor.

    - Dissemination and promotion activities.
- Resolve potential and actual disputes between participants not resolved at lower decision levels.
- Reallocate budgets if necessary.
- Assess gender and ethical issues.

For the day-to-day management the PMB will delegate the responsibilities to the **Project Manager**. The Project Manager will report to the PMB, which will be the highest project authority. Each member of the PMB has one and only one vote in the PMB.

6.2 Project Activity Coordination

The Project Activity Coordination Body (PACB) decides on the day-to-day Project Activity, and the coordination of user requirements w.r.t. the technical effort undertaken in the WPs. It consists of the Project Manager, the Application Manager, the Technical Manager and the WP leaders. PACB is chaired by the Project Manager. The PACB will be delegated the necessary authority to make decisions binding the Project Activity as a whole on the day-to-day basis relative to the Project Plan. The PMB will meet at least every month to actively take decisions and direct the Project Activity. Some meetings may be organised as telephone conferences. The tasks of the PACB include:

- Review the overall Project Activity.
- Coordinate and balance the Project Activity according to user needs and technical developments, including strategic project activity decision to achieve the project objectives.
- Resolve Project Activity disputes not resolved on lower level,
- Develop and follow up the Project Quality Plan.
- Review Quarterly Management Reports
- Develop and follow up plans for:
    - Exploitation and commercialisation.
    - Intellectual property management.
    - Dissemination and promotion activities.
- Re-planning and suggest reallocation of budget if necessary.

6.3 Project Manager

The Coordinating Partner[7] will undertake the overall responsibility for the management of the project, as well as for all liaisons with the Commissioning Party. The **Project Manager's** responsibilities are:

- Implement the strategic project management.
- Overall project management and monitoring.
- Reporting the Project Activity status and plans in the PMB meetings.
- Chairs the Project Activity Coordination Body
- Responsible for the coordination and collaboration with NSM (The National Security Authority).

[7] The Coordinating Partner is the partner with the contractual responsibility towards the Commissioning Party.

- External relations including management contact with the Commissioning Party, other relevant (international) projects and authorities,
- Schedule and organize project review for the PACB with both the User Community Reference Group (UCRG – a panel of national / international user representatives and collaborative partners of the *i-Nord* project) and Scientific Advisory Board (SAB – panel of international experts), at least once a year for each of the UCRG and the SAB.
- Successful operation of the project management and implementation of the project management structure.
- Editor of the Quarterly Management Reports

6.4 Technical Manager

The responsibilities of the **Technical Manager** are:

- Co-Vice Chair of the Project Activity Coordination Body
- Deliverable quality control (peer review)
- Responsible for the *i-Nord* System and Technological strategy
- Coordinating WPs and supervision of the technical progress
- Implement the input from SAB as decided by the PACB and approved by the PMB.
- Provide the necessary input to the Quarterly Management Reports.
- Editor of the Project Review Reports

6.5 Application Manager

The responsibilities of the **Application Manager** are:

- Co-Vice Chair of the Project Activity Coordination Body
- Deliverable quality control (peer review)
- Responsible for the *i-Nord* Application strategy
- Implement the input from UCRG as decided by the PACB and approved by the PMB.
- Provide the necessary input to the Quarterly Management Reports.

6.6 WP Leader

The responsibilities of a **WP Leader** are:

- Co-ordinate the day-to-day activities and tasks within an assigned WP
- Provide the necessary input to the Project Review Reports.
- Resolve WP Activity disputes not resolved on the task level

6.7 Internal and external communication

The project will be officially launched with a kick-off meeting. Every twelve month, the PMB through the Project Manager arrange a complete ‘Open Review’ of the project. Representatives from both the Commissioning Party and other collaborative Partners will be invited, e.g., from the UCRG. An annual report will be issued covering technical, general, financials and administrative activities (work programme, costs breakdown, organisational change, etc.)

Project workshops, involving all project participants and invited external organisations (the members of the UCRG and SAB included), will be set up by the PACB and arranged every twelve months, in conjunction with the ’Open Review’, to make all the project members and external organisations aware of specific project achievements.

For the day-to-day management, the PMB meets at least every three months, approving the Quarterly Management Reports (work done in the WPs and on the corresponding achievements) and the Project Review Reports (progress status of the technical work, results obtained and compliance with the work programme) according to the rules defined by the Contract with the Commissioning Party.

Other communication issues:

- On decision of the WP leaders, technical meetings will be held for each WP. The WPs may also have common jointly meetings with other WPs.
- On decision of the PACB or the WPs, workshops may be held with local reference groups to gather information on requirements and to get feedback on preliminary results.
- In addition to ordinary meetings, telephone conferences, web-meetings and e-mails will be used to reduce travel costs and to ensure high level involvement from all participants.
- A shared electronic workspace will be established to support the daily work in the work packages, and the management and coordination activities. Documents produced by the participants as well as other relevant information will be put on this workspace, and all participants will have writing and reading access to the relevant parts.

6.8 Consortium overview

The following institutions are partners in the project:

- Norwegian Meteorological Institute (met.no)
- Nansen Environmental and Remote Sensing Center (NERSC)
- Norwegian Defence Research Establishment (FFI)
- Institute of Marine Research (IMR)
- Norwegian Polar Institute (NP)
- Norwegian Institute for Water Research (NIVA)
- Norwegian Institute for Air Research (NILU)
- University of Bergen, Geophysical Institute (UiB-GFI)
- University of Tromsø, Center for Remote Technology
- Norwegian University of Science and Technology (NTNU)
- Northern research Institute Tromsø (NORUT)
- Fugro OCEANOR AS
- Kongsberg gruppen (KOG)
    - Kongsberg Satellite Services AS (KSAT)
    - ongsberg Spacetec AS (Spacetec)
    - Kongsberg Defence & Aerospace AS (KDA)
- Saab company
- SINTEF

A description of each institute is given in the following.

6.8.1 Norwegian Meteorological Institute (met.no)

Address: Norwegian Meteorological Institute
P.O.BOX 43 Blindern
NO-0313 OSLO
NORWAY
e-mail: met.inst@met.no
web: http://www.met.no/

The Norwegian Meteorological Institute (**met.no**) was founded in 1866. Today **met.no** has approximately 420 employees, in addition to about 600 observers scattered across the country and at Arctic stations. The main office is in Oslo and there are regional offices in Tromsø and Bergen.

The institute is organised into 6 departments:

- The Meteorology Department operates the public weather service on a 24/7 basis with forecast offices in Oslo, Bergen and Tromsø.
- The IT-department, develops, improves and operates the IT-infrastructure of the institute 24/7.
- The Observations Department is responsible for the observation system, including the in situ observations network as well as remote sensing systems.
- The Climate Department focuses on the assessment of the climatology of Norway including the adjacent seas and the Norwegian sector of the Arctic.
- The Research and Development Department performs research to continuously develop, improve and validate the numerical models used in the daily operational forecasting. Numerical modelling techniques, in situ and remote sensing observations and data assimilation techniques are used in the work, and the research work is carried out in collaboration with national and international research institutions.
- The Administration Department provides administrative support.

met.no is responsible for the public weather service in Norway, covering both civilian and military purposes. The institute is providing information that supports public authorities, businesses and the general public to secure life and property and in support of societal planning and environmental protection.

The tasks of **met.no** is partially solved through public funding and partially through national and international project funding from research councils, EU, ESA, EUMETSAT and others. **met.no** only undertakes externally funded project work that supports the core mission of the institute which is to safeguard life and property.

met.no performs research and development activities related to operational numerical models of the atmosphere; oceanographic and sea ice forecasting are continuously being improved, and environmental models are developed and operated. Climate research ranges from modelling global and regional climate including scenario calculations as well as downscaling to finer resolution over Norway and adjacent seas. Time series analyses of climate variables are carried out, as well as remote sensing research and development of IT-tools and applications.

met.no has an international orientation with a multitude of partnerships both within the operational parts as well as in R&D. The institute educates PhD.s and Postdocs on a regular basis thanks to its close collaboration with (and proximity to) the University of Oslo.

6.8.2 Nansen Environmental and Remote Sensing Center (NERSC)

Address: Thormøhlensgate 47
N-5006 Bergen, NORWAY
Phone; + 47 55 20 58 00, Fax: +47 55 20 58 01
e-mail: adm@nersc.no
web: http://www.nersc.no

The Nansen Environmental and Remote Sensing Center (NERSC) was founded in 1986 as an independent non-profit research institute affiliated with the University of Bergen. *The vision* of NERSC is to provide an international scientific contribution to increase the understanding, monitoring and forecasting of local, regional and global environmental and climate change issues and their impact on society. NERSC performs interdisciplinary basic and applied research related to the physical environment, natural resources and climate by integrated use of satellite and aircraft remote sensing, in situ observations, and numerical model tools, including data assimilation.

NERSC operates on a project basis, with major funding from the European Union research programs, Research Council of Norwegian, the European Space Agency, the Norwegian Space Centre, industry and other governmental and international agencies. The Center has participated in about 70 EC funded research projects, of which 26 have been coordinated by the Center. The Center plans and executes national and international research programs funded by research councils, governmental agencies and industry mainly focused on:

- development and validation of remote sensing methods in earth observation,
- applications of remote sensing in coastal zone management, marine monitoring and forecasting of ocean physical and biological variables, marine pollution and sea ice,
- development of numerical models for studies of marine environmental parameters and global /regional climate variations,
- development of assimilation techniques for utilization of remote sensing data in ocean dynamics, coupled ecology as well as water quality modelling,
- development of marine information systems,
- climate studies with focus on the role of sea ice and ocean circulation at high latitudes,
- modelling of marine ecosystems and carbon cycles,
- studies of vegetation, hydrology and geology using remote sensing,
- teaching and training.

Personnel Resource: By the end of 2007 the staff comprised of 64 persons from 14 nations. The staff members include 33 scientists in permanent and adjunct positions, 14 Ph.D. candidates, seven Post Doc candidates, six Master students as well as administrative/technical personnel. The scientific personnel have professional background in oceanography, climatology, mathematics, physics, informatics/ computer science, geology and biology. The

Nansen Center has a strong international profile working in many multinational projects in Europe including Russia, North America, Asia and Africa.

Scientific Production: The scientific production in 2007 included 33 referee publications, one book and one book contributions, 22 publications in conference proceedings, 26 technical and special reports for clients and 15 popular science articles. In 2007 two Ph.D. Candidates completed their dissertation and four Master exams. The annual number of publications, books and reports has for the last ten years been between 60 and 100.

NERSC is the core founding institution and a member of the Nansen Group, a global research network with about 150 scientists and Ph.D. candidates conducting research projects in cooperation with partners around the world. The Nansen Group also comprises:

- Nansen International Environmental and Remote Sensing Centre - a non-profit joint venture for research in St. Petersburg, Russia (established in 1992).
- Nansen-Zhu International Research Center, a non-profit joint venture for research in Beijing, China (established in 2003).
- Nansen Environmental Research Centre India Ptv. Ltd. - a private, non-profit research company in Cochin, India (established in 1998).
- Nansen Scientific Society – a foundation fostering science cooperation for greater understanding and co-existence in the word - in the spirit of Fridtjof Nansen.

6.8.3 Defence Research Establishment (FFI)

Address: Instituttvn 20, N-2007 Kjeller, Norway
P.O.Box 25, N-2027 Kjeller, Norway
Phone +47 63 80 71 00
Telefax +47 63 80 71 15
E-mail: ffi@ffi.no
web: http://www.mil.no/felles/ffi/start/

FFI is the prime institution responsible for defence-related research in Norway, and has good insight into Norway’s military organisation and military operations. The Establishment is also the chief adviser on defence-related science and technology matters to the Ministry of Defence and the Norwegian Armed Forces’ military organization. FFI has key knowledge of the Norwegian Armed Forces systems and user needs.

Research pinpointed to challenges in the High North has been a foundation pillar in FFI’s priority programme. New strategy plans within FFI also focus on better dual-use of the research establishment’s expertise to improve security of society and of individual citizens in a more civilian context. FFI as an organisation is very multidisciplinary, and can in that respect contribute quite diversely to the *I-NORD* project.

Foreign and Security Policy: In the security policy domain, most of the focus is on developments in Russia in the post-Soviet era. Our focus has been on assessing Russia’s capability and willingness to use military power in the High North Areas and opportunities for cooperation with Russia, both bi-lateral and within NATO.

Geo- and Environmental Science: FFI has carried out long-term research to understand the oceanographic processes in the region. Observations have focused on sea-bed mapping and characterisation, as well as observing sea water properties of the region. More recently, techniques for so-called Rapid Environmental Assessment (REA) have been developed and tested, mainly to support possible military operations. The REA capabilities cover all aspects of oceanography and meteorology from the sea bed to the troposphere. FFI is also involved in research in how marine life is affected by underwater sound, and has together with other institutions developed methods and technology for monitoring behavioural response of fish and sea mammals

Technology Development: In the technology development domain, FFI is working on sensor and information infrastructure development. The High North poses specific challenges: Extreme weather conditions, and very limited means of communications. Within communications network technology, FFI has expertise in network security, communications using limited bandwidth and underwater communications. Regarding platforms and sensors, FFI key areas of expertise include:

- Autonomous Underwater Vehicles, Navigation
- Advanced sonars, including Synthetic Aperture Sonar, both for imaging and target detection Radar sensors for target detection and tracking (ship based, airborne and satellite)
- Micro-satellites for maritime traffic monitoring

6.8.4 Institute of Marine Research (IMR)

IMR, with about 700 employees and 2500 ship days pr. year, is a national governmental institution under the Ministry of Fisheries. The main tasks are to do ecosystem monitoring and research for better management advice on the marine ecosystems of the Barents, Norwegian and North seas and the Norwegian coastal zone, and on aquaculture. In addition IMR has a significant activity in developing countries. IMR has marine experts covering the whole ecosystem from physics to whales. A skilled group of 8 numerical modellers are simulating climate/physics, primary and secondary production, harmful algal blooms, fish larvae growth and distribution, and contaminants with the main aim of understanding the impact of varying climate and lower tropic levels on the dynamics of marine ecosystems/fisheries. IMR also holds major expertise in fish stock assessment and prediction, and in giving marine management advice particularly through ICES and OSPAR, and directly to the Ministry of Fisheries and Directorate of Fisheries. The advice is also related to the Ministry of Environment and the Ministry of Oil and Energy. IMR holds the Norwegian Marine Data center.

6.8.5 Northern Research Institute Tromsø (NORUT)

Northern Research Institute Tromsø (Norut Tromsø) is an applied research institute located in Tromsø Science Park. Norut has particular expertise in the Northern and Arctic regions comprising three research groups: Information Technology, Earth Observation, and Social Sciences. Norut Tromsø carries out contract research for e.g. the industry, the business sector and public administration, the Norwegian Research Council, The Norwegian Space Centre and international clients including the EU Research Programme, and others. Our ambition is that the research shall have practical and proficient results, and with a commercial potential when relevant. We are a subsidiary company in which the University of Tromsø is the major shareholder. The annual turnover is 41 million NOK (2006). The institute has a staff of approximately 60 persons in the three research groups. Norut is also a founding partner of *Centre for Remote Sensing* in Tromsø.

The ICT research group comprises 11 researchers and does net-centric research in a broad range of application fields. Especially relevant for *I-Nord* are Distributed geographical information systems, environmental informatics, robust networking, ad-hoc communication and peer-to-peer systems. The ICT group has a long history of experimental research and development of networked geographical information systems within several national and EU funded projects. In addition we do research on technology for robust and flexible communication over weakly connected networks in communications challenged areas, working together with commercial companies and research partners.

The Earth observation group comprises 15 researchers and one engineer, of which 11 have a PhD degree. The group has largely worked with data from Synthetic Aperture Radar (SAR), but also has long experience with optical and atmospheric instruments. The Earth observation group has skills and experience highly relevant for *I-Nord* and particularly related to: Detection of wind and waves at sea, Mapping of snow and ice, Mapping of vegetation, Mapping of the environment and resources, Mapping effects of climate and periodic changes, Monitoring related to geohazards, and Autonomous Aerial Systems. Key skills have also been successfully applied to data generated by other imaging instruments such as roentgen and acoustic signals.

The Earth observation group has been particularly engaged in several major EU projects, and has functioned as coordinator for EnviSnow, FloodMan and EnviWave, among others. In addition, the group has been engaged in and coordinated a number of major earth observation projects initiated by the Norwegian Research Council, the Norwegian Space Centre and the European Space Agency (ESA).

Highly relevant for *i-Nord* is Norut's CryoWing, a long range small unmanned aerial system (UAS) for scientific measurements as well as environmental monitoring and infrastructure surveillance in arctic regions. Norut have developed CryoWing in order to both complement remote sensed data from orbiting satellites and for new and innovative application in arctic regions.

6.8.6 Fugro OCEANOR

Address: Pirsenteret, 7462 Trondheim, Norway

Fugro OCEANOR has since the establishment in 1984 been one of the leading companies in the field of applied oceanography and meteorology. The company introduced in 1990 the Seawatch system which has been recognized by GOOS as a realization of a GOOS component at least on regional scale. The Seawatch system is implemented many places and includes measurement platforms, a complete suite of numerical models and a module for capacity building.

Fugro is a global earth sciences business with over 9000 employees in 200 offices in 50 countries. Fugro OCEANOR, based in Norway, is a high technology company specializing in the design, manufacture, technological development, installation and support of integrated real-time environmental monitoring, forecasting and information systems for oceans, coastal areas, rivers, lakes, groundwater and soil. The company's multi-disciplinary background within meteorology, oceanography, hydrology and chemistry, as well as water engineering and instrumentation, has contributed to its development of multi-parameter environmental monitoring and forecasting systems. Information systems for the marine and freshwater environment have been installed worldwide for a range of customers. Systems and services are provided and supported globally through the network of Fugro offices. Fugro OCEANOR has established offices to operate the national real-time environmental monitoring systems in Spain, Poland and Thailand. Fugro OCEANOR is certified in accordance with the International Quality Assurance standard ISO9001:2000.

6.8.7 Kongsberg gruppen (KONGSBERG)

Kongsberg Gruppen (Kongsberg) is an internationally-oriented, knowledge-based corporation with two business areas: Kongsberg Maritime and Kongsberg Defence & Aerospace. Kongsberg supplies high-technology systems to customers engaged in offshore oil and gas production, the merchant marine, and the defence and aerospace markets. In 2007, Kongsberg had sales of NOK 8.3 billion and 4 205 employees in more than 25 countries.

Products

The Group is one of Norway's leading technology enterprises and has one of the country's largest industrial engineering communities.
Kongsberg's range of products is characterised by high technology content.
The products must work under demanding conditions, from multibeam echo sounders that survey the seabed at depths down to 11 000 metres, to control mechanisms for solar panels on space probes orbiting through outer space for several years at altitudes of 36 000 km. Consequently, the Group's reliability requirements are sky-high.

Business areas

Kongsberg's two business areas, Kongsberg Maritime and Kongsberg Defence & Aerospace, work in the same areas of technology. They both have their core competencies in signal processing, engineering cybernetics, software development services and systems integration. Both BAs deliver systems that help users take the right decisions.

Kongsberg Maritime

Kongsberg Maritime delivers products and systems for dynamic positioning, navigation and automation to merchant vessels and offshore installations, as well as for seabed surveying, surveillance, training simulators, and for fishing vessels and fisheries research. Important markets include countries with significant offshore and shipyard industries.
Kongsberg Maritime had operating revenues of NOK 4.9 billion and 2 510 employees in 2007. 73 per cent of its operating revenues originated outside Norway.

Kongsberg Defence & Aerospace

Kongsberg Defence & Aerospace is Norway's premier supplier of defence and aerospace-related systems. The Norwegian Armed Forces is the BAs most important customer. Solutions developed in collaboration with the Norwegian Armed Forces have proven competitive at the international level. In recent years, they have achieved a significant export share. All defence-related exports are contingent on the approval of the Norwegian authorities. One key element of the BA's market strategy is to form alliances with major international defence enterprises.

Kongsberg Defence & Aerospace delivers systems for command and RWS, weapons control and surveillance, as well as different types of communications solutions and missiles. Kongsberg Defence & Aerospace had operating revenues of NOK 3.3 billion and 1 595 employees in 2007. 73 per cent of its operating revenues originated outside Norway.

Expertise
Kongsberg is a knowledge enterprise. Having the right expertise promotes added value and is decisive for the Group's competitiveness. Some 70 per cent of Kongsberg's 4 205 employees have higher educations.

Capabilities and relevant experience
KONGSBERG is Norway's premier technology enterprise. Kongsberg has a strategic focus on surveillance and crisis management. This includes satellite surveillance, mapping and surveillance based on subsea sensors, simulations and modelling. Integrated solutions for better security, quality and efficiency in decisions regarding environment, security and management of natural resources are an important target area for KONGSBERG.

KONGSBERG is a customer orientated, international enterprise, which is active in maritime surveillance, security and intelligent information technology solutions. The company actively pursues these niche markets in which its customers demand the most innovative products of the highest reliability and quality. KONGSBERG designs, develops, manufactures and integrates high-technology systems for government and commercial customers worldwide. KONGSBERG is the world leader in the supply of Vessel Traffic Management and Information Systems (VTMIS) having pioneered the development of the modern Vessel Traffic Service (VTS) system. Today, this is reflected by the company's extensive install-base of more than 170 systems around the world.

KONGSBERG offer the marine industry advanced AIS (Automatic Identification System) software products, including AIS Network solutions. With a heritage of more than 30 years experience in marine radar surveillance, KONGSBERG still continues to lead the field in the development of wide area coastal domain awareness and VTMIS today, through internal research and development, joint development programmes and research projects of the European Commission. By participating in international committees formed by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) the company guarantees its customers access to cutting-edge technology with a proven background.

KONGSBERG also provide a large number of relevant technical solutions and services based on satellite surveillance. With more than 20 years of experience in Synthetic Aperture Radar processing and applications, KONGSBERG is one of a handful companies world-wide being able to provide SAR expertise from the antenna system all the way to value added applications. Technology and systems for SAR based ship-detection and oil-spill services has been delivered to operational users for several decades by KONGSBERG.

KONGSBERG delivers end-to-end systems for data acquisition, processing, analysis, and decision support within meteorology, oceanography, climate- and resource monitoring on a global market. KONGSBERG supports most civilian satellites in operational use for earth observation today, and continues to stay at the forefront when new missions become available.

Through KONGSBERG'S delivery of operational satellite ground-stations world-wide, we have a thorough knowledge in systems integration, data acquisition through different channels, as well as application specific data fusion and information extraction.

KONGSBERG has been, and still is, a significant player as a systems and data integrator in international projects, allowing us to get early knowledge to new and coming technologies within data formats and exchange standards, service- and resource oriented architectures and system-of-systems,

6.8.8 Saab company

Address: Saab AB
Bröderna Ugglas Gata (visiting address)
581 88 Linköping
Sweden

When Saab AB, was founded in 1937, its primary aim was to meet the need for a domestic military aircraft industry in Sweden. Today Saab serves the global market with world-leading products, services and solutions ranging from military defence to civil security. Saab has operations and employees on all continents and constantly develops, adopts and improves new technology to meet customers' changing needs. Saab has today 13,700 employees.
Saab develops, manufactures, and delivers advanced systems, products, and services, covering different areas of a total sea-, air-, and land surveillance system. These products range from sensors, transponders, communication solutions, training systems, command and control systems, which can be delivered as stand-alone units or form a part of a larger system. In addition, Saab can deliver software functionality covering data- and multi-sensor fusion, target tracking, communication management, command and control man machine interface etc.
One recognized strength of Saab is systems integration – the ability to assume responsibility for, and to implement large-scale projects in which a number of complex systems have to work together.
Saab's network centric solutions are Saab's combined effort to provide network enabling solutions to the military as well as to the civil security community. Saab has designed network centric system to operate from individual level up to joint level, i.e. combined and inter-agency levels. The general approach is to make use of existing investments and to add the ability to cooperate over networks. Real-time information from different sources is integrated in a modular open networked based architecture.

Examples of Saab's competencies in areas of specific interest to *i-Nord* are:

- IT systems
- Network centric systems/interoperability
- C4ISR
- Communication
- Sensors and platforms
- Vessel monitoring
- Sea surveillance

- Land surveillance
- Air Surveillance
- Crisis management
- Critical infrastructure protection
- Data fusion
- Infrastructure
- Integrated logistic support (ILS)

6.8.9 Norwegian Polar Institute (NP)

Address: Polar Environmental Centre (Polarmiljøsenteret), Hjalmar Johansens gate 14, 9007 Tromsø
Norwegian Polar Institute, Polar Environmental Centre, 9296 Tromsø
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Email: post@npolar.no
WEB: http://npweb.npolar.no/english

The Norwegian Polar Institute is Norway's central institution for research, environmental monitoring and mapping of the polar regions. The Institute is the Norwegian authorities' consultant and supplier of knowledge, and contributes to the best possible administration of Norwegian polar areas.

About the Polar Institute
Through active participation in national and international bodies, the Polar Institute is central when it comes to protecting national interests in matters of research and the environment. Approximately 110 persons are employed at the Institute in Tromsø, Svalbard and Dronning Maud Land.

Long traditions
The Norwegian Polar Institute has roots back to 1906 when the first scientific expedition to Svalbard took place. The Institute is a continuation of Norges Svalbard- og Ishavsundersøkelser (Norway's Svalbard and Arctic Ocean Research Survey) which was established in 1928 and had as its aim the charting of sea and land areas and geological research in the Arctic. The geographical scope was extended to include Norway's claims in the Antarctic in 1948. The area of research was expanded and the name changed to Norwegian Polar Institute. The Institute is since 1979 a directorate under the auspices of the Ministry of the Environment.

Activities at both poles
The Institute's activities are concentrated on environmental management needs at both poles. Global climate, long-range transported pollution, the effect of pollutants on the environment, biodiversity and topographical mapping of the regions are all important tasks, as is environmental collaboration in the Barents Region. The Institute equips and organizes expeditions to both poles, owns the research vessel "Lance" and runs the Norwegian research stations in Ny-Ålesund, Svalbard, and Antarctica.

Dissemination of information
The Norwegian Polar Institute distributes the results of research projects and environmental management projects to the Norwegian administration and to interested scientists and

managers as well as providing information to the public. Reports, a science magazine, websites and books are published, of which the "Polar Handbooks" in particular have obtained a wide readership.
The Institute's library contains large collections of scientific and historic polar literature, as well as hunting and expedition records from as far back as the 16th century.

6.8.10 Norwegian Institute for Water Research (NIVA)

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e-mail: niva@niva.no
Web: www.niva.no

The Norwegian Institute for Water Research (NIVA) is the leading water related environmental research centre in Norway. It is an internationally oriented competence centre for research, development and innovation activities on all aspects of sound water management and facilitation of sustainable utilisation of aquatic resources. NIVA provides advice and information regarding water-related issues at the national and international levels to authorities, the private sector and the public. NIVA is a private research foundation, and is the largest interdisciplinary applied water research centre in Norway. The NIVA Group, comprising NIVA and its four regional offices in Norway, the subsidiary consultancy companies NIVA-Tech AS and BallastTech-NIVA AS in Oslo, Akvaplan-niva in Northern Norway, Aqua Biota Water Research in Sweden, NIVA-Chile in Puerto Montt as well as Geomor-NIVA in Poland, has a total staff of 250 and an annual turnover of over €32 millions.

NIVA's Objective
NIVA serves the authorities, the private sector and the public – both on the national and international levels –towards the common goal of an improved aquatic environment through integrated water resources management.

NIVA's Strengths
- A well-qualified and experienced staff with more than 120 professionals, majority with doctorates in relevant fields
- Comprehensive R&D facilities, including field research stations
- A state grant of 11% of the institute's turnover to ensure state-of-the-art knowledge and continuous competence development
- A Board of Directors appointed by the Norwegian Ministry of the Environment and The Research Council of Norway
- A member of the consortium of The Environmental Research Alliance of Norway (ENVIRA) and the Oslo Centre for Interdisciplinary Environmental and Social Research (CIENS), which comprises approximately 700 employees

Competence & Services
- Integrated water resources management (IWRM)
- Integrated coastal zone management (ICZM)
- Biodiversity and eutrophication in marine and fresh water systems
- Environmental information management systems for water

- EIAs and pollution abatement strategies & action plans, cost-benefit analysis
- Impact analysis on water quality and aquatic ecosystems
- Ecotoxicology and risk assessment
- Modelling of physical, chemical and biological processes and effects
- Water supply and wastewater treatment technology –process optimization
- Acid precipitation and long-range transported pollution
- Flood simulation and protection action planning
- Institutional strengthening/capacity building

International Experience

- Nearly 25% of NIVA’s activities are conducted in international projects during the last years
- A solid basis of competence and a network through over 25 EU research projects at present
- A long-standing tradition in providing services for over 70 countries around the world

6.8.11 Norwegian Institute for Air Research (NILU)

Address: Po.box 100, 2027 Kjeller
Instituttveien 18, 2007 Kjeller
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Fax: +47-63898050
E-mail: nilu@nilu.no
Web: http://www.nilu.no/

NILU is an independent non-profit research foundation est. in 1969, with 175 employees (75 scientists) and annual turnover €14M. NILU conducts environmental research on sources of airborne pollution, atmospheric transport, transformation and deposition, forecasting of long term emission of greenhouse gases, exposure assessment, effects of pollution on ecosystems, human health and materials, including economic assessments. NILU carries out approximately 250 projects each year.

NILU works for national and international customers, often in partnership with other research institutions. Over the years NILU has undertaken many tasks as co-ordinator for international environmental research projects. NILU has since the 4th FP of the EU participated in more than 100 EU-FP projects. Current portfolio includes one Network of Excellence and several Integrated Projects.

NILU plays a central part in preventive environmental research and provides strategic knowledge to the public environmental administration. NILU ensures the quality standard of data in national and international monitoring networks and is custodian to national librarian and database services. NILU gives advice and support to other institutes and laboratories on methods to be used in measurement/monitoring and analysis.

NILU is currently running national monitoring systems for measurements of transboundary and local air pollution of behalf of customers such as SFT and Statens Vegvesen. Measurements are collected in NRT and made available to public and authorities on National and European scale in NRT (less than 3 hours). NILU is currently undertaken several activities on measurements and modelling of atmospheric transport and deposition of heavy metals, environmental toxics such as persistence organic pollutants (POPs) and air quality components such as ozone and particulate matter. NILU is currently running a strategic institute programme on data assimilation aiming to improve analysis and forecast of environmental parameters by merging data models and measurements.

NILU has an internationally central role in collecting and storing measured data from the atmospheric research and monitoring programs. NILU has been hosting a data centre since the middle of the 1970, as the institute was coordinating the data collection in the OECD project of long-range transboundary pollution in Europe. NILU has now become one of the largest institutions within organisation of atmospheric measurements, and is internationally possibly the most central regarding groundbased measurements. The institute is involved in several projects dealing with interoperability and harmonisation of access between various heterogeneous data archives. Examples of projects include EU FP7 infrastructure project GENESI-DR (Ground European Network for Earth Science Interoperations - Digital Repositories), EU FP6 project GEOmon (Global Earth Observation and monitoring, atmospheric composition measurements) and NFR project DOKIPY (Datahåndterings og koordineringstjeneste for norske forskningsprosjekter under det internasjonale polaråret). NILU has furthermore been central in the planning of and developments of the EEA ozoneweb, a publicly available NRT system for European-wide air-quality measurements.

6.8.12 University of Bergen, Geophysical Institute (UiB-GFI)

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Phone +47 55 58 26 02
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web: www.gfi.uib.no

The University of Bergen is a medium-sized European university with broad academic scope but with marine research and global development as its major areas of emphasis. The university is oriented towards international research programs and is particularly successful within European research on environment, climate and marine topics. Marine research constitutes about 1/3 of the total research efforts and PhD production of the entire university. There is an established collaboration with the Institute of Marine Research on operation and access to research infrastructure including research vessels. The university hosts 3 national Centers of Excellence within marine research.

The Geophysical Institute provides education on all levels from bachelor to PhD in physical and chemical oceanography, meteorology and climate dynamics. It is the largest university institute in oceanography in the Nordic countries. The institute coordinates climate research on behalf of the university including the university contribution to the Bjerknes Centre for Climate Research. The institute further leads the newly established national research school in climate dynamics and a new Nordic master's programme study in marine ecosystems and climate. Polar studies, air-sea interaction, physical-biological couplings and operational oceanography are stated target research areas. A course in operational oceanography has been taught regularly since 2003.

The institute performs monitoring of Atlantic inflow and ocean variability in key sites in the Norwegian Sea and monitoring of ocean currents around Svalbard. The ocean carbon cycle research includes development of unique sensors for carbon system parameters including pH and experience from use of voluntary observing ships. Operational measurements including cabled systems with real time data and power are in focus. Research on turbulence, vertical mixing and ice-ocean interaction is performed with advanced instrumentation in process studies ranging from Norway to the central Arctic as well as Antarctic.

6.8.13 Centre for Remote Technology, University of Tromsø

Address: Department of Physics and Technology, Faculty of Science, Auroral Observatory, University of Tromsø, N-9037 TROMSØ
Office:(+47) 77 64 51 69 / Cellphone: (+47) 92 62 48 36
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Centre for Remote Technology is a collaborations between the remote sensing community inn Tromsø. It was founded in January 2008 by The University of Tromsø, Faculty of Science/Department of Physics and Technology, Kongsberg Spacetec, Kongsberg Satellite Services and Northern Research Institute. The Norwegian Polar Institute later joined the centre.

The main goal for Centre for Technology is to strengthen and increase the research in the field by public and private sector, increase the corporation between relevant universities, institutes and companies and contribute to strategy and development of remote sensing.

The Centre is an organization based on the partner's organizations, knowledge and human resources. The center has therefore possibilities to participate in a wide range of different research and development projects and when necessary use the knowledge, competence and human recourses available by the participating partners.

6.8.14 Norwegian University of Science and Technology (NTNU)

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e-mail: postmottak@adm.ntnu.no
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NTNU is a university with a broad academic scope that has its main focus on technology and the natural sciences. NTNU's research has an international focus and can be characterized by being at the leading edge in specific areas of technology, having an interdisciplinary approach. Marine and maritime research was selected as one of the university's six thematic strategic areas.

The vision of NTNU Marine Coastal Development is to provide excellence in research and higher education to support a sustainable coastal development. It encourages the creation of sustainable technological solutions for future marine based industries by combining natural science, marine engineering, humanities and social science.

Scientific domains
The research activities of the Coastal Development focus area is organised within three multidisciplinary themes along the value chain:

- **Ocean Space Research –** Methodological and technology development for research on living and non-living resources. Marine research with a major focus on modern methods and systems for research, mapping, monitoring and management, including studies of ecosystems, exploration and exploitation of living and non-living recourses, and human relations and interactions
- **Fisheries and Aquaculture –** Science, engineering and societal research. Marine aquaculture and fisheries research with a holistic approach and main focus on engineering and sustainable development
- **Marine Resource Processing –** Research on refinement, quality, and advanced industrial applications. Research on major downstream aspects of marine resource refinements and utilisation, including processing engineering, biochemistry and product quality, biopolymers, energy efficiency and control and logistics

Infrastructure
The marine research and education at NTNU is facilitated by a wide range of state-of-the-art facilities:

- Research Vessel "Gunnerus": a multi-purpose platform equipped with an ROV
- Sealab laboratories: facilities for the cultivation of sea- and freshwater organisms under controlled conditions
- Marine cybernetics laboratory: a wave tank suited for tests of marine control systems
- AquaCulture Engineering research infrastructure (from 2009): large-scale test facilities sea-based aquaculture technology, operation and management innovations
- Process and biopolymer laboratories for advanced research on marine resource processing

Master of Coastal Development
An international cross faculty Master programme with a marine profile is open to students with an engineering, natural science, social science or humanities background. The Master offers a foundation, both solid and broad, for a marine related work career.

6.8.15 SINTEF

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web: www.sintef.no

SINTEF is a multidisciplinary project research organisation carrying out research and development based on technology, the natural sciences, medicine and the social sciences. The SINTEF Group is Scandinavia's largest independent research organisation. There are about 1800 employees of whom around 85% are R&D personnel. Turnover in 2007 was NOK 2.3 billion. Contracts for industry and the public sector generate more than 96% of income, from the Research Council of Norway comes 6%; 3% comes in the form of a basic grant and 3% from supporting strategic programmes. SINTEF collaborates closely with the Norwegian University of Science and Technology (NTNU) and the University of Oslo (University of Oslo). Personnel from NTNU work on SINTEF projects, while SINTEF staff teaches at

NTNU. The SINTEF-NTNU community involves the widespread joint use of laboratories and equipment. A similar program of cooperation is being developed with the Faculty of Mathematics and Natural Sciences at the University of Oslo.

SINTEF has broad experience working with *i-Nord* related projects. SINTEF has recently launched Ocean Space Surveillance (OSS) as a strategic priority area within SINTEF. The OSS project is financed by SINTEF itself and is focusing on integrated systems for live observation and modelling of ocean states through the use of underwater sensor networks; highly relevant for reaching the goals of *i-Nord*.

SINTEF Fisheries and Aquaculture has experience in development and use of 3D coupled numerical hydrodynamic and biological (plankton and lower tropic levels) models (SINMOD) through projects funded by EU and NFR. Most of the projects have been in connection with the Arctic. This activity is usually in close cooperation with IMR and/or Norwegian College of Fishery Science, UiT.

SINTEF Materials and Chemistry, Department of Marine Environmental Technology has worked with Arctic oil spill response, marine icing, ecology and toxicology, and numerical modelling of pollutant transport and effects in Arctic areas for over 20 years. The Department is presently responsible for an oil-in-ice program exceeding 50 million NOK in value, and involving a large number of international cooperating organizations.

SINTEF ICT has national and international experience from satellite communication- and navigation -systems to underwater sensor networks, where we have an ongoing EU project UAN and a national Norwegian project NNN-UTS. SINTEF ICT is also currently working in national projects focusing on information security in integrated operations: IRMA (Incident Response Management), Safety and Security in Integrated Operations (IOsafe), and Management and follow-up of integrity for Safety Instrumented Systems.

MARINTEK and SINTEF ICT are involved in the NFR project MarSafe with the aim of evaluating communication systems and solutions for supporting emergency response and safety in the North areas. The project involves investigations on user requirements for satellite communication in the polar region.

7 Budget and finance

The *i-Nord* project activities are proposed to be carried out through five phases (see Figure 9, page 33) of which the cost is estimated for the two first phases from 2009 to 2013. The estimated budget breakdown according to the work package structure is shown in Table 6.

Table 6 Budget according to work package structure

i-Nord Budget								
Phase	Phase I			Phase II		III	IV	V
Work Package Breakdown	2009	2010	2011	2012	2013	2014	2015	2016
WP 1: Maritime Safety, Security and Operations	5.000	7.000	8.000	8.000	8.000	TBD	TBD	TBD
WP 2: Marine Environment and Climate	4.000	6.000	8.000	8.000	9.000	TBD	TBD	TBD
WP 3: Marine Resources	4.000	6.000	8.000	8.000	9.000	TBD	TBD	TBD
WP 4: System Architecture and Information Mgm.	5.000	10.000	10.000	11.000	11.000	TBD	TBD	TBD
WP 5: Communication Systems og Infrastructure	2.000	4.000	7.000	7.000	7.000	TBD	TBD	TBD
WP 6: Observation Systems and Models	2.500	7.000	10.000	15.000	20.000	TBD	TBD	TBD
WP 7: System Coordination and Support	1.000	2.000	3.000	4.000	6.000	TBD	TBD	TBD
WP 8: Quality Assurance	500	1.000	1.000	1.000	1.000	TBD	TBD	TBD
WP 9: Program Management	3.500	6.500	6.500	6.500	6.500	TBD	TBD	TBD
Total	27.500	49.500	61.500	68.500	77.500			
Accumulated	27.500	77.000	138.500	207.000	284.500			

This cost estimate is subject to changes in the main project when the specific activities are specified in detail.

The funding strategy is outlined below.

Table 7 *i-Nord* funding strategy

i - Nord Funding Strategy					
	2009	2010	2011	2012	2013
Norwegian Governmental Funding	27.500	49.500	56.000	60.000	60.000
International Governmental Funding	0	0	5.000	8.500	17.500
Estimated Gross Governmental Funding	27.500	49.500	61.000	68.500	77.500
Framework Program Funding (FP 7)	10.000	10.000	10.000	TBD	TBD
Project Partner Funding	5.900	5.900	5.900	5.800	TBD
Estimated Gross Partner Generated Funding	15.900	15.900	15.900	5.800	0
Gross i-Nord related Funding	43.400	65.400	76.900	74.300	77.500

The funding scheme is based on following strategy:

- **Norwegian Governmental funding** – contribution from the Norwegian Government to the *i-Nord* community.
- **International Governmental funding** – other Governments to the *i-Nord* community.
- **Framework Program Funding** – activities funded through the European Commission R&D schemes, and coordinated with the planed working tasks in *i-*

Nord. Some beneficiaries have on-going FP 7 projects, as well as planned submissions of project proposals for the forthcoming calls. Present known co-financed FP 7 projects are: MyOcean (METNO et al).

- **Project partner/Internal funding –** which is beneficiary funded activity coordinated with the work package description, like OSS – Ocean Space Surveillance (SINTEF).

8 Impact

It is expected that *i-Nord* will be a significant power to address all aspects of operational surveillance in the Arctic and Barents Sea. It is further expected that *i-Nord* will have an implication to provide:

- Reliable and timely information and services related to environmental and security issues in support of public policy makers' needs for sustainable management of the Barents Sea and the Arctic.
- Dynamic and effective risk assessment to support decisions and crisis management.
- Effective and professional services to operators in the region including fisheries, ship transport and offshore industry.
- Basis for regulations and negotiations with neighbouring countries.
- Co-ordination of existing activities in the Barents Sea and Arctic.
- Strengthen the position of Norwegian research of all disciplines related to the priority issues of *i-Nord*
- Norway's contribution to Pan Arctic Observing Network.
- Support to priority sectors defined by Arctic Council.
- Support to Norwegian industry in delivering systems and services related to *i-Nord*.
- To strengthen the collaboration between Norwegian Industry and Norwegian research institutes within the scientific areas related to the issues addressed by *i-Nord*.

8.1 Strategic impact

The High North was in 2005 singled out as the Norwegian Government's most important strategic priority area. There is an increasing need for research-based knowledge about the northernmost parts of the globe and the processes that are taking place there. Central keywords in this regard are global climate change, polar ice melting, resource extraction and marine transportation in northern waters. The economic and strategic significance of the Barents Sea region and the circumpolar Arctic is likely to continue to increase in the years ahead. This places great demands on Norway and other Arctic rim states, many of which have large maritime areas to watch over and manage.

One of the main challenges currently facing Norway and its northern neighbors is the task of making sure that fisheries, petroleum extraction and ship traffic in the High North take place in a controlled way and do not damage the region's fragile nature environment. This task places great demands on the authorities' ability to monitor the region, that is, to monitor relevant activities and processes on land, at sea (over and under the surface), and in the air. It is also important to develop technologies that can help us utilize the region's natural resources in an environmentally safe manner and, to the extent possible, prevent and reduce the negative impacts of current and future human activities. Special attention should be paid to issues related to the Shtokman project and other offshore developments in the Barents Sea.

Equally challenging is the task of maintaining political and military stability in the region. There is a danger that resource scarcity in other parts of the world, particularly when it comes to oil, gas, and living marine resources, may lead to an uncontrolled “resource race” in the High North, and eventually a “remilitarization” of interstate relations in the region. In order to avoid this, Arctic nations must work together to resolve the complex issues of international law, build a comprehensive common knowledge base for industrial development, and create stable and predictable conditions under which domestic and foreign actors can operate. These challenges call for a multidisciplinary and internationally oriented approach as well as the mobilization of research and development (R & D) institutions in Norway and abroad.

Norway’s ambition to become a driving force in international Arctic science and politics requires the joint efforts of R & D communities in Norway and abroad, and the utilization of Norway’s comparative advantages as a platform for research activities in the north. With its extreme northern location and well-developed infrastructure, the archipelago of Svalbard has the potential to become a vital meeting place for scientists from all over the world. A good indication of the international interest shown towards Svalbard is the archipelago’s prominent role in the EU’s new (December 2008) research agreement.

The International Polar Year of 2007–2008 gave a much welcome boost to cooperation among natural and social scientists interested in the world’s northern regions, and it laid a good foundation for multidisciplinary projects. The economic and strategic significance of the High North is growing, and it is in Norway’s long-term interest to strengthen the ties and cooperation between relevant research institutions in Norway and abroad, for the common good of the northern regions and those who inhabit it. The *i-Nord* project aims to make a significant contribution towards this aim.

8.2 Environmental impact

As emphasized in the BICEPS report (Wyatt et al., 2003) environmental policy includes elements relating to identification of issues, formulation of policy, policy implementation, and subsequent appraisal and review. This policy cycle, in turn, interleaves with a cycle of environmental monitoring, scientific analyses and reporting. Scientific understanding and knowledge of the marine environment and its state on the one hand, and data and models to translate this into meaningful and useful information to support sustainable development, and, if necessary, effective interventions on the other hand, are therefore both crucial for marine environmental policy. Otherwise, difficulties inevitably arise both in assessing and prioritizing the issues that need to be addressed, and in defining and selecting between potential policy responses.

The *i-Nord* integrated marine monitoring and forecasting system for the high latitude and Arctic seas will clearly contribute to the interconnection of environmental monitoring, science and policy making, in particular, by provision of

- homogeneous descriptions of temporal and spatial variability and dynamics that complement, combine and extend in-situ and satellite observations;

- more complete and consistent system for satellite and in-situ data application and interpretation
- support to framework for information management and decision support regarding detection and prevention of, for instance, oil spills and episodic harmful events that may affect the state of the marine environment.

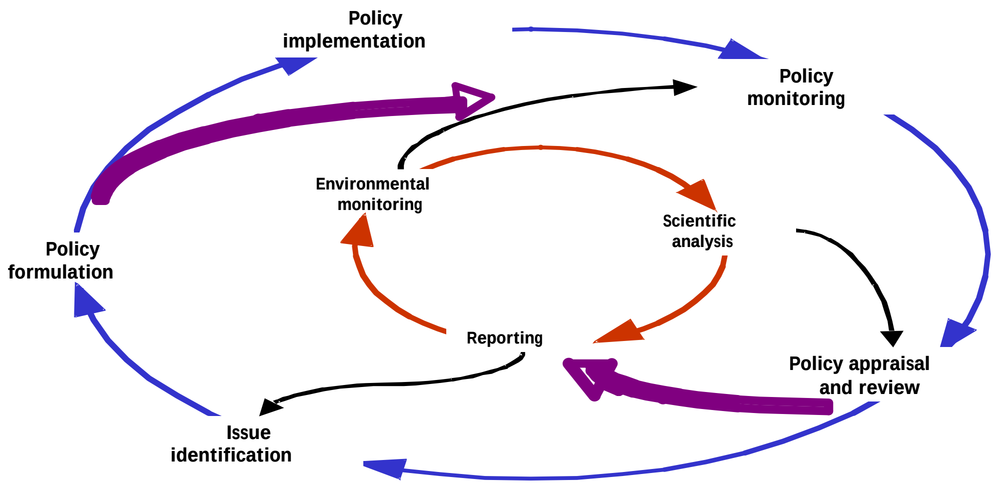


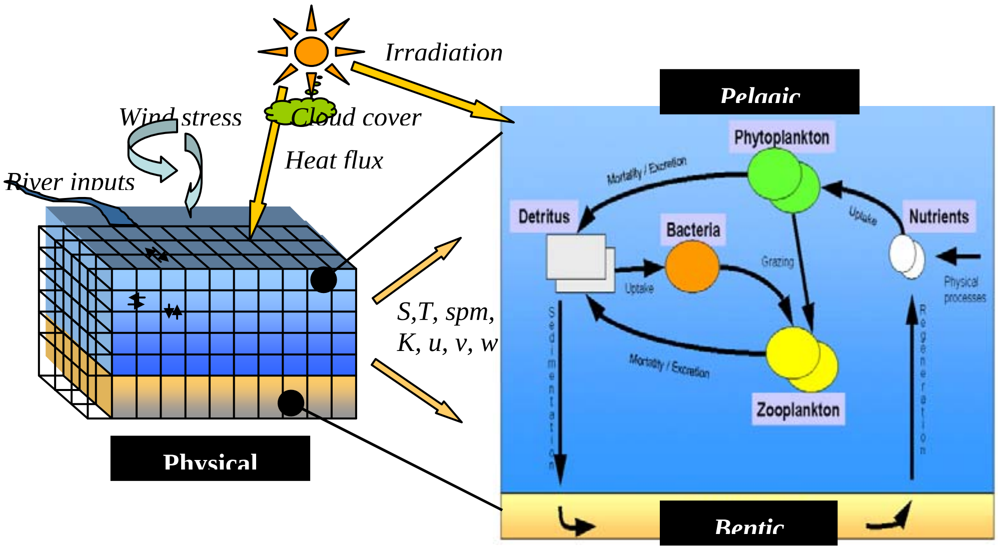
Figure 11 The two-way interconnection of environmental monitoring, science and policy making (slight modification from illustration used in BICEPS report, Wyatt et al., 2003)

i-Nord is furthermore in consistence with the aims of the European Environmental Agency (EEA), AMAP and OSPAR, namely to support sustainable development and to help achieve significant and measurable improvement in Europe´s environment. This will be achieved through the provision of timely, targeted, relevant and reliable information to policy making agencies the public and other users. A coherent and optimum way of providing this type of information is through development of marine indicators and reporting such as specified by EEA/EMMA in the DPSIR framework. (Driver indicators (D) represent anthropogenic forcing of the marine environment, Pressure indicators (P) represent pressures on the system resulting from the drivers, State indicator (S) represent environmental condition, Impact indicators (I) represent the impact of the pressures on the environmental condition, and Response indicators (R) represent the response of society and management to mitigate the impacts.) Indicators are quantified information that helps to explain how the quality of the environment changes over time or varies spatially. Indicators can play a vital part in focusing and illuminating the significance of environmental change and the progress to sustainable development. In consideration of the step-by-step approach in selection and development of indicators the following five criteria are commonly used:

- clearly defined,
- linked to policies,
- easy to understand and interpret (scientifically reliable and significant),

- limited in number,
- based on acknowledged (official) and accessible data.

The State and Impact indicators can receive routine quantitative information from *I-Nord*. In particular, dominant temporal and spatial variability and dynamics can be identified as well as the influence of the physical state on the ecosystem integrity such as, for instance,



eutrophication and water quality. Some of the key quantities in this context range from temperature, salinity and currents via phytoplankton, chlorophyll and nutrients to oxygen. This is conceptually shown in Figure 12, revealing that accurate knowledge of the physical state may be mandatory for reliable description of the biochemical state.

Figure 12 Illustration of the coupling between the physical and the biogeochemical model (Courtesy I. Allen)

i-Nord will also contribute to developing and advancing systems for sustainable, long-term monitoring of the marine environment by merging of observations (in situ and remote sensing) with models and assimilation techniques including re-analyses.

