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Space