8.3 Industrial impact

The impact of *i-Nord* related to industry is two fold. One is services to the industry operating in this region. The other is the opportunity for Norwegian companies specialised in ocean monitoring and forecasting to deliver services to *i-Nord*.

Private companies in fisheries, shipping, oil and gas share the challenges in operating in this hostile environment associated with extreme wind and wave combined with low temperatures. It is difficult and expensive to operate in this region without high quality and reliable weather and atmospheric forecast. Also relevant data to provide precise documentation that the conditions are met in terms of quota, discharge permissions etc. Internal control and documentation is not longer enough, but needs to be supplemented with public controls. *i-Nord* will provide a valuable contribution to support both the industry and public authorities with adequate information. Shipping activities in the Arctic are expected to increase if opening of the North East/West passage permit regular traffic. The implications of such a development are large in terms of security and environmental safety issues.

Some Norwegian companies have strong tradition to provide industrial solutions in the field of *i-Nord* and for some applications are marked leaders. It is expected that *i-Nord* will be become a great opportunity to deliver services and products. Again this will allow Norwegian industry to work with demanding customers and develop solutions of high international standard.

The development of sophisticated solutions for decision support, as *i-Nord*, will give the participating industry the opportunity of gaining early knowledge on new and emerging technologies within data formats and exchange standards, service- and resource oriented architectures and system-of-systems.

This will give the industry better integrated solutions and new innovative products of the highest reliability and quality which may be re-used within a number of different market areas in addition to maritime surveillance and environmental monitoring. Both public and private users will be able to deliver improved services as a result of this.

The proposed development is important nationally as it will enable the industry to develop integrated solutions and product for national users. It is also important considering our strategy to sell the solutions to international customers. This will give the industry an opportunity to form new national and international alliances and strengthen the cooperation between science and industry.

8.4 Synergy with national projects

The *i-Nord* integrated marine monitoring and forecasting system will establish a substantial knowledge base and infrastructure capable of providing hindcasts, analyses and forecasts for a range of users occupied with marine and coastal environment. Emerging from the GMES initiative there is a growing international activity to develop and implement integrated marine monitoring and forecasting systems from the global via the regional to the local scales. It is therefore essential that *i-Nord* capitalizes and ensures optimum synergy with other existing and planned national and international program and projects (e.g. RCN funded Havet og Kysten program, EU funded MyOcean project). In so doing one will remove redundancy, achieve coherence and improve quality. Moreover priorities and efforts can be focused at the gap between the global-to-regional systems which are fairly reliable, at least regarding the physical part, and the shelf-to-coastal areas where most of the environmental challenges exist while the user applications are probably greatest.

The Research Council of Norway program "Oceans and Costal Areas program" (2006 - 2015)

The Oceans and the Coastal Areas" is a coordinating marine research programme under the Research Council of Norway. It is management-oriented, in that it is intended to generate basic knowledge for a future ecosystem-oriented, precautionary management system for marine ecosystems, while being designed to contribute to the increased creation of value from ocean and coastal resources.

The primary objective of the programme is to *encourage creative research of high international quality on the marine environment.* A broad understanding of our marine environment is of great value in its own right for a knowledge-intensive nation such as Norway, at the same time as it will provide us with the foundations of long-term management of our marine ecosystems and their resources as a basis for wealth creation at national and international level. The programme will lead to the development of basic competence both via studies of specific conditions in Norwegian waters and by reinforcing a holistic understanding of the structure, functions and species diversity of the ecosystem. In particular, the programme aims to:

- *Reinforce Norway's position a leading nation in marine ecosystem –related research.*
- *Become a central contributor to the process of generating more knowledge of the marine environment.*
- *Provide a research-based foundation for long-term integrated management and a basis for wealth creation based on marine resources.*

There are seven sub-goals of the Programme, notably:

- To generate new basic knowledge of the structure, functions, driving forces, sub-processes, species diversity and types of nature found in marine ecosystems.
- To generate new knowledge of human impacts on marine ecosystems via the addition and effects of pollution, and to contribute knowledge capable of acting as a basis for measures to clear up pollution from land-fills and sediments. It will also be necessary to focus on the effects of introduced species on the flora and fauna of the coastal zone.
- To increase our knowledge of the long-term effects of petroleum industry emissions to the sea.
- To acquire knowledge and tools capable of contributing to integrated ecosystem-based management of the ocean and the coast, and to conflict resolution between various societal interests and between nations.
- To obtain knowledge that will contribute to the foundations of great wealth creation from marine resources.
- To sharpen the focus and methods, models and technology for generating new ecosystem knowledge and to develop a methodology for the adoption of knowledge based on experience.
- To simulate international research cooperation and exchanges of knowledge.

Several of the areas of effort are closely interrelated as illustrated in the two-dimensional structure of the programme Figure 13.

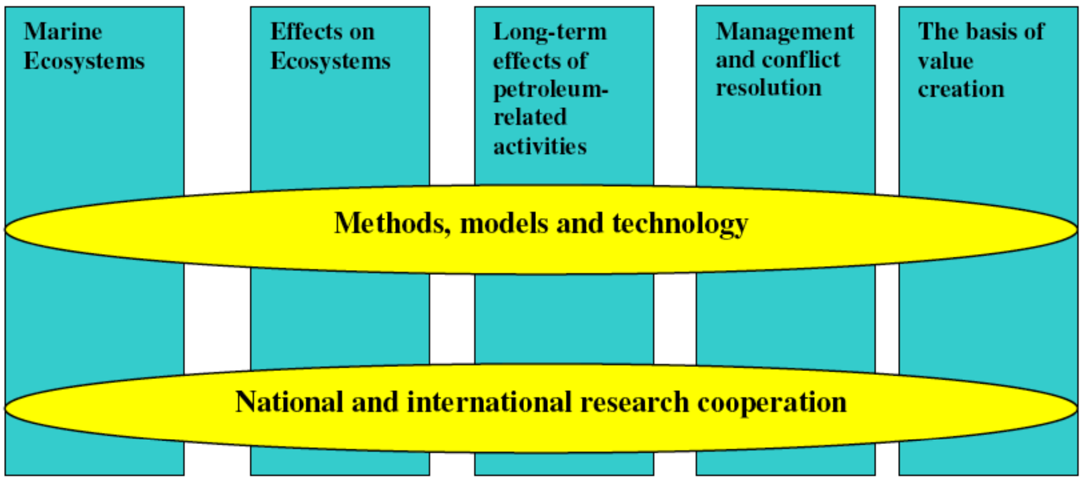


Figure 13 The two-dimensional nature of the programme

9 State-of-the-art projects

In view of dangerous scenarios the UNFCCC specifications (Article 2) on understanding, assessing, predicting, mitigating and adapting to climate variability and change include specific concern with regard to:

(i) Increasing levels of CO2 and other greenhouse gas in the atmosphere (a particular concern being methane emissions due to melting of permafrost)
(ii) Sea level rise
(iii) Acidification of the ocean and oceanic carbon buffering including the link between the carbon, nutrient, and oxygen cycles (for discrimination between the physical and biological parts of the CO2 cycling)
(iv) Deterioration of the marine ecosystem and food-web
(v) Permanent (or near permanent) loss of Arctic summer sea ice

It is essential to recognize that no single data set from any single satellite mission or in-situ platform is sufficient to constitute, independently of other data sources, all the necessary information to monitor and forecast the changes of the state of the environment and climate that contribute to and influence these dangerous climate change scenarios. Only via careful merging and harmonizing of data from different satellite and in-situ sensors and sources with models is it possible to generate a reliable, tested, validated and not least consistent set of data products and information. The main objectives of *i-Nord* are clearly relevant in this context with particular focus on high latitude and Arctic regions. The generation of long time series will also allow easy and efficient access by the climate community for integration into their models.

As the length of existing ECV data records increases, in some cases now to around 20-30 years, and they gradually become of better quality and accuracy, adequate validation and adaptation to better initialization are becoming feasible. In this context, the expected advanced achievements from the *i-Nord*, with its focus on high latitude and Arctic regions, will lead to progress beyond the state-of-the-art. In particular the generation of refined and consistent multidisciplinary time series of:

- ***Ocean physics:*** sea level, current, waves, water masses, fluxes, transport pathways,
- ***Ocean biogeochemistry:*** *Chlorophyll distribution*, river discharge, plankton dynamics, fish larvae drift, dispersion of pollutant material, CO_2 partial pressure and other carbon system parameters
- ***Cryosphere****:* sea ice coverage, volume, drift and deformation
- ***Atmosphere****:* near surface wind field, icing threshold, and CO2 partial pressure

These data will, in turn, make excellent initial boundary conditions to constrain state-of-the-art models. Cox and Stephenson (2007), for instance, have shown that the major element of uncertainty in predictions up to 10-30 years is the lack of adequate information on initial conditions – i.e. lack of quality observations. In order to reduce the uncertainty in these long term predictions, the primary need is for more and better data and model based information such as will become available from *i-Nord*.

9.1 Reference projects

The **Global Monitoring for Environment and Security (GMES)** is a partnership between the European Commission, the European Space Agency (ESA) and their member states (http://www.gmes.info). The initiative is seen by the EU-Commission as a major step forward for European Earth Observation. GMES and INSPIRE is the major European Contribution to GEOSS. GEOSS does not redo or duplicate the work of GMES or any other system. Rather, it includes them and integrates them to provide total coverage, total information for all users.

GMES aims at designing and establishing by 2008 a European capacity for the provision and use of operational services for Global Monitoring of Environment and Security. It supports the following EU objectives and policy domains:

- Europe's environmental commitments, within EU territory and globally, by contributing to the formulation, implementation and verification of the Community environmental policies, national regulations and international conventions
- Other EU policy areas such as agriculture, regional development, fisheries, transport, external relations with respect to the integration of the environmental dimension in the respective domains and their specific requirements
- Common Foreign and Security Policy (CFSP), including the European Security and Defence Policy (ESDP)
- Other policies relevant to European citizens' security at Community and national levels, notably the potential exists for application to policies related to Justice and Home Affairs activities of the European Union, such as border surveillance.

MyOcean
(http://www.myocean.org)
In consistence with the GMES Fast Track Services (FTS) the Marine Core Service element will be implemented and operated under MyOcean for a period of three years from 2009 to 2012. MyOcean will make available and deliver a set of basic, generic services based upon common-denominator ocean state variables that are required to help meet the needs for information of those responsible for environmental and civil security policy making, assessment and implementation. The *Policy drivers* have been identified as:

- Regional Conventions between Member States and the EC (i.e. OSPAR, HELCOM, UNEP/MAP;
- 6th Environmental Action Plan; in particular its Climate Change and Marine Environmental Strategy components;
- The Sustainable Development imperative which is written into the Rome Treaty and is now being developed through the Green Paper on Maritime Policy. (Note that the **Maritime Policy Green Paper** has emphasised that commercial sectors such as shipping, fishing, oil exploration, offshore construction, aquaculture, and tourism, and public sectors such as coastal protection, defence, search and rescue, R&D and government policy making all need data on past, present and future meteorological, oceanographic, hydrographic and ecological state of the seas and the oceans. Global-scale monitoring is required to meet this need and the EU is being encouraged to set up a European Marine Observation & Data Network to provide sustainable, improving access to information.)
- Relevant existing EU Directives, such as the Water Framework Directive in its application to coastal waters.
- Concerns over civil security which manifest themselves in particular for safety of life and property in the marine environment (i.e. EMSA).

MyOcean aims to provide services within four key areas, notably

- Marine and Coastal Environment
- Maritime safety
- Marine Resources
- Climate – Seasonal forecasting

Group on Earth Observations (GEO), Global Earth Observation System of Systems (GEOSS)
(http://www.earthobservation.org)
The World Summit on Sustainable Development, Johannesburg 2002, highlighted the urgent need for coordinated observations relating to the state of the Earth. The First Earth Observation Summit was convened in Washington, DC in July 2003, attended by high-level officials of 33 countries and the European Commission and 21 international organizations involved in Earth observations. Governments adopted a Declaration signifying a political commitment to move toward development of a comprehensive, coordinated, and sustained Earth observation system. The Summit established the ad hoc intergovernmental Group on Earth observation (GEO), co- chaired by the European Commission, Japan, South Africa and the United States of America. A Framework Document was negotiated at GEO-3 in Cape Town and adopted at the Second Earth Observation Summit in Tokyo in April 2004 by 47 nations and the European Commission, joined by 25 international organizations. The Framework defines the scope and intent of a Global Earth Observation System of Systems (GEOSS). The initial 10-Year Implementation Plan has been prepared as well as the work plan for 2006. The Implementation Plan was negotiated by the GEO in Ottawa in November 2004, and adopted at the Third Earth Observation Summit in Brussels, February 2005. Norway is a party to GEO through Ministry of Environment and Ministry of Trade and Industry (which has delegated to Norwegian Space Centre).

Scope of the Global Earth Observation System of Systems (GEOSS) Implementation Plan: The Washington Summit Declaration establishes the objective “to monitor continuously the state of the Earth, to increase understanding of dynamic Earth processes, to enhance prediction of the Earth system, and to further implement our international environmental treaty obligations”, and thus the need for “timely, quality, long-term, global information as a basis for sound decision making”. The Framework Document adds that to move from principles to action, a “10-Year Implementation Plan for establishing the Global Earth Observation System of Systems (GEOSS)”, which should be “comprehensive”, “coordinated”, and “sustained” is needed.

The first 10-Year Implementation Plan of GEOSS defines a sequence of actions and responsibilities, commencing from the Third Earth Observation Summit in February 2005. GEOSS has an indefinite lifetime, subject to periodic review of its continued effectiveness.

In the GEOSS context, the word ‘**global**’ has two meanings. In the first sense, GEOSS aspires to be as inclusive as possible, embracing all nations and parts of the world and the organizations with Earth observation mandates. In the second sense, its priority focus is Earth system processes that operate at scales greater than the individual nation, for instance the global climate system. Phenomena that operate at lesser scales are the primary responsibility of local and national observing systems, but *may* be included in GEOSS if any of the following three conditions are met:

- They have global consequences in aggregate (e.g. desertification)
- They have significant global-scale causes (e.g. biodiversity loss)
- Their observation is enhanced by global systems (e.g. natural hazards).

‘system of systems’: The components of GEOSS consist of existing and future Earth observation systems across the processing cycle from data collection to information production. Contributors maintain their respective responsibilities, ownership and mandates, but commit to making all or a portion of their observations available and easily accessible for collective use. GEOSS thus makes it possible to combine information from currently unconnected sources, in order to obtain a view that is sufficiently comprehensive to meet user needs.

'for Earth Observation': GEOSS will facilitate access to direct *observations* as well as *products* based on the collation, interpolation and processing of observations, and the *services* necessary for such a coordinated system, such as the maintenance of data description and exchange standards. The observations provided by GEOSS will originate entirely from contributing national, intergovernmental and non-governmental systems. They will include observations made outside the territory of any nation, for example of open oceans, Antarctica and from space. GEOSS will give priority to the development of observation-based products that are not currently available. The content of GEOSS will be defined, from time to time, by its governance structures. Initially it covers the nine topic areas agreed by the second Earth observation Summit to be beneficial to many nations, and included in the Framework Document. GEOSS shall be built step-by-step through cooperation among existing observing and processing systems, while encouraging and accommodating new components as needs and capabilities develop. The plan includes the actions needed to build capacity, particularly in developing countries, that will permit the system to be useful to all participants.

GEOSS has nine societal benefits themes

1. Reducing loss of life and property from natural and human induced disasters
2. Understanding environmental factors affecting human health and well-being
3. Improving management of energy resources
4. Understanding, assessing, predicting, mitigating and adapting to climate variability and change
5. Improving water resource management through better understanding of the water cycle
6. Improving weather information, forecasting and warning
7. Improving the management and prediction of terrestrial, coastal and marine ecosystems
8. Supporting sustainable agriculture and combating desertification
9. Understanding, monitoring and conserving biodiversity

The GEOSS plan entails the coordination of a wide range of space-based, air-based, land-based, and ocean-based environmental monitoring platforms, resources and networks - presently often operating independently. Membership in GEO currently includes 51 countries plus the European Commission, and 29 participating international organisations.

Arctic Council

The Arctic Council (see http://new.arcticportal.org) was established in 1996 as a high level intergovernmental forum to provide a means for promoting cooperation, coordination and interaction among the Arctic States with the following members:

- Canada (http://www.gc.ca/home.html)
- Denmark (Including Greenland and the Faroe Islands) (http://www.denmark.dk/en)
- Finland (http://www.suomi.fi/suomifi/english/index.html)
- Iceland (http://iceland.is/)
- Norway (http://www.norway.no/)
- Russian Federation (http://www.gov.ru/index.html)
- Sweden (http://www.sweden.gov.se/)
- United States of America (http://www.usa.gov/)
- Permanent Participants

The Arctic Council deals with common Arctic issues, with the involvement of the Arctic Indigenous communities and other Arctic inhabitants. These issues are, in particular, related to sustainable development and environmental protection in the Arctic. In view of these broad and multidisciplinary challenges several dedicated working groups are established, including:

- Arctic Contaminants Action Program (ACAP) (http://arcticportal.org/en/acap)
- Arctic Monitoring and Assessment Programme (AMAP) (http://arcticportal.org/en/amap)
- Conservation of Arctic Flora and Fauna (CAFF) (http://arcticportal.org/en/caff)
- Emergency Prevention, Preparedness and Response (EPPR) (http://arcticportal.org/en/eppr)
- Protection of the Arctic Marine Environment (PAME) (http://arcticportal.org/en/pame)
- Sustainable Development Working Group (SDWG) (http://arcticportal.org/en/sdwg)

Arctic ROOS (in EuroGOOS)
An Arctic Regional Ocean Observing System (Arctic ROOS) has been established by a group of 14 member institutions from nine European countries working actively with ocean observation and modelling systems for the Arctic Ocean and adjacent seas.
Arctic ROOS aims to promote, develop and maintain operational monitoring and forecasting of ocean circulation, water masses, ocean surface conditions, sea ice and biological/chemical constituents. Arctic ROOS intends to include more members from countries outside of Europe. It also aims to become a GOOS Regional Alliance for the Arctic. Arctic ROOS has established a secretariat at the Nansen Environmental and Remote Sensing Center in Norway.

The key goals of Arctic ROOS (http://www.arctic-roos.org) are to:

- develop and maintain arrangements and partnerships needed for a sustained, cost-efficient provision of Arctic ocean and ice information, following up the enhanced observational efforts of the International Polar Year 2007-2009
- contribute to international planning and implementation of GOOS for Arctic and Sub-Arctic seas, including promotion at national, regional, circumpolar and global level
- deliver data and information from existing observing systems to users, in particular climate research, marine operators, education, media and the public at large, following the open data policy of IPY
- identify emerging priorities for an Arctic ocean observing system and its operational component
- promote the development of the scientific and technical components of the Arctic ocean observing system
- assess and report on the economic and social benefits of operational oceanography in Arctic and Sub-Arctic seas
- support sustainable operation of Arctic Marine Core Services under GMES
- contribute to a GOOS Regional Alliance for the whole Arctic

Arctic ROOS is a contribution to the International Polar year through the IPY project no. 379: "IPY Operational Oceanography for the Arctic Ocean and adjacent seas". A web site for Arctic ROOS has been established where members present their activities, with links to products and services that are presently available. The secretariat has a person who work part time on updating and improvement of this web site. Several satellite monitoring services and forecasting systems present daily updated information on this web site.

Among the key challenges recognized in Arctic ROOS are the urgent need to develop, test and implement cost-effective and long-term in situ observing systems for Arctic and sub-Arctic seas where very few monitoring systems are in operation. Moreover, lack of infrastructure and communication in remote polar regions are major obstacles to implement and maintain in situ observing systems. In this context Svalbard is the most important region where infrastructure allows deploying and maintaining observing systems. Finally, the geopolitical issues in the Arctic with restriction on deployment of observing systems in the ocean are emerging as a growing challenge.

MarNIS (Maritime Navigation and Information Services – www.marnis.org)
MarNIS was terminated in early 2009 after delivering significant contributions to the European e-Maritime concept. The use of the ARKTRANS information architecture and integration of coast state authorities with ports, other authorities as well as with the ships themselves have led to concepts that can be used also in *i-Nord*. This applies to risk assessments, ship supervision, rescue coordination, ECDIS and AIS extensions etc. Results from MarNIS must be adapted to the different climatic and communication constraints that exist in the Arctic, but this is relatively straight forward.

MAREANO
MAREANO maps depth and topography, sediment composition, biodiversity, habitats and biotopes as well as pollution in the seabed in Norwegian coastal and offshore regions. The Programme started in 2006, and focuses on describing the seascape of the Norwegian continental shelf, distributions of habitats, biotopes and biodiversity, the relationship between physical environment, biodiversity and biological resources and contaminants in the sediments. MAREANO is coordinated by the Institute of Marine Research, in collaboration with the Geological Survey of Norway and the Norwegian Hydrographic Service. The Programme is financed by the Ministry of Fisheries and Coastal Affairs, the Ministry of Environment and the Ministry of Trade and Industry via contributions from the National Budget.

Flagship (European Framework for Safe, Efficient and Environmentally-Friendly Ship Operations – www.flagship.be)
Flagship is a leading project for development of new safety strategies in shipping. Elements in Flagship that will be used in *i-Nord* are integrated emergency operations, MIO overlays on ECDIS and concepts from the environmental activities.

IO Centre (Centre for Integrated Operations in the Petroleum Industry – www.ntnu.no/io)
This project aims at improving the operational efficiency in the oil sector by using principles from integrated operations research. MARINTEK is also looking into how these principles can be used in the maritime sector and in particular in time critical and demanding operations involving several floating entities (e.g., rescue operations).

IMBER
http://www.imber.info/
The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project is focusing on ocean biogeochemical cycles and ecosystems. The IMBER vision is to provide a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth System and human society.

HERMES
http://www.eu-hermes.net/
The Hotspot Ecosystem Research on the Margin of European Seas (HERMES) project is an integrated research project designed to gain new insights into the biodiversity, structure, function and dynamics of ecosystems along Europe's deep-ocean margin

ComL
http://www.coml.org/
The Census of Marine Life (ComL) is a global network of researchers in more than 80 nations engaged in a 10-year scientific initiative to assess and explain the diversity, distribution, and abundance of life in the oceans.

Globec
http://www.globec.org/
The aim of the Global Ocean Ecosystem Dynamics project (GLOBEC) is to advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change.

Esonet
http://www.ifremer.fr/esonet/
The European Sea Observatory NETwork (ESONET) goal is networking institutions, persons, tools and know-how on deep sea observatories. It aims to promote the implementation and the management of a network of long-term multidisciplinary ocean observatories in deep waters around Europe. It wishes to define an organization – with the necessary critical mass – capable of gathering the resources of the participating institutes. The ultimate goal is to define durable solutions through a joint programme of activities.

MarBef
http://www.marbef.org/
The Marine Biodiversity and Ecosystem Functioning (MarBef) network is a network of excellence funded by the European Union and consisting of 94 European marine institutes, is a platform to integrate and disseminate knowledge and expertise on marine biodiversity, with links to researchers, industry, stakeholders and the general public.

EMODNET
http://www.esf.org/research-areas/marine-board/
The European Marine Observation and Data Network EMODNET will be an end-to-end, integrated and inter-operable network of systems of European marine observations and data communications, management and delivery systems, supported by a comprehensive user oriented toolkit to enable implementation of the Integrated Maritime Policy for Europe.

SeaDataNet
http://www.seadatanet.org/
The SEADATANET project (2005-2011) aims to develop an efficient distributed Pan-European Marine Data Management Infrastructure for managing large and diverse data sets. The objective is to network the existing professional data centres of 35 countries, active in data collection, and provide integrated databases of standardized quality on-line.

The on-line access to in-situ and remote sensing data, meta-data and products will be provided through a unique portal interconnecting, in the first phase, 11 interoperable node platforms. The development and adoption of common communication standards and adapted technology will ensure the platforms interoperability. This activity will be developed to gradually connect all the other data centres to the interoperable system.

The quality, compatibility and coherence of the data issuing from so many sources, will be ensured by adopting standardized methodologies for data checking, by dedicating part of the activities to training and preparation of synthesised regional and global statistical gridded products from the most comprehensive in-situ and remote sensing data sets made available by the participants. These products, easier to interpret by non-specialist users, will be used first to check the data and the system operability, and further to market SEADATANET and to serve a wider range of uses than raw data: e.g. model initialisation, industrial projects and teaching.

i-Nord
A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean

Main Report

Part 2

Users and Stakeholders Survey

MEMO

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MEMO CONCERNS

i-Nord
A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean

Pre-project

Users and Stakeholders Survey

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90E299	2009-01-31	Aage Jostein Thunem	55

The surveillance of the High North ocean areas.

1 PREFACE

The i-Nord project is a product of Barents2020 which is based on the Norwegian Government's High North Strategy[1]. i-Nord´s main objective is to implement and operate a ***comprehensive monitoring* and information system** of the High North ocean areas, in order to directly address and maintain Norway's ***ambition of playing a leading role*** in the Barents Sea and Arctic Ocean, including proper and sustainable management as well as proactive partnership in the intergovernmental Arctic collaboration.

The mandate for the i-Nord pre-project has been to prepare the best background for the Government's decision of starting the ambitious development of a full i-Nord surveillance system.

The pre-project is initiated and financed by the Ministry of Foreign Affairs (UD) and the Ministry of Fisheries and Costal Affairs (FKD).

The specific objectives of the pre-project have been to:
- Identify the primary stakeholders to such a system
- Describe the i-Nord concept and overall system structure
- Describe best practice for developing such a system
- Identify the need for research and development
- Produce a main project plan
- Propose and coordinate a consortium with the necessary know-how and ambition of carrying out the main project

This report is one of the deliverables from the i-Nord pre-project and describes ***the i-Nord concept and overall system structure.***

The report has been prepared by:

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After receiving the report from the responsible author, the report has undergone only editorial changes by SINTEF as part of the preparation of the final document.

[1] As of 2008-10-22: http://www.regjeringen.no/en/dep/ud/Documents/Reports-programmes-of-action-and-plans/Action-plans-and-programmes/2006/Strategy-for-the-High-North.html?id=448697

2 SUMMARY

An important activity in the *i-Nord* pre-project has been to collect information from all the main interest groups and stakeholders related to such a system. These comprise:

- *Suppliers of information*, such as Institute of Marine Research, The Norwegian Polar Institute, Nansen Environmental and Remote Sensing Center, The Norwegian Meteorological Institute, etc
- *Official authorities*, such as The Norwegian Coastal Administration, The Joint Coordination Rescue Centres, Norwegian Pollution Control Authority, etc.
- *Industrial manufacturers and suppliers*, KONGSBERG Group, Fugro Oceanor AS, SAAB Group, etc.
- *Universities and research Institutes*, such as the University of Tromsø, NTNU, University of Bergen, NORUT, Norwegian Institute for Water Research, Norwegian Institute of Air Research, etc.
- *Consumers* of High North information and services, such as the governmental agencies, public sector in general, citizens, commercial businesses, international partners, etc.

These groups cover a wide range of interests, and play various roles. The *i-Nord* pre-project has therefore been focused on future (and evolving) solutions of systems and infrastructures to facilitate better interaction, interoperation and cooperation between the different interest groups in a much more efficient way than today's infrastructures and systems provide.

The organisations which have been contacted in the survey are listed in the Annex F.

A summary of the main results of the survey

One of the conclusions of the *i-Nord* project is that a surveillance system for the High North should be public, very flexible, and very dynamical facilitating integration, interoperability and scalability

- *i-Nord* should not be regional, i.e. only the Barents Sea, but also include the Nordic Seas and the Arctic Ocean, etc.
- *i-Nord* must be able to communicate and interact with other similar national and international systems, e.g. AIS (Automatic Identification System), GMES (Global monitoring for environment and safety), and projects like MyOCEAN, etc.
- *i-Nord* shall contribute to the Arctic Observing Network
- *i-Nord* shall maintain a strong component to global climate observing network
- *i-Nord* system should be able to operate in different modes so that both large open ocean areas, costal waters, and even fjords can be included in a seamless way.
- *i-Nord* system must be based on internationally accepted standards, including the relevant application domains and reliability, security, and safety requirements. It should also function on a 24-7 basis.
- *i-Nord* must be service oriented[2] and must be universally accessible.

Project partners that are currently authorized responsibility for surveillance of the High North have specified the following overall system requirements:

- A higher degree of integration of data and information that already exist in separate systems.
- More detailed observations of relevant parameters by means of new and more plentiful sensors and sensor networks. This will enhance the quality of existing models. This

[2] Meaning that *i-Nord* is based on modern principles of software system construction, so that functionality, data products, and information are made available and accessible through the net (e.g., Internet).

information is also vital for a better understanding of environmental aspects such as weather and climate, resource management, etc., which are crucial for use in prediction and decision support systems.

- A more flexible support for new services and new models that cannot be achieved by today's infrastructures and systems, e.g. real time systems.
- A more flexible interface for a variety of end users. This will make the system more attractive than a dedicated system for specialized users.

These user needs and users requirements will form a basis for establishing the functional and technical specifications of the main project.

International collaboration

The partners in *i-Nord* have already a comprehensive international contact network and collaboration in all areas covered by the *i-Nord* concept. The collaboration will be further developed during the implementation of *i-Nord*. The collaboration will primarily be focused to the Nordic Countries, EU, USA, Canada and Russia.

EU is one of the key players in the Arctic. In 2002 EU stated the vision "Towards a Strategy to Protect and Conserve the Marine Environment". This vision was followed by several initiatives and in May 2008 the European Council adopted the **Marine Strategy Framework Directive**, which aims at ensuring a healthy European marine waters by **2020**, taking into account the geographic and climatic specificity of different marine ecosystems.

It is underlined by the European Commission that the **Marine Strategy shall apply an ecosystem-based approach** to the management of human activities in order to:

- Ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status
- And that the capacity of the marine ecosystem to respond to human induced changes is not compromised
- While enabling the sustainable use of marine goods and services by present and future generations

i-Nord is based on such an **eco-system approach** and a close collaboration with EU in implementing *i-Nord* is preferenced.

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3 Introduction

The importance of the Arctic region

The retreat of the polar ice cap is opening previously inaccessible parts of the Arctic to new activities like resource extraction and marine transportation. Ice conditions along the northern coasts of Russia and Canada may at some point become favorable for year-round shipping through the Northeast passages and Northwest passages.

The feeding areas of commercially important fish stocks are gradually moving north, due to increasing water temperatures. In the Arctic waters the marine ecosystems are highly productive and of great economic, social and cultural importance, not only to the region itself, but also to many other European nations.

Geophysical processes in the region are of major importance in the regulation of the global climate. The Arctic region offers unique opportunities for monitoring changes in the global environment, and for studying other natural processes of global significance.

Technologies are being developed for the exploration and production of oil and gas resources on the Arctic shelf. As a result of these developments, the Circumpolar Arctic is reemerging as a region of major significance, not only to Norway, but also to Canada, the United States, Russia and the European Union.

The seas north of the Norwegian mainland contain considerable fossil fuel and renewable fisheries resources. They have enormous economic potential which, if managed properly, will have great significance, both for the region and for the rest of the world. In summary:

- 25% of the world's undiscovered oil and gas resources expected to be found in the Arctic region and the Barents Sea
- The Barents Sea and the Arctic continental shelves is one of the world's most fertile ecosystems.
- Breeding grounds for a significant percentage of the world's wild fish populations**.**

In the context of global climate changes and the melting of the polar ice cap, it is necessary to discuss how state and private actors' increasingly active pursuance of oil, gas, fishery and shipping interests in the Arctic may shape the region's future as an international security arena.

Norway is an important state actor in the Arctic, and particularly the European Arctic, and has a long tradition of arctic expeditions and commercial activities in the Arctic. Today, Norway is one of the world's leading petroleum nations and has jurisdiction over a maritime area more than six times the size of its land territory.

The High North has been singled out as Norway's most important strategic priority area, and considerable resources are being devoted to the day-to-day enforcement of Norwegian sovereignty and authority in northern waters. This includes the management of the Barents Sea's living marine resources – a task which is being undertaken in cooperation with Russia.

Norway is the first country to start large-scale petroleum operations in the Barents Sea, at the Snøhvit gas field located 140 kilometers off the coast of Finmark. At water depths between 250 and 350 meters, natural gas is being extracted by remote-controlled seabed installations, piped to the shore, liquefied, and shipped on LNG tankers to European and American markets.

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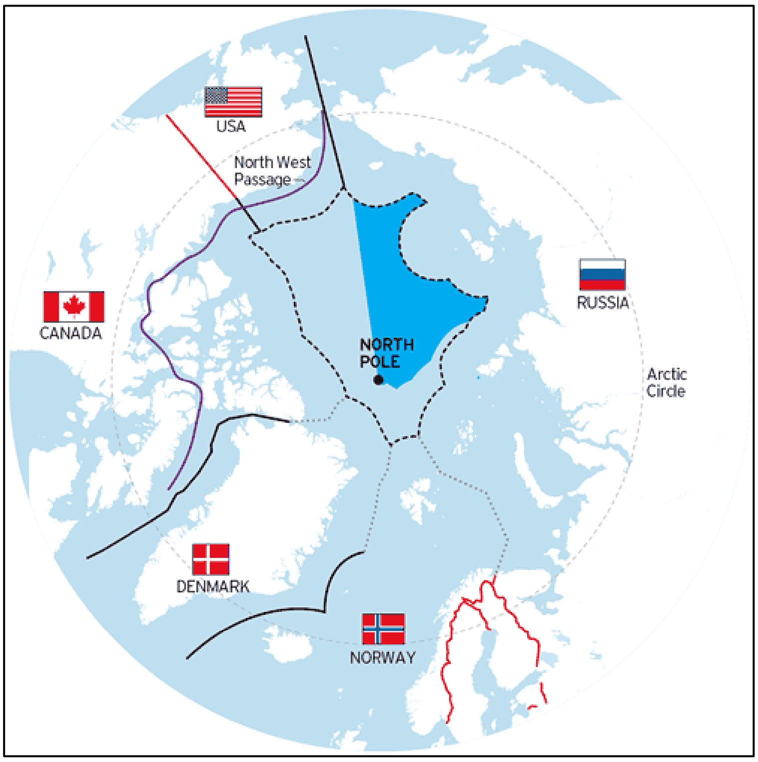

Figure 1: The Arctic coastal states and Russia's shelf claim (dark blue).

The coast along northern Norway is also trafficked by Russian oil tankers transporting crude oil from Western Siberia to European and American markets. The oil and gas exploration and production as well as the transportation of these products constitutes an significant threat to the marine environment when subject to a major oil spill catastrophe.

The European Union and its member states also have significant economic and strategic interests in the Arctic. Denmark, Finland and Sweden all have land territories located north of the Arctic Circle, and fishermen from EU members states have been operating in artic waters, especially the Barents Sea, for a long time. The European Union devotes considerable attention to its "Northern Dimension", which include not only the Union's land areas north of the Arctic Circle, but also areas as far south as the southern coast of the Baltic Sea.

Greenland, is a Danish territory, but unlike mainland Denmark it is not a member of the EU, and Greenland is partly self-governed. As far as the central arctic shelf is concerned, Denmark is the only EU country in position to file a claim to shelf areas beyond the 200 nautical mile zone. A Danish claim to a shelf north of Greenland, may be including the North Pole, is likely to be partly overlapping with Canadian and Russian claims.

Russian is, by virtue of its size, geographical location, and the length of its northern coastline, Russia is destined to remain a key player in international Arctic affairs. Russia's strategic interests in the Arctic are closely related to the country's economic interests in the region.

Canada controls the second largest part of the Arctic. The political entities of the Canadian North – Yukon, the Northwest Territories, and Nunavut, including the Hudson Bay islands, all have a harsh climate and are relatively sparsely populated. This is particularly the case in the Canadian "far North", which refers to the part of the country that is located north of the Arctic Circle. The Arctic continental shelf off Canada is supposed to contain larges quantities of undiscovered oil and gas.

The United States is an arctic nation by virtue of Alaska. Located in the far northwestern corner of the North American continent, Alaska is the largest U.S. state and plays an important role both economically and strategically regarding the Arctic. As for Canada large quantities of oil and gas are likely to be discovered on the Arctic shelf.

Today, more than ever before, arctic politics and governance is about the *access to natural resources and control of these*. The security interests of the circumpolar arctic states are to a large extent related to their economic interests in the region. And their economic interests are often seen as potentially conflicting, rather than shared. States are willing to go to great lengths to defend what they perceive as legitimate sovereignty.

As mentioned the High North is Norway's most important strategic priority area in the years ahead. The Government is intensifying its efforts to exercise Norwegian sovereignty and ensure sustainable management of the rich fisheries and energy resources in the region. Norway's High North policy is intended to protect the environment, maintain settlement patterns and promote business development.

A successful implementation of the i –Nord surveillance and early-warning system will be an important instrument when implementing the Governments High North policy. The **overall goal of i-Nord** is derived from the High North policy and is aligned with and substantiate the policy:

The cutting edge surveillance and information system for maritime security, marine environment and marine resources of the Nordic Seas and the Arctic Oceans

4 The i-Nord concept

The i-Nord concept is described in detail in the project proposal. The outline of the concept and its system components are shown in Figure 3. The i-Nord concept has defined three application domains which have a lot of interaction on a day-to-day basis. The domains are:

- Maritime Safety, Security and Operations
- Marine Environment and Climate
- Marine Resources

The discussions with users and stakeholder have clearly stated that i – Nord should be a public, non classified system owned the Norwegian Authorities.

It should also be acknowledge that i-Nord is a system to be built on existing service providers. Thus i-Nord should take full advantage of existing production chains and provide a facility to exchange data and information more efficient.

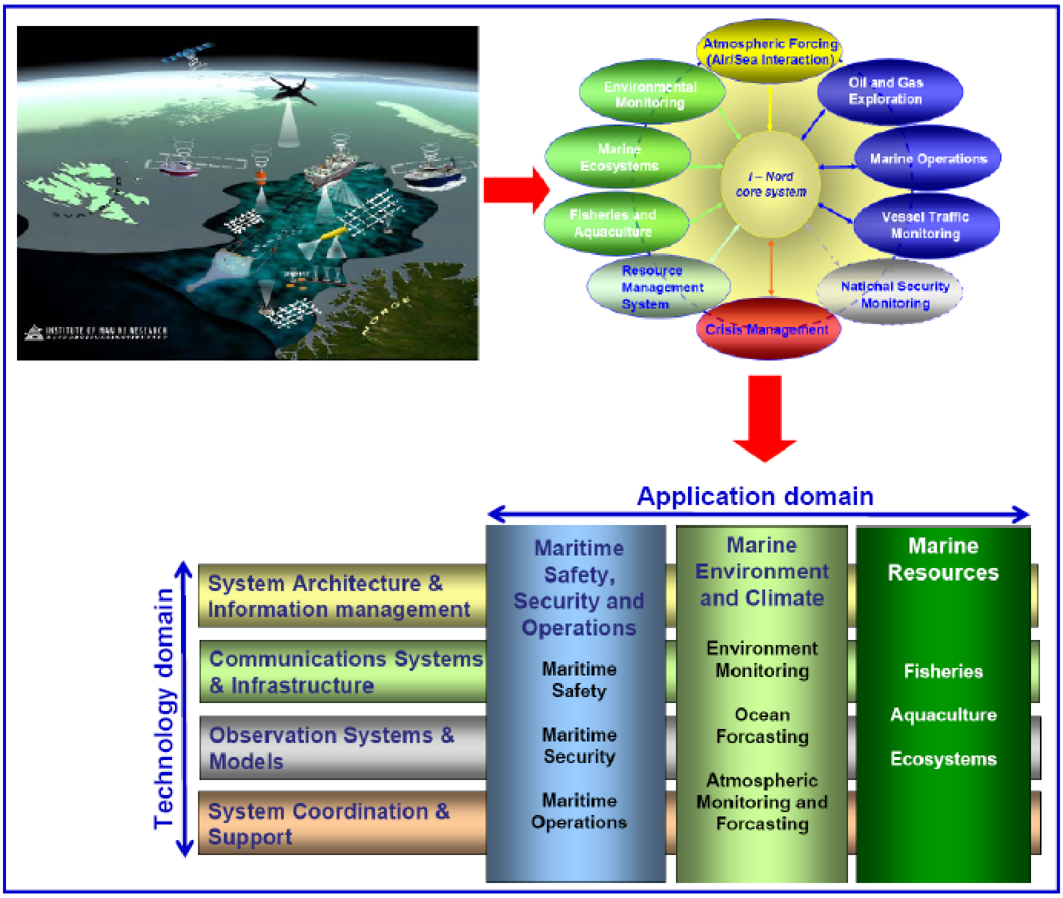

Figure 3: Outline of i –Nord concept and system components

It is supposed to be a tool for as various groups as scientists, industry, public authorities (ranging from local to governmental), as well as non-governmental institutions and citizens. This tool should offer capabilities within areas of daily monitoring of various phenomena, management of resources and crisis management. The various components that are required to set up such a system are schematically outlined in Figure 3.

Given the ambitious intention of i-Nord the new idea is that not only should data, products and information be easily available within the system, but also that potentially necessary interactions between various subsystems should be facilitated. i-Nord thus require interfaces for sharing data and production environments. This do not imply direct access to production chains, which in most cases would violate security policies of those owning the production chains, but definitions of interfaces that may be used in a secure manner to establish relationships between various subsystems that increase the overall performance of the system.

The i-Nord system has to cope with a wide variety of production environments as well as respecting existing IT-strategies within the service providers. As such, the fundamental principle of i-Nord development is definition of services and interfaces offered by existing systems and utilised within i-Nord. To generate a sustainable system the system should be designed in a manner compliant with other requirements the service providers have to fulfil (e.g. INSPIRE, GEOSS and WIS).

There are several initiatives and project going on internationally and it is important that i-Nord should relate to existing Arctic initiatives and activities like e.g. ACIA/NORACIA, AMAP, SAON, SIAEOS as well as ongoing and upcoming operational projects like EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSISAF) and GMES MyOcean and relevant International Polar Year (IPY)-projects like DAMOCLES, iAOOS and IPY-THORPEX.

OSISAF and MyOcean are providing or setting up operational environmental services for the European society while the IPY projects mentioned above have been examining new environmental monitoring technology. The i-Nord system should address key issues the IPY legacy and relate to Arctic Council initiatives.

The Commission on Oceanography and Marine Meteorology (JCOMM) under WMO/IOC took the initiative to establish improved observing systems for the Polar Regions. (JCOMM 2000). The United Nations Framework Convention on Global Change (GCOS) recommends that Artic GOOS should be implemented. i-Nord will comply with the fundamental philosophy of these initiatives and become the Norwegian contribution and participation to these programs.

A more detailed list of state –of –the art projects and programs are provided in the project proposal.

5 The i-Nord application domains

5.1 Maritime safety, security and operations (MSSO)

The first important area of application for *i-Nord* will be maritime safety, security, and operations, supporting functions as day-to-day vessel monitoring, maritime risk assessment, and maritime crisis management. Barents Sea is an important shipping lane to/from north-western part of Russia. It is expected that this traffic will increase, especially in the long term perspective. The melting of the Polar ice could lead to the possibility of a northern shipping lane between the Atlantic and the Pacific Ocean. The navigation conditions in the area are demanding for ship traffic – icing, drifting ice, fog, high sea, and strong winds.

The region’s vast natural resources require efficient management, in particular the fisheries and the offshore oil & gas sectors. Furthermore, Norway, as signatory to the Schengen Agreement, has responsibility for border control in these areas, a challenging task in itself. Increasing human activities in the region will need enhanced vessel traffic monitoring, environmental monitoring and forecasts, and early warning of possibly dangerous situations. The *i-Nord* approach opens for new opportunities:

- improved data collection by development of novel sensor technology and platforms;
- better and easier integration of existing data sets, products and processing chains;
- distribution of navigational and safety information to ships in the area; and
- improved coordination of ships at an emergency scene and Search and Rescue (S&R) assets.

Maritime Situation Awareness has become an important issue especially from the military prospective. The i - Nord Maritime safety, security and operations has a similar approach but now as a public domain system. The data, information, tasks and services of i-Nord MSSO is performed through an extensive interagency co-operation. A key player is the Norwegian Coastal Administration (Kystverket) which is the Norwegian agency for coastal management, marine safety and -communication. The i-Nord MSSO comprises systems and services such as the VTS (Vessel Traffic Centres), Pilot Services, Police, Customs, Port Authorities, Port Notification as well as Maritime/Marine Actors. There is also a close co-operation with Baltic Sea Region Border Control.

A military MSA will be the counterpart to i-Nord MSSO, and the two instances will be able to share data, information and a common situation picture or a Common Operational Picture (COP). Sharing a COP is important when handling whatever type of crisis that may occur (Crisis management). All data and information will be available (open access) for the military MSA and the military MSA will provide all non-classified data and information to the i-Nord MSSO.

The Norwegian joint HQ (FOHK) exercise the command of the Army, Air, Navy, Coast Guard and Sea Home Guard and these military resources are key when handling critical maritime challenges. The Coast Guard is also a key asset exercising maritime challenges and support other national agencies with regard to exercising their authority. There is a need to developed integrating tools for maritime sensor data and distribution of data and information among state agencies. To obtain an improved COP new sensors and sensor- platforms (4D) are required providing data and information as well as requiring new integrating-, simulation- and reporting tools.

The results will provide a higher level of co-operation by sharing risk/threat assessments as basis for joint maritime safety and maritime security operations.

5.2 Marine Environment and Climate

The Ministry of Environment has asked The Norwegian Pollution Control Authorities (SFT) to perform an assessment of the environmental management needs and requirements related to data, information and services to be provided though i-Nord. Input to the assessment has been provided by Norwegian Polar Institute (NPI), Directorate for Nature Management, Norwegian Mapping and Cadastre Authority and the Governor of Svalbard.

The Assessment provides input of great value to key areas cover both by the Marine Environment and Climate as well as the Marine Resources application domains. The entire assessment document (in Norwegian) is attached in Annex A.

The marine environment in the Arctic is very vulnerable and a major crude tanker accident my have severe consequences to the environment and the ecosystem. Such environmental challenges require an urgent implementation of a comprehensive and reliable, while cost-effective capability for monitoring and prediction of the state and changes of the high latitude and Arctic marine environment and climate. The main operational data, information and services presently delivered to users, cover geophysical information including: air and sea temperature, air humidity, wind and waves; concentration, extent, drift and deformation of sea ice; ocean currents and transport pathways; mesoscale ocean variability; properties, distribution and transformation of water masses.

This baseline information moreover allows routine production of oil spill detection and tracking, production of environmental indicators as well as generation of physical-based input to water quality, ecosystem and marine resource monitoring such as plankton dynamics, including algae blooms; operational fish larvae drift; transport, distribution of contaminants, their concentration in the marine food-chain and the exposure on plankton and fish larvae.

Improved and more reliable information are required and can be obtained as a result of a successful implementation of i – Nord products and services. A key element is exchange of information across different authorities, efficient integration of data and information. Integration of satellite radar data with in-situ measurements is focused. Different types of “drop-sensors” can provide additional data of value to plan the clean-up champagne.

It is therefore a need to have a reliable operational pollution detection, monitoring and forecasting system. This system should be capable to detect pollution and sea under all weather and light conditions, identify the likely source of the pollution, predict the temporal evolution, transport, spreading and/or drift, and identify the potential impact e.g. resulting from pollution reaching the beaches. Oil spill detection and monitoring service is likely to be established from integrating the existing satellite and aircraft based detection and monitoring systems with backward and forward numerical drift models, and also by integration with source data and additional non-satellite observations and/or environmental data.

The dynamics of the high latitude seas and Arctic Ocean are characterized by small spatial scales, which are poorly described because of limited in-situ data coverage. This calls for significant challenges and demands regarding monitoring system and modelling capabilities; including validation and data assimilation. The opportunity to utilize new knowledge and data from the growing number of national and international research and application programs, including The International Polar Year (IPY) and its legacy, EC-MyOcean, MD/SFT monitoring programs, must therefore also be systematically incorporated.

MyOcean is briefly described in Annex E

5.2.1 Svalbard Integrated Arctic Earth Observing System (SIAEOS)

The High Arctic represents as a key region for observing global environmental change. The impact of climate change, pollution and other pressures on the environment appear sooner and with more severe consequences in the High Arctic compared to regions at lower latitudes closer to the pollution sources and population centres. This makes the High Arctic an early warning region for global warming.

Due to its geographical location and extensive research infrastructure as well as easy access and good living conditions, Svalbard is uniquely suited as the European hub in High Arctic research and as a node in the planned Sustained Arctic Observing Network (SAON):

Svalbard provides excellent opportunities for studies of ecosystem changes following global environmental change. Oceanic and atmospheric transport patterns prevail in the Svalbard region, allowing for studies of environmental pollution as well as its effects on the food chain. Svalbard is well positioned to observe and analyse the Changing Arctic ice cover as well as its albedo. Svalbard's position underneath the magnetospheric cusp allows for unique studies of the energy balance between the layers of the atmosphere, from the borders of space to the surface. The location of Svalbard and the High Arctic provides for dense satellite monitoring.

SIAEOS has been proposed as an new infrastructure for an Arctic Earth Observing system in and around Svalbard to integrate the studies of geophysical, chemical and biological processes for existing and new sensor and monitoring platforms. SIAEOS will complement the i - Nord initiative and will make a valuable extension to the High North Strategy.

For further detail on SIAEOS see Annex D.

5.3 Marine Resources

Traditionally, the primary user of the northern seas and the Barents Seas, have been the fishing and the maritime transport industries. The oil and gas exploration and production moving to the north as well as an increased transport of crude oil from Russia along the coast of northern Norway has complete change the game. The common denominator for all activities in and on the ocean is the strong interaction with the marine environment and the ecosystem.

The Ministry of Environment has issued (2005-2006) a plan for "Integrated Management of the Marine Environment of the Barents Sea and the Sea Areas off the Loften Islands". The report states that the ecosystem of the Barents Sea and the Sea areas off the Lofoten Islands are of very high environmental value and are rich in living natural resources that are the basis for considerable level of economic activity. By international Standards, the state of these ecosystems is generally good and the area covered by the management plan can be characterised as clean and rich in resources. It is of high importance to safeguard the basic structure and the dynamics of this ecosystem in the long term, maintain it clean, rich and productive.

Norway is the second largest exporter of fish and fish products in the world. This is also the second largest export industry in Norway (after oil and gas), and the largest based on renewable resources. It is therefore of utmost importance that these marine resources are managed in a best possible way.

The existing surveillance system for living marine resources is designed for supporting assessment and management of single populations on an annual basis, often intended for sustainable harvest. This paradigm is now being modified and the new "*Havressursloven*" postulates that management of living marine resources should be performed within an ecosystem approach, secure sustainability and follow the precautionary principle. This poses substantial challenges to the management of living marine resources with regards to demanding a broader perspective on implications of human activities and a more operational management procedure. In the future our advice has to be on ecosystem scales and founded on a much broader data collection and modeling. The *i-Nord* project will support this development.

The new challenges set completely new demands on data, models and ecosystem understanding to support a sustainable area-based management under the ecosystem approach. As part of this development, monitoring programs such as MOSJ ("*Miljøovervåkning Svalbard og Jan Mayen*") and "*Overvåkningsgruppen for Barentshavet*" have been established. These programs typically use spatio-temporally aggregated indicators to evaluate the state of living resources. Practical day-to-day ecosystem-based management will be facilitated by the *i-Nord* initiative by making data and advice from many sectors and parts of the ecosystem available at the same time and place, and at a high spatio-temporal resolution. In the development and follow-up of the integrated management plan for the Lofoten – Barents Sea the need for a coordinated and broadly scoped surveillance and monitoring system has repeatedly been specified. *I-Nord* will fill this need and thereby facilitate the follow-up and revisions of the Lofoten – Barents Sea plan.

The last topic is cover in the assessment carried out by SFT (see Annex A).

6 International Collaboration

There are several stakeholders having different interest in the Arctic. Firstly, the people having the life and work in the Arctic regions, secondly, the political and commercial interest of states with natural boundary the Arctic, and thirdly, the interest of the global community as the Arctic influence the climate on planet Earth. There is already an extensive circumpolar collaboration scientifically, commercially and political.

The implementation of i-Nord requires an international collaboration and the parties behind i-Nord will continue the already established collaboration on a scientific as well as on the state level. An extensive but not exclusive collaboration with European Union, the Nordic Countries, USA, Canada and Russia will be prioritized.

The following chapter describes policy and strategies of the above mentioned states together with a few ongoing activities and projects of specific interest to i-Nord.

6.1 Nordic Collaboration – the Baltic Sea region cooperation

The Nordic Countries have formed and are collaborating, on a wide range of topics, through the Nordic Council. The Nordic Council is also extensively involved in the Arctic co-operation primarily through the Arctic Cooperation Programme.

All Nordic countries are members of the Arctic Council through which the circumpolar collaboration on Arctic issues take place.

On the Nordic arena the Baltic Sea area plays an important role, and are subject to an extensive intergovernmental co-operation between Denmark, Estonia, the European Community, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. HELCOM is the governing body of the "Convention on the Protection of the Marine Environment of the Baltic Sea Area" - more usually known as the Helsinki Convention.The vision is a healthy Baltic Sea environment with diverse biological components functioning in balance, resulting in a good ecological status and supporting a wide range of sustainable economic and social activities.

The HELCOM Baltic Sea Action Plan is an ambitious programme to restore the good ecological status of the Baltic marine environment by 2021. The Baltic Sea Action Plan addresses all the major environmental problems affecting the Baltic marine environment.

The innovative approach is that the plan is based on a clear set of ‘ecological objectives’ defined to reflect a jointly agreed vision of ‘a healthy marine environment, with diverse biological components functioning in balance, resulting in a good ecological status and supporting a wide range of sustainable human activities’

The action plan distinguishes between measures that can be implemented at regional or national level, and measures that can only be implemented at EU level (e.g. Common Fisheries Policy, Common Agricultural Policy, controls over the marketing and use of chemicals) or globally (e.g. the shipping controls defined by the International Maritime Organization).

A pilot area for other European seas

The concept of the HELCOM Baltic Sea Action Plan has already been widely supported by politicians at various forums, and heralded as a pilot project for European seas in the context of the proposed EU Marine Strategy Directive. The European Community has described HELCOM’s plan as a cornerstone for further action in the Baltic Sea region, emphasising that the plan is instrumental to the successful implementation of the proposed EU Marine Strategy Directive in the region.

6.2 European Union

EU is an important player in the Arctic Regions where specifically three elements are focused:

- Environmental protection
- Sustainable use of resources
- Multilateral governance

In 2002 EU stated a vision “Towards a Strategy to Protect and Conserve the Marine Environment”. The vision was followed by several initiatives , and in **May 2008**, the Council adopted the **Marine Strategy Framework Directive**, which aims at ensuring healthy European marine waters by **2020**, taking into account the geographic and climatic specificity of different marine ecosystems.

According to this Directive, Member States will have to develop marine strategies for their European waters, including: a detailed assessment of the state of the environment, a definition of "good environmental status" at regional level by 2012, and environmental targets and monitoring programmes (targets will have to be achieved by 2016). Member States have 2 years to transpose the Directive after its entry into force.

It’s underlined by the European Commission that the Marine Strategy Framework Directive **shall apply an ecosystem-based approach** to the management of human activities in order to:

- Ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status
- And that the capacity of the marine ecosystem to respond to human induced changes is not compromised
- While enabling the sustainable use of marine goods and services by present and future generations

Furthermore, ensure an integration of environmental concerns into different policies which have an impact on the marine environment.

6.3 Global Monitoring of Environment and Security (GMES)

Global Monitoring for Environment and Security (GMES) is the European initiative for the implementation of information services dealing with environment and security issues. GMES is the European contribution to the Group on Earth Observation (GEO).

GMES is based on observation data received from Earth Observation satellites and ground based information. These data are coordinated, analysed and prepared for end-users.

The European Commission and the European Space Agency (ESA) have jointly initiated the GMES, where the overall objective is to build an European capacity to provide operational monitoring services using spaceborne data as a key component. Services developed under GMES will enable decision-makers in Europe to acquire the capacity for global as well as regional monitoring so as to effectively realize the EU's objectives in a wide variety of policy areas. Monitoring the Arctic is one of the thematic areas of the GMES services

GMES is the European participation in the **worldwide** monitoring and management of planet Earth and the European contribution to the Group on Earth Observation (GEO). The global community acts together for a synergy of all techniques of observation, detection and analysis.

The Group on Earth Observations (GEO) established (2005) and adopted a 10 year implementation plan of an integrated Global Earth Observation System of Systems (GEOSS), with the goal of addressing the information requirement for the environment on a global scale.

The GEOSS is an ambitious programme which principally foresees the monitoring and understanding of nature, the extent of disasters due to human activities, the impact of global warming, desertification, erosion and deforestation.

GMES will be the main European contribution to GEOSS.

The progressive implementation of GMES is made possible by the activities and investments of European Union and ESA Member States. These and other public and private contributions are jointly supported by the European Commission (EC) and the European Space Agency (ESA).

GMES started with a pilot phase which targets the availability of a first set of operational GMES services by 2008 followed by the development of an extended range of services which meet user requirements. By building on these services and adding value to them (possibly using other data and observations), more targeted and customised (tailored) services can be developed addressing for instance health issues, productivity increases and other aspects.

The services provided by GMES can be classified in three major categories:

- **Mapping**, including topography or road maps but also land-use and harvest, forestry monitoring, mineral and water resources that do contribute to short and long-term management of territories and natural resources. This service generally requires exhaustive coverage of the Earth surface, archiving and periodic updating of data.
- **Support** for emergency management in case of natural hazards and particularly civil protection institutions responsible for the security of people and property. This service concentrates on the provision of the latest possible data before intervening.
- **Forecasting** is applied for marine zones, air quality or crop yields. This service systematically provides data on extended areas permitting the prediction of short, medium or long-term events, including their modelling and evolution.

The widespread and regular availability of technical data within GMES will allow a more efficient use of the infrastructures and human resources. It will help the creation of new models for security and risk management, as well as better management of land and resources.

Some examples of services are:

- Oil spill/discharge detection & monitoring;
- Land cover/land use for policy making and services to farmers;
- Support to civil protection – rapid mapping;
- Environment and health services – ozone monitoring and UV exposure.

6.4 Services of specific interest to i - Nord

The Forum GMES 2008 marked the launch of the first set GMES services in pre-operational mode:

- Marine Environmental Services
- Atmospheric Environmental Services
- Land Environmental Services
- Support to Emergencies and Humanitarian Aid
- Support to security -related activities
-

The development of these services is supported by implementation groups put in place in the context of the Action Plan 2004 - 2008.

MyOcean is the last step towards the GMES Marine Core Service after many European funded programmes such as POLARVIEW, ECOOP, MARCOAST, MERSEA.

MyOcean
(http://www.myocean.org)
In consistence with the GMES Fast Track Services (FTS) the Marine Core Service element will be implemented and operated under MyOcean for a period of three years from 2009 to 2012. MyOcean will make available and deliver a set of basic, generic services based upon common-denominator ocean state variables that are required to help meet the needs for information of those responsible for environmental and civil security policy making, assessment and implementation. The *Policy drivers* have been identified as:

- Regional Conventions between Member States and the EC (i.e. OSPAR, HELCOM, UNEP/MAP;
- 6th Environmental Action Plan; in particular its Climate Change and Marine Environmental Strategy components;
- The Sustainable Development imperative which is written into the Rome Treaty and is now being developed through the Green Paper on Maritime Policy. (Note that the **Maritime Policy Green Paper** has emphasised that commercial sectors such as shipping, fishing, oil exploration, offshore construction, aquaculture, and tourism, and public sectors such as coastal protection, defence, search and rescue, R&D and government policy making all need data on past, present and future meteorological, oceanographic, hydrographic and ecological state of the seas and the oceans. Global-scale monitoring is

required to meet this need and the EU is being encouraged to set up a European Marine Observation & Data Network to provide sustainable, improving access to information.)

- Relevant existing EU Directives, such as the Water Framework Directive in its application to coastal waters.
- Concerns over civil security which manifest themselves in particular for safety of life and property in the marine environment (i.e. EMSA).

MyOcean aims to provide services within four key areas, notably

- Marine and Coastal Environment
- Maritime safety
- Marine Resources
- Climate – Seasonal forecasting

Norwegian participants in MyOcean are METNO, IMR, NERCE and PI. Major impact on i-Nord.

MyOcean is briefly described in Annex E

6.5 US involvement in the Arctic

6.5.1 Introduction

In 2007 the US Interagency Research Policy Committee (IARPC) called for development of the Arctic Observing Network (AON). This was under joint leadership of NOAA(National Oceanic and Atmospheric Administration) and NSF (National Science Foundation). AON is a system of atmospheric, land- and ocean-based environmental monitoring capabilities—from ocean buoys to satellites. It was a clear recognition that any activities related to research and operational monitoring in the Arctic called for interagency approach, and a strong co-coordinating structure was necessary to address properly, and to manage efficiently the multidisciplinary tasks involved. A rather detailed plan outlined the strategy for the implementation of a join observing system for Arctic that as a first priority serve the multidisciplinary interests addressed in the US , but clearly also addressed international co-operation. This was all a direct follow up of the research plan developed by SEARCH (Study of Environmental Arctic Change.)
Web: http://www.eol.ucar.edu/projects/aon-cadis/projects/

6.5.2 SEARCH and objectives

The history behind SEARCH is a little vague as there were several initiatives that led to the final establishment, but back in 1999 a group of scientists drafted the SEARCH science plan which was published in 2001. This plan raised the issues and questions related with the changes that was observed in the Arctic already over a long period. This plan was accepted by the Interagency Arctic Research Policy Committee (IARPC) who called for immediate actions and an Interagency Program Management (IPMC) under NOAA chairmanship was established. IPMC consists of eight federal agencies and further IPMC has linked to international programs such as Arctic Climate System Study (ACSYS), the Climate and Chryosphere Project (CLIC) and the Climate Variability and Predictability (CLIVAR
Web: http://www.arcus.org/search/index.php

SEARCH has raised following questions?

1. Is the Arctic system moving to a new state?

2. To what extent is the Arctic system predictable and what are the uncertainties?
3. To what extent can recent and ongoing climate changes be attributed to anthropogenic forcing rather that to natural modes of variability
4. What is the direction and relative importance of system feed-backs?
5. How is the terrestrial and marine ecosystems affected by human activities?
6. How do cultural and socio economic systems interact with Arctic environmental change?
7. What are the most consequential links between the Arctic and Earth system?

The SEARCH implementation plan identifies a wide range of observing activities necessary to address these questions. Improvement of observation density, effective and adequate sampling strategies to better study the fundamental processes involved.
The conceptual framework of AON has four core components:

1. Operational Observing
2. Research Observing,
3. Community based observing ; local and traditional knowledge
4. Data and Information Management.

Operational Observing component: Mainly based on NOAA/NWS stations providing meteorological data and NASA polar orbiting satellite observations. NASA suite of satellites for this region contribute significantly to provide regular and detailed information of physical, biological and chemical in the circum Arctic with high resolution in time and space.
United States participate in the GEOSS which is an effort to link together all quality controlled data resources to strengthen the overall observation capacity.

6.5.3 Federal Arctic Observing Activities

USCG (US Coast Guard) contribute to ice observations either from satellite or ships.
USCG operates ice-breakers which are a great asset to support Arctic research activities. Part of it also includes the IPP (International Ice Patrol). Increased maritime activities in the years to come USCG has begun the ADA (Arctic Domain Awareness) program to provide a baseline for an improved preparedness for challenges associated with increased maritime activities in this region.
Web: http://www.uscg.mil/lantarea/iip/

Department of Defense (US Submarine Force, ONR and Arctic Submarine Laboratory) and NSF have been supporting the Submarine Arctic Science Program (SCICEX) which has a prime target to understand the Arctic Ocean processes and how it impact the earth climate regulating mechanisms.

MMS (Mineral Management Services) Arctic Research Program involves a large number of projects addressing all kind of topics related with engineering in the Arctic and environmental impact assessments. MMS also manage a large number of moorings to provide input of physical oceanographic parameters. Some of the moorings deliver data in real time and provide input to ocean circulation models.
Web: http://mms.gov/alaska/ess/ongoing_studies/ongoing_studies.htm

NASA are operating many polar orbital satellite which provide input about gravity anomalies, surface ocean observation of waves, traffic and ocean circulation based on SAR and altimeter, ocean color for primary production assessment, AVHRR for SST etc.
Web site : http://podaac-www.jpl.nasa.gov/

RUSALCA (Russian- American Long Term Census of the Arctic) operates an observation network to quantify the oceanic through flow from the Pacific to Atlantic through the Bering Straight including physical and biogeochemical properties.
Web site: http://www.arctic.noaa.gov/aro/russian-american/

Alaska Fisheries Science Center (AFSC) conducts a large number of scientific assessment initiatives to estimate the marine living resources in Gulf of Alaska, Aleutian and Bering Sea. Together with NOAA PMEL(Pacific Marine Environmental Laboratory) and FOCI (Fisheries Oceanography Coordinated Investigation) share responsibility to operate moorings including sensors for wind, temperature, pressure, SST, current light nitrate and chlorophyll. Ambient noise observations from marine mammals is also done from the moorings. The latter is part of the PAOOS (Passive Acoustics Ocean Observing System) which is further developed at NOAA Fisheries Office of Science and Technology.
Web site: http://www.afsc.noaa.gov/

NOAA Center for Operational Oceanography Products and Services (CO-OPS) operates about 200 water level stations in the National Water Level Observing Network (NWLON). This is real time observations of water level and meteorological data. 28 of these stations are in Alaska near the Arctic Circle. The motivation is to provide validation to oceanographic model output, satellite sea surface height, but also support investigation and research on water level rise due to climate change.
http://www.tidesandcurrent.noaa.gov/

NOAA /NDBC (National Data buoy Center) has three moorings in the Bering Sea including water level pressure, waves and SST.
Web site: http://www.ndbc.noaa.gov/maps/Alaska.shtml

NABOS (Nansen and Amundsen Basins Observational System) is a cooperation between partners in US, Russia, Norway, Japan, Poland, Canada and Germany to study circulation, transformation of water masses in the pathway from Nordic Seas towards the central parts of Arctic. Norwegian Partners are: The Norwegian Meteorological Institute and Polar Institute
http://nabos.iarc.uaf.edu/data/registered/main.php

AOOS (Alaska Ocean Observing System) represents an umbrella structure including several measurement networks in Gulf of Alaska, Bering Sea, Prince William Sound, Cook inlet and Arctic. This has been initiated as part of IOOS (Integrated Ocean Observing System). AOOS began operations in 2003 and serve regular real time data and data product to a large number of scientific institutions and operational units. AOOS plans for 2008 to include PAL (Passive Acoustic Listener) sensor to observe and estimate migration rate of marine mammals.
http://ak.aoos.org/

6.5.4 Human Dimensions

The SEARCH Implementation Plan identified several aspects of environmental change of concern to Arctic societies, including the extent and nature of sea ice, storminess and erosion, marine and terrestrial ecosystems (especially fish and mammal populations), permafrost, and vegetation. The Plan considers people, both individuals and institutions, as part of the Arctic ecosystem and recognizes the importance of interactions between humans and the rest of the ecosystem to predicting social outcomes and ecosystem feedbacks..

The Fisheries Monitoring Program also works to integrate Alaska Native and rural organizations into the management of subsistence fisheries resources through the Partners for Fisheries Monitoring Program.
http://www.subsistence.adfg.state.ak.us/

The MMS, Alaska Outer Continental Shelf Region, conducts ongoing environmental studies, including socioeconomic research and multidisciplinary, participatory work to assess the potential effects of oil and gas development.
http://www.mms.gov/alaska/

The Centers for Disease Control and Prevention, Arctic Investigations Program, has established an International Circumpolar Surveillance (ICS) system for infectious diseases by creating a network of hospital and public health laboratories throughout the Arctic. The network allows collection and sharing of uniform laboratory and epidemiologic data among Arctic countries that will describe the prevalence of infectious diseases of concern to Arctic residents and assist in the formulation of prevention and control strategies.
http://www.cdc.gov/eid/content/14/1/18.htm

Many regional and national surveillance networks exist for monitoring health conditions of concern. Within the State of Alaska, the Alaska Surveillance, Epidemiology and End Results (SEER) program collects and publishes cancer data as part of the National Cancer Institute's overall SEER program, and the Alaska Native Stroke Registry is a project to increase the understanding of stroke in Alaska Natives
http://seer.cancer.gov/

6.5.5 Data and information management

As part of its IPY investment in AON, NSF is funding the development of the Cooperative Arctic Data and Information Service (CADIS), a joint project of NSIDC and the Earth Observing Laboratory at NCAR. Initially, CADIS is being developed to support the NSF AON projects, and their users and stakeholders. It will be a Web-based service that enables data discovery, access and use by providing a metadata archive and portal for data discovery, a data and products archive, and tools for data manipulation and analysis. The data and products archive will not hold content from all AON projects. Many projects will archive their own data and CADIS will be a portal to those distributed archives as well as to data and information held in the CADIS data and products archive.
http://www.eol.ucar.edu/projects/aon-cadis/

6.5.6 Planned Federal Arctic Observing activities for years to come

NASA

NASA has seven satellite missions in development that will be launched in 2008-2014. Satellite missions of Arctic interest include the Orbiting Carbon Observatory (OCO) atmospheric carbon dioxide, Glory aerosol characteristics, NPP ocean color, GPM (Global Precipitation Measurement) rainfall, LDCM land imagery, OSTM (Ocean Surface Topography Mission) global mean sea level, and Aquarius sea surface salinity. These missions are described in the 2007 NASA Science Plan.
As part of its IPY activities in cooperation with other Federal agencies and international partners, NASA will conduct the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) mission in April and July 2008.
http://www.espo.nasa.gov/arctas/

NOAA
NOAA will provide active contribution to AON will follow the implementation design presented in the SEARCH Implementation Plan (SEARCH, 2005). It will continue with the observations network including moored buoys, satellites.
NOAA will continue to support the Radiosonde stations in Alaska and possibly update many stations with the Radiosonde Replacement System in the coming years.
NOAA will critical examine the observation platforms they have to check if they still fulfil the original mission or need to be re- vitalised in terms of equipment or abandoned as the original mission has been accomplished or changed.

6.5.7 US- Links to Pan Arctic co-operation

The US activities in the Arctic represents a strong contribution to a pan Arctic observing network with international participation. The SEARCH initiative has been followed up with an MoU with the EU funded DAMOCLES (Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies). The objective is to study air-ice-ocean interaction during IPY (International Polar Year) and emphasizes the importance of integration of SEARCH and DAMOCLES observational data, to support comprehensive pan-Arctic observing network.

Totally 48 institutions from 11 European countries plus Russia and Belarus participate. Norway is represented by Institute of Marine Research (IMR), The Norwegian Meteorological Institute (met.no), Nansen Environmental and Remote Sensing Center and Norwegian Polar Institute (NERSC) University of Bergen (UIB), The University Center in Svalbard, Center for International Climate and Environmental Research (CICERO), NAXYS and Aanderaa Data Instruments (Aanderaa). The Russian branch office of NERSC ; NIERSC is also participating.
http://www.damocles-eu.org

6.6 Canada

Canada has a substantial Arctic research activity and are in several of these programs and projects collaborating with Norwegian institutions. Both Canada and Norway are cooperation through the Arctic Council as well as on a bilateral level.

One project of specific interest to i-Nord is the “Integrated access to data and information for the sustainable management of the St. Lawrence global ecosystem” which is operated by the St. Lawrence Global Observatory.

The St. Lawrence is a major ecosystem with a rich ecological diversity, extreme physical conditions, (tides, ice, temperature and currents), sensitive coasts and habitats, a large populations and numerous sosio-economic and development activities like maritime transportation, fishing aquaculture, ecotourism, coastal engineering etc. The geographic area covered by St. Lawrence Global Observatory includes the ST. Lawrence River, Estuary and Gulf which represents over 250 000 square km. It also extends to the St. Lawrence waterheds.

6.7 Russia

Several of the i – Nord has collaboration with Russian authorities, R&D organization and companies. Institute of Marine Research (IMR) has been co-operation with its Russian counter partner for long time as described below. The Norwegian Meteorological Institute (met.no) has also an extensive collaboration with its Russian counter partner. Nansen Environmental and Remote Sensing Center (NERSC) has an affiliated organization in St. Petersburg.

6.7.1 The Norwegian – Russian Fisheries Commission

Norway and Russia have had a cooperation around research and monitoring of the Barents Sea and the Norwegian Sea in more than 50 years. The work started in the 1950's when the Arctic Fisheries Working Group in ICES were established. This met the first time in 1959, and set the basis for the data collection program necessary for good fish stock assessment in the Barents Sea. The cooperation accelerated in the mid 1960's when the annual international 0-group investigations were established.

This annual field experiment has been run up to day since 1965, and it is a cooperation between IMR and PINRO in Murmansk for estimating the year class strength of the most important commercial fish stocks in the Barents sea. Later this developed into a closer research and management advice cooperation, with focus on cod, herring and capelin. In the early 1980's the cooperation also included common symposia, and so far 12 such symposia has been hold, where common research challenges and results about the Barents Sea and surrounding areas are presented and discussed.

This Norway-Russia cooperation has partly been initiated through ICES and it's relevant working groups for the northern regions, and partly initiated through the needed knowledge of the Norwegian-Russian Fisheries Commission in it's work for better management of the marine resources.

Recently also a Norwegian-Russian Commission for the Environment has been established, and on a European level under EuroGOOS the Arctic ROOS (Regional Ocean Observing System) cooperation agreement was recently agreed with focus on operational oceanography. Last year IMR signed a cooperation agreement with VNIRO in Moskva, but still the main cooperating institute is PINRO in Murmansk.

During the latest years specific research project proposals related to our northern ecosystems has been submitted to EU and NFR where several Russian institutes have been key collaborators. Unfortunately none of these proposals were funded.

6.8 Artic Council

Arctic Council
The establishment of Arctic council in 1996 was a step to build a framework between countries with borders to the Arctic to recognize the important issue of a common approach to foster activities and policy to provide sustainable development and environmental protection of the Arctic. Arctic Monitoring and Assessment Program (AMAP); conservation of Arctic Flora and Fauna (CAFF); Protection of the Arctic Marine Environment (PAME); and Emergency Preparedness and Response (EPPR) are all initiatives from Arctic Council to meet the challenging targets defined in the Declaration statement of Arctic Council. Norway represented by The Minister of Foreign Affairs has the chairmanship of The Arctic council for the period 2006-2008
http://arctic-council.org

The Arctic Council is an intergovernmental organization focusing on the protection of the Arctic environment and sustainable development as a means of improving economic, social and cultural well-beeing. The Arctic Council provides a mechanisme to address the common concerns and chanllenges faced by the Arctic governments and the people of the Arctic. The Arctic Council runs several R&D programmes which need (require) monitoring and data for assessment of the environment of the Arctic areas.

One working group is PAME, Protection of the Arctic Marine Environment, with responsibilities to take preventative and other measure, directly or through competent international organizations, regarding marine pollution of the Arctic , irrespective of origin. PAME has produced the Snap Shot Analysis of Marine Activities in the Arctic (PAME,2000) and Guidelines for Arctic Oil and Gas (PAME,2002) activities to minimize negative impact on the environment, for example drilling sites. The other working Groups include AMAP (Arctic Monitoring and Assessment Programme), CAFF (Conservation of Arctic Flora and Fauna), EPPR (Emergency Prevention, Preparedness , and Response), ACAP (Arctic Contamination Action Program) and SDWG (Sustainable Development).

6.9 Important Observing Systems

6.9.1 The GOOS hierarchy

The Global Ocean Observing System (**GOOS**) is an international programme preparing the permanent global framework of observations, modelling and analysis of ocean variables needed to support operational ocean services wherever they are undertaken around the world. GOOS is promoted by the following UN Agencies:

- Intergovernmental Oceanographic Commission (IOC)
- World Meteorological Organisation (WMO)
- United Nations Environment Programme (UNEP)
- International Council of Scientific Unions (ICSU)

GOOS is sponsored by these agencies and GOOS was launched at the Second World Climate Conference in 1990. It provides the ocean component of the Global Climate Observing System (GCOS).

EuroGOOS

Members of EuroGOOS co-operate to establish a concerted European approach to the following:

- Identifying European priorities for operational oceanography, promoting the development of the scientific, technology and computer systems for operational oceanography, and its implementation, assessing the economic and social benefits from operational oceanography
- Contributing to international planning and implementation of GOOS and promoting it at national, European and global level

EuroGOOS activities are designed to collaborate with and maximise the benefits from existing activities in operational oceanography, promoting the integration of these activities within the framework of GOOS. Members of EuroGOOS collaborate and support the following groups of activities:

- Advancing European operational oceanography in GOOS

- Promoting development of European regional and local operational oceanography, taking into account the Modules of GOOS for the Coastal Zone, Health of the Ocean, Living Marine Resources, Climate, and Ocean Services.
- Promoting development of common European operational data procedures and services, including data quality control and data management for operational oceanography.
- Promoting research and pre-operational research which will solve problems relating to operational oceanography.
- Promoting pilot studies in GOOS operations, local, regional, or global.
- Promoting development of common European operational oceanographic services and products of maximum value to European Governments and Agencies, furtherance of European industries and service companies, and the protection of the environment and health in the European coastal and shelf seas.

6.9.2 ArcticGOOS

The recent Arctic Climate Impact Assessment studies have identified a number of severe impacts of Arctic warming on society. Changes in air temperature, precipitation, river discharge, sea ice, permafrost, glaciers and sea level have been documented and further changes are expected in the next decades. The Arctic region is coming under increasing pressure from unsustainable development with pollution and other negative effects on the environment. The exploitation of resources, including sea transportation and offshore operations will be heavily affected by the climate- variability and long-term changes at high latitudes. The northeast Atlantic, including Greenland and Icelandic waters, the Barents Sea and other Arctic ice edge regions, provides 20% of the world’s fish catch. Ocean temperature is one of the key variables that have influence on fisheries. Various offshore operations in ice-covered waters will increase such as offshore exploration, drilling, oil and gas production, and gas transportation, pipeline deployment in the seabed, and building of terminals in several locations along the Arctic coasts. All these activities will increase the risk of accidents and severe pollution of the fragile Arctic environment.

The Arctic areas have rough weather and ice conditions which require improvement of operational monitoring and forecasting services in order to safeguard all types of marine and coastal operations. The operational services should also include long-term data archiving services to build up statistics of the environmental conditions. Operational services on met-ice-ocean conditions in theses areas are extremely important for safe and cost-effective industrial and transport activities as well as for protection of the vulnerable environment.

The overall objective of IPY Arctic GOOS to develop and implement operational monitoring and forecasting systems in the Arctic Ocean and adjacent seas. The systems will be based on state-of-the-art remote sensing, in situ observations, numerical modelling, data assimilation and dissemination techniques. The activities will include the development and maintenance of observing system for sea ice and physical, chemical and biological ocean parameters. The observing systems need to including icebergs, potential oil spills, radioactive spreading and other pollutants. In addition to observations, the systems will include numerical modelling and data assimilation for production of short-term forecasts. New models and data assimilation techniques need to be developed where needed. A long-term objective is to develop modelling systems for seasonal prediction of sea ice, hydrographic and current conditions. State-of-the-art climate models will be used to quantify climate change and variability and prediction of future climate changes under greenhouse gas scenarios.

6.9.3 Arctic ROOS

An Arctic Regional Ocean Observing System **(**Arctic ROOS) has been established by a group of 14 member institutions from nine European countries working actively with ocean observation and modelling systems for the Arctic Ocean and adjacent seas.

Arctic ROOS will promote, develop and maintain operational monitoring and forecasting of ocean circulation, water masses, ocean surface conditions, sea ice and biological/chemical constituents.

One of the goals of Arctic ROOS is to contribute to the legacy of IPY, maintaining cost-effective and useful observing systems after the end of IPY.

Arctic ROOS intends to include more members from countries outside of Europe and become a GOOS Regional Alliance for the Arctic. Arctic ROOS has established a secretariat at the Nansen Environmental and Remote Sensing Center in Norway.

6.9.4 AON- Arctic Observing Network (US –IPY initiative)

The contribution from US represented by NSF and supported by NOAA to create an Arctic Observing Network is expected to become an active and sustainable component to operational research activities in the Arctic. It totally complies with the Polar Research Board to implement a multidisciplinary polar observing network as outlined in the report Toward an Integrated Arctic Observing Network.

NSF grants to support the development of the AON have been made to 21 IPY projects, for a total of approximately $37 million to be spent on AON between 2007 and 2010.

NSF is the lead federal agency for implementing U.S. Arctic research policy, and chairs the Interagency Arctic Research Policy Committee, which includes representation from the White House Office of Science and Technology Policy, Agriculture, Commerce, Defense, Health and Human Services, Homeland Security, Interior, State, and Transportation departments, the National Aeronautics and Space Administration (NASA), the Environmental Protection Agency, the Smithsonian Institution and the National Endowment for the Humanities.
NSF, through its Division of Arctic Sciences, has supported long-term observing projects in the Arctic since 2003. These include the North Pole Environmental Observatory, the Beaufort Gyre Observatory, and the Circumpolar Environmental Observatories Network.
As the lead agency for SEARCH and Interagency Arctic Research Policy Committee, NSF is working with the National Oceanic and Atmospheric Administration (NOAA) to develop an AON Implementation Plan that will identify current observing assets, assess future needs, and improve coordination among research and operational agencies
.

Annex A – Miljøforvaltningens behov i forhold til tjenester som er forespeilet at i – Nord vil kunne tilby

Statens forurensningstilsyn
Norwegian Pollution Control Authority

SINTEF
Ved Odd Kr. Ø. Pettersen
7465 Trondheim

Statens forurensningstilsyn
Postboks 8100 Dep, 0032 Oslo
Besøksadresse: Strømsveien 96

Telefon: 22 57 34 00
Telefaks: 22 67 67 06
E-post: postmottak@sft.no
Internett: www.sft.no

Dato: 19.01.2009
Vår ref.: 2009/69
Deres ref.:
Saksbehandler: Ola Glesne, telefon: 22573486

Miljøforvaltningens behov i forhold til tjenester som er forespeilet at i-Nord vil kunne tilby

Vedlagt følger et notat om miljøforvaltningens behov i forhold til tjenester som det er forespeilet at i-Nord vil kunne tilby. SFT har ledet arbeidet og fått innspill fra Norsk polarinstitutt, Direktoratet for naturforvaltning, Statens kartverk og Sysselmannen på Svalbard.
Vi har konsentrert oss om overordnet informasjon. Vi ber i-Nord ta direkte kontakt med enhetene der det er behov for nærmere detaljer og avklaringer. Det gjelder både forprosjektperioden og en eventuell senere avklaring og planlegging av prosjekter.

Det er viktig at aktivitetene i i-Nord baserer seg på sentrale, klart definerte brukerbehov i forvaltningen og samfunnet ellers. Den informasjon miljøforvaltningen har fått om dette hittil har vært lite konkretisert. Vi regner derfor med at det legges stor vekt på det i siste fase av forprosjektet.
Når det gjelder tjenester knyttet til overvåking av klima og klimaeffekter, har det vært vanskelig å gjøre en tilfredsstillende kartlegging av behovene innen den tiden vi har hatt tilgjengelig. Vi ber derfor om å bli konsultert dersom disse temaene kommer til å inngå i i-Nord.

Med hilsen

Kari Holden
seksjonssjef

Ola Glesne
prosjektleder

Vedlegg: Notat

Kopi til: MD, Direktoratet for naturforvaltning, Norsk polarinstitutt, Statens kartverk, Sysselmannen på Svalbard

Miljøforvaltningens behov i forhold til tjenester som er forespeilet at i-Nord vil kunne tilby

Innspillet har en generell del og en spesiell del. Den generelle delen framhever behovet for rolleavklaring mellom aktører, tilgjengeliggjøring av data, faglig samordning, effektiv bruk av ressurser og infrastruktur og bruk av metoder. Det er dessuten viktig å benytte eksisterende systemer for formidling av miljøstatus og overvåkingsdata.
Den spesielle delen viser behov som kan være aktuelle for i-Nord innenfor den ressurs- og tidsramme som er forespeilet. Vi ber i-Nord ta direkte kontakt der det er behov for nærmere detaljer og avklaringer.

1. Innledning

Miljøverndepartementet har bedt SFT kartlegge miljøforvaltningens samlede behov sett i forhold til de tjenestene som i-Nord vil kunne tilby. Norsk polarinstitutt, Direktoratet for naturforvaltning, Statens kartverk og Sysselmannen på Svalbard har gitt innspill. Vi har konsentrert oss om overordnet informasjon. Vi ber i-Nord ta direkte kontakt der det er behov for nærmere detaljer og avklaringer.

I-Nord skal være et helhetlig overvåkings- og varslingssystem for havområdene i nord. Det skal være et integrert system som skal muliggjøre innsamling og bearbeiding av data, presentasjon for brukerne, effektiv samhandling og pålitelig beslutningstøtte, osv., og gjerne i sann tid.
Systemet skal gi mulighet for samordning av overvåking (kan være ressursbesparende). Det kan også forenkle krisehåndtering, gi bidrag til bedre beredskap, være tilgjengelig for alle (på ulike nivåer).

Det er viktig at aktivitetene i i-Nord baserer seg på sentrale, klart definerte brukerbehov i forvaltningen og samfunnet ellers. Den informasjon miljøforvaltningen har fått om dette hittil har vært lite konkretisert. Vi regner derfor med at det legges stor vekt på det i siste fase av forprosjektet.

Systemet legger stor vekt på løpende målinger med høy frekvens og on-line tilgang i sann tid. Dette gir spennende muligheter, men vi vil samtidig påpeke at det for mye av miljøforvaltningens overvåking ikke finnes egnete sensorer eller metodikk for automatisert prøvetakning. Det er derfor viktig at i-Nord også kan basere seg på manuelle metoder der det er nødvendig. Ofte vil dette dreie seg om behov som er knyttet til indikatorer som midles over et visst tidsrom (uke/måned/år) og for problemer som har langsom utvikling.

I flere sammenhenger vil i-Nord også kunne støtte annen overvåking ved at systemet kan skaffe indikative data eller modellberegninger som kan bidra til å få høyere oppløsning på resultatene fra allerede eksisterende overvåking. Det er imidlertid viktig at det som tas inn av miljøovervåking i i-Nord gir pålitelig informasjon for forvaltningen, og at bruken av indikative data først og fremst brukes der det er dokumentert at de har god nok utsagnskraft.

2. Generelle synspunkter

2.1 Rollefordeling

Det er ikke naturlig at kommersielle aktører skal ha koordineringsansvar for offentlige varslings- og overvåkingstjenester. Dette ansvaret må ligge hos offentlige institusjoner som har ansvar for de problemstillingene tjenestene er knyttet til. Det er viktig at forprosjektet tydeliggjør rollefordelingen mellom i-Nord prosjektet og forvaltningen generelt.
Systemet må levere data og informasjon i pakt med klart spesifiserte behov som defineres av forvaltningen og andre sentrale brukere i samfunnet. Kommersielle aktører kan ut fra disse behovene få oppdrag med å utvikle tekniske verktøy for prosessering, integrering og rapportering av resultater og data.

2.2 Tilgang til data

Det er viktig at alle miljødata som framskaffes gjennom i-Nord følger retningslinjene som er gitt gjennom SEIS og INSPIRE. I Norge blir det viktig at arbeidet i prosjektet knyttes tett opp mot arbeidet i Norge digitalt. Gjennom en slik kontakt vil en kunne gjenbruke tekniske og administrative løsninger for deling av informasjon. Statens kartverk som koordinator for Norge digitalt og den fagetat som følger opp Inspire bør trekkes aktivt med i prosjektet i-Nord.

Miljøforvaltningen følger prinsippet om at våre overvåkingsdata skal være allment tilgjengelige så snart de er publisert. Vi arbeider i øyeblikket med å bedre den praktiske tilgjengeligheten av vanndata, slik at de blir søkbare på nett. Vi har utviklet en Vannmiljøbase som skal lagre biologiske og kjemiske tilstandsdata. Det blir tilgang til denne basen i andre halvår av 2009.
DNs Naturbase er også tilgjengelig på nett. Den har data om naturtyper, viktige verneverdier og verneområder.
For Svalbard, Jan Mayen og tilgrensende havområder er aggregerte miljødata tilgjengelig på nett gjennom Miljøovervåkingssystem for Svalbard og Jan Mayen (MOSJ).

Alle miljødata som framskaffes gjennom i-Nord prosjektet må tilgjengeliggjøres for forvaltningen og allmenn bruk. Dette må skje gjennom nedlastning av data fra elektronisk tilgjengelige baser. Der slike baser allerede finnes i forvaltningen bør disse benyttes. Uansett må det være et krav at det skal være lett å utveksle data og metadata mellom basene.

Dataene skal også kunne rapporteres til EEA og til AMAP og andre internasjonale konvensjoner når det er relevant.

I tillegg må forvaltningen kunne hente ut informasjon fra systemet om f.eks skipstrafikk i våre farvann. Systemet bør ha mulighet for å kunne logge/se bevegelser tilbake i tid ved etterforskning av hendelser. For øvrig forutsetter vi at et fullt utbygd AIS – system som inkluderer Svalbard blir en integrert del av prosjektet.

2.3 Bruk og utvikling av metoder.

For å sikre gjenbruk av data er det viktig at det brukes samme eller likeverdige metoder for måledata og registreringer der det er mulig. Det viktig å følge de indikatorer, standarder og veiledninger som er knyttet til Vanndirektivet, Havdirektivet og viktige internasjonale miljøkonvensjoner. DN og SFT kan etter behov veilede i-Nord om dette.

Det er uklart i hvor stor grad i-Nord tar sikte på å utvikle teknologi for ny og bedre overvåkingsmetodikk. Det er imidlertid på teknologiutvikling det største behovet ligger. Der metodeutvikling har stor betydning for etablering av en viktig tjeneste, bør dette kunne dekkes innenfor prosjektmidlene. Det er naturlig å gi slike oppdrag til industrielle aktører gjennom anbud eller utlysing av utviklingsmidler. Prosessen må styres aktivt av oppdragsgiver.
Det er også relevant å teste ut metodikk der det i utgangspunktet er usikkerhet om metodikkens presisjon.

Det bør være et overordna mål å utvikle overvåkingsmetodikk som gir tidlig varsling med minst mulig fotavtrykk.

2.4 Faglig samordning og effektiv ressursbruk

Aktiviteter som planlegges i i-Nord prosjektet må være godt samordnet med eksisterende overvåking i forvaltningen. Det forutsetter godt samarbeid med de aktuelle etatene for å sikre effektiv ressursbruk og god bruk av tjenester som utvikles gjennom i-Nord.

Det er spesielt viktig for miljøforvaltningen at i-Nord kan gi en vesentlig støtteaktivitet til overvåking knyttet til Vanndirektivet, havforvaltningsplanenes overvåkingsgrupper og programmet Miljøovervåking på Svalbard og Jan Mayen (MOSJ). For alle disse tre aktivitetene eksisterer det overvåkingsfora der flere etater samarbeider. Det er naturlig at i-Nord, dersom det blir igangsatt, knytter kontakt med disse.

2.5 Effektiv utnyttelse av infrastruktur

Om prosjektet i-Nord blir igangsatt, vil det føre til betydelig flyt av data og informasjon. Det er viktig at en benytter og følger standarder. Det vil være riktig at i-Nord knyttes inn i den nasjonale geografiske infrastrukturen Norge digitalt, og også opp mot den europeiske geografiske infrastrukturen Inspire. Det er pr. 2009 ca 600 etater som er parter i Norge digitalt, bl.a. ca 40-50 nasjonale fagetater. Det vil være effektivt å benytte vedtatte tekniske standarder benyttet i Norge digitalt. Infrastrukturen inneholder allerede betydelige mengder data og tjenester. Det er å anbefale at infrastrukturen brukes i så stor grad som mulig, og at ad.hoc dataflytløsninger unngås. Infrastrukturkomponentene som finnes inkluderer metadata, wms-tjenester, wfs-tjenester, katalogtjenester, transformasjonstjenester og bruk av felles koordinatsystemer. Videre finnes forum og tekniske/ faglige nettverk for utveksling av kunnskap og "best practices". Disse bør utnyttes av i-Nord.

Eksisterende infrastruktur knyttet til miljøovervåkingen, som etablerte stasjoner, faste tokt, automatisk prøvetaking fra fartøy eller bøyer og lignende, benyttes der det er relevant og mulig. Miljøforvaltningen er åpen for å gi veiledning ut fra våre aktiviteter. Videre må eventuell infrastruktur som bygges opp gjennom i-Nord planlegges slik at den kan utnyttes til eksisterende eller framtidig overvåking som drives av forvaltningen. Der det er relevant, forutsetter vi at Miljøforvaltningen vil bli konsultert om plassering av nye registreringspunkter eller overvåkingsstasjoner.

Det er også viktig at infrastruktur som bygges opp gjennom i-Nord prosjektet kan benyttes av offentlige overvåkingsprogrammer for måling, registrering eller prøvetaking der det er aktuelt. Dette bør gjelde uavhengig av nytten for i-Nord, dersom det er tilgjengelig kapasitet og interessenten betaler for merkostnader.

Det er behov for å sikre at i-Nord benytter det nasjonale kartverket i så stor grad som mulig. Statens kartverk vil kunne tilby informasjon om land og sjøområder, landområdene for Svalbard dekkes av Norsk Polarinstitutt. Institusjonene vil kunne tilby et konsistent informasjonsgrunnlag. En videreføring av arbeidet med sjømålinger innenfor Mareano er viktig for i-Nord-satsningen. Det er Statens kartverk som organiserer sjømålingsarbeiet som går inn som en deloppgave i Mareano. Andre tjenester knyttet til administrative grenser, territorialgrenser, kontinentalsokkel mv blir viktige datasett som Kartverket kan tilby eller delta i arbeidet med å tilgjengeliggjøre. Tjenester i regi av Kartverkets geodesidivisjon vil også være aktuelle for i-Nord.

2.6 Benytte eksisterende systemer for formidling av miljøstatus og miljøovervåkingsdata

Det er viktig at informasjon som framkommer gjennom i-Nord kan gjøres tilgjengelig for ulike former for formidling av miljøinformasjon, og at i-Nord ikke bygger opp informasjonstjenester som overlapper med dagens etablerte systemer i forvaltningen. Miljøforvaltningen samarbeider med en rekke etater om helhetlig formidling av miljøstatus for hav og vann, og vi kan gi veiledning og referanser til aktører og systemer.

Nedenfor følger en liste over viktige nettsteder som formidler miljøinformasjon. Flere av nettstedene gir også mulighet for innsyn i miljødata:

- Miljøstatus i Norge (SFT)

- Miljøstatus for Svalbard (NP/Sysselmannen)
- MOSJ - Miljøovervåking av Svalbard og Jan Mayen (NP)
- Havets ressurser og miljø (HI)
- MAREANO (HI)
- SEAPOP (NINA/NP)
- Klimaobservasjoner og klimastatistikk (met.no)
- Norge Digitalt (SK)
- FerryBox (NIVA)
- Algeinfo (NIVA/HI)
- Vannett (NVE) – Formidler informasjon knyttet til Vanndirektivet

Vi vil legge til at alle overvåkingsrapporter Miljøforvaltningen framskaffer er elektronisk tilgjengelige på etatenes nettsteder. Overvåkingsgruppene for havforvaltningsplanene vil utarbeide statusrapporter for sine områder. Dette fases inn gradvis. For Barentshavet er det levert årlige tilstandsrapporter siden 2007, basert på overvåkingsdata.

Vi nevner også Norsk-russisk miljøstatusrapport for hele Barentshavet (NP, HI, PINRO og SEVMORGEO) og Norsk-russisk miljødataportal/Barentsportalen (NP og SEVMORGEO). Miljøstatusrapporten planlegges ferdig i juni 2009, og miljødataportalen er operativ fra første halvår 2009.

2.7 Annet

SIAEOS (Svalbard Integrated Arctic Earth Observing System) er tatt inn i det oppdaterte EU-veikartet for forskningsinfrastruktur. Det vil danne en finansiell og organisatorisk ramme for utviklingen av overvåkingssystemer på og rundt Svalbard.

Nytt senter for is og klima ved Norsk Polarinstitutt. Etableres i 2009. Vil primært levere overvåkingsdata gjennom MOSJ.

3. Behov for tjenester

3.1 Tilførsler til Norske havområder

For miljøforvaltningen er det viktig å få informasjon om hvordan forurensninger og uønskete arter tilføres og spres i norske havområder. Det er viktig å overvåke tilførsler utenfra, både via havstrømmer og gjennom atmosfæren. Her er det store utfordringer med hensyn til målemetodikk og stasjonsplassering. Det er viktig å se på eksisterende obsevasjonsnett for søke å utnytte tokt som f. eks gjennomføres av NIVA på oppdrag for SFT og Havforskningsinstituttet. Videre er det viktig å utnytte eksisterende faste målestasjoner, Polarfront (Værskipet på 66^{o}N, 02^{o}Ø) og de meteorologiske stasjonene på Hopen, Bjørnøya og Jan Mayen, fast forankrede bøyer og lignende. Dataene som samles inn bør kombineres med observasjoner av temperatur, saltholdighet og strømdata i flere dyp. Det er stort behov for gode modeller som kan gi informasjon om strømhastighet og strømretning som grunnlag for transport av forurensninger. Her er det flere modeller i bruk, blant annet hos Havforskningsinstituttet, Nansensenteret, Strålevernet, Meteorologisk institutt, NIVA m. fl.

3.1 Tilførsel og spredning av miljøgifter.

SFT har i lang tid hatt overvåking som dekker miljøgifter langs kysten og i fjorder. Aktiviteten støttes av et program som måler tilførslene til kysten med store elver. Fra 2007 er det satset midler til å bygge opp et overvåkingsprogram som skal gi informasjon tilførsler til norske havområder med kyststrømmene. Dette er fra i år etablert som et løpende program. SFT har også overvåking av miljøgifter i luft og nedbør, og data fra denne aktiviteten har også relevans for tilførsler til havet.

Det er viktig for miljøforvaltningen at miljøgifter inngår i de aktivitetene i-Nord skal dekke. Ut fra de aktiviteter som i-Nord har synliggjort tidlig i forprosjektfasen er det svært relevant å sikre data om hav og luftstrømmer som grunnlag for modellering av tilførsler og spredning, og utvikle modeller som kan brukes til å beregne konsentrasjoner på bakgrunn av de måledata som samles inn. Modellene bør ta hensyn til at ulike miljøgifter har ulike egenskaper når det gjelder nedbrytning, fordampning, sedimentering og lignende.
Det er viktig å sikre at prøvetaking for miljøgiftovervåkingen, så langt mulig, framskaffes gjennom eksisterende infrastruktur. Det vil sikre kostnadseffektivitet.

Hvis det er tilsvarende muligheter for å forbedre modeller for spredning av radioaktive stoffer i havet, vil det være en god støtte for den overvåking Statens strålevern står for.

3.2. Overvåkning av algeoppblomstringer, eutrofi og partikler.

SFT overvåker eutrofi langs kysten fra svenskegrensa til Stadt. Denne overvåkingen går bare unntaksvis inn i fjordene, og systematisk eutrofiovervåking mangler lenger nord. Overvåkingen må bygges ut som følge av kravene i EUs vanndirektiv. For nordlige marine områder er det særlig viktig for miljøforvaltningen å få informasjon om referansetilstand og mulige ringvirkninger av akvakultur.

Operative og rutinemessige tjenester basert på satellittdata og in-situdata er under utvikling for overvåkning av planktonalger og vannkvalitet i fjorder, langs kysten og i åpne havområder. For åpne havområder fungerer satellittproduktene for klorofyll-a og suspendert materiale tilfredsstillende. Det er imidlertid behov for å forbedre dagens standard satellittprodukter for å få bedre presisjon i kystområder og innsjøer fordi land- og atmosfære-forhold påvirker satellittobservasjonene. Dette krever blant annet å etablere nedlesningsrutiner for høyoppløselige satellittdata.

Det er viktig å fokusere på disse utfordringene for å få frem produkter som tilfredsstiller bl.a. Vanndirektivets krav. Behovet er også sterkt aktualisert med satsningen på nordområdene og få frem indikatorer som kan bidra til en bedre forvaltning av nordområdene og havområdene utenfor Lofoten. Det pågår norske utviklingsprosjekter på feltet (SATHAV), og i-Nord oppfordres til å bidra til å utvikle tjenestene så de kan bli en viktig støtte til forvaltningens marine overvåking. Det er søkt midler fra Norsk romsenter i 2009, men det er behov for midler utover dette.

3.4 Annen luftforurensing

Forbedring av modeller som beregner spredning og avsetning av andre luftforurensninger enn miljøgifter vil i en del sammenhenger være interessant for Miljøforvaltningen. Slike modeller brukes til å lage avsetningskart, avklare opphav til tilførslene og modellere virkningene av tiltak. Norsk miljøforvaltning bruker blant annet modellverktøy som er utviklet for Konvensjonen for langtransportert luftforurensning i Europa (UN-ECE-CLRTAP).
Dersom i-Nord setter i gang aktivitet der det framskaffes bedre grunnlagsdata for denne typen modeller, er det viktig at i-Nord vurderer om det er økonomisk mulig å utvide prosjektets perspektiv, slik at også nordlige landområder også dekkes.
Tilsvarende gjelder for konkret forbedring av eksisterende modeller eller utvikling av nye.

3.3 Oljevern og offshore petroleumsaktivitet

Det er særlig to områder fra SATHAV som peker seg ut: Oljedeteksjon og vannmasseovervåking.

Det finnes i dag en operativ tjeneste for oljedeteksjon. Den leveres av KSAT og benyttes i overvåkingen av oljesøl langs kysten. Det er imidlertid behov for forbedringer, innpassing av nye datakilder, nye algoritmer og valideringer. Radarsat 2 er tatt i bruk og det er behov for implementering av automatisk algoritme for satellittbilder fra denne satellitten. Det er dessuten behov for forbedring av andre algoritmer som for eksempel kan si om det er høy, middels eller lav sikkerhet for at det er olje som observeres på bildene.
Dette, sammen med andre forslag ligger inne i søknad til Norsk Romsenter, men de har trolig ikke midler til å dekke det omsøkte fullt ut.

Det er behov for å utvide vannmasseovervåkningen i Nordområdene. SATHAV gjennomfører prosjekter innen overvåkning av vannmassene av NIVA med Nansensenteret som bidragsyter.
I tillegg til prosjektet i nordområdene har NIVA også prosjekter innen satelittprodukter for vannkvalitet i innsjøer og vassdrag og fjord og kystfarevann som kan være aktuelle også i Nordområdene. Også her er det søkt Norsk romsenter om midler.

Met.no. har en operasjonell isvarslingstjeneste som er svært viktig for skipstrafikk og operasjoner i Arktis. Denne tjenesten blir videreutviklet, blant annet sammen med Norsk Polarinstitutt i SATHAV prosjektet og den baserer seg i stor grad på bruk av satellittdata.

Isvarslingstjenesten kan fortsatt utvikles videre, og bli et enda nyttigere verktøy for sikkerhet og transport i området.

Sporing av isfjell vil bli viktig etter hvert som olje- og gassaktiviteten øker i Barentshavet. Norsk Polarinstitutt har utviklet en algoritme for å skille mellom skip og isfjell i radarbilder. Denne kan sammen med KSATs skipsdeteksjonstjeneste danne grunnlag for informasjon som vil være viktig for risikovurderinger og risikohåndtering i forbindelse med petroleumsaktiviteter.

Statens kartverk er involvert i ulike former for havnivå- og bølgemålinger som er relevante for i-Nord-satsningen og krisehåndtering i forbindelse med oljeforurensning.

3.5 Arktis

For miljøovervåkingen i Arktis er det viktig at i-Nord tar hensyn til den overvåking som foregår i programmet Miljøovervåking på Svalbard og Jan Mayen (MOSJ) og overvåkingen som er knyttet til forvaltningsplanen for Barentshavet. Vi viser her til Polarinstituttets koordinering og utvikling av MOSJ og til rapporten fra 2008 som er utarbeidet av Overvåkingsgruppen for Barentshavet[1]. MOSJ-indikatorene er gjengitt i vedlegg 1.

Følgende behov står særlig sentralt:

- Metode og teknologiutvikling knyttet til:
    - Automatiske klimastasjoner på land, på is og i havet
    - Fysiske, kjemiske og optiske sensorer i havet
    - Satellitter med bedre oppløsning og flere sensorer
    - UAV og ROV med sensorer bl.a. for istykkelse og biota
    - Sensorer og satelittsendere på dyr
    - Akustiske metoder for oseanografi og biologi
    - Kamera for overvåking og effektstudier
- Økosystem-modellering
- Overvåking av fartøyer: Båttrafikken på Svalbard
- Statens kartverk har antenne på Svalbard for nedlasting av ulike former for miljøinformasjon.

3.5 Naturforvaltning

I utgangspunktet vil naturforvaltningens behov være at en grunnleggende kartlegging av biologisk mangfold ligger i bunn. Det er viktig for at bruken og konklusjoner av en del overvåkingsdata blir riktig. Hvis i-Nord kan bidra til å utvikle mer kostnadseffektive metoder for metodeutvikling og kartlegging av biologisk mangfold, vil det være viktig.

[1] http://www.imr.no/__data/page/3839/Saernummer_1b_08.pdf

Det vil også være nyttig hvis det kan knyttes en kobling mellom Direktoratet for naturforvaltnings verdivurdering/sårbarhetssystem og menneskelige aktiviteter som registreres i i-Nord. Her kan DN bidra med informasjon og veiledning.

Det må videre sikres at kunnskapsmangler blir synliggjort, og at det legges opp til at kunnskapshull blir fylt (forsert havbunnskartlegging, tilgjengeliggjøring av eksisterende biologiske data opparbeiding av eksisterende prøver). For å sikre dette bør miljødirektoratene delta i en referansegruppe eller lignende.

Statens forurensningstilsyn
Norwegian Pollution Control Authority

Vedlegg 1

Miljøovervåkingssystem for Svalbard og Jan Mayen (MOSJ).

Nedenfor er det gitt en oversikt over indikatorer i systemet per 9/1-09. For hver indikator er det angitt om det pågår overvåking eller om indikatoren er under utvikling og utførende institusjon for overvåkingen (nåværende og fremtidig). Ytterligere informasjon om systemet og indikatorene (inkludert data) finnes på mosj.npolar.no.

Forkortelser for institusjoner: NILU: Norsk institutt for luftforskning, SSV: Statens strålevern, NP: Norsk Polarinstitutt, HI: Havforskningsinstituttet, NIFES: Nasjonalt institutt for ernærings- og sjømatforskning, SMS: Sysselmannen på Svalbard, AWI: Alfred Wegener Institute, MI: Meteorologisk institutt.

(1) Forurensning

Indikator	Status	Utførende institusjon
Luftforurensning i Ny Ålesund	Pågående	NILU
Klimagasser i Ny Ålesund	Under utvikling	NILU og Universitetet i Stockholm
Radioaktivitet i luft og vann	Pågående	SSV
PCB i bunnsedimenter	Pågående	Akvaplan-NIVA
Strandsøppel	Pågående	SMS
Miljøgifter i isbjørn	Pågående	NP
Miljøgifter i fjellrev	Pågående	NP
Miljøgifter i ringsel	Pågående	NP
Miljøgifter i hvalross	Under utvikling	NP
Miljøgifter i storkobbe	Under utvikling	NP
Miljøgifter i hvithval	Under utvikling	NP
Miljøgifter i polarmåke	Pågående	NP
Miljøgifter i polarlomvi	Pågående	NP
Miljøgifter i ismåke	Under utvikling	NP
Miljøgifter i polartorsk	Pågående	HI og NIFES

Miljøgifter i lodde	Pågående	HI og NIFES
Miljøgifter i dyreplankton	Under utvikling	Ikke avklart
Miljøgifter i svalbardrype	Pågående	NP
Miljøgifter i røye	Under utvikling	Ikke avklart

(2) Ferdsel

Indikator	**Status**	**Utførende institusjon**
Ilandstigninger innen cruiseturisme	Pågående	SMS
Ilandstigninger utenom cruiseturisme	Under utvikling	SMS
Overnattinger i Longyearbyen	Pågående	SMS
Antall registrerte snøscootere	Pågående	SMS
Helikoptertrafikk i verneområder	Under utvikling	SMS
Reisende i meldepliktig område	Pågående	SMS
Antall registrerte småbåter	Under utvikling	SMS
Slitasje på vegetasjon fra ferdsel	Under utvikling	Ikke avklart

(3) Fangst, fiske og jakt

Indikator	**Status**	**Utførende institusjon**
Uttak av Svalbardrein	Pågående	SMS
Uttak av Svalbardrype	Pågående	SMS
Uttak av fjellrev	Pågående	SMS
Uttak av svalbardrøye	Under utvikling	SMS
Effekter av tråling på bunnfauna	Under utvikling	AWI
Fangst av lodde i Barentshavet	Pågående	HI
Fangst av sild	Pågående	HI
Fangst av nordøstarktisk torsk	Pågående	HI
Fangst av norsk-arktisk blåkveite	Pågående	HI
Fangst av uer	Pågående	HI
Fangst av snabeluer	Pågående	HI
Fangst av grønlandssel	Pågående	HI

Fangst av klappmyss	Pågående	HI

(4) Annen påvirkning

Indikator	**Status**	**Utførende institusjon**
Tunge tekniske naturinngrep	Pågående	SMS
Areal vernet	Pågående	SMS
Introduserte arter (østmarkmus)	Pågående	Universitetet i Tromsø

(5) Klima

Indikator	**Status**	**Utførende institusjon**
Lufttemperatur	Pågående	MI
Nedbør	Pågående	MI
Ozon og UV-stråling	Pågående	NILU
Atmosfærisk stråling	Pågående	NP
Havis	Pågående	NP
Havtemperatur, saltholdighet og strøm	Pågående	NP
Havnivå	Under utvikling	Ikke avklart
Massebalanse for isbreer	Pågående	NP
Varighet av snødekke på land	Under utvikling	MI
Gjennomsnittlig albedo	Under utvikling	Ikke avklart
Temperatur i permafrost	Under utvikling	MI

(6) Marin fauna og flora

Indikator	**Status**	**Utførende institusjon**
Havis som habitat	Under utvikling	NP
Isbjørn	Pågående	NP
Hvalross	Pågående	NP
Ringsel	Pågående	NP
Steinkobbe	Under utvikling	NP

Storkobbe	Under utvikling	NP
Grønlandssel	Pågående	HI
Klappmyss	Pågående	HI
Hvithval	Pågående	NP
Grønlandshval	Pågående	NP
Narhval	Pågående	NP
Nordøst-arktisk torsk	Pågående	HI
Sild	Pågående	HI
Lodde	Pågående	HI
Polartorsk	Under utvikling	HI
Blåkveite, uer og snabeluer	Pågående	HI
Dyreplankton	Pågående	NP
Planteplankton	Under utvikling	NP
Mikrobiell fauna	Under utvikling	Ikke avklart
CTD	Under utvikling	NP
Benthos	Under utvikling	Ikke avklart
Makroalger	Under utvikling	Ikke avklart
Nye arter i marint miljø	Under utvikling	Ikke avklart
Polarlomvi	Pågående	NP
Lomvi	Pågående	NP
Krykkje	Pågående	NP
Polarmåke	Pågående	NP
Alkekonge	Under utvikling	NP
Ærfugl	Pågående	NP
Ismåke	Under utvikling	NP

(7) Terrestrisk fauna og flora

Indikator	**Status**	**Utførende institusjon**
Svalbardrein	Pågående	NP
Fjellrev	Pågående	NP

Svalbardrype	Pågående	NP
Vegetasjon	Under utvikling	Ikke avklart
Gjess	Under utvikling	Ikke avklart
Vadefugl	Under utvikling	Ikke avklart
Svalbardrøye	Under utvikling	Ikke avklart

(8) Kulturminner

Indikator	**Status**	**Utførende institusjon**
Antall registrerte kulturminner	Under utvikling	SMS
Ferdselsslitasje	Under utvikling	SMS
Erosjon	Under utvikling	SMS

Annex B - Innspill til i – Nord fra Nordland Fylkeskommune

Notat: Brukerbehov knyttet til i-Nord.

Fra: Terje Stabæk, Norconsult
Til: SINTEF IKT v/forskningssjef Odd Kr. Pettersen
Kopi: Andreas Flåm. Nordland Fylkeskommune

Arbeidsseminar 25.11.2008 i Bodø

Tilstede på arbeidsseminaret var:

- Steinar Jonassen, daglig leder Nordland Fylkesfiskarlag
- Edel Storelvmo, regiondirektør NHO
- Ivan Jørgensen, havnekaptein Narvik Havn KF
- Hans-Christian Engum, GIS-ansvarlig Nordland Fylkeskommune
- Anatoli Bourmistrov, Nordområdesenteret, Høgskolen i Bodø
- Andreas Flåm, Rådgiver, Nordland Fylkeskommune
- Terje Stabæk, Norconsult AS
- Odd Kr. Pettersen, forskningssjef SINTEF IKT

Viktige elementer i forprosjektet

Beskrivelsen av forprosjektet ligger vedlagt.

Fra presentasjonen ble følgende elementer understreket:

- Viktig forutsetning er at systemet skal gi/sikre samhandling mellom ulike delsystemer og klarere data for bruk
- Det skal i utgangspunktet ikke være et forvaltningssystem
- EU-direktiv ”Inspire” ligger i bunnen
- Knyttet til selve registreringen av data, må det utvikles modeller som kan beskrive en utvikling basert på punktdata
- Systemet skal være nasjonalt og gi data som er knyttet til havområdene inkl fjordområdene
- Det er vesentlig at systemet kan bidra til frigivelse av en stor del av de militære dataene, i og med at om lag 95% av disse ikke har/trenger militær klassifisering. Systemet skal være sivilt.
- Systemet må ha forskjellig gradering av sikkerhet, slik at brukerne kan klassifiseres med ulikt sikkerhetsnivå, men: utgangspunktet er at så mye som mulig skal være tilgjengelig
- Havforskningen har pt. få tidsseriedata, ønsker flere og bedre observasjonspunkter
- Dataene skal i utgangspunktet være gratis, og både tjeneste og bakenforliggende data skal være tilgjengelig. Hvis ikke gratis, forutsettes lik pris for alle brukere
- Systemet skal gå inn i hele verdikjeden, dvs. datainnsamling – systemutvikling – sluttbruker - datalagring. Innsamling, systematisering og lagring av data skal skje desentralt hos den enkelte institusjon, men systemet skal koordinere, kvalitetssikre og

distribuere data. Det skal etableres et avtaleverk mot den enkelte institusjon for å lette leveransene av grunnlagsdata.

- Hovedprosjektet
  - Skal gi oppdaterte situasjonsrapporter
  - Skal gi myndighetene mulighet til å følge med utviklingen over tid og i krisesituasjoner
  - Skal integrere eksisterende systemer og utvikle nye systemer og teknologi
- Tre hovedområder:
  - Marine ressurser
  - Marint miljø
  - Marine operasjoner
- Prosjektet skal være sluttført til 2016. Versjon 0.1 (pilot) skal være tilgjengelig i løpet av 2010.

INNSPILL:
Med basis i Odd Kr. Pettersens presentasjon, var følgende momenter sentrale i diskusjonen:

Behov for etablering av et kompetansesenter på anvendelse i nord
Brukermiljøene for data/informasjoner fra i-nord ligger i det daglige i nordområdene, selv om statsadministrasjonen ut fra forvaltningsmessige oppgaver ligger i Sør-Norge. Deltakerne var enige om at det var et klart behov for å etablere et kompetansesenter på anvendelse av ressurs- og miljødata i kommersiell aktivitet i nordområdene. Naturlige samarbeidspartnere i et slikt kompetansesenter er foruten brukergrupper Høgskolen i Bodø (Nordområdesenteret, Space Information Management), Høgskolen i Narvik (satelitt/sensor-teknologi), Andøya (Romsenteret, rakettskytefeltet, opplæring), Tromsø (universitetet, KSAT). Naturlige suppleanter er de militære institusjonene (Reitan, Kystvakta, Andøya, Sørreisa ++). Kobling mot Arena-nettverket Rom-jord er også vesentlig.
Viktig oppgave for et slikt senter er å utvikle ekspertise på bruk av systemene, og spre kunnskap i anvendelse av denne type informasjon i verdiskapende aktiviteter.

Samarbeidet med Russland
Det ble i møtet etterlyst en strategi i forhold til å etablere et samarbeid med russiske institusjoner. Russerne har selv fremmet et forslag til Arktisk råd om et eget radarsatellittsystem, Arctica. Vesentlig å etablere dialog omkring utvikling av sivile systemer og mulig anvendelse. Samarbeidet har vært diskutert i prosjektet, og flere av partnerne har denne type kontakter. Det er likevel i konsortiet blitt enighet om at dette foreløpig holdes utenfor.
Klar oppfordring fra deltakerne om at det bør søkes samarbeid mot Russland med basis i forvaltningssituasjonen i Barentshavet.

Kommersiell tankegang i design av system
Nordområdesenteret har registrert gap mellom tilgangen på data og tilgang på tjenester, dvs. at det foreligger muligheter for kommersialisering som ikke er utnyttet. Dette må bygges inn i startfasen og at data tilrettelegges på en slik måte at det letter bruken for tjenesteleverandører og systemutviklere (rettet mot sluttbruker).
Nedstrømsmarkedet for systemleverandører kan være betydelig for informasjon fra i-nord. Det er viktig å bidra til at slike leverandører kan utvikles i Nord-Norge, nært til de initielle brukerne. Slike systemer og tjenester rundt disse kan også ha et globalt marked, da dette er en internasjonal sektor i utgangspunktet.

Vi viser i denne sammenheng til behovet for å trekke kommersielle aktører inn allerede i pilotfasen for å sikre tilrettelegging for kommersiell bruk.

Behov knyttet til fiskerinæringen

Fiskerinæringen har flere ulike interesseområder. Det er ressursrelatert informasjon, miljørelatert informasjon, sikkerhet (vær, vind, strøm) og informasjon knyttet til ulik bruk av havområdene.
Ressursrelatert informasjonsbehov:

- I ressursforvatningen kan et overvåkingssystem bidra ved å få frem mer korrekte bestandsanslag for de ulike fiskearter vi har i nordområdene, både de som vi utnytter kommersielt direkte og de arter som er føde for de artene vi beskatter direkte. Dette betyr at et slikt system kan bli et instrument i forhold til en helhetlig forvaltning av ressursene i havet.
- Sensorer som kan registrere konsentrasjoner av fisk og sjøpattedyr vil kunne bidra til å redusere driftskostnader og miljøskadelig utslipp fra fiskeflåten ved at en i større grad kan få opplysninger om i hvilke områder det er større konsentrasjoner av fisk.

Sikkerhet:

- I-nord vil også kunne bidra til sikrere værprognoser og registrering av aktuelt vær noe som igjen fører til økt sikkerhet for alle som ferdes til sjøs. Havstrømmer er også viktig å ha best mulig kunnskap om, samt is-overvåking.

Miljø:

- Miljøovervåking er meget viktig for fiskerinæringen. Endringer i bl.a. temperatur og salinitet påvirker fiskens gang i havet og overvåking vil kunne gjøre fisket mer effektivt og rasjonelt. Overvåking av all skipstrafikk, gjerne med angivelse av både last og mengde bunkeres om bord vil kunne gjøre både beredskap og bergingsoperasjoner / forhindring av forurensning mer effektive.
- Algeovervåking og varsling er viktige parametre som ikke bare angår fiskerinæringen. Algeoppblomstring påvirker også villfiskens utbredelse og fiskerne opplever ofte at et område blir fullt av alger og fisken forsvinner da. Dette vil kunne gjøre fisket mer effektivt. Det vil samtidig være nyttig informasjon knyttet til oppdrettsnæringen.
- Et overvåkingssystem kan også brukes i forhold til overvåking av petroleumsvirksomheten og evt. utslipp relatert til fiskerinæringen. Ved uhellsutslipp kan systemet også brukes på en slik måte at de enkelte aktører som skal involveres i opprydding får en mer koordinert og optimal bruk av ressursene.

Ulik bruk av havområdene:

- Konkurrerende bruk av havet både nært land og lenger ut kan også være et stikkord. Forsvaret har sine øvelser og man er avhengig av sameksistens for å få dette til. Systemet bør også brukes i forhold til seismisk aktivitet for å redusere konfliktnivået ved at seismikkprogram legges inn i sjøkartsystemene og avklares med fiskerne. Traseer for rørledninger og overvåking av disse kan også være et satsingsområde.

De fleste fartøy har nettilknytning gjennom mobile systemer, slik at distribusjon via internett er i dag uproblematisk i forhold til fiskerinæringen. Dette medfører også muligheter for å anvende båter i fiskeriflåten som sensorbærere slik at det kan oppnås kontinuerlige målesystemer.

Behov knyttet til beredskap (særlig vesentlig for kommunene som har ansvar for strandsonene)

Siden 0.1-versjonen skal basere seg på et pilotcase med deltakere fra Kystverket og FKD basert på et skipsuhell/forlis i Moskenesstraumen, er det helt sentralt å koble på de som står i den praktiske situasjonen med beredskap. Et felles informasjonssystem er helt sentralt for koordinert aksjon. Det etablerte nettverket for oljevernberedskap, Arctic Protection, anbefales trukket med i pilot-prosjektet (etablering av versjon 0.1.) for å sikre at også aktørene i beredskap (private og offentlige) trekkes inn for å definere systemenes utforming.

Kobling til Arena Havbruk

Deltakerne anbefalte at prosjektet søkte tilknytning til NCE Havbruk med sikte på å utvikle systemer knyttet til behovet for data som har betydning for driftssituasjonen i havbruksnæringen (algesituasjonen, temperaturer, forurensningsfare, utslippsdokumentasjon++).

04.12.08
Terje Stabæk

Annex C – Feedback to the project “i – Nord”

High North Center for Business and Governance
Bodø Graduate School of Business

<u>Short about Bodø</u>

Bodø Graduate School of Business (HHB) has been cooperating with Baltic State Technical University (BSTU) in St. Petersburg (Russia) since 1991 in establishing cooperative programs on Bachelor, Master and PhD levels in management. Baltic State Technical University is a famous university in Russia when it comes to design of space and satellite systems. After year 2000, HHB and BSTU have started new stage of cooperation focusing on development of research and education programs in relation to “space information management”. The project is based on expected grow in needs for project managers when it comes to commercialization of Earth Observation services particularly in relation to management of natural resources in the High North. In addition, Bodø has good cooperation with Russian Association of Aerospace Universities with headquarters in Moscow as well as relevant institutions in the Northern Norway (e.g. Narvik University College, Andøya Rocket Range).

Based on existing competence, High North Center for Business would like to propose itself for the forthcoming project as a partner for “i-Nord” in relation to 1) establishing and maintaining contacts with relevant space related institutions in Russia and 2) as project partner responsible for commercialization aspect of future services of the systems.

<u>Comments to “i-Nord” project report based on our competence</u>

<u>1. Long-term system development thinking requires serious attention to what is going on in Russia</u>

During the process of the design and development of the Norwegian monitoring and earlier warning system for the ocean/sea areas in the High North, not only EU/US but also Russia should be considered as a possible partner for the design and operation of the system.

Since Norway does not have own satellite systems, the design and production of services in the future system depends upon the long-term development in the Earth Observation industry worldwide to secure that the system development from start is based on the best current/future possible solutions.

Currently, there are no satellites which are specifically suited for the current and future purposes of the High North. Most of existing commercially used satellites are single functional, e.g. they are developed based on the idea of covering the whole Earth and therefore based on the global demand for e.g. optical and radar-based image information. The number of satellites is also not enough to timely cover the Artic regions with observation data and therefore provide timely information to users. In addition, current low polar orbits of these satellites do not provide opportunity to collect and provide access to necessary information about High North on a continuous basis.

It is therefore argued, particularly on the Russian side, that there is a potential for exploring synergies which are there in respect to production capacities and information needs of nations in the Artic region, especially Norway and Russia. These needs can be covered by a development of new class of multifunctional satellites which will have: 1) specialized equipment suited for the needs of majority users particularly in the High North and 2) highly elliptical orbits (so called “Molnia” orbit) which will allow satellites to “hang over” the polar territories for the most of the time and in this way provide continuous monitoring and use access to necessary data.

As an example, Russia's Lavochkin research and production association initiated in 2007 a new satellite cluster project, called "Arktika". The project aims at start of implementing monitoring of the Earth's polar regions in 2010. The project was approved by the Russian President Vladimir Putin. The project was also proposed for a consideration of the Arctic Council in October 2007 in terms of defining basic technical parameters of the mentioned above system and providing partial financing for the system building. The major part of the project, however, is supposed to be financed by the budget of the Russian Federation.

Therefore, the design of the Norwegian system will benefit from consideration of the Russian experience and future plans in relation to Earth Observations in the High North and close involvement of Russia into the cooperation.

2. Consideration of Russian is important in terms of international cooperation

Russian and Norway have similar challenges in managing resources in the High North. This recognition opens up for cooperation in developing similar approaches to the sea monitoring and earlier warning systems. In case each country develops its own monitoring system, there is a big possibility that these different systems (which for sure will not be harmonized) will produce different set of data and analysis. Different set of data will probably not be a good point of departure to make joint and cooperative management of resources in the High North especially in case of possible conflicts. There are already some examples showing that different research data and analytical models create different interpretations and maintain disagreements related to how fish resources in the Barents Sea should be managed.

In addition, the fact of not considering Russia as possible cooperative partner in itself can create atmosphere of secrecy and mistrust between Russia and Norway. Already during the launch of the “i-Nord” project, NUPI researcher Julie Wilhelmsen warned that Russia may negatively react to the project even though it has the purpose of the civilian monitoring[3].

3. Potential for commercialization of services should be considered earlier in the project stage

The consideration of commercial potential of the system is important in order to demonstrate that the system can cover some (preferably most) of its operational costs from sales of services to the private sector. However, some research has concluded that the traditional way of designing space based monitoring systems are not efficient in terms of fully utilizing the commercialization potential[4]. There seems to be a gap between users and providers of data. Commercialization potential depends upon the professional consideration of potential revenues and costs along the whole value chain of the expected service (i.e. from design of data collection devices to be placed on satellites till the final customer who pays for the service) and not only on the expectations that data can be useful to the end-up users. Through entrepreneurship and innovations, space

[3] http://www.hblad.no/nyheter/article159314.ece
[4] NOAA’s survey of Remote Sensing Market Aerial and Spaceborne (2005)

information can represent unique business opportunities for small and medium-sized enterprises. It is important to explore what kinds of innovations can create business opportunities applying space information. Therefore, assessment of the potential services should not come from users alone, but from cooperation between potential service providers, data providers and commercialization experts (knowledge parks, business school, etc.).

For instance, today fish farming is important industry in Nordland and fast growing industry in Russian North-West. Climate and environmental changes create some opportunities for fish farming (e.g. increasing temperature of the sea allows new types of fish to be farmed) but also threatening conditions for operations of fish farms (e.g. increase threat from species which harmful to fish, e.g. algae bloom). Profitable operations in the future in the industry will depend on receiving timely information regarding the location, magnitude and direction of threat from sea in terms of e.g. dangerous for fish species and sea pollution. Currently, methods of analysis and access to information exist about how e.g. algae bloom population has being developing for several years around the Norwegian coast. However, such information seems to have more scientific nature rather then industrial use. Information is not available on a real time basis and its decision-making value to fish farmers can be questioned. There is however commercialization potential by developing better links between information supply, e.g. scientific organizations using information from satellites, and potential information users, represented by fish farmers. There is a commercialization potential of the real-time warning system because the cost for the fish farmers of getting service from the system can be substantially less then possible loses of biological assets due to the effect of the treat factors. The access to timely information about the possible biological and environmental treat from the sea will allow fish farms to gain time to develop and introduce proactive measures in order to be capable of responding to threat in a most cost efficient way in order to preserve biological asset, e.g. timely changing location of fish farming installations, deployment of the protections devices, etc. Therefore, considering the whole value chain will give opportunity to design a service package and make feasible specification of information required for service provision.

Anatoli Bourmsitrov
Associate professor, PhD
High North Center for Business and Governance
Bodø Graduate School of Business
Bodø University College

Annex D – Svalbard Integrated Arctic Earth Observing System (SIAEOS)

IPCC, ACIA and UNEP have all pointed towards the High Arctic as a key region in global environmental change. The impact of climate change, pollution and other pressures on the environment appear sooner and with more severe consequences in the High Arctic compared to regions at lower latitudes closer to the pollution sources and population centres. This makes the High Arctic an early warning region for global warming.

Due to its geographical location and extensive research infrastructure as well as easy access and good living conditions, Svalbard is uniquely suited as the European hub in High Arctic research and as a node in the planned Sustained Arctic Observing Network (SAON):

- Svalbard provides excellent opportunities for studies of ecosystem changes following global environmental change.
- Oceanic and atmospheric transport patterns prevail in the Svalbard region, allowing for studies of environmental pollution as well as its effects on the food chain.
- Svalbard is well positioned to observe and analyse the Changing Arctic ice cover as well as its albedo.
- Svalbard's position underneath the magnetospheric cusp allows for unique studies of the energy balance between the layers of the atmosphere, from the borders of space to the surface.
- The location of Svalbard and the High Arctic provides for dense satellite monitoring.

The research infrastructure in Svalbard is extensive:

- Research organizations from 20 countries are present on a regular basis, operating a wide variety of advanced facilities, field stations and research vessels.
- Norway has established an international university in Longyearbyen (UNIS) with students and staff from 25 countries.
- Ny-Ålesund has been developed into an international, high standard field station focusing on environmental and climate research.
- Svalbard is accessible all year round because of its advanced community infrastructure and its relatively mild climate.
- Svalbard has the highest available data bandwidth in the High Arctic.

It is the goal of this proposal to establish an Arctic Earth Observing System in and around Svalbard that integrates the studies of geophysical, chemical and biological processes from all research and monitoring platforms. This will be done through:

1. Organize all infrastructure and all research and monitoring activities into 4 observation platforms being land-based, sea-based, glacier/ice-based and space/air-based.
2. Assess the present infrastructure and activities to identify gaps and weaknesses in the system. Invest in additional infrastructure and activities to close these gaps.
3. Establish a Knowledge Centre in Longyearbyen for data assessment, storage and delivery, education and outreach, and input to Earth System modeling.
4. Take actions to coordinate the SIAEOS initiative with complementary ESFRI efforts as well as other Earth Observation Systems and related modelling efforts.

A High Arctic Earth Observing System based on Svalbard representing the hub for European Arctic environmental research requires additional infrastructure in a variety of fields. All such new research and monitoring activities addressing gaps in the knowledge base and providing better temporal or spatial resolution of measurements or involving new technologies are welcome to contribute and benefit from the SIAEOS. Among the needs that emerge are:

Sea observatories: There is a great potential in establishing a Svalbard Marine observatory system based on the ARCTOS mooring network, the Hausgarten mooring system and long term hydrography, benthos and zooplankton data series. Buoys deployed during the IPY will have to be extended and replaced as part of the effort, others have to be installed.

Air and space research: The Svalbard environment offers a unique combination of location (geographic and geomagnetic) and infrastructure to study the energy budget and dissipation of solar wind energy in the circumpolar regions. Several groups have programs and infrastructure that will be coordinated and integrated. Some supplementary infrastructure is required in addition to extending the capabilities of existing facilities. This includes lidars, radars and sounding rockets.

Validation programs: There is a pressing need for individual sets of measurements to be systematically tested for representativity in space and time. This requires campaigns of “over-sampling” to determine the resolution required for sustained acquiring of representative monitoring data. The main effort is twofold; to use an extended set of automated field stations in comparison with existing infrastructure and to integrate space based monitoring with the field measurements for mutual validation and calibration. (Appendix 5)

Knowledge Centre: All activities of the SIAEOS initiative will be coordinated and all research and monitoring data shared at the SIAEOS Knowledge Centre located in the Svalbard Science Centre in Longyearbyen. The Knowledge Centre comprises of divisions for

- data handling, storage and delivery,
- data assimilation including the integration of satellite and field data,
- space and time integrating facility,
- input to Earth System Modeling,
- outreach and information.

All participating nations will have equal influence on priorities and equal access to results. In the operational phase, we foresee a small organisation/facility with a permanent staff of 6-10 persons who are linked up to collaborating networks elsewhere. A Board should be established with representatives from the major research institutions in Svalbard.

Longyearbyen January 25th 2009

Gunnar Sand
Director of the University Centre in Svalbard

Annex E – MyOcean

MyOcean (http://www.myocean.org) In consistence with the European GMES Fast Track Services (FTS) the Marine Core Service element will be implemented and operated under MyOcean for a period of three years from 2009 to 2012 aiming at deploying the first concerted and integrated pan-European capacity for ocean monitoring and forecasting. The ultimate challenge is to transfer operational oceanography to a full service driven by user needs, and linked on a sustainable basis with the main stakeholders. 60 partners spread over 28 different countries participate in the project.

MyOcean will make available and deliver a set of basic, generic services based upon common-ocean state variables that are required to help meet the needs for information of those responsible for environmental and civil security policy making, assessment and implementation. It corresponds to the main variables needed to depict the ocean state: temperature, salinity, currents, sea level, ice coverage and thickness, primary ecosystem variables, etc. MyOcean provides this information for the daily state of the ocean (real-time), its short-term evolution (forecast for the days coming, up to 10-14 days), and its history over the past 20-50 years (hindcast and reanalysis). Users will access the information through a centralized service desk. The MyOcean service is intended to serve any users requesting generic information on the ocean, and especially downstream service providers using this information as an input to develop value-adding services to end-users as illustrated in Figure 1. These “intermediate users” cover a wide range of downstream sectors of the marine field itself but also connected fields (e.g. climate, living resources, etc.). In particular the services targeted four key areas, notably;

- Marine and Coastal Environment
- Maritime safety
- Marine Resources
- Climate – Seasonal forecasting

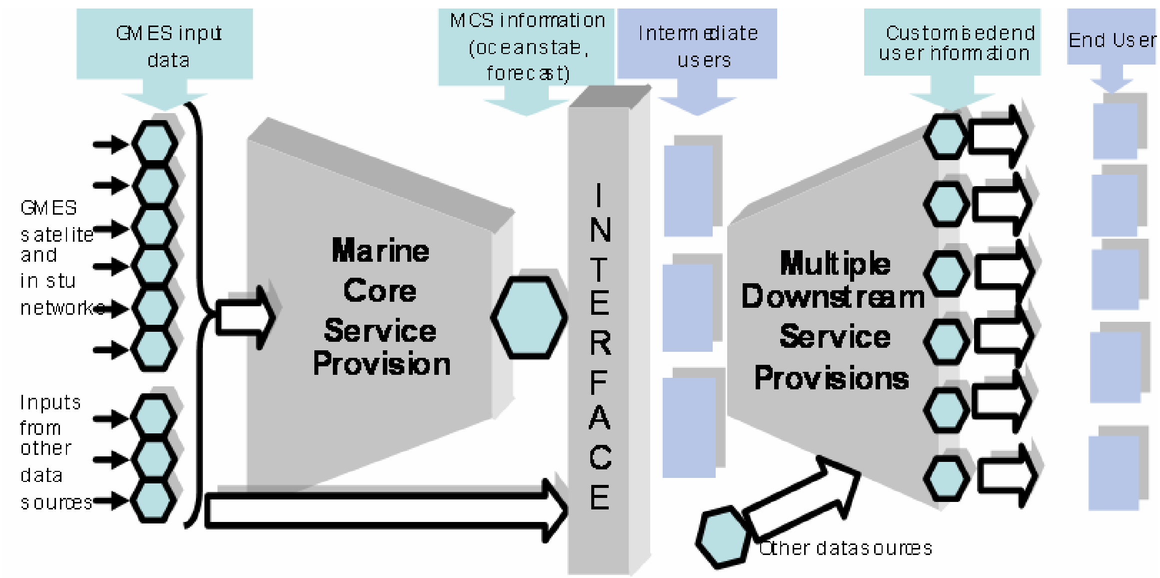

Fig.1: The GMES value-adding chain for the marine information services, positioning the Marine Core Service

A special attention has been paid to (i) the involvement of the *users* in the decision chain regarding the service evolution (be driven by usefulness), (ii) the *integration* of the pan-European production system in a limited number of functional components (reduce and control operation and maintenance cost), (iii) organize conditions for a regular *improvement* of the service in product quality and reliability (ensure competitiveness), and (iv) focus the service on the "*European added-value*", i.e. the value that is better obtained through a pan-European approach than any other (e.g. national). This "European added-value" for marine services has been defined as the marine "core service": it's the foundation of the MyOcean service. The service will cover the global ocean as well as the regional seas of Europe including the Mediterranean, the North Atlantic and European Northwest shelves, the Baltic Sea and the Nordic Seas and the Arctic Ocean. It is highly relevant and complementary with I-Nord, in particular regarding the Arctic services .

The *Policy drivers* have been identified as:

- Regional Conventions between Member States and the EC (i.e. OSPAR, HELCOM, UNEP/MAP;
- 6th Environmental Action Plan; in particular its Climate Change and Marine Environmental Strategy components;
- The Sustainable Development imperative which is written into the Rome Treaty and is now being developed through the Green Paper on Maritime Policy. (Note that the **Maritime Policy Green Paper** has emphasised that commercial sectors such as shipping, fishing, oil exploration, offshore construction, aquaculture, and tourism, and public sectors such as coastal protection, defence, search and rescue, R&D and government policy making all need data on past, present and future meteorological, oceanographic, hydrographic and ecological state of the seas and the oceans. Global-scale monitoring is required to meet this need and the EU is being encouraged to set up a European Marine Observation & Data Network to provide sustainable, improving access to information.)
- Relevant existing EU Directives, such as the Water Framework Directive in its application to coastal waters.
- Concerns over civil security which manifest themselves in particular for safety of life and property in the marine environment (i.e. EMSA).

Annex F – Meetings overview

The following meetings have been carried out as part of the project

Meetings with partners in the consortium

- Institute of Marine Research (IMR)
- Nansen Environmental and Remote Sensing Center (UNERSC)
- Northern Research Institute Tromsø (NORUT)
- Norwegian Polar Institute (NPI)
- Norwegian Defence Research Establishment (NDRE/FFI)
- Norwegian Meteorological Institute (met.no)
- Norwegian Institute of Water Research (NIVA)
- Norwegian Institute for Air Research (NILU)
- SINTEF

- University of Tromsø , Center for Remote Technology
- Norwegian University of Science and Technology (NTNU)
- University of Bergen, Geophysical Institute (UiB-GFI)

- Kongsberg Group (KOG)
  - Kongeberg Spacetec AS
  - Kongsber Satellite Services AS (KSAT)
  - Kongsberg Defence and Aerospace AS (KDA)
- Fugro OCEANOR AS
- SAAB Group

Meetings with possible users and stakeholders

- StatoilHydro
- ConocoPhillips
- Shell
- ACONA (ArcticWeb)
- Management Forum
  - Advisory group on monitoring
  - Forum on environmental risk management
- Norwegian Space Centre (NR)
- Norwegian Coastal Administration (Kystverket)
- The Norwegian Pollution Control Authority (SFT)
- Norwegian Coastguard
- The Directorate for Nature Management (DN)
- Ministry of the Environment (MD)
- Municipals and County Municipalities of Northern Norway
- Fellesoperativt hovedkvarter (FOHK)
- Landsdelskommando Nord-Norge (LDKN)
- Norwegian Police Directorate
- The Customs Authorities
- National Safety Authority (NSM)

- The Governor of Svalbard (Sysselmannen)
- University Centre in Svalbard (UNIS)

Collaboration meetings with the Norwegian Coastguard, *i-Nord* and stakeholders to the Coastguard's project "Beslutningsstøtte Kystvakt" (Decision support Coastguard):

- The Directorate of Fisheries
- Institute of Marine Research (IMR)
- Norwegian Nature Inspectorate (Statens Naturoppsyn (SNO))
- Police Department
- The Customs Authorities
- FOHK
- FK KKIS
- Joint Rescue Coordination Centre (HRS)
- Norwegian Police Directorate
- FOHK
- Met.no
- KNMT METOC

Presentations at conferences

- Maritime Situational Awareness seminar.
- Norwegian Research Council "Northern Area Conference"
- Svensk-norsk samarbeide i Nord, Tromsø, 1-2 september 2008

Status meetings with ministries

- Ministry of Fisheries and Coastal Affairs (FKD), Client
- Ministry of Foreign Affairs (UD), Client
- Minister of the Environment (MD)
- Ministry of Defence (FD)
- Ministry of Justice and the Police (JD)
- Ministry of Trade and Industry (NHD)
- Ministry of Education and Research (KD)

i-Nord
A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean

Main Report

Part 3

Description of system concepts, including demonstrator

SINTEF

MEMO

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MEMO CONCERNS

i-Nord
A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean

Pre-project

Description of system concepts, including demonstrator.

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The surveillance of the High North ocean areas.

PREFACE

The i-Nord project is a product of Barents2020 which is based on the Norwegian Government's High North Strategy[1]. i-Nord´s main objective is to implement and operate a ***comprehensive monitoring* and information system** of the High North ocean areas, in order to directly address and maintain Norway's ***ambition of playing a leading role*** in the Barents Sea and Arctic Ocean, including proper and sustainable management as well as proactive partnership in the intergovernmental Arctic collaboration.

The mandate for the i-Nord pre-project has been to prepare the best background for the Government's decision of starting the ambitious development of a full i-Nord surveillance system.

The pre-project is initiated and financed by the Ministry of Foreign Affairs (UD) and the Ministry of Fisheries and Costal Affairs (FKD).

The specific objectives of the pre-project have been to:

- Identify the primary stakeholders to such a system
- Describe the i-Nord concept and overall system structure
- Describe best practice for developing such a system
- Identify the need for research and development
- Produce a main project plan
- Propose and coordinate a consortium with the necessary know-how and ambition of carrying out the main project

This report is one of the deliverables from the i-Nord pre-project and describes ***the i-Nord concept and overall system structure.***

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After receiving the report from the responsible author, the report has undergone only editorial changes by SINTEF as part of the preparation of the final document.

[1] As of 2008-10-22: http://www.regjeringen.no/en/dep/ud/Documents/Reports-programmes-of-action-and-plans/Action-plans-and-programmes/2006/Strategy-for-the-High-North.html?id=448697

SUMMARY

The overall objective of the i-Nord system is to position Norway in the front concerning monitoring and forecasting of high latitude ocean areas. This report contributes to that objective by outlining the i-Nord infrastructure that reflects a system-of-systems approach.

In order to develop a sustainable system, it should be modular to allow further development as requirements or technology changes.

The infrastructure developed within i-Nord has to interface existing infrastructure. The infrastructure of institutions contributing to the system has been developed over many years and reflects both national and international requirements. Establishing a completely new infrastructure is not cost efficient, thus i-Nord must focus on interoperability and development/description of interfaces that connects existing and new systems.

The pilot project has examined relevant national and international requirements (e.g. WIS, GEOSS, INSPIRE) and propose to build i-Nord using a service oriented architecture (utilising OGC WMS, WCS, WFS, CSW) where new and existing infrastructure is interfaced using web services however opening for support of other interoperability standards where appropriate. As the full functional requirements of the system are yet not known, this report does only present an outline of the system and no detailed specification.

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1 Introduction

1.1 Background

This report addresses the issues raised in the specification document issued by SINTEF for the i-Nord pilot project [1]. It has been created by a working group (Table 1).

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1.2 Applicable documents and specifications

[1] I-Nord specification document issued by SINTEF formulating the requirements on the A2 working group.

[2] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an INfrastructure for SPatial InfoRmation in the European community (INSPIRE), L.108/1, EU.

[3] INSPIRE Guidelines for the encoding of spatial data, 2008-06-27, INSPIRE Drafting Team Technical Specifications.

[4] INSPIRE Metadata implementing rules based on ISO19115 and ISO19119, INSPIRE Drafting Team Technical Specifications.

[5] INSPIRE web site, http://inspire.jrc.ec.europa.eu/

[6] WMO INFORMATION SYSTEM Compliance Specifications of GISC, DCPC, and NC, v.1.1, WMO Secretariat.

[7] EU GEOSS portal http://ec.europa.eu/research/environment/geo/article_2450_en.htm.

[8] GEOSS, http://www.earthobservations.org/

[9] GEOSS standards, http://seabass.ieee.org/groups/geoss/

[10] Schwarz da Silva, Joao, EU approach towards the Future Internet. In The Future Internet, EURESCOM mess@age magazine, 1/2008. Online at http://www.eurescom.eu/~pub/about-eurescom/message_2008_01/Eurescom_message_1_2008.pdf.

[11] European Future Internet Portal, http://www.future-internet.eu/home.html.

[2] Changed to Helge Sagen during the project period.

[12] OECD Information and Technologies, http://www.oecd.org/topic/0,3373,en_2649_37441_1_1_1_1_37441,00.html

[13] SEIS, Shared Environmental Information System, http://ec.europa.eu/environment/seis/index.htm

[14] WISE, Water Information System for Europe, http://water.europa.eu/

[15] WMO Information System, http://www.wmo.int/pages/prog/www/WIS-Web/RefDocuments.html

[16] GMES, http://www.gmes.info/

[17] Fielding, Roy T.; Taylor, Richard N. (2002-05), "Principled Design of the Modern Web Architecture" (PDF), *ACM Transactions on Internet Technology (TOIT)* (New York: Association for Computing Machinery) **2** (2): 115–150, doi:10.1145/514183.514185, ISSN 1533-5399

[18] Veiledning i verdivurdering, Nasjonal sikkerhetsmyndighet, November 2005, http://www.nsm.stat.no/Documents/Veiledninger/veiledning_verdivurdering.pdf

1.3 Scope

The overall objective of the i-Nord system is to position Norway in the front of monitoring and forecasting for the ocean areas in the North [1]. The goal of the pilot project is to generate background material that addresses the issue of developing a unified monitoring and forecasting tool for ocean areas of the North. The pilot project examines the possibility of setting up such a system, along with requirements. The system will integrate existing infrastructure and systems, as well as develop new when relevant or required.

The mandate of the working group is to define the overall system architecture, relations to existing infrastructure as well as a (functional) breakdown into modules/subsystems. Furthermore, this should evolve into a more detailed work plan for the main project including priorities of various parts. How existing infrastructure is to be integrated shall be indicated.

This report is accompanied by a demonstrator which reflects a potential use case for the i-Nord system.

1.4 Impact by international initiatives

In order to develop a sustainable system, it should be modular to allow further development as requirements or technology changes. Furthermore, it should facilitate the shift towards a more integrated and interoperable networked society and industry. The i-Nord development must to take into account to a large extent the developments internationally through e.g. INSPIRE [2] and GEOSS developments [7]. INSPIRE aims to create a European spatial information infrastructure that delivers integrated spatial information services to the users, while GEOSS will provide decision support tools linking existing and planned observation systems for a wide range of application areas.

Of somewhat more generic interest is the following notions also adopted by the European Commission [10], [11].

- The future internet, the convergence of communication technology, such as internet, telecom (mobile fixed networks), TV-networks, etc into a single network. This implies increased accessibility to services and content provided authorised access.
- The internet of services, meaning that software, data sets and other products are either provided by, accompanied by, or accomplished by a networked service. This is at the core of the proposed i-Nord system architecture, which is based on service-oriented principles.

- The internet of ”things”, meaning that not only computers are interconnected, but all “things” (e.g., vessels, vessel equipment, sensors for environmental monitoring etc) may be connected to the internet in intelligent ways.

2 Framework and constraints

2.1 Context

The intention of i-Nord is rather ambitious. It is supposed to be a tool for as various groups as scientists, industry, public authorities (ranging from local to governmental), as well as non-governmental institutions and citizens. This tool should offer capabilities within areas of daily monitoring of various phenomena, management of resources and crisis management. The various components that are required to set up such a system are briefly and not completely outlined in Figure 1.

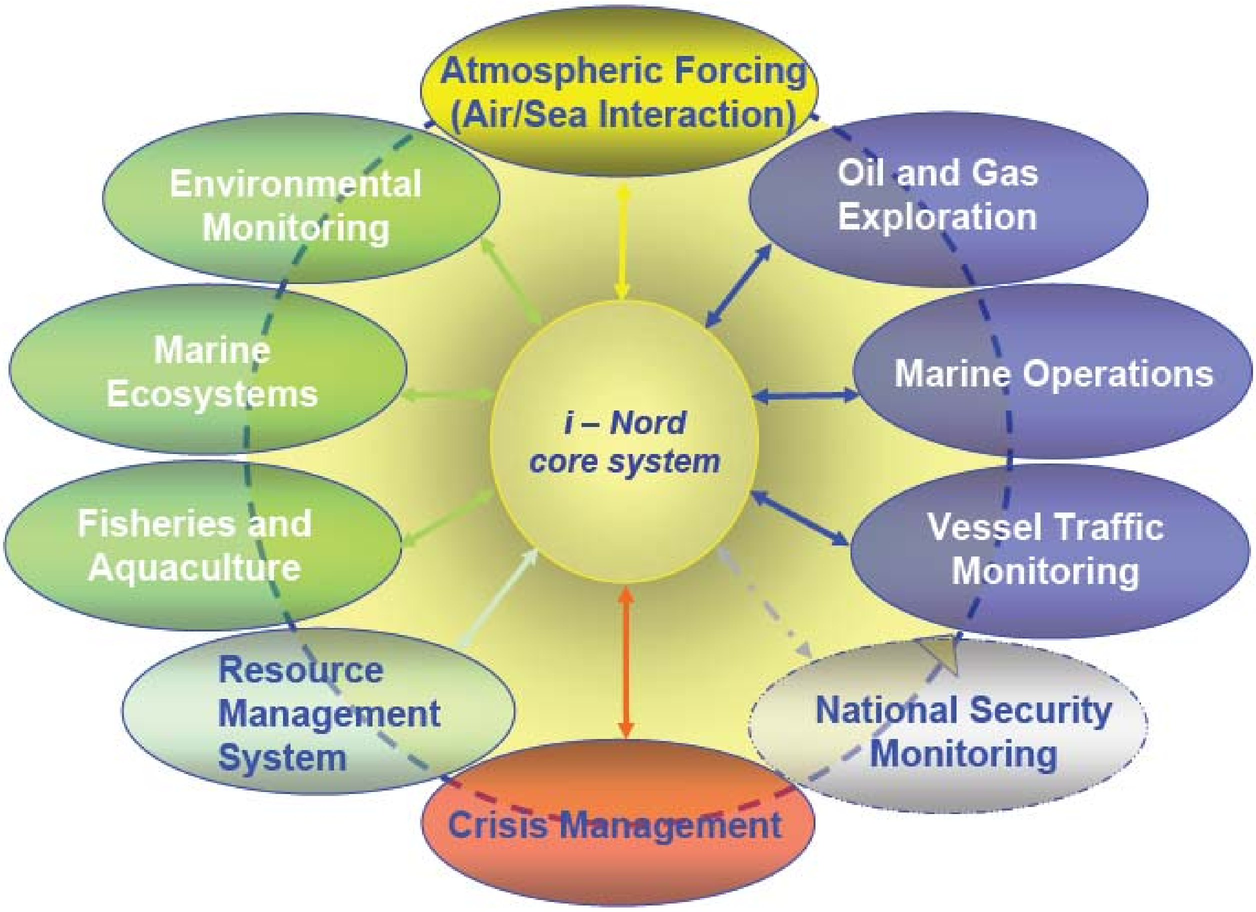

Figure 1 Initial outline of i-Nord system components (Odd K. Pettersen, SINTEF).

Given the ambitious intention of i-Nord the new idea is that not only should data, products and information be easily available within the system, but also that potentially necessary interactions between various subsystems should be facilitated. i-Nord thus require interfaces for sharing data and production environments. This do not imply direct access to production chains, which in most cases would violate security policies of those owning the production chains, but definitions of interfaces that may be used in a secure manner to establish relationships between various subsystems that increase the overall performance of the system.

The i-Nord system has to cope with a wide variety of production environments as well as respecting existing IT-strategies within the service providers. As such, the fundamental principle of i-Nord development is definition of services and interfaces offered by existing systems and utilised within i-Nord. To generate a sustainable system the system should be designed in a manner compliant with other requirements the service providers have to fulfil (e.g. INSPIRE, GEOSS and WIS).

Furthermore, i-Nord should relate to existing Arctic initiatives and activities like e.g. ACIA/NORACIA, AMAP, SAON, SIAEOS as well as ongoing and upcoming operational projects like EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSISAF) and GMES MyOcean and relevant International Polar Year (IPY)-projects like DAMOCLES, iAOOS and IPY-THORPEX. OSISAF and MyOcean are providing or setting up operational environmental services for the European society while the IPY projects mentioned above have been examining new environmental monitoring technology. The i-Nord system should be part of the IPY legacy and relate to Arctic Council initiatives.

2.2 Relation to existing infrastructure

The infrastructure developed within i-Nord has to interface existing infrastructure. The infrastructure of institutions contributing to the system has been developed over many years and reflects both national and international requirements. Establishing a completely new infrastructure is not cost efficient, thus i-Nord must focus on interoperability and development/description of interfaces that connects existing and new systems.

Furthermore, during the International Polar Year as well as within other Arctic initiatives (e.g. AMAP, SAON, SIAEOS) much infrastructure and methodology has been developed or is under development. The experience during these activities has to be evaluated and where appropriate infrastructure or other solutions adopted.

2.3 Compliance with relevant initiatives

On the international level several initiatives focus on interoperability and are defining measures to achieve interoperability and extended services. Among these initiatives are global initiatives like GEOSS [7][8][9], OECD [12] and WMO Information System [6][15], European initiatives like Shared Environmental Information System (SEIS) [13], Water Information System for Europe (WISE) [14] and not to forget the technical infrastructure utilized by the more topic specific initiatives, INSPIRE [5]. At the technical level SEIS and WISE rely on INSPIRE specifications. INSPIRE and Global Monitoring for Environment and Security (GMES) [16] are major European contributions to GEOSS.

INSPIRE requirements are defined in [2], [3] and [4]. The main requirement to consider in the present situation is the requirements on metadata which are required to follow ISO19115 and ISO19119. Furthermore, INSPIRE focus on interoperability using OGC standards like WMS, WCS, WFS and CSW 2.0.2 with ISO metadata. At the national level the implementation of INSPIRE is expected to be handled through the existing framework Norge digitalt. A national process defining the relationship between INSPIRE and Norge digitalt is currently in progress.

WMO Technical specifications for WMO Information System are provided in [6]. The most important requirement in the current specification is the requirement of using ISO19115 for metadata (implemented using the WMO Core profile). Furthermore, there is a requirement in the WIS specifications towards ISO23950 (with references to the GEO profile and SRU) for catalogue interoperability. WMO and WMO members in Europe have a dialogue with INSPIRE concerning the future development of standards within the INSPIRE framework.

Concerning GEOSS many standards are listed in the GEOSS standards registry (http://seabass.ieee.org/groups/geoss/index.php?option=com_geoss), but very few of them are approved in the current situation. The standards mentioned above are however on that list.

2.4 A sustainable solution

Setting up a complex system like i-Nord only makes sense if it continues to be useful for the contributors and users throughout a long time period. To achieve this, the system has to be modular in design implying that parts of the system may be exchanged as time passes. The reason for exchanging parts of the system may be that new technology is available or that other solutions may be more cost effective. If the system fails to be cost effective it will not be maintained over time.

A crucial aspect concerning designing a cost effective system is that it should not duplicate nor require changes in existing systems, but rather interface them. The infrastructure established for i-Nord should be utilized beyond specific i-Nord purposes. Several of the service providers contributing to i-Nord has public commitments that are also regulated by various national and international requirements. Some of these are, for example INSPIRE and Norge Digitalt. Such requirements should be covered by the system to avoid maintenance of duplicate systems by the service providers. Most of the requirements potential service operators (and data providers) experience today are to make data and products widely accessible and useful for external users and business. This interoperability requirement is usually imposed by some metadata standard and the use of OpenGeospatial services or other interoperability standards and protocols like e.g. World Meteorological Organisation (WMO) file formats, WMO manual on codes or other community specific standards like e.g. OpeNDAP and other file formats.

The policy of using black box software may vary between the production chains being integrated. As a basic principle, black box software components should primarily be used on the client side rather than at the service provider side, and whenever such components are included in the system their functionality and interfaces should be very well documented.

Modularity reduces the risk of the system failing to achieve long term commitment as technology or production environments change. To achieve modularity all software components should fulfill a specific function and contain well defined interfaces as well as documentation.

A major challenge of the future operation of i-Nord is the operational responsibility for sensors contributing to the information flow within the system and at which level these should be integrated with the system.

The i-Nord system focus on integrating data and production chains in Norway, however the system should be able to use data and products openly available elsewhere in the world whenever this is feasible. Such information may be available at open WMS, WCS, FTP, HTTP or OpeNDAP-servers and may be identified through CSW or OAI-PMH harvesting.

2.5 Service oriented architecture

The i-Nord system should provide the services required to fulfill the overall objective of the system. This includes interactive and machine interfaces to catalogues (data discovery and data retrieval), interactive and machine interfaces to production chains, intersystem communication (e.g. notifications and warnings) and visualization (maps, time series, etc.).

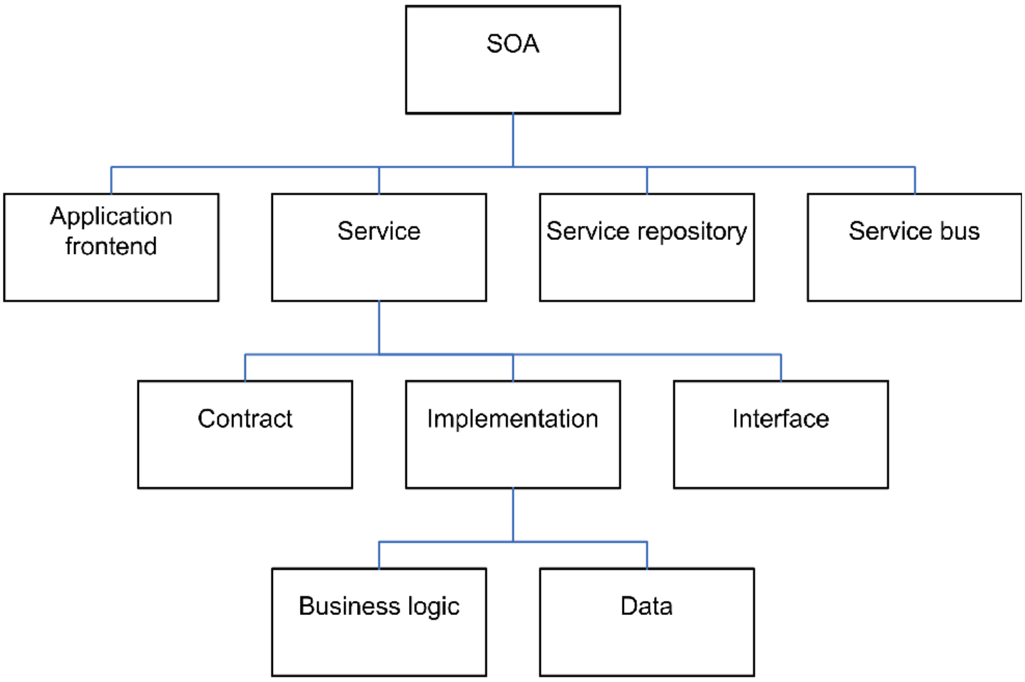

Figure 2 Elements of SOA, by Dirk Krafzig, Karl Banke, and Dirk Slama. Enterprise SOA. Prentice Hall, 2005

Service-oriented architecture (SOA) is chosen as the architectural principle, as this is viewed as the best current approach to satisfy the architectural goals of i-Nord. The main elements of SOA are indicated in Figure 2. SOA views business functions as *Services*, and provides for access to those functions from a broad array of platforms, runtimes, and languages. Services are accessible through the *Service bus* and the *Service repository*. The service repository is maintained by a service broker. Services are published to a service broker and a service consumer looks up services through the service broker before starting to interact directly with the service in a client-server style. Through the *Service bus* and *Service repository* SOA is providing a process oriented, loosely coupled, build to change approach, as opposed to the traditional function oriented approach that is built for permanence, thus, enabling a flexible environment that adapts to business changes**.**

2.6 Interoperability

Figure 3 shows reference architecture for IT system interoperability[3]. This architecture highlights the different dimensions that are relevant to focus on in order to achieve interoperability between potentially collaborating partners.

[3] Aagedal Jan Ø. : Information Architecture for upstream, SINTEF Memo produced for OLF, November 2006. Further elaborated in the Athena and Interop EU projects

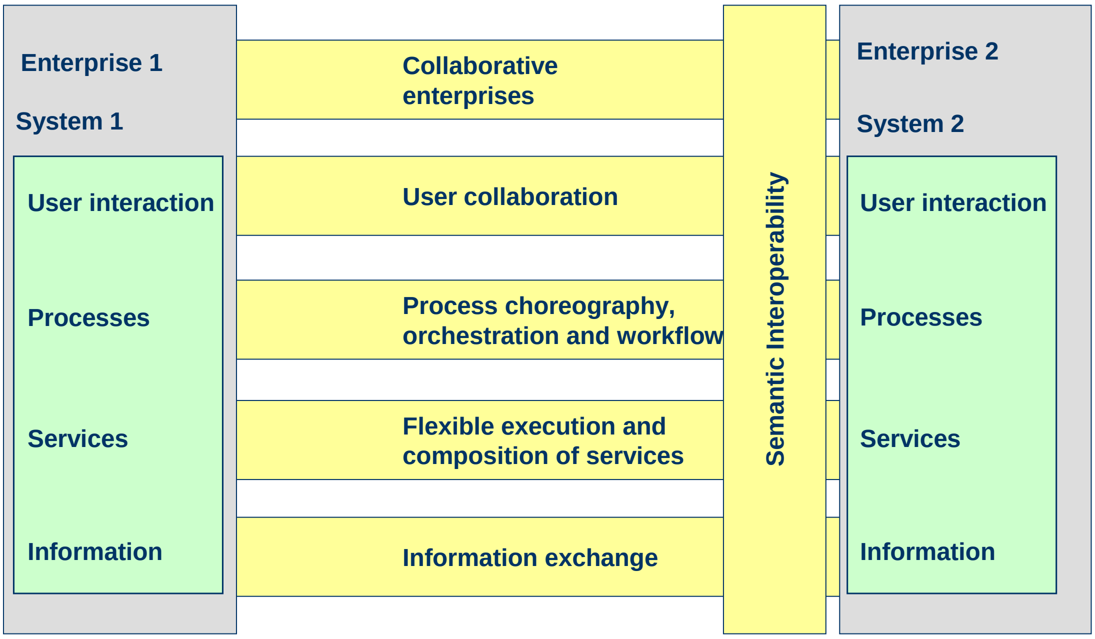

Figure 3 The Reference Architecture for IT system Interoperability

It shows two enterprises that have decided to cooperate, Enterprise 1 and Enterprise 2. Their intentions to cooperate, the purpose and nature of the cooperation and the policies that govern the cooperation are defining the first horizontal bar between the enterprises named “Collaborative Enterprises”. Even if the reference architecture focuses on IT systems, it is important to realise that unless a shared business objective and common understanding of the intentions to collaborate are established, interoperability between IT systems is irrelevant and effort spent on this is effort wasted.

The remaining dimensions are focused on IT system interoperability and are briefly described below:

- User collaboration providing *user interaction interoperability* is typically the focus of environments for computer-supported collaborative work (CSCW). Such environments often provide shared workspaces across system boundaries where the end users can collaborate based on a shared user interface to a system.

- Process choreography, orchestration and workflow providing *process interoperability* are concerned with fitting together the relevant processes between the collaborating partners. Processes describe sequencing of work in terms of actions, control flows, information flows, interactions, protocols, etc. Process interoperability is achieved through “Process choreography, orchestration and workflow” These terms have different meaning in literature. The most common that we adopt here is let process orchestration represent automatable processes whereas workflow means process with human intervention. Process choreography combines orchestrations and workflows to meet the business objective of the collaboration.

- Flexible execution and composition of services providing *service interoperability* is concerned with externally initiated execution of services. For an external client to invoke a service there must exist a shared understanding of what the services does and upon which assumptions it relies. Once a service is well-defined (i.e., it has a well-defined interface) the client does not care which server (software component or IT system) that actually executes the service. This is referred to as “Flexible execution and composition of services” in the figure. The composition-part of this clause refers to the fact that a client does not care whether a service is an atomic service or whether it is a composition of services.

- Information exchange providing *information interoperability*. Information is related to the data exchanged, processed and stored by software systems. Business concepts are represented in software as information messages that are provided or required by services and processes. Information interoperability is concerned with the exchange of data so that each party in the collaboration interprets the data in the same manner (i.e., the information is shared).

These interoperability dimensions are related in the sense that they are basically different views on the interoperation of two systems. This means that the dimensions should be consistent. One aspect of this consistency is that the dimensions have a common frame of reference. We refer to this as *semantic interoperability*. By semantic interoperability we mean that there should be established a shared meaning of the concepts used in more than one of the dimensions.

In addition to the above presented dimensions, there are other aspects that also must be considered in the context of system interoperability. These aspects are cross-cutting through all the dimensions identified above. In Figure 4 below, we tilt the reference architecture shown in Figure 3 and show examples of cross-cutting layers beneath.

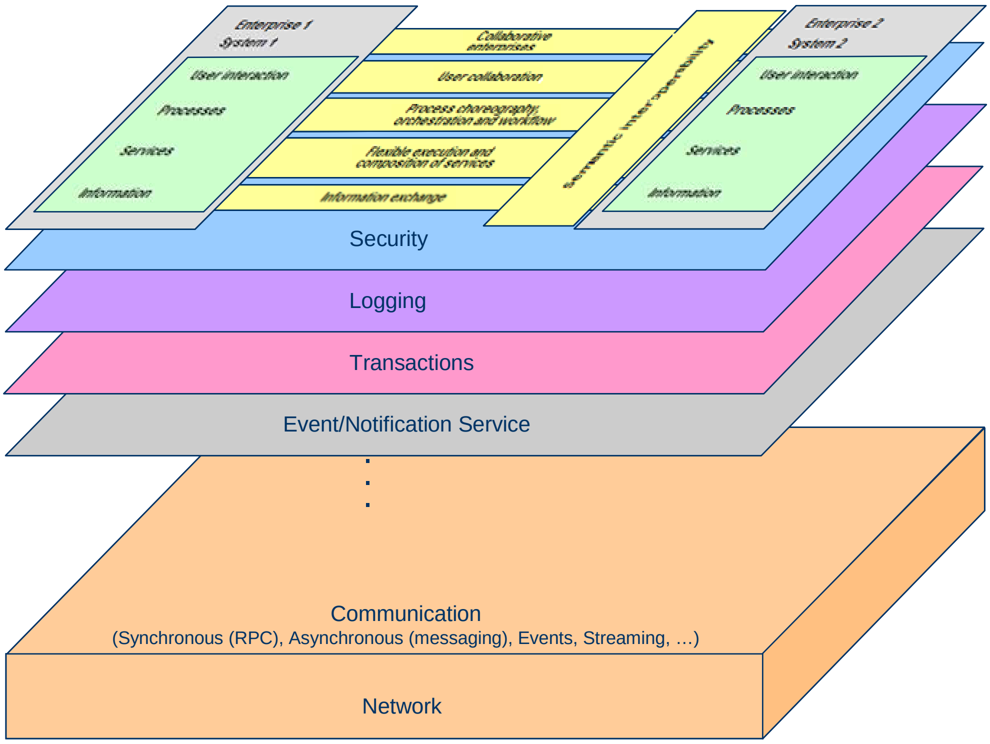

Figure 4 Cross-cutting layers of the Reference Architecture for IT systems Interoperability

Typical examples of cross-cutting layer are *Security* and *Communication*. Security is an aspect that underlies every interoperability dimension and is as such a prerequisite for interoperability. The interoperating parties need to agree on a security policy and some security mechanisms in order for them to interoperate, but security does not provide any functionality to the interoperating parties. The interoperating parties also need to agree on the communication paradigm and technology to use. However, like security, communication does not add anything semantically to the interoperation, it is rather an aspect that makes interoperation possible.

2.7 Security considerations and national requirements

The i-Nord system considers a wide range of security solutions depending on the users and service providers involved and the service required. Internal and external security requirements may vary between the service providers. Security solutions should include, but not be restricted to, IP-address filtering and access by username/password using secure HTTP servers, Public Key Infrastructure (PKI) and Virtual Private Networks (VPN). The solution chosen would depend on the value of the data and information to be handled.

Given the expected complexity and wide range of users as well as the data and information the system is expected to handle the Norwegian National Security Authority (NSM) must be involved throughout the project to avoid any delays due to potential certification of the system at a later time. The first task of the project must be an evaluation of the value of the data and information within the system according to [18]. Interoperability is a main issue for i-Nord and the evaluation following the outline of [18] need to focus on separate sources of data and information as well as the integrated approach of i-Nord. To keep i-Nord as unclassified system specific considerations on the information available within the system may be required. The public Certification Authority for IT Security in Norway (http://www.sertit.no) issues Certificates and Certification Reports. The purpose of the Norwegian Certification Scheme is to cover the needs of government and industry for cost effective evaluation security evaluation and certification of IT systems. The use of the certification scheme is voluntary and the potential requirement for this within i-Nord would depend strongly on the evaluation of the value of the data and information within i-Nord.

3 System concept

3.1 Main concepts and logical structures

The overall objective of the i-Nord system is to position Norway in the front concerning monitoring and forecasting high latitude ocean areas. This pilot-project contributes to that objective by outlining the i-Nord infrastructure that reflects a system-of-systems approach and that is in line with parallel initiatives internationally. The i-Nord approach opens for new opportunities:

- Better and easier integration of existing data sets, products and processing chains.
- Improved data collection by development of novel sensor technology and containers.
- Optional new services on top of existing services, products and data.

A major feature of i-Nord is that it supports the value chain from collection of raw data, through basic processing to the generation of higher level data sets and products that can be used by decision makers and others. The value chain comprises to a large extent the production chain. In consequence, the most important feature of i-Nord is that it can make production chains more effective by offering interoperation and integration of production chains. It offers a new type of production chains that are extended into the end user environment. A generic visualisation of the value chain, including production chain, and support by i-Nord is provided in Figure 5.

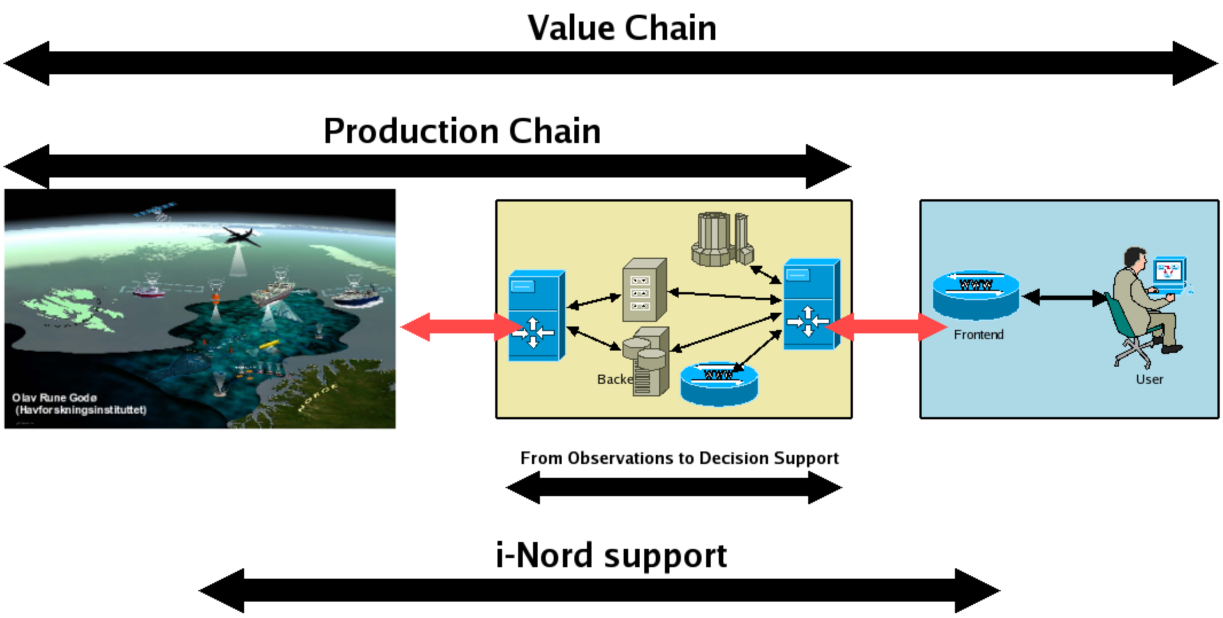

Figure 5 The relationship between value chain and production chains and the support of i-Nord.

Figure 5 shows the relationship between the value chain and the production chain which is essential to understand the whole i-Nord system concept. The i-Nord infrastructure supports the production chain with services that improves interoperation (e.g. between institution specific production chains) and integration (e.g. of data). Production chains are subsets value chains, thus i-Nord also partly supports value chains. Figure 5 indicates that value chains may extend the scope of i-Nord and most of the relevant production chains. This is true because there may be actors whose processes and services that collect and refine data are only indirectly connected to the production chains of the core systems (see Section 3.3). See also Annex A for a more elaborated description of these relations.

The i-Nord overall system architecture have two main elements (Figure 6); *frontend services* and *backend services* (Figure 6). The backend services provide access to data and products. The frontend services typically provide User applications that can utilise the information provided by the backend services. Frontend services range from dedicated software applications to functionality served through a web browser (or a machine-machine interface). Users may also be internal to the system. The overall i-Nord system architecture is based on Service Oriented Architecture (SOA) principles, where the services are published to a service broker. The service broker maintains the service repository. A service consumer looks up services through the service broker before starting to interact directly with the service in a client-server style.

The Service Bus represents the interaction infrastructure in line with the Service Bus concept of SOA as described in section 2.5, enabling service interaction in general and access from frontend services to backend services in particular. In order to simplify and quality assure the interaction between the frontend and backend the i-Nord service bus contains catalogue services (which is the service broker and includes service repository, service publishing and service look-up facilities as explained in section 2.5), security services, message/event services, data visualisation services, data access services, data processing services etc.

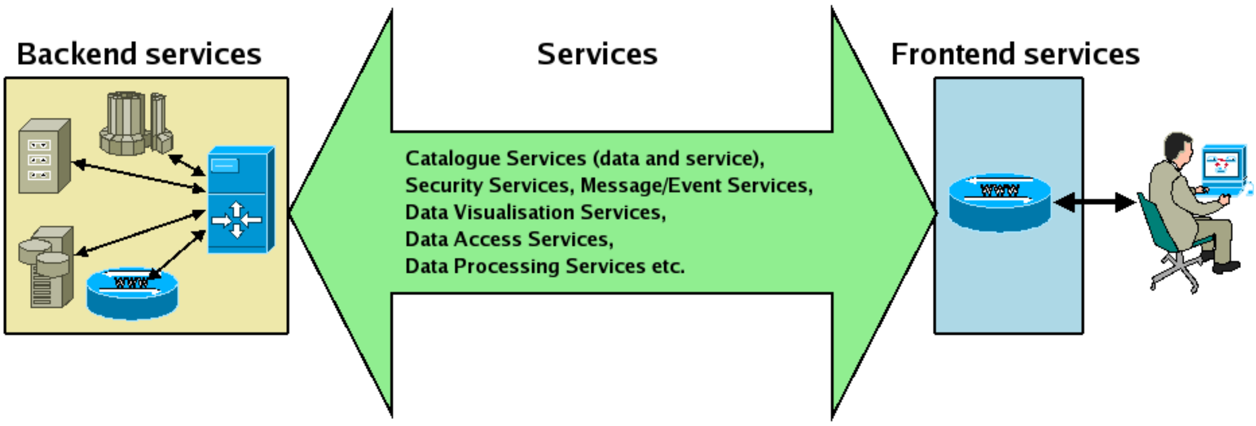

Figure 6 The two main components of the i-Nord system. The frontend serves the specific needs of the user, and the backend provides an interface to data and services (graphical, data access and processing services) offered by service providers within the system. The service bus includes the set of services and communication infrastructure that is required to make the system work.

The i-Nord requirements are relatively complex and are yet not fully known. However a generic understanding of the system, following the principles of the conceptual view presented in Figure 6, is provided in Figure 7. Within this the need for open and secure communication (either in a group or bilaterally) is illustrated. Service and data access must be controlled by the appropriate metadata. The i-Nord infrastructure should also support peer to peer (P2P) communication. The basic principle of a distributed i-Nord system requires a P2P approach. The P2P approach has some issues concerning security, but will also make the system more robust. Furthermore, for some use cases in i-Nord it can be important to allow a peer to peer kind of interaction in order to allow autonomous i-Nord hosts/actors to communicate real time, for instance in crisis management use cases where events and information preferably should be sent directly between peers.

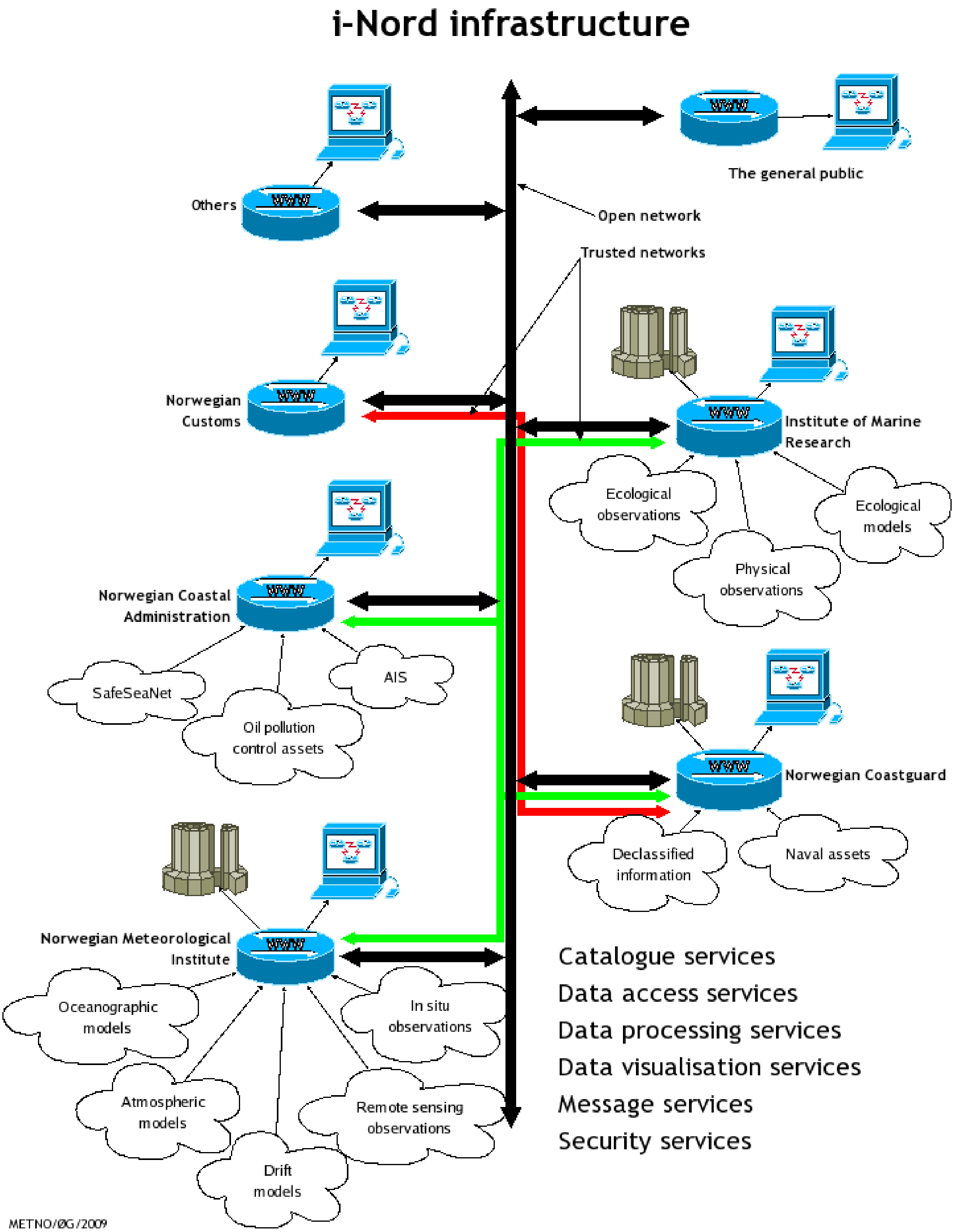

Figure 7 The i-Nord infrastructure shall integrate existing data sources, processing resources as well as support secure communication between users. Access to data should be done according to the authorisation level required by the dataset. This illustration is an outline of a potential Maritime Safety Awareness system and is by no means complete.

3.2 Potential organizational solution concepts

Basically two different concepts could be evaluated. Between these two several mixed solutions may exist and may be preferred. Both solutions are based upon catalogues, services and human and machine interfaces to these. These concepts have been identified under assumption that all data and service providers maintain operational robust systems including failover systems etc to maintain data and service availability under all situations[4]. Interaction between production chains may be done using REST style web services (HTTP/GET, HTTP/POST/, HTTP/DELETE, HTTP/PUT) and necessary security layers.

One concept is to build a centralised system (Figure 8) which offers a central access point for users of the system. This central portal would then authenticate/authorize users, coordinate data access, requests for interaction between production chains etc. This centralised solution would offer custom made portals for various users. Service providers maintain catalogues and expose data and products for access through the centralised site. The centralised site also triggers communication between production chains when this is required.

The other solution could be a fully decentralised system (Figure 9) where each service provider sets up a portal and services. The portal should both provide updated information as well as an overview of the data, products and services offered. Within this system catalogues may be synchronised if required. This may provide redundancy if required. Given the requirement of i-Nord as an operational system for crisis management, redundancy and robustness are important factors.

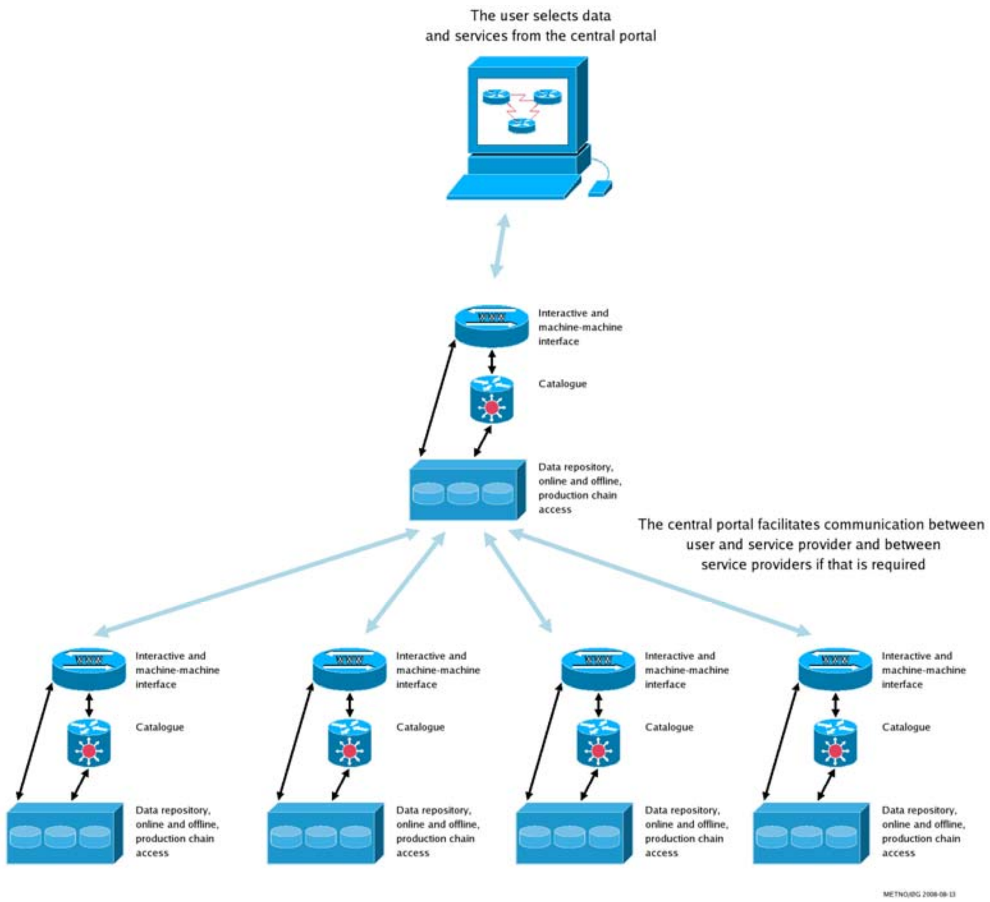

Figure 8 Generic illustration of a centralised concept.

[4] Given that i-Nord is a system developed for e.g. crisis management.

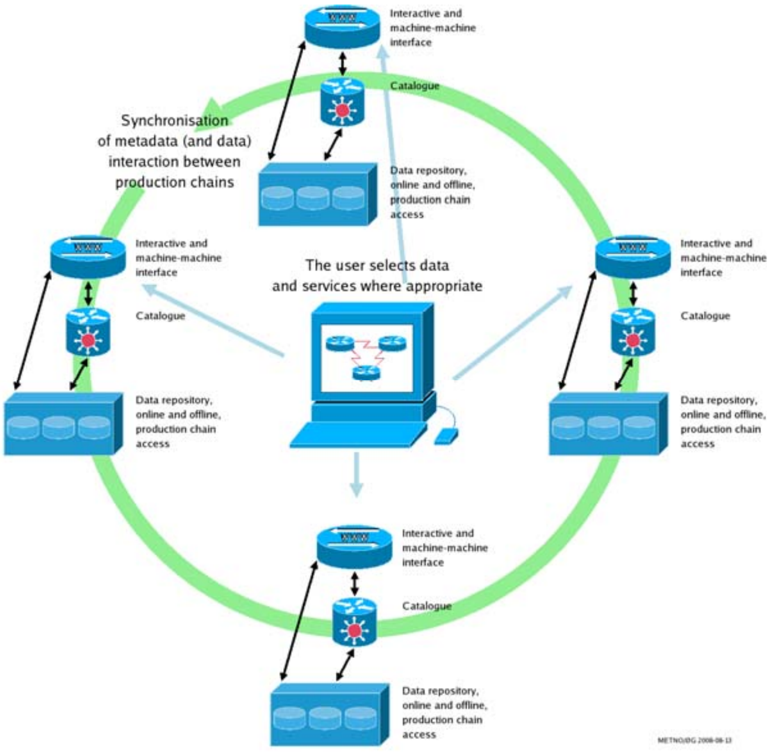

Figure 9 Generic illustration of a decentralised concept.

It is believed that the decentralised solution is the most sustainable and the preferred one within i-Nord. The data and service providers are responsible for the quality of the data, products and services they offer. Interaction between elements of the system is achieved by use of Service Level Agreements and the i-Nord infrastructure.

3.3 Backend services

3.3.1 Introduction

The services related to the areas described below may rely on resources distributed over several institutions. The basic philosophy follows the philosophy of ISO topic categories. The backend provides access to data, information and e.g. processing services within the area of responsibility. Services may be catalogue services, maps, statistics as well as processing capabilities and serving the raw[5] data.

3.3.2 Climatology/Meteorology/Atmosphere

These services contain information, datasets and resources describing the atmosphere and atmospheric phenomena. It will rely on resources made available by the Norwegian Meteorological Institute, AVINOR, Institute of Marine Research, Fugro Oceanor, Kongsberg Satellite Services, Norwegian Polar Institute, Norwegian Pollution Control Authority, etc.

3.3.3 Oceans

These services contain information datasets and resources describing the oceans and oceanographic phenomena like tides, currents, physical properties etc. It will rely on resources made available by Institute of Marine Research, Sjøkartverket, Norwegian Meteorological

[5] Quality controlled and flagged/tagged with quality levels.

Institute, SINTEF, FUGRO OCEANOR, Nansensenteret, Norwegian Pollution Control Authority, etc.

3.3.4 Biota

These services contain information, datasets and services describing ecology, stock, fisheries, marine mammals, birds and habitats etc. It will rely on resources made available Norwegian Polar Institute, Institute of Marine Research, Norwegian Institute for Nature Research, Norwegian Pollution Control Authority, Directorate for Nature Management etc.

3.3.5 Economy

These services contain information, datasets and services describing economic activities. This may be fisheries, aquaculture, and other exploration or exploitation of natural resources like oil and gas. It will rely on resources provided by the Norwegian Petroleum Directorate, the oil industry, Directorate of Fisheries etc.

3.3.6 Transportation

These services contain information, datasets and services describing resources used to transport people and goods. E.g. shipping routes, vessel locations, vessel information, roads, airports etc. It will rely on information provided by Norwegian Coastal Administration, Defence Systems (when available), Norwegian Public Roads Administration, etc.

3.4 Frontend services

3.4.1 Introduction

The front end services are the applications used by the primary users defined for the project. These applications rely on data and services made available by the backend systems.

3.4.2 Client side applications

The presentation tier generally is present on the client hosts. Four different cases exist, having different impact on security, system management, development and deployment:

1. Local standalone application.
2. Web applications - Web applications that residing in a web server in the application tier are downloaded on demand by the user and executed in a web browser.
3. Dedicated client applications - A purpose built client tightly coupled to a server application is installed and executed on the users work station.
4. Terminal server clients - Client software executing on the client workstation, all application executes remotely on the terminal server and is accessed by the thin client. The client can also execute on thin client hardware.

In most existing systems the case 1 is combined with 2, 3 and 4. Cases 2 and 3 simplify system management by minimizing the need of software installation on the client hosts. The presentation tier is usually the only tier that users can access directly, unless they are system or security administrators.

In this architecture Web application, is the primary choice. However Local standalone application could also be considered if the have the capability to consume OGC compliant services.

Communication between client hosts normally goes via the Application tier with the possible exception of audio and video streams. The Figure 10 shows an architecture with a web application that consumes a OGC compliant Web Map Service.

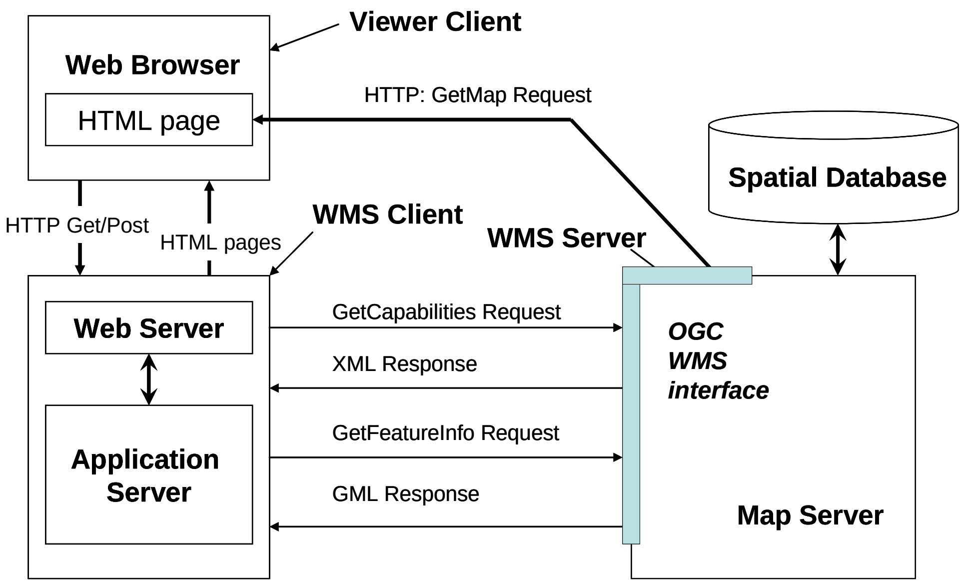

Figure 10 Web application that consumes a OGC compliant Web Map Service

The viewer client is a series of HTML pages running inside a Web browser that can interact directly with a map server via the HTTP profile of the OGC Web Mapping Interface. WMS client manages the interactions with OGC web mapping interfaces via HTTP, and dynamically generates HTML that can run in the Web Browser. WMS server is a map server that provides three OGC Web Mapping Interfaces (GetCapability, GetMap, and GetFeatureInfo). WMS server accepts requests from WMS client and viewer client in the form of HTTP URL strings, and returns results encoded as XML, GIF, GML, and so on. The database stores geo-feature data that can be accessed and utilised by the WMS server to generate GML documents or draw maps.

As illustrated in Figure x1, the user interacts locally with Viewer Client and submits HTTP GET/POST requests to the WMS client. The web server in the WMS client accepts user requests and parses them before forwarding them to the application server. The application server then processes these requests in an application, and returns dynamically generated HTML pages to the web browser.

3.4.3 Considerations for a client

The following section highlights some criteria that should be considered when selecting OGC WMS client applications:

- Ease of parsing XML/GML: Parsing XML/GML documents are an important task to be achieved by these clients, since WMS and more significantly WFS (Web Feature Service), will utilise e XML/GML to transfer information. The ease with which clients that process XML/GML can be implemented will be influential in determining which approach is adopted for client development.
- Map handling: Retrieving and organising image maps are another key issue that needs to be addressed in a WMS client application. The maps that could be retrieved from one server or different servers, could present a common area or different extents on the earth, or may be overlapped for display to the user. In addition, changing the order of overlapping maps may result in different effects.

- Multiple server interaction: In a distributed system, a client may wish to allow information from different servers to be retrieved and then merged into a single cohesive response for display to the user. The issue to be addressed here is the extent to which the implementation of such processing within a client is supported.
- Interface layout: WMS client applications use the web browser as the user interface. How easily a client can generate dynamic web pages is an important issue need to be considered.
- Execution speed: Speed is a factor that always been used to measure the efficiency of an application or a program. The issues to be addressed here include the speed of compiling, the speed of request handling, and the speed of pages loading.
- Ease of revision: It is normal to modify an established page and application by adding or cutting some components and functions during the development. The issue addressed here is to critique how easily the client can make changes or upgrades based on the previous work with the three approaches.

4 Standards

4.1 Introduction

Web services should preferably be implemented using RESTful technology. That technology scales well, can have several security mechanisms, is easy to maintain and error check as well as has the benefit (due to scaling) to serve a large public community as well (e.g. the experience gained through http://yr.no/). Other important factors are to focus on existing OGC standards for all parts of the system. OGC provide several standards that can reduce the amount of data transferred using filters and boundary boxes and also give the user the ability to control the visual portrayal of the geospatial data. A filter expression can logically combines constraints on the properties of a feature in order to identify a particular subset of features to be operated upon.

The standards listed below are the ones basically exposed through INSPIRE, WIS and GEOSS documents. Future interoperability perspectives all relate to some OGC specification, sometimes to the ISO version of the OGC specification (e.g. ISO19128 for OGC WMS).

4.2 Metadata

The most widely used metadata standards are ISO19115 and various profiles of this (e.g. the WMO Core Profile) for spatial data sets and ISO19119 for service metadata. ISO19115 do however have some insufficiencies concerning controlled vocabularies. A thorough investigation of such would be required in the main project. Especially when concerned with metadata it is expected that the system will have to support several standards as well as mappings between them. The need for controlled vocabularies without reinventing the wheel is especially important as this may be resource consuming effort. Existing international activities within meteorology, oceanography, biology, geology should be thoroughly investigated and preferably addressed whenever insufficiencies are discovered.

4.3 Services

4.3.1 Introduction

Web services should preferably be implemented using RESTful technology. Representational state transfer (REST) is a set of principles of how to define and address resources in a network. It is also often used to describe interfaces that use HTTP as the transport mechanism avoiding any additional message or session control layers like Simple Object Access Protocol (SOAP) or HTTP cookies.

The services specified are mainly the ones addressed by WIS, INSPIRE or GEOSS (OGC CSW, WMS, WFS and WCS), OGC SWE will be considered to ensure flexibility in the future although it is yet not clear how it will be utilised within the operational system.

4.3.2 Catalogue Services for the Web (CSW)

The system must rely on OGC CSW catalogues specifying data, products and services. CSW can be implemented several ways, but in the current situation REST style is preferred due to robustness, scalability, and security. Whether ISO23950 binding of CSW should be implemented or not is to be determined within the main project, but that is definitively preferable due to INSPIRE, GEOSS and WIS requirements.

4.3.3 Web Feature Service (WFS) / Web Feature Service Transactional (WFST)

WFS should be used to serve non gridded data online.

4.3.4 Web Coverage Service (WCS)

WCS should be used to serve gridded data.

4.3.5 Web Map Service (WMS)

Visualisation should be implemented using WMS. Challenges are related to how WMS handle multiple time specifications, vertical levels and datum references. The latter is especially important when combining layers from various WMS servers (e.g. MapServer). Furthermore, the performance of WMS is of concern. This may be solved by tiled WMS.

4.3.6 Web Processing Service (WPS)

Interaction between production chains are implemented using REST style web services defined by the OGC WPS when this is mature enough and given that is acceptable by security requirements. Basic REST services are used where possible until WPS is acceptable.

4.4 Other protocols

4.4.1 OpeNDAP

OpeNDAP (http://www.opendap.org/) is a cost effective interface providing distributed online access to several types of data. It supports a limited number of file formats which however are widely used as standard file formats and adaptors may be created to extend this list. It also gives access to a relatively large amount of data already available elsewhere that may be utilised by the system in combination with the data covered by the system and partners therein.

OpeNDAP and WCS can be offered for a wide range of products using THREDDS Data Server (TDS). TDS also offers access policies at data set level. The WCS support of TDS is experimental.

OpenDAP will be used by GMES MyOcean and is currently widely used within geophysical communities. Enabling OpeNDAP support to the system vastly increases the amount of data that can be utilised by the system.

4.4.2 Multimedia Streaming

Multimedia streaming is multimedia that is being delivered by a streaming provider and is constantly received by, processed, and normally presented to an end-user at real time.

Datagram protocols, such as the User Datagram Protocol (UDP), send the media stream as a series of small packets. This is simple and efficient; however, there is no mechanism within the protocol to guarantee delivery. It is up to the receiving application to detect loss or corruption and recover data using error correction techniques. If data is lost, the stream may suffer a dropout. The Real-time Streaming Protocol (RTSP), Real-time Transport Protocol (RTP) and the Real-time Transport Control Protocol (RTCP) were specifically designed to stream media over networks. The latter two are built on top of UDP. Currently, the worldwide movement toward broadband and IP in the network has led to the various approaches for multimedia streaming real-time multi-media service delivery platforms (SDPs). These services have been implemented through the evolution of technologies that aim to enable the next generation of advanced telecommunication services, IP Multimedia Subsystem (IMS), and Fixed Mobile Convergence (FMC). Currently there is a proliferation of various, heterogeneous SDP designs, however there is a demand for standardisation to have a homogeneous, single modular infrastructure, preferable based on commercial of the shelf (COTS) hardware platforms, for service delivery beyond IMS to boost the convergence of e.g. Session Initiation Protocol (SIP)[6] based IMS, SOAP based IP-TV services and service combinations.

Today's standard approach to overcome infrastructure heterogeneity IMS as proposed by 3GPP for conversational services, can only be a part of the answer. Application servers and SDP's practice convergence solely on application level, which still does not resolve the "stove pipe" issue of a multitude of separated application environments

[6] IETF standardization body

5 System design

5.1 Introduction

i-Nord must implement functionality to support:

1. Acquisition of real time, near real-time and historic data and products from new observation systems as well as existing observation systems. Data are made available through services and can be utilised within internal and external applications of i-Nord.
2. Distributed processing through linkage of existing and new processing chains. New processing functionality could be added when data from several systems are combined and correlated.
3. Dissemination of information (including messages). Data and services are made available to the user community via single window. Catalogues services are used to achieve a unified view of the data and services which are available to the users. Message services are used for secure communication between relevant users. Real time sub setting of data and information is required to provide information in the condensed form required to serve the needs of users relying on low bandwidth connections.

The above mentioned functions may be used in an open environment, but there is a specific need for security mechanisms controlling who has access to which services within the system. Security is an overarching task within i-Nord.

5.2 System design process

i-Nord will be a distributed system utilising existing infrastructure and in line with international requirements represented by INSPIRE, WIS and GEOSS. All these represent the new generation of systems which all are distributed in nature and utilise Service Oriented Architecture to interface existing infrastructure.

The main challenge when designing the i-Nord system is the variety of sub systems and applications the system shall serve. i-Nord is linking communities with very different requirements and expectations of the i-Nord content and performance.

i-Nord shall facilitate mechanisms for sharing data, processing resources and information both in an open environment as well as in a secure manner. That is, the system shall support both the general public and governmental agencies in need of secure communication of information and data. All requirements need to be identified along with user communities. It is important to realise that i-Nord shall not affect the internal systems of participating entities but interface these. Furthermore, i-Nord must comply with international technical requirements represented by INSPIRE, WIS and GEOSS requirements. This implies in short that OGC standards CSW, WMS, WFS, and WCS, and ISO standards ISO19115, ISO19119, and ISO23950 must be supported. Other standards should be supported wherever beneficial for the system, e.g. by the amount of additional data that may be available within the system by adding such interfaces.

All functional and technical requirements must be identified, documented and related to specific user communities within or external to the system. All functional requirements must be described using use cases.

The functional and technical requirements must be broken down into a detailed specification which is suitable for implementation. The detailed specification must be unambiguous when used for implementation.

i-Nord will use known technology and standards wherever possible. When the functional and technological requirements along with the detailed specifications identify tasks that cannot be solved using known technology or standards, research and development is required. This should however preferably be done through existing bodies and by influencing the relevant standards. Research and development in such situations must be closely related to the user requirements whether internal to i-Nord or external.

The technology and standards identified has to be implemented and used to integrate existing infrastructure. This is a stepwise task and requires strong coordination within the project to achieve the functional requirements identified. A specific test plan has to be identified and followed to make sure the implementation comply with the requirements. The test plan should relate directly to functional and technological requirements identified.

5.3 System modelling

5.3.1 Viewpoints

It is acknowledged that specifications of complex system such as i-Nord are so extensive that no single individual can fully comprehend all aspects of the specifications. Furthermore, there are different interests in a given system and different reasons for examining the system's specifications. A business executive will ask different questions of a system make-up than would a system implementer. Viewpoint modelling has become an effective approach for dealing with the inherent complexity of large distributed system specifications. Current software architectural practices, as described in IEEE Std. 1471, divide the design activity into several areas of concerns, each one focusing on a specific aspect of the system. ISO RM-ODP is probably the best known and referenced viewpoint modelling framework other examples include the "4+1" view model, the Zachman framework, TOGAF and DoDAF

The concept of ISO RM-ODP viewpoints framework is to provide separate viewpoints into the specification of a given complex system. These viewpoints each satisfy an audience with interest in a particular set of aspects of the system. Associated with each viewpoint is a viewpoint language that optimizes the vocabulary and presentation for the audience of that viewpoint. Although separately specified, the viewpoints are not completely independent; key items in each are identified as related to items in the other viewpoints. Moreover, each viewpoint substantially uses the same foundational concepts (defined in Part 2 of RM-ODP). However, the viewpoints are sufficiently independent to simplify reasoning about the complete specification. The mutual consistency among the viewpoints is ensured by the architecture defined by RM-ODP, and the use of a common object model provides the glue that binds them all together.

The RM-ODP framework provides five generic and complementary viewpoints on the system and its environment:

- The enterprise viewpoint, which focuses on the purpose, scope and policies for the system. It describes the business requirements and how to meet them.
- The information viewpoint, which focuses on the semantics of the information and the information processing performed. It describes the information managed by the system and the structure and content type of the supporting data.
- The computational viewpoint, which enables distribution through functional decomposition on the system into objects which interact at interfaces. It describes the functionality provided by the system and its functional decomposition.
- The engineering viewpoint, which focuses on the mechanisms and functions required to support distributed interactions between objects in the system. It describes the distribution of processing performed by the system to manage the information and provide the functionality.

- The technology viewpoint, which focuses on the choice of technology of the system. It describes the technologies chosen to provide the processing, functionality and presentation of information.

5.3.2 Architectural framework

In a complex system like i-Nord it is important to have a good understanding of both the business architecture and the IT architecture related to the system. Recent work in the area of Enterprise architecture provides a foundation for this with architectural framework standards like Ministry of Defence Architecture Framework (MoDAF), Department of Defense Architecture Framework (DoDAF), Federal Enterprise Architecture (FEAF) and NATO Architecture Framework (NAF). Furthermore there is supporting methodologies like The Open Group Architecture Framework (TOGAF). Also the Object Management Group (OMG) has recently adopted UPDM (UML Profile and Metamodel for DoDAF and MODAF) as a standard UML profile for creating such models, and the BPMN (Business Process Modeling Notation) as a standard language for describing related Business processes.

5.3.3 System Models

The service oriented architecture of i-Nord should be specified using appropriate modelling techniques. It is suggested to use UML 2.0 for this purpose, in particular taking advantage of the port-connector model of UML 2.0 and the new SoaML (Service oriented architecture Modeling Language) standard. Model driven technologies can support the mappings from these models to the chosen realisation platform and technologies such as web services.

This is consistent with the modelling approach of ISO/TC211 and OpenGIS which successfully have used these principles as a basis for the development and standardisation of open geospatial services. See ISO 19103 and ISO 19119 (also OpenGIS Geospatial service architecture).

6 Realisation

6.1 Introduction

Given the various existing systems that has to be integrated as well as the new functionality and methods needed to fulfil the ambition of the project, it has to evolve over time. The first version will be a version merely integrating existing systems that more or less comply with SOA. These systems will use interfaces that do not fully comply with the wanted standards, but will result in a basic functionality quite fast. Then existing and new systems are developed to comply with the interface specifications required. This may be done in a leap frog scheme making new developments available to the users more or less continuously. When the interoperability framework is getting in place addition of new functionality, sensor systems, analysis tools etc is initiated. This is a process that will have to be performed in parallel with examination of new technology or other adaption of the system to keep it operational.

The i-Nord system will be developed in several phases adding functionality and products more or less continuously within these phases.

6.2 Elements

The i-Nord system will be divided into two main parts:

- Backend is the distributed services offered by the data and service providers. It covers DAR interfaces as well as processing services and higher end products (e.g. WMS-layers) according to agreed specification (to avoid inconsistencies when used in clients). Observation systems would be part of the i-Nord backend and access to data from the observation systems would be backend services.
- Frontend is the client side element of the system. It is the tools used by the users and that provides access to the data and services offered by the backend.

6.3 Organisation

Setting up a system like i-Nord is a commitment on long term. The system has to be able to evolve and adapt to changing requirements as well as being easy and not least cost effective to maintain. Some sort of coordination is required to ensure that the backend and the frontend of the system as well as potential security aspects handled in a continuous manner. The system and the organisation of the project should be done in a manner capable of adapting to a completely new operation environment where users can specify/develop their own clients or procure these wherever they find it cost effective. This is achieved by using open standards and a scalable and modular solution.

7 Demonstrator

7.1 Background

The demonstrator is set up to illustrate the type of services and interfaces that is to be developed within the main project. It should demonstrate elements of the functionality required by the main project. It does not conform to the standards wanted for the final service, but should in most aspects illustrate functionality of the final system. The demonstrator is established using existing systems operated by the partners of the project. These systems may be part of the final system after further development bringing them to a certain international standard. Furthermore, the demonstrator scenarios should be event rather than management driven.

The demonstrator will serve two tasks:

1) How i-Nord can use existing data-sets and present relevant information in an integrated manner
2) What is missing with existing data, system architecture etc. to serve as an even better tool for strategic and tactical management.

7.2 Scenarios

Scenarios are listed in chapter 12. These scenarios are elaborated using a visual presentation based upon video techniques. No functional demonstrator is provided.

7.3 Implementation

A demonstrator is being designed and built using Demonstrator Scenario 1. The demonstrator will be built as a movie by an external company with extensive use of animations.

8 Acronyms and Definitions

Acronym	Description
CSW	Catalogue Services for the Web
DODAF	Department of Defense Architecture Framework
PKI	Public Key Infrastructure
MODAF	Ministry of Defence Architecture Framework
NAF	NATO Architecture Framework
OGC	OpenGeoSpatial Consortium
SAS	Sensor Alert Service[7]
SOA	Service Oriented Architecture
SOS	Sensor Observations Service[7]
SPS	Sensor Planning Service[7]
SWE	Sensor Web Enablement
TOGAF	The Open Group Architecture Framework
WFS	Web Feature Service
WCS	Web Coverage Service
WMS	Web Map Service
WNS	Web Notification Services[7]
WPS	Web Processing Service

[7] Part of SWE.

9 Annex A – Production chains

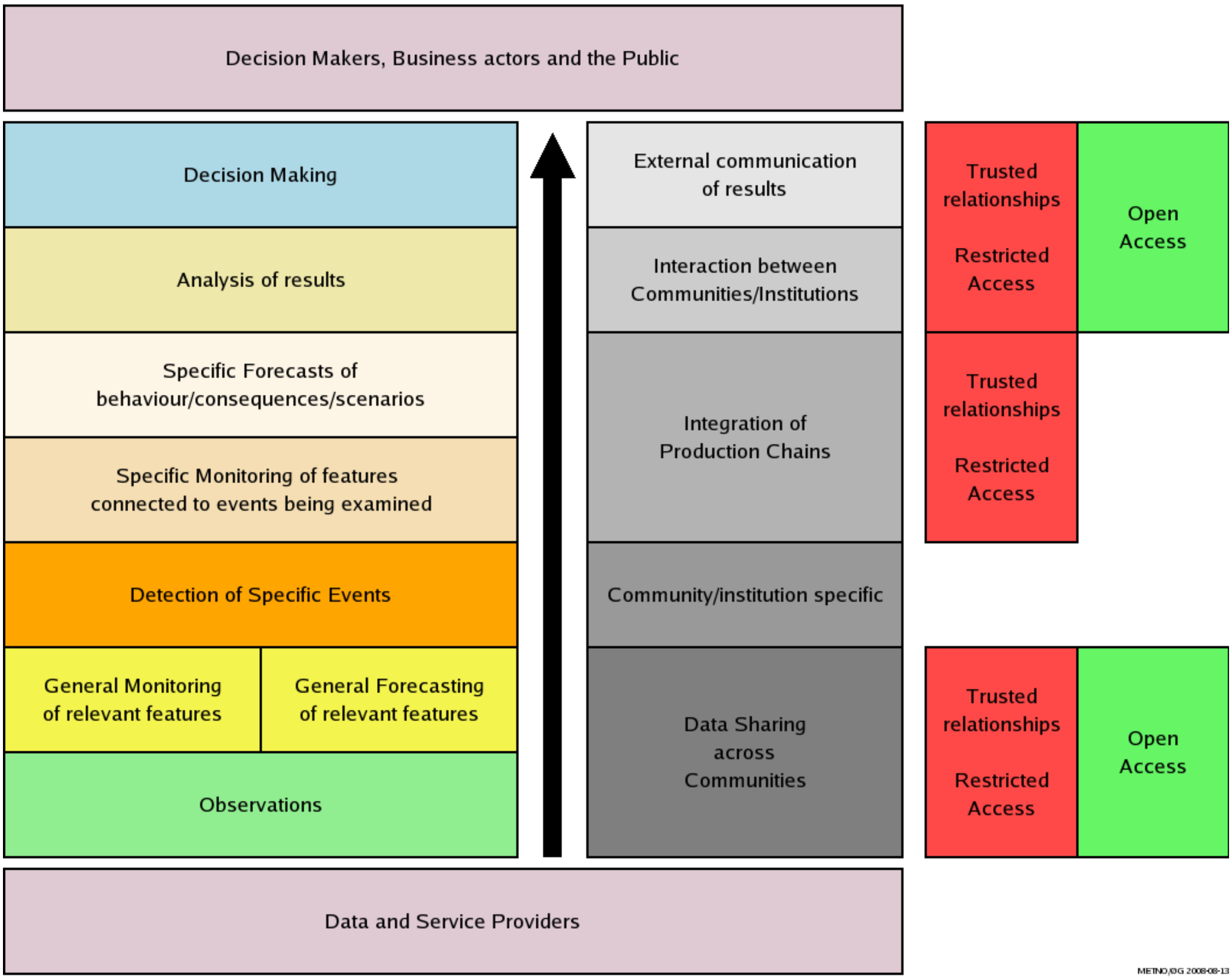

Figure 11 Generic illustration of the functionality required by the system.

Figure 11 contains 3 main columns and reflects the process of communication between data and service providers and users of the system.

The left column describes a generic production chain that may be part of the system. It is based upon observations, analysis of observations and forecasts using the observations, detection and monitoring of specific events, specific forecasting of elements critical for understanding events and analysis. This process may be the process of weather forecasting polar lows, oil spill from shipping, algae blooming, etc. This is what is being done by several institutions nationwide today. The intention of i-Nord is to integrate data, products and services from various service providers to get a better overview and background for decisions in the area covered.

The middle column (greyish) represents scope of the processes involved. Some of the processes are the responsibility of a single institution while others will require interaction between several institutions (e.g. by preparing input data for models operated by another institution, running forecasts on demand or providing access to data).

The rightmost column illustrates the access privileges required to maintain integrity throughout the process. A system fulfilling the intention of i-Nord cannot be open to everybody everywhere (red boxes). However it can use open data wherever possible and open interfaces (green box) to the system is needed to serve some of the potential users of the system (e.g. the public).

The main challenge of the project is how to integrate, and offer open interfaces to the system and at the same time maintain integrity of the various production chains and potential users involved.

It is believed that a service oriented architecture (SOA) is the best solution for such a complex system.

Given the wide range of potential users expected, ranging from highly specialised users e.g. Hovedredningssentralen, LDKN, Kystverket etc, to the ordinary public, it is expected that several interfaces to the system has to be developed. How the user interfaces should be developed has to be decided in dialogue with the users themselves. Towards the public, the natural solution if to use an interface created for an ordinary web browser providing access to OGC WMS presentations along with additional graphical presentations (time series, profiles, wind/current roses etc.) as well as textual information. Interfaces towards more advanced user may also use web browsers, but another option is to provide portable applications, dedicated for the specific use of that user, that may operate in a wide variety of environments and that connects to services offered within the system using the necessary security mechanisms (username/password, IP-address, VPN, PKI, etc) required to maintain system integrity.

10 Annex B - Use Cases

10.1 Introduction

The use cases described are by no means complete and need further elaboration.

The following user groups (actors) will use the I-Nord system:

Data Publisher	<Explain what data publishers will use the system for>
Data User	<Explain what data users will use the system for; outline what specialisations of data user can occur, e.g. decision-maker, policy-maker, scientist, etc>
i-Nord partner	<Explain what data users will use the system for; outline what specialisations of data user can occur, e.g. decision-maker, policy-maker, scientist, general public, etc>

These user groups will use the system for different purposes, as outlined in the step-wise descriptions of high-level operations (use cases) given below.

The following table explains the elements of the Use Case template used in this report. The use cases defined are high level use cases that should be broken down during the design process.

Table 2 Key elements to use in the Use Case specifications.

Use Case Goal - Brief description of the reason for and outcome of this Use Case, or a high-level description of the sequence of actions and the outcome of executing the Use Case.
Actors - An actor is a person or other entity, external to the system being specified, who interacts with the system (includes the actor that will be initiating this Use Case and any other actors who will participate in completing the Use Case). Different actors often correspond to different user classes, or roles, identified from the customer community that will use the product.
Trigger - Event that initiates the Use Case (an external business event, a system event, or the first step in the normal flow.
Pre-conditions - Activities that must take place, or any conditions that must be true, before the Use Case can be started.
Post-conditions - The state of the system at the conclusion of the Use Case execution.
Normal Flow - Detailed description of the user actions and system responses that will take place during execution of the Use Case under normal, expected conditions. This dialog sequence will ultimately lead to accomplishing the goal stated in the Use Case name and description.
Alternative Flows - Other, legitimate usage scenarios that can take place within this Use Case.
Exceptions - Anticipated error conditions that could occur during execution of the Use Case, and how the system is to respond to those conditions, or the Use Case execution fails for some reason.
Includes - Other Use Cases that are included (“called”) by this Use Case (common functionality appearing in multiple Use Cases can be described in a separate Use Case included by the ones that need that common functionality).
Notes and Issues - Additional comments about this Use Case and any remaining open issues that must be resolved. (It is useful to Identify who will resolve each such issue and by what date.)

10.2 High level features needed

Use Case 1 Sharing public available data or products

Use Case Goal	Data or products are made available to users within and external to the system.
Actors	Data Publisher
Pre-Conditions	• The Data Publisher is authorised to perform the action • The Data Publisher has the necessary meta information
Post-Conditions	• Metadata corresponding to the data set is available in a catalogue • The actual data set is available online and linked from the metadata • Metadata and data are tagged as freely available
Normal Flow	1. The Data Publisher use a human or machine interface of the system to upload metadata, including distribution statement, for a given data set 2. Metadata are checked, errors reported or metadata accepted for publishing 3. If metadata are accepted, data are accepted and made available online 4. Metadata are made available in the online catalogue 5. Metadata are synchronised between catalogue nodes in the system
Notes and Issues	Public available data may be located outside the i-Nord system, but used within and must be handled accordingly.
Last Updated	2 October 2008
Last Updated By	Øystein Godøy

Use Case 2 Sharing confidential data or products

Use Case Goal	Data or products are made available to users within to the system.
Actors	Data Publisher
Pre-Conditions	• The system can handle trusted networks • The Data Publisher is authorised to perform the action • The Data Publisher has the necessary meta information
Post-Conditions	• Metadata corresponding to the data set is available in a catalogue • The actual data set is available online and linked from the metadata • Metadata and data are tagged as confidential and handled accordingly
Normal Flow	1. The Data Publisher use a human or machine interface of the system to upload metadata, including distribution statement, for a given data set 2. Metadata are checked, errors reported or metadata accepted for publishing 3. If metadata are accepted, data are accepted and made available online 4. Metadata are made available in the online catalogue 5. Metadata are synchronised between catalogue nodes in the system
Notes and Issues	Whether this information should be located in a different catalogue or subsystem is to be determined according to the possible restrictions by relevant authorities.
Last Updated	2 October 2008
Last Updated By	Øystein Godøy

Use Case 3 Accessing public available data or products

Use Case Goal	Access and use public available data and products
Actors	Data User

Pre-Conditions	• The metadata catalogue is available for browsing and searching • The metadata catalogue have been properly synchronised within the nodes contributing to the system
Post-Conditions	• The Data User receives the information requested
Normal Flow	1. The Data User use a human or machine interface to browse or search the catalogue (e.g. by temporal period, geographical extent, parameter or keywords) 2. The Data User receives information on the data or products requested provided the data are tagged as freely available 3. If the Data User requests the actual data set or product this is made available through the service requested.
Notes and Issues	• It should be decided whether the system should support subscription as well as ad hoc requests. • Data and products may be served to the users in many ways.
Last Updated	2 October 2008
Last Updated By	Øystein Godøy

Use Case 4 Accessing confidential data or products

Use Case Goal	Access and use confidential data and products
Actors	Data User
Pre-Conditions	• A user catalogue and trusted relationships/networks are available • The metadata catalogue is available for browsing and searching • The metadata and data are tagged as confidential and accompanied by a distribution statement • The metadata catalogue have been properly synchronised within the nodes contributing to the system
Post-Conditions	• The Data User receives the information requested
Normal Flow	1. The Data User is authenticated and authorised access according to the user catalogue 2. Trusted relationships/encryption is used if required 3. The Data User use a human or machine interface to browse or search the catalogue (e.g. by temporal period, geographical extent, parameter or keywords) 4. The Data User receives information on the data or products requested provided the data are tagged as freely available 5. If the Data User requests the actual data set or product this is made available through the service requested.
Notes and Issues	• Security mechanisms are likely to be subject to national regulations. • It should be decided whether the system should support subscription as well as ad hoc requests. • Data and products may be served to the users in many ways.
Last Updated	2 October 2008
Last Updated By	Øystein Godøy

Use Case 5 Integration of production chains

Use Case Goal	Linking different production chains
Actors	i-Nord partner Numerical Models

Pre-Conditions	• Service Level Agreements • Service Catalogue • Trusted relationship/encrypted network • A production chain needs input from another production chain (e.g. updated atmospheric or oceanographic forecasts)
Post-Conditions	• New product
Normal Flow	1. Input data are requested (on ad hoc or routine basis) from another element in the i-Nord system according to the specification provided in the service catalogue 2. Processing is initiated using the initial conditions provided (either through the ad hoc request or through routine specification) 3. Processing ends with a message to the Requester and either direct delivery of or information on where to find the product 4. The Requester gets the data and initiates the local processing
Notes and Issues	• This may be necessary both on routine (e.g. when the production chain involves several partners) and ad hoc basis (e.g. when handling an oil spill or other pollution/accident) • It may be necessary to nest several production chains
Last Updated	2 October 2008
Last Updated By	Øystein Godøy

Use Case 6 Utilisation of sensor networks

Use Case Goal	Collection and distribution of data, i.e., observations or measurement, from the surrounding in a controlled and dependable manner (e.g., physical environmental data by an underwater wireless sensor network, satellite image by satellite communication, real-time video&audio streaming, etc.)
Actors	Data User, e.g., in cirsis management, or i-Nord partner Numerical Models.
Pre-Conditions	• Necessary and trusted Service Level Agreement (SLA) • Dependability requirements satisfied, in case of crises and emergency • Either 1. Sensor Service Catalogue available, or 2. Sensor Alert / Notification Service enabled by client • Client (i.e., receiving system/equipment) has the capacity needed, in case of streaming. • Client receives data and streams based on known quality, formats and standards.
Post-Conditions	• Sensor data received according to SLA • Sensor network recovery and evaluation according to operational policies. • Traceability of the data collection is accounted for.
Normal Flow	1. Sensor Service discovery enabled 2. Sensor Observation Service and Client interconnect established. 3. Collection of data, e.g., physical environmental data by autonomous sensors connected by an underwater wireless network. 4. Distribution (in real time) to the receiving systems, e.g., critical data for crisis management purposes. 5. Either: 1. Decisions in case of real-time use, e.g., in case of emergency, or

	2. Raw data received for further refinement, e.g., in a production chain.
Notes and Issues	For i-Nord autonomous sensor networks will be very important in the future, e.g., for marine underwater surveillance. Applications could be either long-time monitoring or short time high intensity operations in situations of accidents or impending disasters. In particular ad-hoc sensor networks could then be deployed and activated quickly at local site in case of accidents etc. Data collection and real-time distributions of critical actual data for crisis management purposes will then be a reality. Commercial operational systems are not available today, but could be realized relatively quickly, based on known technology.
Last Updated	17 December 2008
Last Updated By	Bjørn Skjellaug

Use Case 7 Communication of results to the public

Use Case Goal	Dissemination of relevant information to the general public
Actors	The general public
Pre-Conditions	• An existing in-Nord infrastructure containing catalogues of data and services and access to these
Post-Conditions	• Information and products to the general public
Normal Flow	1. A user requests some information through a web portal solution 2. Catalogue services are used to identify the required services 3. Data services utilise catalogue services to find the requested information, data or product 4. Results are presented to the user
Notes and Issues	
Last Updated	12 January 2009
Last Updated By	Øystein Godøy

Use Case 8 Communication of results to decision makers

Use Case Goal	Dissemination of relevant information to decision makers
Actors	Decesion makers
Pre-Conditions	• An existing in-Nord infrastructure containing catalogues of data and services and access to these • The system can handle authentication/authorisation and the user has access to the information requested
Post-Conditions	• Information and products to decision makers
Normal Flow	1. A user requests some information through a web portal solution 2. Catalogue services are used to identify the required services 3. Data services utilise catalogue services to find the requested information, data or product 4. Results are presented to the user
Notes and Issues	
Last Updated	12 January 2009

Last Updated By	Øystein Godøy

Use Case 9 Integration of value added analyses

Use Case Goal	Integration of production chains
Actors	Data producers
Pre-Conditions	• Trusted network • Catalogues • Processing interfaces • Data interfaces
Post-Conditions	• New product based upon input from many production chains
Normal Flow	1. A new production instance is initiated 2. I-Nord catalogues are examined for the distributed data and services needed to fulfil the current production 3. External processing is requested 4. External data and products are requested 5. Local production is initiated 6. Results are published through catalogues
Notes and Issues	
Last Updated	12 January 2009
Last Updated By	Øystein Godøy

11 Annex C - Existing infrastructure

Table 3 Operational environment, data and services at Institute of Marine Research (IMR).

IT-strategy	The information technology environment at IMR is mainly based on Open Standards and Open Source software. The IT department is responsible for operating the Linux and Windows servers. They are guaranteed operational during working hours on work days, 8 hours, 5 days, but are usually operational outside working hours as well. The operational data flow varies from different systems. Data are downloaded from surveillance buoys every hour, fixed coastal stations within the first 24 hours since measurement were taken and research vessels every 24 hours during night time. This system collects observations and distributes results to users and the public community. Systems for data/product distribution and presentation has been and are being developed in various projects, these are now being harmonised to reduce operation costs. Visual presentation of data is done through WMS servers, Web pages and data queries on different web sites. The programming languages that are accepted for operational use are primarily PHP and Java. The open data policy of the institute confirms to OECD principles and other international accepted policies.
Operationality	8/5 monitoring by data centre staff.
Production environment	• Mainly Linux Enterprise Edition 4, but some Windows 2003 servers
Programming languages	• C/C++ • Fortran in various flavours • Perl, Python • PHP, Java
Service technology	• WMS • WCS, WFS and CSW are being examined • THREDDS Data Server (offering OpeNDAP and WCS) is being tested • Hyrax OpenDAP for Java is being tested • OAI-PMH and DigIR for metadata harvesting is being tested.
Existing public services	• http://mareano.no/ (MAREANO portal, WMS, ArcIMS, JavaScript) • http://data.nodc.no/stasjoner (Fixed hydrographical stations, PHP PostgreSQL) • http://data.nodc.no/termograf (Coastal steamer, thermograph, salinograph) • http://data.nodc.no/observasjonsboye (Surveillance buoy in Hardangerfjord) • http://atlas.nodc.no/website/havets_ressurser (Distribution maps WMS ArcIMS) • http://maps.nodc.no/sonate (Distribution maps WMS Mapserver) • http://www.dokipy.no (IPY data management portal) • http://www.imr.no/datakatalog (IMR dataset catalog) • Data services pushing data to METNO, to be used at kilden.no.

Table 4 Operational environment, data and services at The Norwegian Coastal Administration (NCA).

IT-strategy	MS Windows, extensive use of consultants (3 companies) for software

	development based upon specifications written in house.
Operationality	Several 24/7 systems monitored by operators. Vi har flere 24/7 overvåkingsystemer systemer som monitoreres av operatører, VTS-systemer, AIS-systemer, bølge og strømvarsling.
Production environment	Mainly MS Windows. Operational system are covered by UPS and are using hot standby servers.
Programming languages	Most systems are delivered by external contractors based upon specifications made in house. Systems are delivered as black boxes.
Service technology	• WMS
Existing public services	• SafeSeaNet • http://kart.kystverket.no/

Table 5 Operational environment, data and services at The Norwegian Polar Institute (NPI).

IT-strategy	The NPI production environment is based upon a combination of proprietary and open source software. The strategy is to use open standards and open source software whenever it is possible.
Operationality	All NPI products are produced off-line, but services are running at a 24/7 basis. There is no operators available at a 24/7 basis. The systems are serviced and maintained during normal working hours.
Production environment	• Windows • Centos and Suse Linux
Programming languages	• C/C++ • Perl • PHP • Java • Ruby • Zope/Python
Service technology	• WMS is under development • RESTful (HTTP/GET) is under testing • THREDDS Data Server is being examined • OAI-PMH, for metadata exchange is under testing
Existing public services	• http://risapi.data.npolar.no (RESTful framework for Science in Svalbard) • http://risapi.data.npolar.no/oai (OAI metadata service for Science in Svalbard)

Table 6 Operational environment, data and services at Nansen Environmental and Remote Sensing Center (NERSC).

IT-strategy	The production environment at NERSC is based on open standards and a combination of open source and commercial software. Majority of processing chains are automated and generate products on (average) daily basis. Products include many types of satellite data (e.g. SAR, ASAR, MERIS, MODIS,

	SSMI), in situ data for the North Sea (primarily) and numerical model forecasts for several areas (e.g. North Sea, Arctic, North Atlantic, Indian Ocean, Gulf of Mexico, Agulhas). Products are stored in standard formats (e.g. GeoTIFF, JPG, PNG, NetCDF) for distribution and display in web information systems. Web-GIS development is done in compliance with OGC standards. Metadata generation follow ISO standards, and we are in the process of automating generation as part of the established processing chains. NERSC is contributing to the development of several GMES services, e.g. Marine Core Services, through a number of international and national RTD projects.
Operationality	NERSC is an RTD organisation. Product generation is for the most part automated, but there is no 24/7 support in case of problems.
Production environment	• Primarily Linux (Red Hat)
Programming languages	• Matlab • Fortran • Python • PHP, Java and Ajax in web information systems
Service technology	• WMS • WCS and CSW under testing • THREDDS Data Server (offering NetCDF) in operation • WFS is being examined
Existing public services	• http://topaz.nersc.no (met-ocean forecasts) • http://www.arctic-roos.org/ (Arctic Regional Ocean Observing System; information and data products) • http://hab.nersc.no/ (HAB monitoring service for Norwegian Waters) • http://wms.nersc.no/norway/ (WMS service for Norwegian Waters) • http://wms.nersc.no/barents/ (WMS service for Barents and Kara Seas) • http://msc.nersc.no/ (Mohn-Sverdrup Center for Global Ocean Studies and Operational Oceanography; information and data products) • http://gcr.nersc.no/ (GCR Climate Institute)

Table 7 Operational environment, data and services at The Joint Coordination Rescue Centres. Not contacted yet.

IT-strategy	
Operationality	
Production environment	•
Programming languages	•
Service technology	•
Existing public services	•

Table 8 Operational environment, data and services for the Norwegian Armed Forces.

IT-strategy	Norwegian Defence Logistics Organization (NDLO) is responsible for the support of all operational information and communications activities in the military. This also includes procurement and investment, supply, maintenance and storage of materials. The Information and Communication Technology (ICT) division of the Logistic branch are committed to operate, maintain and develop the military's ICT systems and services. Focus is to make information available for the decision makers and at the same time uphold the best possible security level. This work is conducted in collaboration with the National Security Authority. Information harvest from different sources, also civilian, is crucial for obtaining the best possible situation awareness. The strategy is also changing from “need to know” to “need to share”. Hence, the I-NORD initiative can contribute to a more seamless dataflow between the Armed Forces and other stakeholders.
Operationality	24/7
Production environment	• Windows servers
Service technology	• WMS • Other OGC standards are being examined in accordance with NATO’s strategy for information sharing
Existing public services	• None
Existing services for other government agencies	Sharing sensor information with: • The Norwegian Coastal Administration (Radar) • Met.no (Weather information from the Coast Guards vessels and from some of the radar locations). • Avinor (Air traffic, radar) Deployable commando control systems for crises management.

Table 9 Operational environment, data and services at Kongsberg Satellite Services (KSAT).

IT-strategy	Kongsberg Satellite Services AS (KSAT) is a commercial Norwegian enterprise, providing services based on data from polar orbiting satellites such as Telemetry, Tracking and Command services (TT&C), Global data dump services and Operational Earth Observation. The KSAT Earth Observation (EO) products and services include near real-time and off-line products and monitoring services. KSAT has also developed strong interests and expertise in providing marine services from EO data. The company currently operates four ground stations; the Tromsø Station at 69°39´N 18°56´E , Svalbard Satellite Station (SvalSat) at 78°15´N 15°80´E., Grimstad, (South Norway) at 58°20´N 8°21´E and TrollSat 72°S 2°E. (Antarctica) These stations all have direct data capture systems that acquire the raw data from the satellite directly to disks. The Tromsø station is the prime site for direct downlink and for service production. The Svalbard station is applied for global on-board recorder dump, but can also be applied for extending the direct

	downlink coverage area in particular in the Arctic region. KSAT offers satellite based oil and ship detection services as the core products and services within marine monitoring. KSAT also focuses on developing new services based on user requirements, e.g. real-time image access for navigation, detection and tracking of icebergs and provision of wind speed and direction from SAR data. The KSAT processing facilities and distribution chain has been designed and developed explicitly for fast deliveries of data to customers with operational needs. The objective is to provide information to the customer in near real-time, which in this context means in less than 30 minutes. The services developed by KSAT include processing of standard image products and provision of operational oil and ship detection services. The ship- and oil spill detection services operational today utilises Radarsat-1, Radarsat-2 SAR-data and Envisat ASAR SAR-data. KSAT's services are operating in waters all over the world.
Operationality	The operational service has been provided on a 24/7 basis since 1997. The customers include national and international institutional as well as commercial users; pollution control authorities, defence and coast guards, offshore oil companies, shipping companies. During the recent 2-5 years KSAT has served the majority of the operational users in Europe having a need for operational oil spill detection.
Production environment	•
Programming languages	• Perl • Java • C++ • IDL and ENVI
Service technology	• WMS • Java
Existing public services	• European Maritime Safety Agency (EMSA) oil spill detection service • Ship detection • Image Anywhere – low bandwidth delivery system • Ice navigation support • Snow mapping

Table 10 Operational environment, data and services at The Norwegian Meteorological Institute (METNO).

IT-strategy	The production environment operated by METNO is based upon Open Standards and Open Source software. This concept has proven to be cost effective and reliable. All production is scheduled through a job control system that is monitored on a 24/7/365 basis by operators. This system collects observations (in situ, remote sensing, etc), operates numerical models (ocean, atmosphere, pollution, emergency response, etc.) and distributes results to users and the public community. Systems for data/product distribution and presentation has been and are being developed in various projects, these are

	now being harmonised to reduce operation costs. Public services that are offered include OGC WMS for visual presentations, Web Services to the Climate database and RESTful services to various data sets and products. No black box applications are allowed within the METNO production chain. The programming languages that are accepted for operational use are primarily Perl, Fortran, C/C++, however PHP and Java are also being used in Internet solutions. An important aspect for METNO when setting up various services is that new development should be available for use to fulfil the public commitment of the institute and it should not object to the open data policy of the institute. Furthermore, METNO may be part of various systems and can bring in operational experience. However, METNO will only guarantee operational services within an environment controlled by the institute. Services may however utilise products etc located elsewhere.
Operationality	24/7 monitoring by operators, Supervisor Monitor Scheduler) job control system. Production is divided in PriProd, FlexProd and TestProd classes. PriProd tasks are maintained within a hot redundancy environment, FlexProd in a fully UPS environment, and TestProd may vary.
Production environment	• Mainly Debian Linux
Programming languages	• C/C++ • Fortran in various flavours • Perl • PHP, Java mainly in internet/portal solutions,
Service technology	• WMS • WCS is being tested • WFS and CSW are being examined • RESTful (HTTP/GET) interface to data and products is operational • SOAP based web services to the climate database • THREDDS Data Server (offering OpeNDAP and WCS) is being tested • OAI-PMH for metadata exchange is being tested.
Existing public services	• http://yr.no/ (WMS, RESTful interfaces aimed towards the public) • http://api.met.no/ (RESTful framework) • http://eklima.met.no/ (Interactive interface to the climate database) • http://sharki.oslo.dnmi.no/wsKlima/start/start_no.html (Web services interface to climate data) • http://wms.met.no/ (WMS interfaces for various projects) • http://kilden.met.no/ (Interactive interface to data and processing capacities for governmental agencies) • http://ipycoord.met.no/, http://dokipy.met.no/ metadata and data interfaces for scientific projects within the International Polar Year.

Table 11 Operational environment, data and services at Fugro Oceanor.

IT-strategy	The production environment at Fugro OCEANOR is based on Microsoft Windows and Sun Unix. Real time buoy data are presented on a Web server for public or password protected access. The buoy data are transferred using an in-house encrypted data format, which can be transferred to other data formats such as text file, Excel, MS ACCESS, ODBC, GTS, Arkmin, Orkan, Log,

	ENSIS or MySql. All measured data are stored in Packet File Format (PFF), or an in-house developed data base (ORKAN) The programming languages used mainly are Fortran, C/C++ under UNIX, C++ in Microsoft Visual Studio, and MATLAB
Operationality	Operational with emergency alarm outside office open time.
Production environment	• Microsoft WINDOWS • Sun Unix
Programming languages	• C/C++ • Fortran in various flavours • Microsoft Visual Studio • MATLAB
Service technology	•
Existing public services	• http://www.oceanor.com/barents_sea • http://www.barentssea.no

Table 12 Operational environment, data and services at Directorate for Nature Management (DN).

IT-strategy	MS Windows, extensive use of consultants for data collection and service provision.
Operationality	NA
Production environment	• Microsoft WINDOWS
Programming languages	• NA
Service technology	• WMS
Existing public services	• http://www.dirnat.no/content.ap?thisId=2624 • http://dnweb12.dirnat.no/nbinnsyn/ • http://www.rovviltportalen.no/content.ap?thisId=500026686&language=0 • http://dnweb12.dirnat.no/wmsdn/ • http://dnweb12.dirnat.no/wmsdn/villrein.asp • http://dnweb12.dirnat.no/wmsdn/villrein.asp

Table 13 Operational environment, data and services at Norwegian Pollution Control Authority (SFT).

IT-strategy	MS Windows, extensive use of consultants for data collection and service provision.
Operationality	NA
Production environment	• Microsoft WINDOWS

Programming languages	• NA
Service technology	• WMS
Existing public services	• http://www.miljostatus.no/ • http://www.pib.no/

Table 14 Operational environment, data and services at Norwegian Institute for Air Research (NILU).

IT-strategy	The production environment at NILU is based on Microsoft Windows and various *nix flavours. NILU operates several data bases on behalf of various agencies. Some of these are available to a certain extent online through Internet although most of them only offer a limited number of discovery services.
Operationality	NA
Production environment	• Microsoft WINDOWS • Sun Ultrix • Red Hat
Programming languages	• PHP • .Net
Service technology	•
Existing public services	• http://luftkvalitet.info/

Table 15 Operational environment, data and services at Norwegian Institute for Water Research (NIVA).

IT-strategy	NIVA is working with development of monitoring systems, data modelling tools, ocean and ecosystem numerical modelling, GIS analysis applications, database systems and related services. NIVA has expertise in establishing complete monitoring solutions with a service chain reaching all the way from data acquisition to web presentation and access. NIVA has developed strong competences on realtime operational monitoring systems for environmental warning and decision-making. NIVA has established a main database which includes most of the data from the national monitoring programs. The Web-based portal, AquaMonitor, is developed for accessing and presenting data with GIS-functionality and several export formats. Data from AquaMonitor can also provide web-services as input to other systems. NIVA is also hosting several European environmental databases. Programming languages in use are VB.NET and ASP.NET used for developing web applications and windows applications. Java is used for some web applications. PL-SQL is used for programming Oracle database

	functionality. Some applications are developed with C /C#. LabView (NI) is used for developing monitoring applications with data logging and realtime operation NIVA is a partner in Norge Digitalt, which is a nation-wide program for co-operation on establishment, maintenance and distribution of digital geographic data. NIVA's services shall comply with standards set by Norge Digitalt and related EU directives.
Operationality	Databases are daily (5 day week) monitored by operators. The ships of opportunity system are operated more frequently specially during marine events.
Production environment	• MS Windows server platform (some Unix and Linux) • Oracle database • ESRI ArcIMS, ArcSDE, (MapServer, GeoNetwork internal)
Programming languages	• VB.NET • ASP.NET • VBA • PL-SQL • Java • C and C# • LabView • MatLab
Service technology	• WMS • WFS • CSW (internal)
Existing public services	• www.aquamonitor.no/ytreoslofjord (example) – Portal for NIVA's central database. Access for many monitoring projects. Offering online and archived data. GIS and graph view. Web services. • www.ferrybox.no – Realtime monitoring data from ships-of-opportunity and • realtime monitoring combining Ferrybox data, satellite data, lab analysis and expert assessment (SatHav). •

12 Annex D – Demonstrator scenarios

Demonstrator Scenario 1 Decision support in the situation of a combined scenario including oil spill in an ecological sensitive area as well as nuclear material and bad weather conditions.

Scenario Goal	Handling of an escalating situation, including a ship carrying nuclear waste in bad weather conditions outside Vesterålen, resulting in a damaged ship within an ecological sensitive area. .
Actors	• Kystverket • Fiskeridirektoratet • Hovedredningssentralen • DSB • Fylkesmannen i Troms • Fylkesmannen i Finnmark • Mattilsynet • NIFES • Havforskningsinstituttet • SFT • UD • LDKN • Strålevernet
Pre-Conditions	• Ecological information on fish, mammals and birds • Information on habitat classification (benthic, pelagic and littoral) • Updated weather information (winds, icing conditions etc) • Updated oceanographic information (waves, currents, tides etc) • Updated Vessel Traffic Services Automatic Identification System • Information on oil removal assets and capacity (position covered by the previous element) • Information on ships and owners • Information on aquaculture farms • Information on protected areas, temporarily closed areas, MPAs etc • Information on defence deployments (Classified) • Emergency plans (evacuation routes, shelters, etc)
Post-Conditions	• Knowledge of hazardous materials involved • Knowledge of source • Knowledge of human consequences • Knowledge of ecological consequences (for fisheries, stock management, bird colonies, …) • Knowledge of economical consequences (tourism, …)
Normal Flow	1. Severe weather warning from METNO 2. Simulation of consequences if a ship loose power within the main ocean route along the coast 3. Decision to move the main ocean route to increase the time window available to handle a potential situation 4. A cargo ship sends out a distress signal due to engine trouble in the area west of Vesterålen 5. Emergency handling assets (helicopters, tugs, …) are pre-positioned 6. Potential consequences of a full engine failure are simulated using drift models

	7. Oil removal assets are discovered (location, availability, capacity) and pre-positioned taking weather limitations in mind 8. New distress message from the cargo ship which now have lost all engine power, and is taking water in the engine compartment 9. A rescue operation is initiated, crew rescued by helicopter and the ship is drifting freely 10. Updated drift models indicate that the ship will drift on land 11. Tugs move in attempt towage 12. Ship and management information indicates that the ship is carrying nuclear waste and a substantial amount of oil 13. Tugs are put on hold 14. UD is involved to increase the knowledge of the cargo 15. Nuclear response teams are scrambled for risk evaluation 16. Autonomous sensors (glider type) registering oil and nuclear radiation and transmitting in real time are deployed to monitor the situation around the ship 17. Simulation of oil drift and of nuclear material drift in atmosphere and ocean to provide decision support 18. Simulation of ecological consequences, vulnerable areas etc according to the present knowledge of the cargo to provide decision support, decision support on where to tow the ship 19. Nuclear response teams acknowledge emergency towing attempt 20. Emergency towing to reduce consequences, positioning support of oil removal assets 21. Autonomous sensors discover oil around the ship 22. Weather and waves forecasts indicate that skimmer technology is unsuitable 23. Evaluation of chemical treatment of the oil spill, simulation of ecological consequences (e.g. on fish larvae depending on season and area) 24. Ship enters sheltered waters 25. Chemical treatment of oil spill together with wave mixing 26. Autonomous oil registering sensors (gliders) follow the oil spill, reports smaller and smaller amounts of oil 27. Situation under control, ship in sheltered water, oil removal assets surrounding it, nuclear response team controlling and securing the cargo 28. Simulation of long term ecological consequences
Notes and Issues	• i-Nord provides decision support, not decisions • Responsibility and interaction of the involved actors. • Kystverket has the responsibility for coordinating the national efforts in case of an accident.
What can iNord show	• How can an i-Nord integration of existing data improve management of the situation
What we could have done with more data, methods	• What can we achieve with a full scale i-Nord project.
Last Updated	5 February 2009
Last Updated By	Øystein Godøy

Demonstrator Scenario 2 Decision support in the situation of oil spill in an ecological sensitive area

Scenario Goal	Handling of an escalating situation in bad weather conditions outside Vesterålen, resulting in a damaged ship during the main fishing season
Actors	• Kystverket • Fiskeridirektoratet • Hovedredningssentralen • DSB • Fylkesmannen i Troms • Fylkesmannen i Finnmark • Mattilsynet • NIFES • Havforskningsinstituttet • SFT
Pre-Conditions	• Ecological information on fish, mammals and birds • Information on habitat classification (benthic, pelagic and littoral) • Updated weather information (winds etc) • Updated oceanographic information (currents, tides etc) • Updated Vessel Traffic Services Automatic Identification System • Information on oil removal assets and capacity (position covered by the previous element) • Information on ships and owners • Information on aquaculture farms • Information on protected areas, temporarily closed areas, MPAs etc • Information on defence deployments (Classified)
Post-Conditions	• Knowledge of source • Knowledge of ecological consequences (for fisheries, stock management, bird colonies, …) • Knowledge of economical consequences (tourism, …)
Normal Flow	1. Tanker from Murmansk sends distress signal due to engine trouble in bad weather conditions 2. Potential consequences of engine failure are simulated using drift models 3. Towage and oil removal assets support in evaluation (capacities), assignment (capacity and location) and pre-positioning 4. Ship looses engine power 5. Rescue operation initiated and ship abandoned 6. Ship breaks apart 7. Simulation of ecological consequences, vulnerable areas etc according to the present knowledge of the cargo 8. Emergency towing to reduce consequences, positioning support of oil removal assets 9. Detection of oil spill and subsequent decision support 10. Simulation of long term ecological consequences
Notes and Issues	• Responsibility and interaction of the involved actors. • Kystverket has the responsibility for coordinating the national efforts in case of an accident.
What can iNord show	• How can an iNord integration of existing data improve management of the situation
What we could	• What can we achieve with a full scale iNord project.

have done with more data, methods	
Last Updated	5 February 2009
Last Updated By	Erik Olsen

Demonstrator Scenario 3 Decision support in the situation of damaged ship in the North East passage

Scenario Goal	Handling of ship transporting dangerous goods (e.g. nuclear waste) damaged by sea ice in the North East passage
Actors	• Fiskeridirektoratet • Norsk polarinstitutt • Hovedredningssentralen • Statens Strålevern • DSB
Pre-Conditions	• Static ecological information on fish, mammals and birds • Updated weather information • Static information on ships and owners
Post-Conditions	• Knowledge of source • Knowledge of ecological consequences (for fisheries, stock management, bird colonies, people, …)
Normal Flow	1. Ship carrying nuclear waste sends distress signal due to engine problems 2. Simulation of atmospheric and oceanic distribution of the waste, affected areas and levels 3. Simulation of where the ship would drift 4. Weather and current conditions sends the ship towards the Norwegian waters and the ice edge 5. Overview of available assets, pre-positioning support
Notes and Issues	• Responsibility and interaction of the involved actors.
What can iNord show	How can an iNord integration of existing data improve management of the situation
What we could have done with more data, methods	What can we achieve with a full scale iNord project.
Last Updated	5 February 2009
Last Updated By	Erik Olsen

13 Annex E - IDEF0/SADT diagrams

A top level view of the i-Nord system is provided using the IDEF0/SADT technique. A brief explanation of how to read the diagrams is provided inFigure 12 The i-Nord top level functional description is provided in Figure 13, and a brief breakdown of functionality is provided in Figure 14.

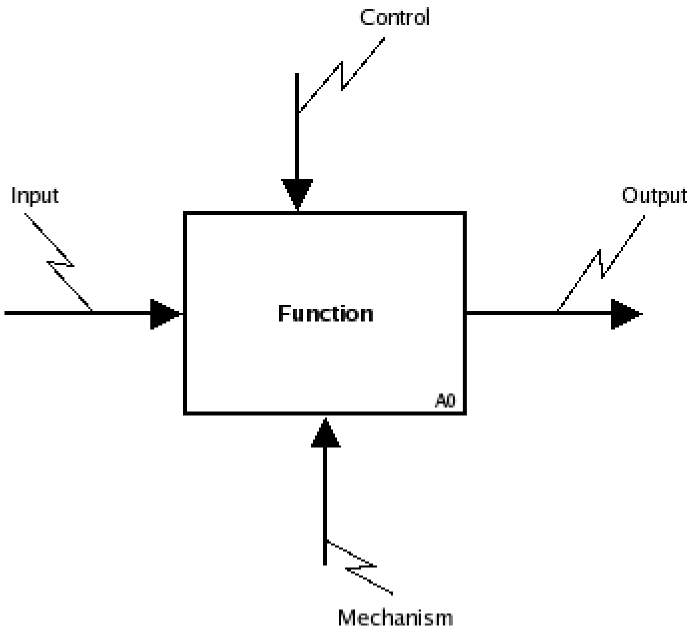

Figure 12 An introduction to how the IDEF0/SADT diagrams are interpreted.

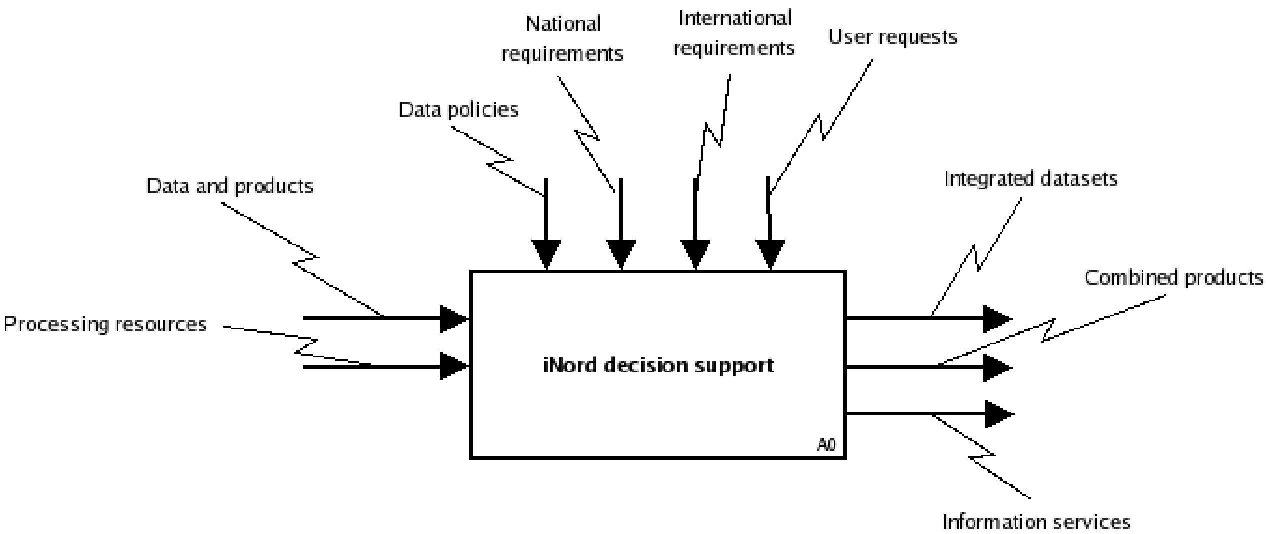

Figure 13 Top level description of the i-Nord system.

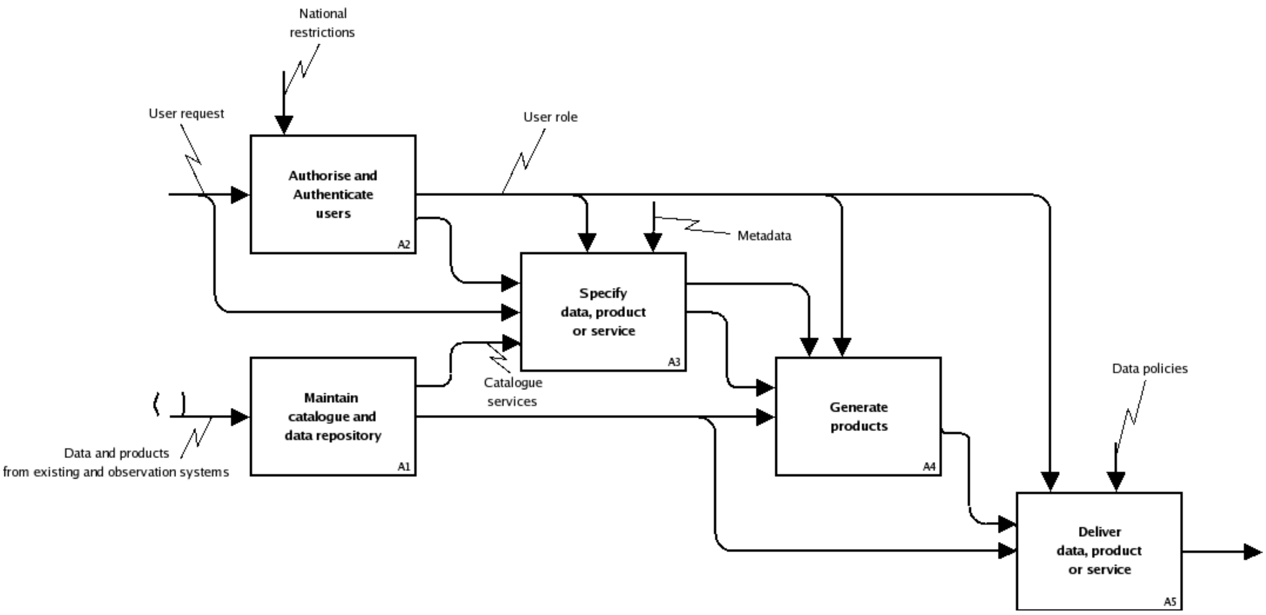

Figure 14 Main functions within the i-Nord system.

14 Annex F - Open issues

1. What the system actually should deliver.
2. The actual need for which framework, which complexity is required.
3. The need for sensor networks as a basic infrastructure and how to operate and maintain these in an operational context.
4. The responsibility for operational services, including the new potential sensors of the system.
5. The responsibility for observations not required or performed by operational institutions.
6. The relationship to other initiatives in the region (Forvaltningsplan Barentshavet, AMAP, SAON, SIAEOS, ACIA/NORACIA, IPY etc).
7. Which standards to support in which phase, evaluation of maturity and future perspectives (including cost efficiency).
8. Project organisation during development and after the project period.

i-Nord
A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean

Main Report

Part 4

Baseline for main project

SINTEF

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MEMO

MEMO CONCERNS

i-Nord
A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean

Pre-project

Baseline for main project

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The surveillance of the High North ocean areas.

Preface

The i-Nord project is a product of Barents2020 which is based on the Norwegian Government's High North Strategy[1]. i-Nord´s main objective is to implement and operate a ***comprehensive monitoring* and information system** of the High North ocean areas, in order to directly address and maintain Norway's ***ambition of playing a leading role*** in the Barents Sea and Arctic Ocean, including proper and sustainable management as well as proactive partnership in the intergovernmental Arctic collaboration.

The mandate for the i-Nord pre-project has been to prepare the best background for the Government's decision of starting the ambitious development of a full i-Nord surveillance system.

The pre-project is initiated and financed by the Ministry of Foreign Affairs (UD) and the Ministry of Fisheries and Costal Affairs (FKD).

The specific objectives of the pre-project have been to:

- Identify the primary stakeholders to such a system
- Describe the i-Nord concept and overall system structure
- Describe best practice for developing such a system
- Identify the need for research and development
- Produce a main project plan
- Propose and coordinate a consortium with the necessary know-how and ambition of carrying out the main project

The report presented here is one of the deliverables from the i-Nord pre-project and describes ***the best practice for developing i-Nord and identifies the need for research and development.***

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After receiving the report from the responsible author, the report has undergone only editorial changes by SINTEF as part of the preparation of the final document.

[1] As of 2008-10-22: http://www.regjeringen.no/en/dep/ud/Documents/Reports-programmes-of-action-and-plans/Action-plans-and-programmes/2006/Strategy-for-the-High-North.html?id=448697

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1 Suggested prime deliverables/products from an *i-Nord* system

The prime deliverables are based on the needs to: ***Deliver operational information of the status, variability and predicted change of the marine environment and ecosystems of northern Atlantic regions with focus on the Barents Sea, Norwegian Sea and (north) Norwegian coastal areas, including effects of climate and human activity. Support and improve marine research and knowledge-based ecosystem assessment prediction and management, marine operations, and marine safety.***

It is anticipated that i-Nord will deliver the following basic and derived state variables "continuously" in time and distributed in 3D space: temperature, salinity, transport/currents, frontal positions, turbulence, vertical mixing depth, stratification, wave height and direction, seabed shear stress, sea ice concentration (including ice edge positions), ice type and thickness, light (in the water column), suspended particulate matter (SPM), upwelling index, oxygen, CO2/pH, nutrients, chlorophyll, algal and zooplankton production and abundance of functional groups, (harmful) algal blooms, river plumes and loads, fish larvae growth, mortality and distribution, transport and dispersion of various contaminants (including oil) and their concentration in the marine food-chain, fish and mammal distribution.

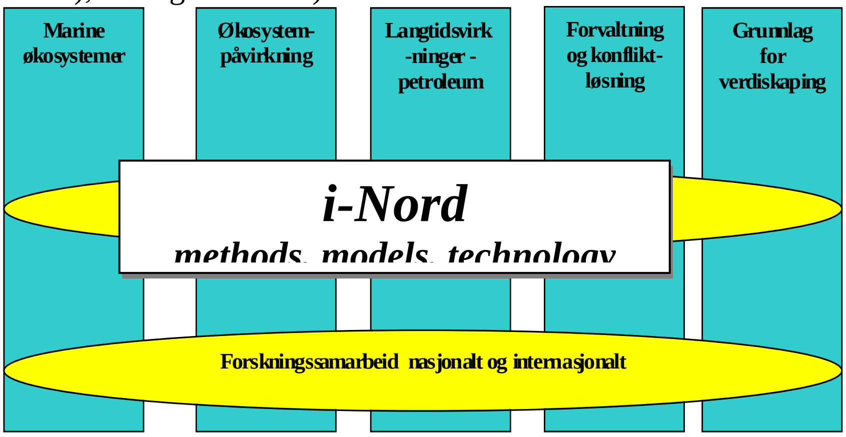
As far as possible i-Nord will relate today's status and prediction of the ocean to historic norms and variability. Thus we need to make long observational time series available and create new modeled time series, preferably for the past 50-100 years. The variability as despite from historical long time series is the basis for designing "optimal" observational strategies and systems. But the most likely scenarios of climate change should be account for to some extent.

From these basic "state variables" i-Nord will also deliver quantitative interactions between variables, such as overlap between predators and prey, and overlap (doze) between pollution and biota (plankton, larvae, macro algae, shell fish and farmed-fish).

This information will be the basis for creating new indicators for early warning of ***changes*** in the marine ecosystems (e.g. ecosystem functioning, recruitment, growth, mortality, and distribution of the main fish stocks and stresses on the aquaculture industry). This will form basic information for improved resource management advice and create key information to the "ecosystem approach to research and management" and sustainable use of the ocean for the benefit of future generations. It will also deliver key information to marine operations and support decision support systems for crisis management.

From the user point of view the information shall be made available on a web portal similar to yr.no, and the data should be easily and freely accessible.

It is worth noting that i-Nord also will be a realization of the cross-cutting theme "methods, models and technology" in the ongoing Norwegian Research Council (NRC) programme (Hav og Kyst (Ocen and Coast), see figure below).



2 Summary

The knowledge base and need for research within i-Nord is related to the goal to: *Deliver operational information of the marine environment and ecosystems of northern Atlantic regions with focus on the Barents Sea, Norwegian Sea and (north) Norwegian coastal areas. Support and improve marine research and knowledge-based ecosystem assessment prediction and management, marine operations, and marine safety.* A general challenge is to optimize observational systems in concert with mathematical models in relation to user oriented products and needs.

Operational atmospheric forcing, physical oceanography and climate are key factors for serving most products anticipated within i-Nord. The status of knowledge and operationality are quite advanced in Norway on these themes, with good international cooperation. However, there are clear needs for regional and local developments due to the specifics of the high north and the need for relatively high time and space resolution on some of the products.

Pollution is a major potential threat to the marine ecosystems, and except for oil spill pollution, our ability to realistically estimate the distribution in time and space is limited, partly due to lack of source information. A major issue is to estimate the overlap and doze of contaminants on biota, and combined with laboratory experiments of contaminant effects on individuals, estimate the effects on total stocks of e.g. plankton and fish and threats to birds and fish farms.

There is a great lack of integrated modeling and observational systems to quantify and predict the variability of the marine ecosystems. Several research and semi-operational systems of parts of the ecosystems are developed, but we lack a “system of systems” to integrate the knowledge and methodology already existing. An ecosystem modeling system (Atlantis) is already developed (in Australia) for this purpose, which need to be implemented and adapted for the northern ecosystems. In addition developments are needed for better quantification of specific species groups as either stand alone products or input to the Atlantis model. Certainly improved observational systems are important for producing realistic results. We need to improve the data flow and ensure that the flow is functioning well and be as up-to-date as possible, from observation to analyzed result.

The main information needed to better serve marine operations is related to improve the physics (currents, wind, waves, temperature, salinity (density), sea ice (distribution, thickness, type) and icing, meaning improved combination of observations (from ships, buoys, AUVs, radars, satellites and aircrafts) and numerical models. This also means increased use of new platforms (e.g unmanned aircrafts) and sensor technology, and improved understanding and application of e.g. satellite data. It also means improved (particularly underwater) communication and streamlining of data flow for a range of downstream service providers and direct users.

The above requirements are also of utmost importance for handling of crisis and related to marine safety. This includes search and rescue support to rescue centres, support to Norwegian coastal administration and support to the police.

3 Best practice

3.1 Atmospheric forcing, oceanography and marine climate

3.1.1 Atmosphere

Background

METNO operates a suite of operational weather forecasting models (Figure 1) which cover various spatial scales and geographic regions. Boundary fields are received from ECMWF, the main regional modeling is done through the HIRLAM model, present operating at approximately 12 km, with a range of other models nested into this. Assimilation of observations is done in HIRLAM12 as well as within some of the other models.

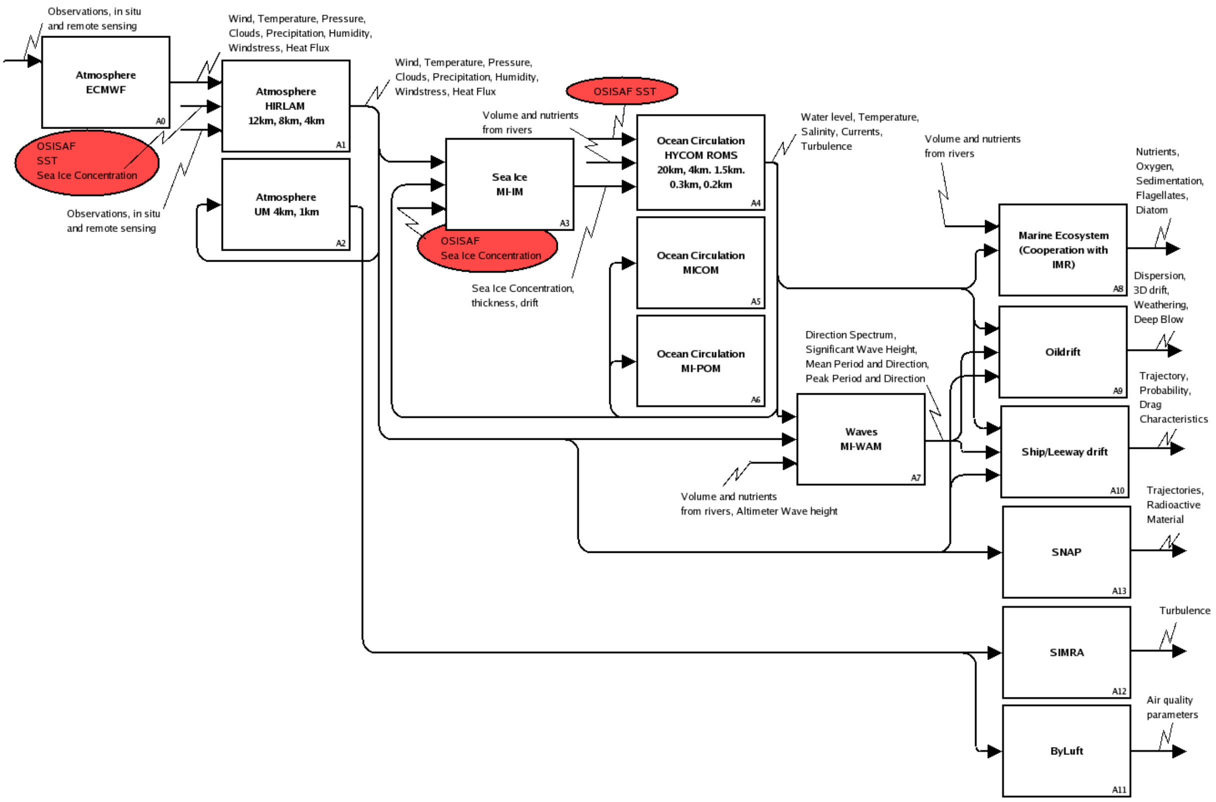


Figure 1. The operational model pool at METNO.

The output of this model suite has a variety of users. Some of the models are meant for the public, while other are dedicated services aimed towards specialised users and operated upon demand (basically the rightmost column of Figure 1. Information for the public is routed through http://yr.no/ and information for various stakeholders through http://kilden.met.no/. Furthermore a new interface dedicated to providing access to the actual data sets is being developed.

Atmospheric modelling is facing a number of challenges at high latitudes. The in situ observational input is too sparse, especially in the spatial sense. Thus remote sensing data is of particular use in the Arctic. The best situation would however be a more balanced situation concerning in situ and remote sensing observations as the remote sensing techniques and numerical models both need observations both for input and validation.

Another aspect of atmospheric forcing is the challenges concerning nowcasting and very short range forecasting under Arctic conditions and with the limited in situ observations available. This field is anywhere in the world based upon a combination of in situ and remote sensing techniques using numerical modelling as support. It requires high spatial and temporal resolution, a requirement usually best achieved by combination of in situ and remote sensing observations. In this field the prime remote sensing sensor is the weather radar that may provide high temporal resolution (down to about 5 minutes) for a rather large area. This activity is especially important for air traffic, but do also have a large impact on other operations, including detection, tracking and forecasting polar lows.

In addition to the modelling activities at METNO, the institute participates in many national and international projects utilising remote sensing data in an operational context both for atmospheric and ocean modelling. The main focus of the activities at METNO is operational products and how these can be used in numerical modelling as well as in monitoring. At high latitudes remote sensing data is extremely useful in numerical modelling due to the sparse in situ data available. I-Nord tries to improve access to in situ data, but it is still expected that the most cost effective observations to be used in both atmospheric and ocean modelling will be remote sensing data. However, remote sensing data can not be used for interior information in the ocean.

Remote sensing products developed by the EUMETSAT Ocean and Sea Ice SAF – High Latitude Centre at METNO may be useful as input data for oceanographic modelling. To really advance

the understanding of the Arctic regions it is recognised that atmospheric, oceanographic and sea modelling has to be coupled and that the understanding and information concerning the freshwater cycle in general has to be improved.
METNO operates a in situ and surface remote sensing observation system covering the needs of the institute. These platforms report in real time and most of them are public available in real time or near real time after quality control. Evaluation of the observation system (in situ and remote sensings platforms) are being undertaken continuously both on a national as well as on a European scale. Sensitivity studies using models are crucial in this work along with cost benefit analyses.

Necessary R&D for Atmosphere

- Cost effective in situ sensors and platforms
- Weather radar coverage.
- Utilisation of remote sensing data, especially microwave measurements from weather radar in numerical models but also atmospheric profiles and cloud motion from satellite measurements.
- Coupling of atmospheric, oceanographic and sea ice models.

3.1.2 Ocean and sea ice

Background

From the earlier and ongoing EU projects MERSEA and ECOOP (http://www.mersea.eu.org/, http://www.ecoop.eu/) , EUMETSAT Ocean and Sea Ice SAF (http://saf.met.no/) and through ongoing Norwegian activities (http://retro.met.no/kyst_og_hav/havvarsel.html), (http://www.yr.no/hav_og_kyst/), (http://topaz.nersc.no/) many of the technical solutions and infrastructure to deliver operational information of the physics/climate of the ocean is (being) developed on global, regional and partly down to coastal scales. This will further be developed in the new major EU-project MyOcean (http://en.wikipedia.org/wiki/MyOcean), starting January 2009, where key Norwegian institutes are participating (met.no, NERSC, IMR, NIVA, NP). However, these products are today mainly based on numerical models with active use of satellite data and increasingly use of hydrographic profiling observations from the global ARGO program (http://www.argo.net/). It is therefore anticipated that the larger scale physics will be operationally available for i-Nord.
With focus on the ecosystem of the Norwegian/ Barents seas and the Norwegian coast and fjords, there will be a need for downscaling the physical models to the relevant scales and formats of the products and services to be delivered. Met.no are running operational systems (Figure 1) with relatively high resolution for different parts of the coast (http://retro.met.no/kyst_og_hav/havvarsel.html), and for southern Norway such an operational system was developed by met.no, NERSC and IMR including biolocal processes; however not with a resolution relevant for fjords (http://wms.met.no/moncoze/). The search and rescue (SAR) model is part of the suite of operational emergency drift models (see Hackett et al, 2006). Empirically derived coefficients for 63 categories of search objects compiled by the US Coast Guard are ingested to estimate the leeway of the drifting objects. A limited set of field exercises show good agreement between model trajectories, search areas, and observed trajectories for life rafts and other search objects (see Breivik and Allen, 2008). The operational version of the model

is currently operating on a 4km grid, but this is not sufficient to model the current conditions along a complex coastline.
Several of the Norwegian institutes are running models in non-operational mode to study climate variability and change, including sea ice and some of them coupled with biological modules for the lower trophic levels of the ecosystem (e.g. Svendsen et al, 2006), Skogen et al, 2004, Johannessen et al., 2006, Budgell 2005, Schrum et al). Also models have been set up for simulating physical, chemical and/or biological processes, also in fjords; but can not be run operationally because of a lack of relevant observations (Bjerkeng et al., 1997; Gjevik, 20XX; Slagstad and Skadhamar, 20XX).
A major challenge concerning operational ocean modeling is the lack of real time in situ measurements. At present, models are mainly forced with remote sensing sensors and boundary conditions from atmospheric models. Thus, in the present situation, too little is known about the realistic oceanographic conditions and dynamical processes. Furthermore, coupling of atmospheric, oceanographic and ice models is essential to improve the understanding of ocean and atmospheric conditions and climate in the Arctic region.
A key challenge is the need for strategic in situ observational programs coordinated with satellite observations and the numerical models to optimize the quality of information. The needed density of observations (in time and space) can be analyzed from existing models in relation to the user need of information/products. Synergy between 0perational point and profiling measurements from buoys, as well as continuous surface transect measurements from ship-of-opportunities have shown high potential to provide observations at relevant time and spatial resolutions.

Necessary R&D for Ocean and sea ice

- Downscaled (coast and into fjords, operational and 60 year hindcast) atmospheric forcing, including short wave (light) radiation, sea surface heat exchange, precipitation (also over land), evaporation….
- Freshwater runoff from hydrological model (operational and 60 year hindcast) and from fixed measurement stations, resolving individual fjords and daily time steps. Interesting question: How has the hydroelectric power industry changed the coastal and fjord hydrodynamics?
- Define an “optimal” (but realistic) observational strategy, with focus on mesoscale activities, and initiate the implementation.
- Set up and run the model systems operationally on all needed scales and areas, including assimilation of observations
- Perform the long term hindcast simulations on all needed scales and areas, including assimilation of existing observations
- Develop and include (in the above simulations) the specific user-oriented products, including the needs within i-Nord related to marine ecosystems, operations and safety.
- Develop technical solutions for the user to extract the wanted products
- Coupling of atmospheric, oceanographic and sea ice models.
- Conduct field campaigns in collaboration with the Norwegian Coast Guard to establish drift properties of poorly studied object classes (e.g. cargo containers)

- Utilize high-resolution current and wind fields in the search and rescue models
- Provide high-resolution wind field for fjord modelling
- Real time and near real time oceanographic observations.

3.1.3 Marine Climate

Background

Today in Norway there is a quite strong community related to climate research, particularly in Bergen related to the Bjerknes Center for Climate Research (UoB, Unifob, NERSC and IMR) and in Oslo related to the CICERO Center for International Climate and Environmental Research (UoO) and met.no. In addition a new climate and ice centre (ICE) is being established at NP in Tromsø. Also a Norwegian Climate Centre (Norsk klimasenter) has been established to ensure a better cooperation among the Norwegian climate experts and users and a national research school in climate dynamics is starting in 2009 (coordinated by UiB-GFI with totally 10 Norwegian and 8 international partners). Internationally we are also active in programs such as ACIA (Arctic Climate Impact Assessment) and AMAP (Arctic Monitoring and Assessment Program).
Due to these relatively strong activities, i-Nord does not intend to create new climate research as such. However, there is a strong need to link today's environmental status to the past variability and trends. It is therefore important for i-Nord to ensure existing long time time-series be easily available and compatible with new data/information. It is also important that new operational data gathered within i-Nord has a quality to be relevant as an extension of present long climate time-series and thus being relevant for future climate research.

Necessary R&D for Marine Climate

- Make “all” relevant existing climate time-series (preferably from the past 50-100 years) easily available for the i-Nord participants and their users.
- By numerical model hindcast simulations create new relevant long climate time series (preferably from the past 50-100 years) easily available for the i-Nord participants and their users.
- Develop the necessary tools for linking i-Nord operational products to the historic variability and trends.
- Analyze the historic variability (in time and 3D space) to optimize a future observational system.

3.2 Marine ecosystems

3.2.1 Environment

Within the term marine environment we address matters which may have negative impact on ecosystem functioning. This relates to eutrophication, including oxygen condition and nutrients; suspended matter; light; algae, including harmful algae, and pollution (e.g. heavy metals, chemicals, oil and its degradation products, produced water, radio-nucleides).
Today several Norwegian institutes (IMR, NERSC, Sintef, met.no, UiB, NIVA operate 3D primary production models. Most of them include a few functional groups of algae, nutrients

(nitrogen, phosphorous and silica), suspended particulate matter (SPM), simple description of light in the water column and oxygen, and are driven by the physics from 3D ocean circulation models. One of the systems (developed by IMR, NERSC and met.no) is also set up for southern Norway and run in operational forecast mode (http://wms.met.no/moncoze/). These systems are run with very little or no input of biochemical observations, and the quality of the products can absolutely be questioned. Validation is done on hindcast simulations mainly related to observations of nutrients and oxygen (e.g. Søiland and Skogen 2000).
Met.no has the national responsibility for forecasting the transport and dilution of oil spills at the sea surface. The oil module is mainly based on developments at Sintef. Since most accidental oil spills take place along the coast, the largest uncertainties in these forecasts are associated with unknown mesoscale physics (meanders and eddies) which at present is not correctly represented in the circulation models. The model includes the effects of waves (Stokes drift) and to some degree wind drag. Stokes drift calculations are based on wave energy spectra from the operational wave model. The oil drift model uses the same computational grid as the ocean model, at present 4 km in our areas. Ten layers are present in the vertical. Normally 500 oil particles are seeded and traced in time and space. Oil particles can either stay on the surface, submerge, disperse, decay, get stranded or evaporate. It normally takes just a few minutes to run the oil drift model for a period of several days and the runs are at present limited to +60 hours. About 90 oil types are present. The quality of the oil drift forecast output is highly dependent on the geophysical input data. Currently, the oil drift model is limited to point sources.
In hindcast mode, Sintef models the transport and distribution of produced water from the offshore oil industry. This is linked to stationary maps of e.g. fish larvae to estimate dozes and risks. A key issue for i-Nord will be to couple the dynamic pollution with dynamic knowledge/models of fish eggs and larvae, both in an operational mode.
NIVA, NILU and NRPA are presently conducting efforts (SFT project) on the modeling and simulation of the transport and dispersion of dissolved or absorbed contaminants (organic, heavy metals, radio nuclides,) from all sources (air, boat traffic, land, offshore industry) and for the entire Norwegian maritime domain (NIVA report, 2007, 2008). There is also ongoing research on modeling of accumulation of contaminants in the food-chain, including an IPY project. Results from these two ongoing activities are of direct relevance for the implementation of i-Nord.
Furthermore, none of the above-mentioned models encompass specific harmful algae modules, although relevant knowledge exists.
Whereas there is a great need for more sophisticated models to address specific environmental issues, there is also a clear need for new and/or better observations. It is important to continue the few existing long time-series which often have a great stand alone value such as for detecting climate and environmental trends or assessing effects of pollution remediation. More efforts should be put on analyzing long term model results for optimizing observational systems.

Necessary R&D for Environment

- Downscaled (coast and into fjords, operational and 60 year hindcast) simulations of primary production, and system ready for simulating accidental pollution

- Operational and historic input of freshwater nutrients (liked to hydrological model) resolving individual fjords and daily time steps. Interesting question: How has the hydroelectric power industry changed the coastal and fjord primary production and oxygen conditions?

- Define an “optimal” (but realistic) observational strategy for improved accuracy, and initiate the implementation.

- Integrate multi-source contaminants transport, dispersion and accumulation into 3D hydrodynamic model
- Develop modules for contaminants accumulation in the trophic-chain into ecosystem model
- Develop modules for specific harmful algae
- Include line sources and area sources of oil within the oil drift model.
- Include drift of algae and plankton in the oil drift model.
- Backtracking of oil spills.
- Set up and run the model systems operationally on all needed scales and areas, including assimilation of observations
- Perform the long term hindcast simulations on all needed scales and areas, including assimilation of existing observations
- Develop and include (in the above simulations) the specific user-oriented products, including the needs within i-Nord related to marine ecosystems, e.g. calculating the doze from contaminants on stationary biota (macro algae, farmed fish, coasts in general) and moving biota (algae, zooplankton, fish eggs and larvae, (fish)..
- Develop technical solutions for the user to extract the wanted products

3.2.2 Ecosystems

Northern marine ecosystems are productive and relatively simple, and as few abundant species dominate each trophic level they are highly attractive to fisheries. For instance, the Barents Sea holds the world's largest stocks of cod, capelin and prespawning herring. The inflow of warm Atlantic and cold Arctic water masses, together with transitions from the deep Northern Seas to the shallow Barents Sea, set important physical limitations to species distributions and thus to system structure. However, the northern marine ecosystems are highly dynamic. The inflow of water masses varies, influencing the primary production, the advection of zooplankton into the marine systems, and the recruitment of many fish species by drifting the fish larvae from spawning grounds to important feeding grounds (Sakshaug et al. 1994, Ådalnsvik and Sundby 1994, Fiksen and Slotte 2002, Wassman et al. 2006). There is a strong seasonal component in species distributions and in productivity, which is high during a short summer period, especially along the polar front. Furthermore, combined effects of fisheries, strong species interactions and climate cause dramatic shifts in the structure, functioning and commercial value of these systems (Hamre 1994, Jackson *et al.* 2001, Hunt *et al.* 2002, Hjermann *et al.* 2004, Frank *et al.* 2005). For instance, fluctuating abundances of pelagic fish in the Barents Sea have severely influenced the demography, movements and distributions of predators such as piscivorous fish, marine mammals and seabirds (Hamre 1994, Nakken 1998, Nilssen *et al.* 1998, Yaragina and Marshall 2000, Fauchald and Erikstad 2002).

The pelagic system, consisting of zooplankton, pelagic fish and their predators are linked with the demersal component of the ecosystem (benthos, demersal fish) through various processes such as ontogenic shifts, nutrient cycling, vertical migrations and predator-prey interactions, (e.g Boero *et al.* 1996). Food webs on Arctic shelves often have a strong benthic component, meaning that much of the energy in the system flow through the benthos, and these organisms provide nutrition for seabirds, benthic-feeding fishes, and marine mammals. Benthic communities, made up by more than 3000 invertebrate species (Sirenko 2001), are affected by many environmental factors, including sediment characteristics, temperature, and other depth-related factors, but food supply seems to be among the most important in determining both structure and function (e.g. Grebmeier et al. 1989, Rysgaard et al. 1998, Dunton et al. 2005, Renaud et al. 2007).

Many areas of the continental shelf have rich communities of both infauna and epifauna (Zenkewitch and Brotzky 1939, Grebmeier 1993, Pogrebov 1994, Kiyko and Pogrebov 1997, Denisenko 2001, Piepenburg 2005). While shallower high-biomass banks usually are dominated by epifauna, the deeper basins, having a lower biomass, consisting mostly of infaunal taxa (Piepenburg et al. 1995). The high primary production over banks of the Barents Sea is primarily a result of hydrographic processes supplying nutrients to surface waters, while deeper areas are fueled by strong pulses of phytodetritus from MIZ blooms and from ice algae (Carmack and Wassmann 2006, Wassmann et al. 2006).

Due to the commercial importance of the resources in the northern marine ecosystems, time series on the physical, benthic, demersal and pelagic components of the northern systems are, together with models, available for developing procedures for 'now-' or 'forecasting' the marine ecosystems in i-Nord, although significant achievements within research and development are needed to obtain the required precision levels. Below, we give a brief overview of the present knowledge base, and outline the main challenges for future research and development required for efficient 'now-' or 'forecasting' the ecosystem within the iNord framework.

Ocean climate and physical-biological coupling

Phytoplankton dynamics is closely connected to physical variability of the marine ecosystem. Present physical-biological coupled models reproduce adequately the response of the phytoplankton community to physical forcing in terms of biomass and productivity (bulk modelling) when growth has resumed in spring (e.g. Skogen and Søiland 1998). However, there is a need to carry out a confirmation/adaptation of ecosystem models to the actual conditions in the different regions of the Nordic and Barents Seas, and to increase the number of functional groups from two (e.g. diatoms and flagellates) to about five, to satisfy food quality issues relevant for zooplankton. It is also important to include an explicit secondary production level into the model in order to provide a realistic control on the primary producers.

Benthic communities

The benthic system is in general more stable than pelagic system, and is therefore not expected to depict rapid and significant changes between years, except for the case of a significant increase of external pressure on the system. Distribution and abundance of benthos organisms taken as by-catch in bottom trawl is surveyed annually (species, weight, number and length measures) and has showed changes in distribution possibly as consequences of increased abundances of king and snowcrabs, bottom trawling or temperature increases. Despite increased attention to benthos of the Arctic region in recent years, it is still difficult to make any generalizations about the structure or function of these communities. Biomass hotspots have been recorded on the shallow banks and slopes and along the continental slope from the Norwegian Sea and into the Barents Sea. The biomass-hotspot of the Spistbergen and Goose bank are in accordance with Zenkevitch (1956), while the low biomass values south of Novaya Zembla (Pechora Sea) and at southern part of Storbanken are low compared to a recorded biomass-hotspot in Zenkevitch (1956). Better knowledge of the distribution of benthos species, bottom fish species, and pelagic productivity transported to the seabed will make it possible to follow benthic dynamics and trophic interactions.

Zooplankton

Zooplankton, and particularly copepods, krill and amphipods, are key species in energy transfer from the primary producers to the higher trophic levels. Distribution and abundance of zooplankton is surveyed annually. Samples are divided into size categories and weighed, but due to the labor intensiveness the samples are not determined to species or species groups. At present we have a fair understanding of basic biology, population dynamics and the seasonal interplay between keystone species within zooplankton. However, less information is available on distribution patterns on meso and large scale, and hence a restricted understanding of the mechanisms behind the interannual variability in abundances and predator-prey dynamics. The only large scale 3-D models available are related to copepods (*Calanus finmarchicus).* No such models exist for krill, amphipods, microzooplankton and gelatinous predators, all assumed to be important players for the ecosystem dynamics. The lack of data also decreases the opportunity for validating existing models.

The ongoing development of new technology, such as platforms based on acoustics and optics, will greatly improve data collection, and biomolecular methods are being developed for automating species identification and density estimation in samples.

Fish

The distribution and abundance of juvenile and adult fish of the commercial species is surveyed 2-3 times a year, depending on the stock, and stock abundances are estimated annually using various stock assessment models. Distribution of non-commercial species is surveyed 1–2 times a year. No assessment of abundances is performed for these species, but annual abundance indices can readily be made. Diet of several commercial species is sampled annually to investigate fish-prey interactions. In addition to these routine activities, several recent and ongoing process studies have focused on spatial processes and migration patterns of adult fish, by the use of tagging, and on interactions between various fish species and their prey. The active movement of adult fish has not been addressed to the same degree as drift of larval fish, due to the facts that the active movement of adult fish is the result of complex processes involving trading off of a number of factors involving growth, mortality and reproduction; many fish species in the northern ecosystems also migrate between spawning areas and feeding areas. Furthermore, modelling the migration-distribution of fish has traditionally been difficult due to the great computing power required, poor description of relationships between environment and fish, and lack of methodology. However, computing power is ever increasing and now allows simulations of the entire Norwegian Sea at a fine scale with fish stocks and 3D environmental description. The observation system proposed within the i-Nord framework will generate a lot of data on the distribution of fish that can be assimilated into models of 3D fish stock distribution. Individual based modelling with super individuals provides us with a highly flexible tool for simulating the entire life cycle of fish stocks, including larval drift and adult migrations. The super individuals each represent thousands and even millions of identical individuals. This allows us to simulate entire fish stocks that in reality consist of billions of individuals through thousands of super individuals. This approach is very flexible and allows a straight forward implementation of migration/distribution at high temporal resolution. These models therefore readily integrate into the oceanographic models and provide a link between ecosystem modelling and fisheries modelling. Such models have now been developed for cod and capelin in the Barents Sea and are under development for Norwegian Spring spawning herring.

There are several ways to implement migrations in these models depending on whether the motivation for the modelling is to maximize learning or predictive ability. In the former case emphasis should be put on testing ideas and principles and looking at how different assumptions affect the model output. In the case of maximizing the realism of the predicted distributions more emphasis should be put on developing rules for migration that accommodates realistic distribution as revealed from observations from historic survey time series and new observations gathered within the i-Nord framework. For i-Nord the emphasis will be more on the providing realistic fish distributions, and the ongoing NFR financed INFERNO and ECOFISH projects at IMR are presently developing a coupled physics-phytoplankton-zooplankton-herring model in line with the framework sketched above.

Fish stock recruitment is related to both egg production and to survival of the recruits. While egg production is dependent on stock abundance and condition, the survival and growth of fish larvae is related to advection to productive areas with abundant zooplankton and sea temperature. Abundance and distribution of fish larvae is surveyed annually. Egg models are developed for several species, and downscaling the oceanographic models to relevant scales yields good predictions of the drift and distribution of fish larvae. However, more realistic models of zooplankton distribution are required for improved modeling of larval growth and survival.

Marine mammals

Some marine mammals stay within the northern marine systems year round, while others migrate to northern feeding areas only during the summer months. Abundances for the harvested species, and for a couple of the hunted seal species, are assessed every 5-6 years. The diet of these species, from stomach samples, is investigated in recent and ongoing projects. Information on species distributions (also non-harvested species) at sea are obtained through dedicated surveys yielding complete coverage of the north-east Atlantic over 6-year periods, through using marine mammal observers on board the ecosystem surveys, and through the use of satellite tagging. Marine mammals are large-ranging animals, and some may cover entire ecosystems during the annual foraging migrations. Being generalists, their diet often reflects the abundances of relevant prey species within the feeding areas (Haug et al. 1995), and thus varies between different areas (Haug et al. 2002). Some species, such as the harp seals, can inflict a significant mortality to pelagic fish (Lindstrøm and Tjelmeland in prep.). Other species, such as baleen whales, seem to compete strongly with pelagic fish for krill and amphipods, likely determining the late summer distribution of baleen whales in the Barents Sea (Skern-Mauritzen et al. in prep.). However, more information on migration patterns, timing of migrations and interactions with other species in the different parts of the ecosystems are required for both being able to predict the marine mammal distributions in time and space, and to understand the species interactions in which they are involved.

Species interactions and ecosystem structure, dynamics and regulation

Marine ecosystems are partly structured by the physical habitat, such as water masses and ocean depth for pelagic ecosystems (Mann and Lazier 1991), and bottom substrat for benthic ecosystems. However, the spatial distribution of species within these systems is complex, aggregated and dynamic, resulting from strong species interactions between predators and prey, and between competitors (Murphy *et al.* 1988, Fauchald *et al.* 2000). Although some species interactions are well studied (*e.g.*, between herring, capelin, cod), further research on species interactions is crucial to enable modeling and predictions of species distributions and interactions through space and time. Species interactions are also central to regulation of marine ecosystems, determining the systems responses to perturbations such as fisheries or climate variation (Cury *et al.* 2000, Rice 2001). In bottom-up regulated systems the primary production limits the higher trophic levels, yielding strong competitive interactions. In top-down regulated systems predators hinder population growth at lower trophic levels. Fisheries, typically removing larger piscivore predators from the system may cause trophic cascades in top-down systems (e.g. Frank *et al.*2005), but limited effects in bottom-up systems. In the northern marine systems, zooplankton abundances are negatively associated with capelin abundance (Dalpadado *et al.* 2002). At the same time, fluctuations in pelagic fish affects the demography movements and distributions of their predators (Yaragina and Marshall 2000, Nilssen *et al.* 1998, Fauchald and Erikstad 2002), suggesting a ‘wasp-waist’ type of control, where the crucial intermediate level of pelagic fish exerts top-down control on zooplankton and bottom-up control of predators Ciannelli *et al.* (2005). However, more research on trophic regulation is needed to understand how perturbations will propagate through the marine ecosystems, and thus to enable predictions of responses to system perturbations at different trophic levels.

Necessary R&D for Ecosystems

- carry out a confirmation/adaptation of the primary and secondary production model(s) to the actual conditions in the different regions of the Nordic and Barents Seas, and to increase the number of functional phytoplankton groups from two (e.g. diatoms and flagellates) to about five, to satisfy food quality issues relevant for zooplankton.
- Improve the understanding of the benthic dynamics (variability in space and time), including trophic interactions and its importance for fish. This means improved knowledge of the distribution of benthos species, bottom fish species, and pelagic productivity transported to the seabed.
- Improved knowledge of the zooplankton distribution patterns on meso and large scale, and the mechanisms behind the interannual variability in abundances and predator-prey dynamics.
- Develop and implement large scale 3-D models for the main copepods (other than *Calanus finmarchicus* already developed), including krill, amphipods, microzooplankton and gelatinous predators, all assumed to be important players for the ecosystem dynamics. Improved observations are needed for validation of and assimilation into existing and new models.
- The ongoing development of new technology, such as platforms based on acoustics and optics, will greatly improve data collection, and biomolecular methods are being developed for automating species identification and density estimation within samples.
- Sensitivity analysis, parameterization, and improvement of (near) existing fish migration models
- maximizing the realism of model predicted fish distributions with more emphasis on developing better rules for migration that accommodates realistic distribution as revealed from observations from historic survey time series and new observations gathered within the i-Nord framework
- more information on marine mammal migration patterns, timing of migrations and interactions with other species in the different parts of the ecosystems are required for both being able to predict the mammal distributions in time and space, and to understand the species interactions in which they are involved

3.2.3 Fisheries and Aquaculture

Fisheries

The fishing industry presently operates mainly based on historic knowledge and information about harvest rates during the ongoing season. There are no services that locate the fish and provide advice to fisherman about where to fish. However, such systems are operational in Pacific tuna fisheries based on analysis of potential tuna habitat from satellite observations and general knowledge of migration routes. An operational system with real time book-keeping of population distribution could potentially be useful to fishermen and reduce fuel expenditure related to reduction of search time and better planning of fishing and landing areas. In particular such a system would be useful for migratory fish stocks such as herring, capelin and mackerel.

The fishing fleet can also be a major fleet of so called ships of opportunity. Thus fishing vessels can be used to collect data on for example temperature and acoustics. There are presently ongoing projects related to making acoustics data from fishing vessels available for scientists on short in real time.

Aquaculture

There is a considerable aquaculture industry in the i-Nord area and that could benefit from the operational system developed under the project. For example prediction systems could be useful to the aquaculture industry related to preparing for harmful conditions related to oil spill, temperature, current anomalies, and algal blooms.

Necessary R&D for Fisheries and Aquaculture

- In order to achieve a system for forecasting fish distribution for fishing purposes, an operational model for spatial-temporal book keeping of fish stocks needs to be developed. This is an integral part in the developments sketched in activity 5.2.2.2 on ecosystem dynamics. The system will, however, have to be further validated for fishing usage.
- A front end system for internet access to the distribution needs to be developed.
- The on-ship system for utilization of ships of opportunity needs to be further developed and optimized and on shore infrastructure needs to be developed accordingly.
- Methods and algorithms for assimilating data from ships of opportunity and buoys into operational physical and biological models need to be developed.
- Forecasting systems for extreme situations related to temperature and currents, oil spills or algal blooms should be developed along with suitable front end internet system for easy access for users in the aquaculture and fisheries sector.

3.2.4 Resource management advice

There are in general two pillars in today’s management of marine resources and ecosystem. First, there is the single species assessment and advice for fish stocks and marine mammals, which is a well established international system witin ICES and national- and bi-lateral negotiation management. Second, there is the advice related to the integrated management plans, which are more focused on general objectives concerned with value creation and coexistence between industries, and more specific targets for managing biodiversity, combating pollution and ensuring safe seafood.

The systematically integrated data and model results, in time and space, which will be delivered from the i-Nord project has a great potential as useful input to the established management structures in the Barents Sea (ICES stock assessments, The Joint Russian-Norwegian Fisheries Commission, The Joint Russian-Norwegian Commission on the field of environmental protection and national management plans)

Concerning stock assessment, i-Nord should focus on giving better basis information to the established stock assessment system, rather than develop new assessment approaches. Today a step-by-step approach is taken in implementing ecosystem knowledge in assessment by using so-called extended single-species assessment models. This is done by adding on the most important interactions (e.g. predation by cod on capelin) to the existing single-species models. In order to quantify the interactions as well as possible, it is important to use more complex ecosystem models (like Atlantis and Gadget)to extract knowledge which then can be implemented in practical assessment using extended single-species assessment models. Development of these ecosystem models within the i-Nord project will therefore be a valuable step towards the next generation of stock assessment framework.
Concerning management plans, i-Nord should focus on integrating data from the entire ecosystem and develop approaches which will be an asset for ecosystem based management within the framework of the management plans.
Though no models today, or in the nearest decades, will be able to incorporate all ecosystem information into a single framework with acceptable high precision, several model frameworks exists that can prove valuable for scenario testing for limited components for the ecosystem both nowcast operationally and in forecasting ecosystem responses. These kinds of models (Atlantis and Gadget) should be further developed and implemented as independent parts of the i-Nord framework to investigate ecosystem responses to challenges on the ecosystem (such as expected effect of oils spill, future climate change, radioactive leakage, different fishing pressure), with basis in the monitoring data system of i-Nord. Each of the models has strengths at different parts and levels of the ecosystem, and therefore all should be included in the project. If these models are improved, then primary outputs from i-Nord can be channelled through the models, and the results be used in a satisfactory and holistic way towards ecosystem based management. A national effort must be made to incorporate spatial dimensions in these models, which is sparse or lacking completely today.
Another type of models that need to be further developed in i-Nord is larvae drift models, which links closely to the hydrodynamic models (ref section on ecosystem), and stock migration models. Both larvae drift and migration models will be an indispensible support for an ecosystem-based management which is spatially explicit. Creating migration models is a large undertaking for which focused devotion from several co-operating institutions may be necessary.
The management plans proposes to use a set of indicators that will provide a unified description of the condition and development in the ecosystem. The primary i-Nord monitoring and up-to date-data flow, is a necessity for indicators to be able to give early warning about changes in the ecosystem, and therefore let the management be able to pro-active make management adjustments in time.

Advice on commercial fish stocks
The commercial fish resources in the Barents Sea are shared stocks between Norway and Russia, and the basis for the assessment and advice on commercial fish stocks are mainly Norwegian and Russian data from research surveys, biological sampling and fisheries statistics. The data are coordinated and applied in assessment models under the auspices of the International Council for Exploration of the Sea (ICES). The i-Nord primary deliverables will be important foundation for developing this knowledge base. i-Nord should focus on giving better basis information to the established assessment model framework development within ICES, rather than develop new assessment approaches.

Integrated Management plans
A Management Forum is responsible for the coordination and overall implementation of the scientific aspects of the Norwegian Barents Sea management plan. Two other forums (Advisory group on monitoring and Forum on environmental risk management) report to the Management Forum, which further reports to a steering committee headed by the Ministry of Environment.

Management Plans are particularly concerned with valuable and vulnerable areas and points out the need for better knowledge about the ecosystem of these, especially in connection with increased human activity. Burden is already high from fisheries, shipping and pollution of valuable and sensitive areas. A national management plan is already developed for the Barents Sea, and the Russians are in the start point of generating a similar plan for their areas. The development of a national management plan for the Norwegian Sea is ongoing, and a similar plan for the North Sea will be developed.
Monitoring of the ecosystem is a major challenge, and coordination of activity, and evaluation of the condition and development are priority tasks for management. The report from the Advisory Group for monitoring of the Barents Sea focuses on these challenges, and gives some aspects of monitoring and assessment of ecosystem of the Barents Sea.
Work on the follow-up of White Paper on "Integrated management of the marine environment in the Barents Sea and waters off the Lofoten Islands (management plan)" is now in its second year. Work in different groups and forums will lead to a revision of the management plan in the course of 2010 and may be of great significance for the future use of our northern marine areas.
It is said clearly that the Norwegian management of the marine environment should be based on scientific results, and that knowledge of how the ecosystem works will be an important basis for such an administration.
The monitoring group's report for 2008 gives a separate chapter on the "ecosystem based management". The white paper on "Clean and rich sea" says the following: "*Ecosystems approach to management of the sea is an integrated management of human activities based on the ecosystem's dynamics. The aim is to achieve sustainable use of resources and benefits from ecosystems and maintain their structure, functioning and productivity*." The monitoring group has tried to show how the monitoring, and use of indicators, can give a relevant knowledge base for management. The management plan proposes to use a set of indicators that will provide a unified description of the condition and development in the ecosystem. Development of appropriate indicators, based on the selection of the management plan, will be crucial for the knowledge can be presented to management in such a way that decisions can be based on an ecosystem approach. The Monitoring Group sees this year's report as a first step towards delivering a knowledge base for an ecosystem-based management. This includes an appropriate description of the ecosystem and its functionality as well as the development of the indicators so that new knowledge can be established through an overall assessment.
The i-Nord deliverables will be important asset for develop this knowledge base.

Necessary R&D for 5.2.2.4 Resources management advice

- Ensure that the data flow is functioning well and as up-to-date as possible, from observation to analyzed result.
- Fill the knowledge gaps in the management plan for the Barents Sea, according to the report from the Management Forum ((St.meld.nr. 8, 2005-2006)
- i-Nord should stress to maintain and improve the indicator time series according to the Management Forum (St.meld.nr. 8, 2005-2006). Also an important task will be to make a continuous evaluation of the indicators to assess these against the approved environmental goals in St.meld.nr. 8 (2005-2006).
- Develop and implement the Atlantis model framework at IMR for the northern areas. Especially important is to implement spatial features in the model.

- Further development of the Gadget multispecies model at IMR for the northern areas for use as a nowcast and forecast scenario tool. Especially important is to implement spatial features and more species in the model.
- Further develop Larvae drift models, and implement this in the i-Nord model framework.
- Develop and implement migration models

3.3 Marine operations

3.3.1 Oil and gas exploration

The Barents Sea is considered to contain 15-20% of world reserves of oil and gas. This will give a large increase of the activities in this region in the coming years both on the Norwegian and Russian shelf, including significantly increased marine transport with potential accidents and pollution situations.
The production of gas at Snøhvit started in 2007 using subsurface frames. Eni has decided to develop the Goliat oil field. Goliat is located north of Hammerfest approx. 65 km from the coast. Eni has decided the use a “round rig” floating production vessel. Installation work is planned during the summer seasons in 2011 and 2012 and start of production in 2013. In 2007 Hydro discovered the oil and gas field Nucula which is located approx. 50 km north of North Cape. It is indicated that the reserves at Nucula is larger than at Goliat. Obsum is also a discovery which has to be followed up.

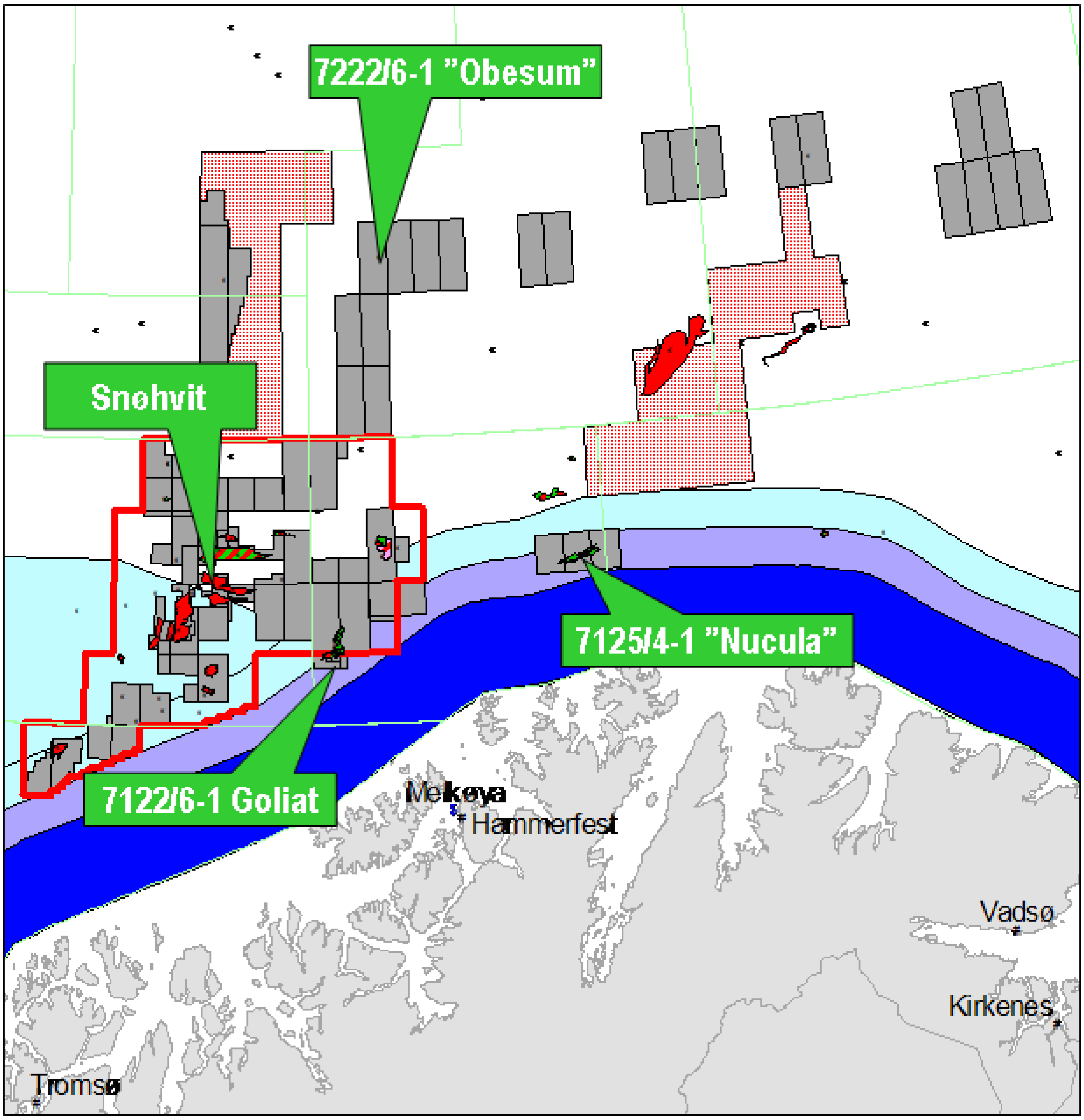


Figure 2. Findings and exploration blocks in the Barents Sea. Courtesy from Bente Nyland, NPD

In addition to the activities related to the discoveries, exploration drilling will continue. In 2008 4-5 exploration wells were drilled, with the northernmost wells located at 73.5°N. In the 20th licensing round which will be awarded in 2Q 2009, the Norwegian Petroleum Directorate (NDP) has released 28 blocks.

In 2007 the Integrated Management Plan was approved by the governments. According to this plan no petroleum activities shall be carried out in the near coast areas north of Lofoten. Data acquisition including seismic data collection will, however, be performed. The management plan will be revised in 2010, and the result of that will influence the activities especially in near-coastal regions.

User requirements

Both during exploration drilling and prediction reliable weather forecasts, especially on polar lows, are required. The rapid change in weather and wave conditions associated with Polar Lows have serious impact on offshore operations such as helicopter transport, vessel operations etc. Various operators and contractors have highlighted the difficulties encountered with unpredictable downtime due to local environmental conditions, particularly those related to Polar Low Pressure Systems. To improve the weather forecasts StatoilHydro has purchased two Wavescan buoys

from Fugro OCEANOR which are deployed southwest and southeast of Bjørnøya after advice from METNO.
Offshore icing is also an operational problem, often in combination with polar lows. This will cause increasing loads on vessel and helicopters and slippery conditions on platforms. Icing can also cause problems on oil and gas terminals. During the storm Narve in January 2006 all outdoor activities were stopped at the Melkøya terminal. During oil spills icing on the oil booms will hinder the operation of the booms. For icing predictions observations and forecast of wind, waves and air temperature are required.
Several operations require real time observations of the vertical current profile. Examples of operations are exploration drilling, ROV operation and covering of pipeline where stones are lowered from a vessel and the current will cause the dumping material to move away from the pipeline. When Hydro started the drilling at Nucula they had to stop the drilling due to strong currents causing large forces on the drill string. Although current models will give overview of the current conditions, they are at present not accurate enough for prediction of local current conditions for operational planning. Current profile observations are therefore often required. Such profiles can be measured by an Acoustic Doppler Profiler (ADCP) either moored to the seafloor with cable connection to shore or to a surface buoy with radio or satellite communication, or mounted on the platform/vessel.
Heavy lifting operations are sensitive to waves, especially long periodic swell. Waves are also required for operations such as loading of oil to shuttle tankers.
For floating production systems the combination of the directional divergence of wind, waves and currents are determining the orientation of the systems, which is especially important during loading of oils from FPSO’s (Floating Production System Offloading).
For bottom mounted platforms it is required to predict the air gap which is estimated from the sum of the sea elevation and crest height. For some platforms like Ekofisk this can imply evacuation of the platform with large economical impacts. As a consequence of this METNO has a forecasting service at Ekofisk for ConocoPhillips.
During an oil spill, wind, wave and surface currents are required for planning the operations and as input to oil drift models. For this purpose NOFO has purchased a Seawatch Mini from Fugro OCEANOR. The buoy data are transmitted to SINTEF where there they are used in their oil spill model. This has been tested during several oil spill exercises. For tracking of oil spills, surveillance from air planes and satellites using radar is an important tool.
To avoid using ice protecting vessels in open sea, the oil is often reloaded in selected areas, preferable in fjords. During the reloading precaution on oil spills are required by the authorities.
No oil and gas activities are planned in the near future in ice affected regions in the Norwegian part if the Barents Sea. This is, however, a problem in the Russian part of the Barents Sea. APL has for instance expressed interest in ice forecasting for their oil loading at the Priarzlomnoya field in the Petchora Sea.
If the activities move south of Bjørnøya, ice bergs will became a problem, but presently no blocks are released in this area.

3.3.2 Other marine operations

As for the oil and gas industry reliable weather forecasts are important for all marine operations such as fishery and coast guard. Other requirements are given below.

Seismic and bathymetric survey

For seismic surveys it is important to know and predict the current strength and direction to optimize the survey operation. This will be obtained by selecting lines that will tie well with its neighbors and therefore minimize the amount of infill (fill of gaps) needed.
For seismic 4D surveys a “replica” of a previous survey is wanted. To be able to get the seismic sources (air guns) and streamers (seismic cables) in the same positions as previous surveys, knowledge of the currents in the area of interest is a key factor to succeed.
Wind and waves will also influence the pre and in situ survey planning and are also a requirement.

Operational streamer (seismic cable) depths can vary from 2 – 15m but are most often done at 7-8m.
In addition to the data described above, bathymetric surveys will need sea elevation data to determine the reference level.

Vessel traffic

All larger vessels have AIS (Automatic Identification System) and information is transmitted to the Vessel Traffic Centre (VTC) in Vardø. One important task for the VTC is surveillance of the vessel traffic from Russia which often content oil and radioactive matters. This traffic is located approx. 50 km from the coast. The Coastal Administration is interested in the current profile down to the keel depth which is approx 20 m, in addition to wind and waves. These data are especial important during accidents such as discharges and drifting vessels. The Coastal Administration has therefore deployed a Wavescan buoy 40 km off the coast of Nordkyn.
The Vessel Traffic Centre requires that all environmental data should be transmitted by AIS.

Radioactivity

The Norwegian Radiation Protection Authority is interested in gamma radiation both in air in addition to their land based network, and in water to monitor any discharge from vessels.

Necessary R&D for Marine Operations

- Industrialisation of radioactivity sensor developed by the Technical University of Athens
- Implementation of AIS for transmission of buoy data to VTC
- In AMASS which is an EU project under FP7, camera technology for buoy application and new energy sources (wind, fuel cells) will be developed. This could be implemented on standard buoys.
- Development of bottom mounted data collection stations. This should be coordinated with the NNN project at SINTEF
- Combination of satellite and buoy data e.g. comparing lidar measurements from buoys with lidar measurements from the ESA ADM satellite which will be launched in 2010
- Combine model results and buoy data for optimising measurement locations
- Development of a non-optical oil sensor. A feasibility study is carried out in an NCEI project

3.4 Marine Safety

3.4.1 Crisis management

Background

There is no single definition of “crisis” since it depends of the context the term is used in. However, common for most definitions is that a crisis is a situation where the need for resources exceeds the availability of resources. There are mainly two types of crises: 1) Large scale accident 2) Environmental crisis. The management of such situations needs to be carefully planned, prepared and trained. It is imperative that all involved actors are aware of their responsibilities and capabilities. Thus, an essential part of establishing a Crisis Management system is the education and training.
Access to timely and updated information is key in managing crises. A post.. of the 9/11 incident in New York revealed that lack if coordination and access to updated information …

Similarly, the terrorist attacks in Istanbul…
During large-scale civilian incidents it is necessary to use resources from the military. The Navy, Airforce and the Army have experiences and equipment that can support all levels of handling the crisis, from medical assistance to strategic evacuation planning. In Norway, this civilian-military collaboration (CIMIC) is a cornerstone of the crisis management strategy.
As of today, there is no common dedicated communication network that allows civilian and military units to share information. Satellite communication and cellular networks are the primary .. Evaluation reports from Barents rescue exercises show that …
New and improved information and communication technology opens a huge potential for improvement of the crisis management support in the northern region. Long-range wireless broadband communication, satellite surveillance, digital maps, positioning systems, backend information systems, simulation platforms, +++ will improve the situational awareness and provide vital information at tactical, operational and strategic levels. Still, it should be emphasized that training of personnel and joint exercises will always be the best way to prepare for crises.

Current CONOPS
- Coastguard (CDR Steve Olsen)
- University Hospital in Northern Norway (Dr Mads Gilbert)
- Police
- Military (FOHK)
- CIMIC – Barents Rescue 2007 – coordination (DSB)

Political issues

Plan / Activities:

Activity
Identify actors/stakeholders and describe their concerns and responsibilities
Identify existing systems for information capture and sharing
Review current Concept of Operation (CONOPS)
International presence
Language barriers (e.g., coastguard + fishing boats: spanish, portugese, russian, ++)

Necessary R&D for Crisis Management
- Visualization (large screen display - watchboard?)
- Semantic Interoperability and dynamic service composition
- Development of standards for status reporting (NATO has some, but these are not sufficient)
- Security management (different levels of access control – civilian and military information)
- Communication (satellite communication is limited in some areas)

3.4.2 Marine situation awareness

"MSA is the capability which delivers the required information to promote effective planning and execution of maritime operations. In order to achieve Maritime Situational Awareness, key requirements are to collect situational data, exchange information between the stakeholders and produce and distribute a unified presentation of the maritime situation.

Introduction
Ocean areas under Norwegian jurisdiction are illustrated in Figure 3. A number of agencies, or government stakeholders, have responsibilities for monitoring and managing these areas, from both an environmental as well as a human activity perspective. The region's vast natural resources require efficient management, in particular the fisheries and the offshore oil & gas sectors. Safe

navigation is also required, and vessel traffic in the area is on the rise. Furthermore, Norway, as signatory to the Schengen Agreement, has responsibility for border control in these areas, a challenging task in itself. As part of maritime security, Norwegian port security is also of importance, and international regulations also impose requirements for monitoring and control of such facilities. Norway's exclusive economic zone is about 2.2 million square kilometres, the largest in Western Europe.

The Norwegian Armed Forces is one of the main contributors to maritime safety and security in Norwegian waters, the Navy, the Coast Guard, the Maritime Patrol Aircraft and the SAR helicopters being the most important. These units are all operating under the same authority, namely the National Joint Headquarters at Jåtta, Stavanger. The Coast Guard is given additional powers through the "Coast Guard Law" and may act on behalf of the Fisheries Directorate, Customs and Police.

The Norwegian Armed Forces have a number of fixed installations, aircraft, helicopters, vessels and procedures to provide surveillance of Norwegian areas of interest in the high north.

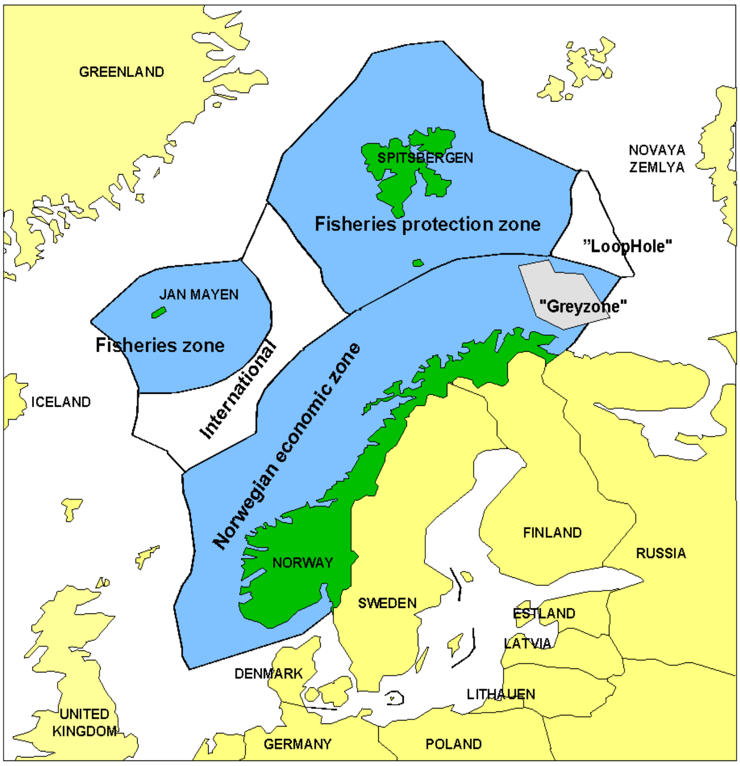


Figure 3. Ocean and coastal areas under Norwegian jurisdiction

The military contribution

The Armed Forces' number one priority is to ensure that the country and its citizens enjoy peace, prosperity, security and freedom. It shall also defend the country and the people in the event of crisis or war and uphold our national sovereignty. However, whilst always being prepared for this one primary role, the Armed Forces have able capabilities and conduct a variety of other important tasks for Norwegian authorities in general.

Maritime Military forces other than the coast guard

The Navy will by 2012 consist of the following forces:
5 Fridjof Nansen class frigates with helicopters.

6 Skjold class Fast Patrol Boats.
6 Ula class submarines.
4 Oksøy class minehunters.
2 Alta class minesweepers.
The Naval Ranger branch.
The Logistics branch.
Maritime tactical command element (NOTG).
In addition the Air Force operates the following maritime units:
6 P3 Orion Maritime Patrol Aircraft (MPA) from Andøya airbase.
Sea King Search and Rescue helicopters (Rygge, Sola, Ørlandet, Bodø and Bandak)

The Navy does routinely support the civilian society within several areas. The most important are:
• Search and rescue (SAR) support to Rescue Centres.
• Support to Norwegian Coastal Administration.
• Support to the Police.
When providing such support, the Armed Forces are not the primary service. The primary service i.e. the Police will lead the operation and will be responsible for the result. A typical contribution from the Armed Forces is resources and expertise. The contribution from the defence forces will always be under the command of military authorities, while the primary service will have a right to give instructions relevant to the operation carried out. Military units could in some circumstances be given the Scene of Action Commander duty.

The Coast Guards Operational Roles
The Coast Guard is an integral part of the Navy and the Coast Guards first operational priority is Norwegians security operations. However, the Coast Guard is special trained to support the civilian authorities in the fish and recourse management, co-operating with other civilian law enforcement. These special features are among others confirmed in the Norwegian Law 1997-06-13 no 42 Law Regulating the Coast Guard (Kystvaktloven) provides within a juridical framework additional tasks and operational responsibilities beyond the Armed Forces responsibilities. The sensitive issue of using military / naval resources in maintaining the common law in peacetime is therefore being resolved through this framework. The Coast Guard is now through legislation able to carry out such roles in peace time. There exists an interdepartmental procedure to request other recourses from the Armed Forces to support civilian authorities for a range of tasks.

Thus the Coast Guards operational roles falls into one of two categories; those in which the Coast Guard is the primary responsible official body and those in which the Coast Guard supports in some capacity other Government bodies.

The roles which fall under the principal responsibility of the Coast Guard includes the following with reference made where relevant to the Coast Guard Law (Kystvaktloven).

1. Maintaining sovereignty at sea (Coast Guard Law §8). The Coast Guard shall maintain Norwegian sovereignty and Norwegian law. Any coast guard vessel on active duty at any time perform operations to this effect in order to maintain, handle crisis / escalation situations and handle violations according to the law.
2. Control of Civilian and Commercial Shipping (Coast Guard Law §18 and §31). The coast guard will maintain control of shipping in Norwegian territorial waters and inner waters and passageways including examining, optionally board and check papers, crew, passengers, and cargo.
3. Maintain law and order at fishing areas at sea (Coast Guard Law §24).

4. Ensure safety standards at sea (Coast Guard Law §9 and §29). Optionally the coast guard shall board any vessels in violation of relevant material or safety standards.
5. The coast guard shall monitor, rapport and if possible neutralise any floating / drifting hazards found at sea (Coast Guard Law §16).

Supportive and secondary roles on behalf of other government bodies include the following :

1. Provide support to the Police in preventing crime and maintaining law and order (Coast Guard Law §12 and §17).
2. Maintaining border control with respect to foreign citizens including maintaining Norways Schengen responsibilities (Coast Guard Law §12).
3. Provide support to the Norwegian Custom & Excise authorities, by reporting and provide direct support when requested (Coast Guard Law §10).
4. Support in executing monitoring and other roles with respect to environmental issues (Coast Guard Law §11).
5. Support other Government bodies with the execution and safety of their principal tasks (Coast Guard Law §12). These include the Norwegian Coastal Administration (Kystverket) with respect to safety at sea, use of pilots and control of harbours and ports
6. the Norwegian Survey Authority (Sjøkartverket)
7. the Norwegian Maritime Authority (Sjøfartsdirektoratet)
8. Perform humanitarian SAR (Search and Rescue) missions at sea and in coastal waters (Coast Guard Law §14).

The Coast Guards Operational Capabilities

The Coast Guard is organized under the Joint National Headquarters in two squadrons. Coast Guard Squadron South based in Bergen and Coast Guard Squadron North based in Sortland.
The Coast Guard will by 2010 consist of the following units:
The Svalbard class (1 unit) is a 6375 ton ice-reinforced vessel equipped with a helicopter and is fitted for firefighting and counter-pollution work. She carries two motor cutters and a sea-raider type dinghy.

Figure: Svalbard class

The Nordkapp class (3 units) is a 3300 ton vessel equipped with helicopter., motor cutter and a sea raider type dinghy.

Figur: Nordkapp class

The Barentshav class (3 units) is a 4000 ton vessel specially designed to support other government services. She has a crew of 20. She is armed with a 57 mm Bofors gun.

Figure: Barentshav class

The Nornen class (5 units) is a 761 ton vessel specially design to operate in inshore waters. She is equipped with counter pollution gear and armed with a 12.7 mm Colt. The crew is 13.

Figure: Nornen class

Monitoring resources
The Norwegian Coastal Administration (Kystverket), the Norwegian national agency for coastal management, marine safety and communication, has several Vessel Traffic Service (VTS) centres that are responsible for ensuring safe and efficient navigation and protecting the marine environment against undesired events. The northernmost station is located in Vardø. This VTS monitors the traffic, interacts with vessels and exchanges information with other government agencies for the Norwegian Economic Zone from Rørvik (65 degrees North) to the Russian border. This work in North Norway is conducted in close conjunction with Regional Joint Headquarters North-Norway (Norwegian Armed Forces) located at Reitan, outside Bodø.

A key information source for monitoring the civilian vessel traffic is AIS (Automatic Identification System), see Figure 4. AIS is mandated by the International Maritime Organisation (IMO) for all ships larger than 300 tons.   The Automatic Identification System is a system used by larger ships and VTS principally for identification and locating vessels. All passenger ships licensed to carry 12 or more passengers in Norwegian waters are also required to operate AIS transponders.

AIS provides a means for ships to electronically exchange ship data including at least identification, position, course, and speed, with other nearby ships and VTS stations. The AIS messages, combined with radar information, provide relatively good insight for the ordinary surface vessel traffic in the near shore region (~20 nautical miles).

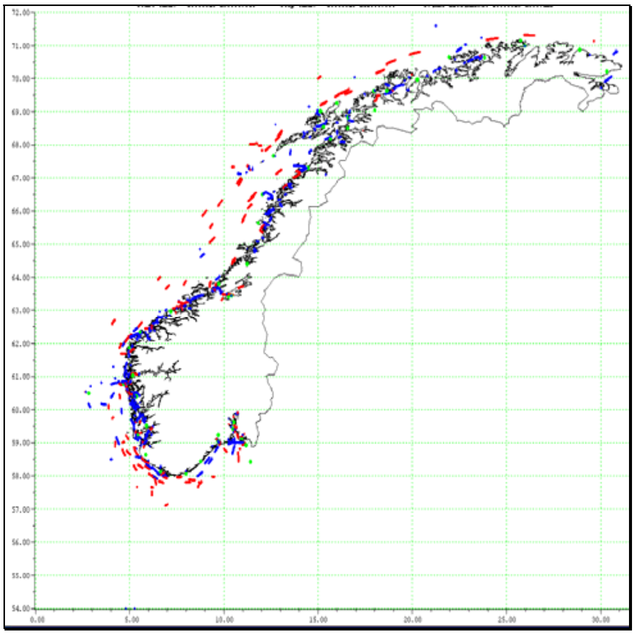
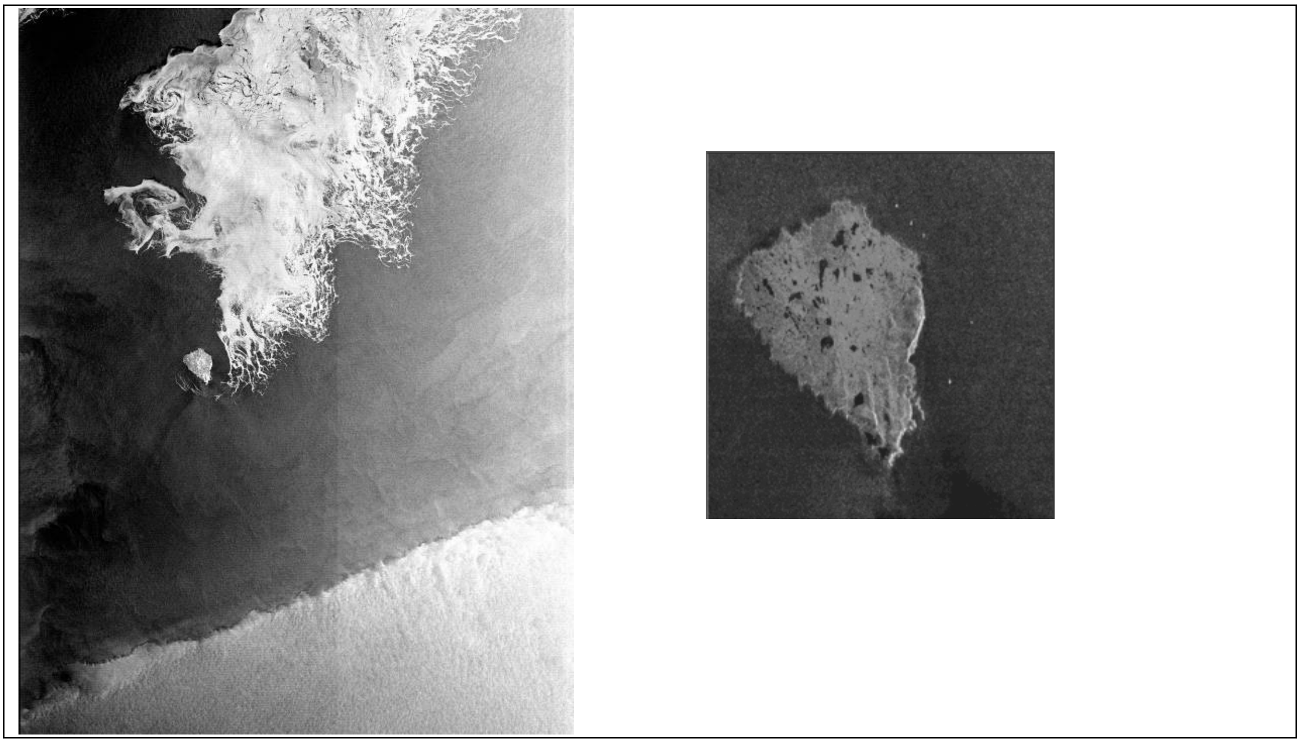


Figure 4. Example of ship tracks from the NCA’s coastal AIS chain. Norwegian and foreign vessels are colour coded with different colours.

Since the early 1990’s, the launch of several Earth observation satellites into near-polar orbits has given Norway the opportunity to make use of such tools for more efficient maritime monitoring and surveillance. Today, Norway is a significant user of radar imagery in particular, from the European ENVISAT satellite and the Canadian Radarsat-1 and -2, in particular for fisheries monitoring, oil spill detection, and also for ice monitoring.



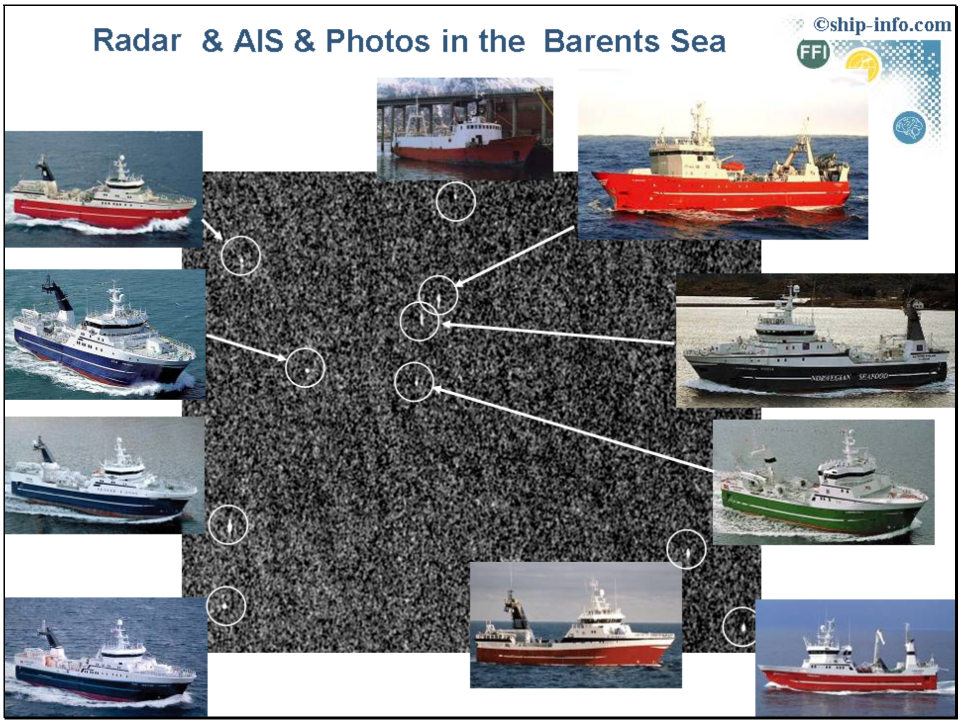


Figure 5. Examples of use of satellite radar imagery. The upper panel shows a Radarsat-1 image from the Barents Sea, with Bear Island in the centre. Sea ice can be seen NE of the island, and a strong weather front further south. The close-up of Bear Island shows fishing vessels (white dots) under the lee of the island. The lower panel shows a similar radar image in the background, overlaid with pictures of vessels identified with help of an AIS receiver on a coast guard aircraft.

More recently, a national program has also been established to demonstrate deployment of an AIS receiver in low Earth orbit. A micro-satellite is scheduled for launch in 2009, to demonstrate reception of AIS messages over the entire Arctic. This has the potential for extending the AIS operational coverage from coastal, as illustrated in Figure 4 to the whole region, Figure 6.

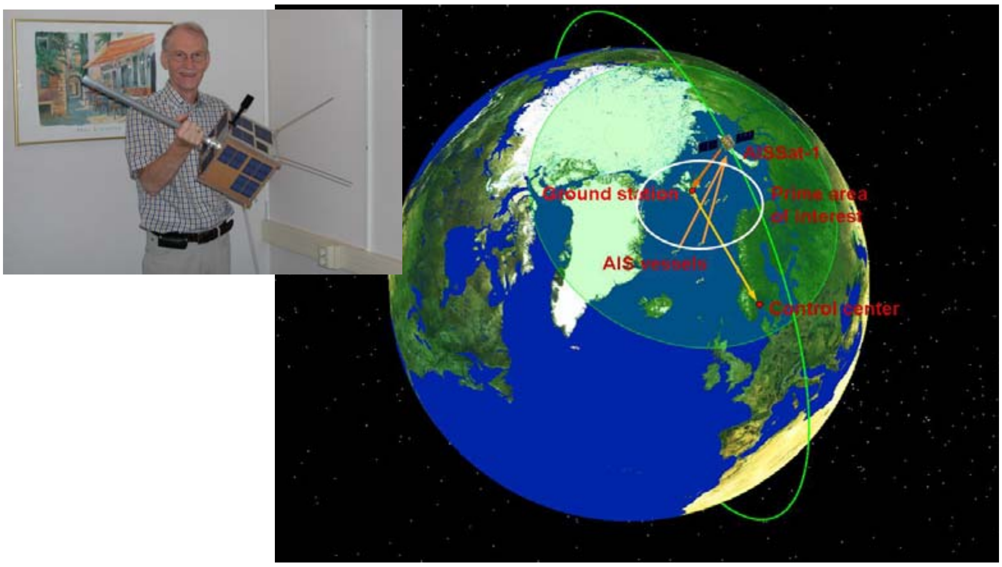


Figure 6. The Norwegian AISSat-1 mission. Equipped with an AIS reeiver, the 6-7 kg microsatellite will demonstrate possibilities for monitoring ship traffic in the HIgh North.

The IMO has also introduced the so-called Long Range Identification and Tracking (LRIT) system. From 2009, vessels are required to report their position once every 6 hours. These reports must go to the authorities of their flag states, the authorities of coastal waters they are navigating in, and to port authorities at their destination. The system will predominantly rely on reporting using Inmarsat, which has limited coverage in the Arctic. At present, it is uncertain how well this will serve Norwegian monitoring needs.

Coordination of maritime surveillance

A more seamless maritime safety and security architecture for information exchange between different government agencies and sensors will improve the enforcement of Norwegian fisheries jurisdiction and the overall surveillance capability for this giant area. Furthermore, more sophisticated sensors will produce an overload on the decision makers. Hence, effort should also be taken in automatic anomaly detection. Automatic anomaly detection may require further investigation and verification in order to reach a decision whether to monitor or act thereby directing further resources towards the object or geographic area. This may involve cross-sectorial coordination in order to organize resources beyond own sector.

A MSA (Maritime Situation Awareness) forum has been established by initiative of the Norwegian Armed Forces (FOHK) and the Norwegian Coastal Administration. This forum is in its birth phase and is trying to establish a proper mandate for its existence. Hopefully, some of the planed working groups within this forum can contribute to a more seamless maritime safety and security architecture. This will be beneficial both for the decision makers as well as those doing maritime operations and explorations in our area of responsibility.
One of these initiatives will invite cross-sector nomination of requirements which will enable to establish a web-based MSA-picture by integrating multi-sensor information and add on functions nominated by the different sectors in order to provide more effective services combining supporting efforts.

3.5 Technology (platforms, sensors, communication)

We need a cost-effective monitoring system that will provide relevant data for the foreseen i-Nord products at a resolution capable of reflecting temporary changes in the ecosystem, whether these

are caused by over-harvesting or pollution, or are simply the result of climatic oscillations. To some extent such a monitoring system is already in place, as indicated in the best practice reports for the various target areas. However, the foreseen products in many cases suffers from lack of resolution and coverage of available data, and the data (if existing) are often not easily available at the right time and in the right format. Therefore there is clearly a need for enhancing the monitoring system, both in terms of extending existing systems and in terms of developing and deploying new technology.
There is a considerable experience in the Norwegian offshore industry using underwater cables for communication and power transmission. Cabled systems may be preferred for in situ instruments requiring high bandwidth, real time data transmission, adaptive sampling strategies and/or high power consumption. However, high deployment costs prevent widespread use beyond a few key locations. Wireless underwater communication is well suited when cabled solutions between underwater systems are not, e.g. when using mobile underwater units. The improvements in performance and robustness seen in the field of acoustic underwater communication over the last decade is very promising for future use in long-term environmental monitoring systems in the High North/Barents Sea region.

The suggested structure of an automated observation-database-ecosystem model system for the Barents Sea is:

1. An adequate collection of observation and sampling platforms (research vessels, ships of opportunity, network of buoys, landers, long range acoustics etc.)
2. Distributed databases for key variables (CTD, nutrients, phytoplankton, fish samples, acoustics, zooplankton samples, marine mammals,).
3. Automated flow of data from the different observation and sampling platforms to the databases at highest feasible update rate.
4. An operational 3D ecosystem model that captures the entire ecosystem at an adequate resolution in space and taxa that is automatically updated regularly (daily for example) when new information is entered in the databases. The ecosystem model will continuously generate present status and a set of adequate length forecasts (e.g. week, month).

The collection of monitoring data is based on three elements: sensors, infrastructure and communication
The monitoring systems can be divided into three main categories: systems placed in the ocean (on the surface or submerged), systems place on satellites and systems placed on airborne platforms like planes or balloons.

3.5.1 Sensing systems for oceans

The establishment of satisfactory sensing systems for oceans in general has been hampered by the extremely high cost of gathering marine data. The main reason for this high cost is the need for expensive vessels as platforms for the most important monitoring sensors and systems. Consequently a main challenge lies in being able to place relevant sensors on autonomous platforms or platforms of opportunity that happen to be at the relevant location. This will require the systematic development of technological infrastructure and communications solutions which are capable of operating in such environments. In particular this will require system elements with a high degree of autonomy and capability of forming ad hoc and dynamic collaborating structures involving potentially large numbers of heterogeneous elements.
The rapid development of information and communication technology (ICT) has opened up new possibilities for the observation and monitoring of the marine ecosystem. New sensor and instrumentation technologies have also revolutionised the potential for gathering high-quality data from a much broader spectrum of platforms than specialised research vessels alone. The concept of distributed data acquisition via an advanced infrastructure demands the adoption of technology

and methods originally developed for other purposes, particularly in sensor and communications technology and self systems.
The project *Nordområdenes Nye Nervesystem Undervanns trådløst sensornettverk* (NNN-UTS) develops an underwater hydroacoustic wireless network, aimed to communicate sensor data for biological/environmental and safety/security applications. The project is supported by the Research Council of Norway, and is a cooperation between Kongsberg Maritime, SINTEF, IMR, Fugro Oceanor, WesternGeco and StatoilHydro. Hardware is being commercialized by partner Kongsberg Maritime. The project will finish in 2009, by demonstrating a small network including sensor input and wireless communication.
Two of the partners from NNN-UTS; SINTEF and Kongsberg Maritime also participate in the EU 7th framework programme project *UAN – Underwater Acoustic Network*, together with several European institutions and companies (http://www.ua-net.eu/). The project runs 2008-11, and shall develop and demonstrate a wireless network specifically optimized for safety/security of critical infrastructure such as oil and gas production facilities. The network shall handle both static and mobile (AUV) sensor nodes. Again Kongsberg Maritime will commercialize the necessary hardware.
FFI currently has two projects addressing acoustic communication systems in Northern areas. One explores the potential of commercially available technology, while the other seeks to provide a tool to help improvement and adaption of communication algorithms to the specific High North ocean environment.

In a project called ”Underwater Network-Centric Warfare” (Nettverksbasert forsvar under vann), FFI is developing a demonstrator system for autonomous deployable underwater sensor networks. The system consists of relatively small and light sensor nodes, which have been given the name NILUS (Networked Intelligent Underwater Sensors).

Each sensor node has passive acoustic and magnetic sensors, able to detect objects in the water volume and on the surface. Signal processing is done locally in the node in order to minimize the communication requirements. The sensor nodes are equipped with underwater acoustic modems. The demonstrator system uses an underwater communication network system developed by the US Navy, but the system is modular such that it is also possible to equip the nodes with alternative underwater communication systems.

The demonstrator system was used in sea trials for the first time in September 2008, with promising results. The current project will last until the end of 2009, but FFI tries to get a follow-up project in place, which is likely to include industrialization of the concept.

The developed technologies may also be used as a basis for surveillance systems around civilian high-value assets, like harbours and oil installations.

In the “Underwater communications optimization for northern waters”-project, FFI will expand a communication channel simulation tool. The underwater channel, and consequently the performance of underwater communication systems, varies greatly in time and space as a function of oceanography (“underwater weather”), seafloor conditions, sea surface conditions and man-made noise sources. A simulation tool enables testing, adaption and development of communication algorithms for realistic underwater environments without expensive at-sea tests. A tool previously developed for specific geographical area and acoustic modems, will in the upcoming project be expanded to simulate High North environments and a broad frequency range (underwater communication systems).

Autonomous underwater vehicles

Integration of autonomous underwater vehicles (AUV) will enable the gathering of data of unprecedented resolution and quality. Such vehicles excel in efficient gathering of a wide spectrum of information. Depending on the size of the AUV, almost all existing sensors (of use in this kind of work) can be fitted to it. Since an AUV very often can position the sensors optimally according to the sensors characteristics, an AUV can usually provide better sensor quality than other – often larger and more expensive – systems. AUV's comes in different sizes, which gives them different properties concerning available sensors, range, portability etc. In this context it is primarily the large and medium size AUV's that is of interest as smaller AUV's typically have to short endurance and range to be of use. So-called gliders (another very interesting concept that can be described somewhat loosely as "un-powered AUV's") often has extreme endurance, but can only bring along a few small and very low-power sensors and are totally dependent on wind and oceanic currents for movement. In 2008 IMR in cooperation with the UoB was operating three gliders.

Through a number of years FFI has had a close collaboration with Kongsberg Maritime in developing the HUGIN AUV's. The HUGIN class AUV's dominate the civilian AUV market, and are also one of the world leading suppliers in the military marked. May 2008 FFI got its own, operational HUGIN system, the HUGIN 1000 HUS. This AUV is the first type of the new member of the HUGIN family, an AUV primarily for scientific use. It has been designed to be equipped with a large range of different, interchangeable sensors. It can be operated from almost any vehicle of opportunity, although it will primarily be used from FFI's research vessel "H U Sverdrup II".

Ferrybox systems/ships of opportunity
Since 1936 until today IMR has operated a simplified "ferry box" system on the Hurtigruten to regularly map the surface temperature and salinity along the coast of Norway. Similar systems have also been operated from different cargo vessels across the North Sea. Since 1936 (1942) until today IMR also started to use local fishermen for measuring temperature and salinity from the surface to the bottom at 8 stations along the coast (http://atlas.nodc.no/stasjoner/). These data gives key information about the ocean climate development along the coast.
NIVA has for 8 year developed a network of ships of opportunity systems in Norway including the northern area with the Hurtigruten and the Tromsø-Svalbard transect. The Hurtigruten line has two advanced Ferrybox systems operated by NIVA and IMR, and new environmental sensors are continuously implemented when tested and validated. The present core systems of sensors measures, temperature, salinity, oxygen, algal concentration, and particles. Advanced sensors tested on some ships are e.g. oil sensors, pCO2 system and advanced high precision pH measurements. In addition the ships of opportunity platform can be used for metrological measurement and for validation of satellite products using optical sensor on deck.
Just recently IMR and the Coast Guard agreed to mount Ferrybox systems on Coast Guard vessels, and the first will come in operation in 2009. IMR has also a long tradition in obtaining data from the fishing fleet. A reference fleet of both large offshore and smaller coastal fishing vessels has been established, taking a range of measurements on the demand from IMR. Regular meetings are hold to discuss practical issues and the usefulness of data.

Necessary R&D for Sensing systems for oceans
Five core areas for research and development has been identified.

- Methods and models for optimal model-based data collection and data assimilation

- Telecommunications: integrated networks on and beneath the sea surface

- Sensor technology and sensor networks for measuring parameters for fish and plankton, oceanography, pollution and other environmental parameters
- Self-* (self-organising, self-adapting, self-healing etc.) systems
- Energy: storage, supply, and harvesting for operation of sensors and communication network
- Improved and rapid availability of data

3.5.2 Satellite remote sensing

Earth observation systems rely extensively on satellite remote sensing techniques for ocean surface winds, sea surface temperature, sea level, ocean colour, and sea ice, which all again are highly affected by ocean waves. In future it is expected that also sea surface current, ocean salinity and ocean waves measured from space, will play important roles in the Earth observation system.

Any earth observation system for northern areas must include satellite borne sensors measuring land, ocean and atmospheric parameters. A wide range of atmospheric and terrestrial parameters are intimately linked to the state of the ocean. Important atmospheric parameters largely dependent on satellite observations are e.g. precipitation, earth radiation budget, cloud properties, upper air temperature and aerosol properties (including ozone). Important terrestrial parameters include e.g. snow cover, glaciers and albedo.

The mutual coupling between different ocean (and atmospheric) parameters and how they are manifested in satellite measurements, require precise modelling and measurements of all key parameters. The long term goal of any Earth observation and monitoring system must be to provide information that is consistent with measurements provided by satellites, drones and/or in-situ networks.

The satellite remote sensing research should aim at providing the best possible measurements of ocean surface parameters, as well as deriving relevant products for input to the modelling activities. Optimal utilization of remote sensing products within numerical models require care in the product definition process as well as in the assimilation development. Because of the harsh environment and often inaccessibility of high latitudes, satellite remote sensing presents a highly efficient monitoring device in the Arctic, especially in the microwave region due to the frequent cloud cover and the polar night.

The satellite remote sensing research will thus be concentrated on data from microwave instruments, with special focus on active instruments such as radars. High-resolution radar instruments such as SAR systems measure the ocean surface and sea-ice roughness from which surface winds, waves, currents and sea ice coverage can be retrieved. The SAR signature of an ocean surface is in general a mixture of many geophysical phenomena (see Figure 7) that even are mutually connected such as for instance the wind, wave and current. The interpretation SAR ocean signatures and the derivation of robust and consistent retrieval algorithms are difficult, and require in most cases a coupled modelling and inversion strategy. Multi-channel SAR systems may help in resolving the various ocean signatures in SAR images.

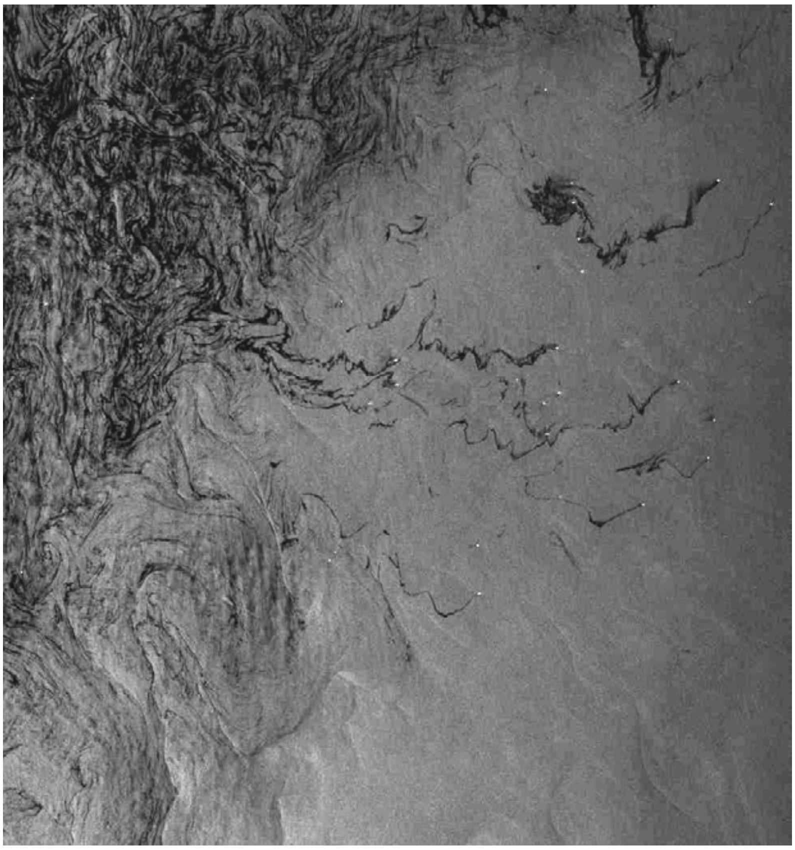


Figure 7. SAR ocean image showing various ocean surface signatures (natural slicks, wind, oil slick, ships)

The combination of high spatial resolution and temporal coverage of existing satellite SAR systems, has led to the development of satellite based ship traffic monitoring systems. Norwegian research institutes and industry have had a leading role in this development. The main limitations of existing ship detection systems are related to false alarms, imperfect land masking, dependency on background image statistics, and limited classification capabilities. The use of Polari metric information together with advanced signal processing is believed to improve the classification capabilities of SAR systems. Today the classification is limited to only position and ship size. Example of enhancement of ship signature by advanced signal processing is shown in Figure 8 below:

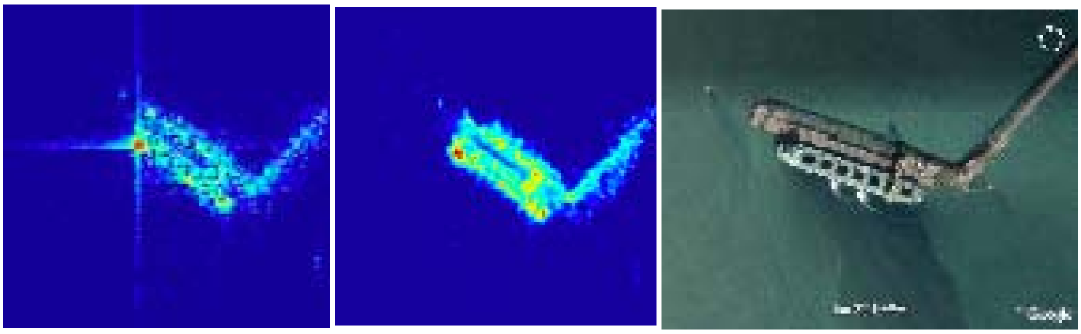


Figure 8. a) SAR ship image processed with standard technique, b) SAR ship image processed with super-resolution technique, c) optical image of the ship. The SAR image is from Radarsat I, and the data are processed at Norut

Ocean colour

Satellite based measurements of ocean colour are important to derive the productivity of the ocean. At a local scale, satellite observations of ocean colour, in combination with sea surface temperature, can be used to infer productivity, alga blooms and pollutions. However, most standards products are produced with atmospheric and bio-optical models developed for waters far from our northern areas. Here extensive work are ongoing in the Norwegian space agency program SATHAV and in different ESA project to develop and validate new products for the area. There is here a strong coupling to the in situ data for validation and algorithms development.

Ocean topography and currents
Ocean circulation is important for the earth's climate system. Ocean circulation can be inferred from ocean surface topography, which can be measured using satellite altimetry. Ocean surface circulation may also be observed indirectly by features as currents and frontal boundaries in SAR imageries, and differences in temperature and colour observed from visible and infrared instruments.

Ocean salinity
Ocean mixing of heath and gasses and water mass formation are intimately related to variation of surface salinity. Some ocean models show that sufficient surface freshening will slow down the meridional circulation. Sea surface salinity products from satellite remote sensing is a new research field applying brightness temperature at L-band (microwaves). Combining sea surface salinity measured from satellites with ship and buoys in-situ measurements will provide a key input to measure ocean circulation changes. Today there are no space based observations. However, ESA will in 2009 launch the SMOS satellite to measure sea surface salinity (and soil moisture), and NASA will fly Aquarius in 2010 to measure salinity.

Ocean surface winds
High-resolution wind vector measurements at the ocean surface are required for modelling the atmosphere, ocean surface waves and ocean circulation. Polar orbiting satellites provide sea surface wind information global coverage and acceptable accuracy. Scatterometers provide dense observations of wind direction and speed along a narrow swath (however, new and planned scatterometers will provide 90% global coverage daily). Passive microwave imagers and altimeters provide information on wind speed only, but work is ongoing to improve the capability of passive microwave sensors to make scatterometer quality measurements.

Sea surface temperature
Sea Surface temperature (SST) is linked closely with the ocean circulation. Satellite remote sensing is the only practical way to establish global or regional SST datasets. However, in-situ data have a key role in calibrating satellite data and providing necessary information for providing bulk temperatures.

Wave height and spectrum
SAR instruments can provide information on the 2D wave spectrum with good accuracy but relative low temporal resolution. SAR instruments can measure changes in waves and winds, wavelength and wave direction. Radar altimeters can provide significant wave height.

Other applications
Other than specific oceanographic parameters, a large number of sensors can provide a range of ocean images that will be useful. High to medium resolution sensors are useful for coastal zone areas and can give information on e.g. sedimentation, bathymetry and can be used for coastal zone monitoring. SAR instruments will provide all weather, day and night high-resolution images on sea-ice, pollution (oil-spill), ship detection, and iceberg detection. Optical sensors are used to provide the radiation budget at the surface and optical and microwave sensors are used for sea ice detection, concentration and drift.

Necessary R&D for Satellite remote sensing

The satellite remote sensing research to be conducted in the framework of Earth observation system and ship traffic monitoring are described in the following.

Main research topics:

- Deriving coupled retrieval methodology and algorithms for ocean surface parameters from SAR systems.
- Developing new bio-optical models and satellite products for optical satellite data.
- Validation of satellite measurements against aerial platforms and in-situ sensors.
- Deriving higher order ocean products for input to Earth observation system.
- Better utilization of existing observations through improved assimilation methods

Basic supporting research:

- Deriving better theoretical models for describing the scattering of microwave from ocean and sea ice surfaces at the scale observed by SAR systems.
- Deriving better understanding of the effect of wave breaking and sea surface statistics on the microwave signature. This research will be supported by a collocated satellite, drone, and in-situ measurement campaign.
- Better understanding of polarimetric signatures from ships.

Adaptation to future technology:

- Develop algorithms that use the dual- and fully-polarized capability of the new generation SAR systems (Radarsat-II, Sentinel-1) to detect ocean, sea ice and ship parameters.
- Develop algorithms to fully exploit the MetOP data for sea-ice mapping, especially the capabilities of the new ASCAT instrument.

3.5.3 Aerial sensor systems

An unmanned aerial system (UAS (balloons, aircrafts)) has the promise of being a vital component in surveillance and monitoring of the environment in the high north. In the arctic region, surveillance with manned aircrafts is extremely expensive due to the vast distances, sparse population of airfields, few available suitable aircrafts and harsh climate. Satellites are extremely efficient at gathering data in the arctic regions, but has limitations to what can be detected and when. The extensive cloud cover has proved to limit the availability of optical data as well as high latitude makes data from geostationary satellites ill suited for this region. Hence, a small inexpensive UAS with long endurance and range is well suited for a cost effective surveillance in the arctic.

Within i-Nord use of UAS as an inexpensive airborne instrument platform, opens new possibilities within resource management, environmental surveillance and further research. Possible applications relevant to i-Nord are:

- Atmospheric and meteorological measurements. Lack of in-situ data in the Barents Sea region is currently hampering the accuracy of numerical weather prediction models
- Resource management, grazing load, population estimates of seals, reindeers, polar bears, etc
- Detection of oil spills
- Surveillance of offshore oil and shipping activities
- Natural disaster management
- Research within a number of fields

- Satellite validation and testing
- Detection and surveillance of algae blooms

The majority of UAS research and development has traditionally been focused on military systems and applications. In military UAS systems range, endurance and/or cost are compromised in favor of e.g. stealth properties and the ability to carry military payloads. Lately, there has been an increasing focus on scientific UAS applications.
Norut Tromsø has developed CryoWing (Figure 9), a long-range small UAS system for scientific measurements as well as environmental monitoring and infrastructure surveillance in arctic regions. The airframe was designed to fulfill our requirements for a low cost, long endurance, moderate payload capacity platform with the capability to operate without a runway. The CryoWing UAS system consists of an airframe with an autonomous autopilot controlled through a satellite or a GSM communication link by an operator. The payload is controlled by an onboard computer system which stores the data from different sensors and instruments and handles the communication and live data transfer to the internet.

Figure 9. Norut's unmanned aerial system in Antarctica in 2008

A wide range of instrumentation is already developed for this platform. Current instrument suit exist for the CryoWing UAS:

- Imaging Spectrometer 256 channels 400-700 (950) nm wavelength (Fred Sigernes, UNIS)
- Digital camera 10 MPX
- C-band radar sounder
- Laser profiler
- Meteorological instr. package (Temp, hum, press, wind)
- Laser-scanner 12500 pts/s 10cm accuracy
- Turbulent heat flux sensors (Temporary loan, Univ. of Braunscweig)
- SST meter (IR thermometer)

Additions under work ready spring/summer 2009.

- Ramses Spectrometer (up and down looking)
- Synthetic aperture radar (Ku-band)

Necessary R&D for Aerial sensor systems

Further research and development in unmanned aerial system specifically targeted to i-Nord needs:

Development of new products

- Development of automated processing algorithms for detection of sea ice cover and ice thickness based on photos and laser altimeter measurements.
- Automated counts of seals and polar bears on sea ice based on pattern recognition
- Automated detection of oil and its thickness distribution based on c-band sounder data and Ku-band SAR.

New instruments and algorithms

- IR camera for detection of oil spills and oil spill distribution
- Aerosol sampler to detect airborne pollution and its distribution.
- Detection and identification of ships based on use of radar and camera in combination
- Drop sondes for meteorological profiling of the atmospheric boundary layer

Platform improvements

- Icing sensor to ensure safe operation under all weather conditions
- Sense and avoid radar based system to improve safety and thereby increased flexibility for operations in normal airspace
- Increase range and vertical dynamical range

Control and data communication infrastructure

- Mission coordination
- Flexible data communication over heterogeneous networks
- Between UAV's, with ocean sensors, with satellites, base etc.
- Sensor data management
- Local storage, peer-to-peer synchronization
- Live sensor feedback to aircraft control system

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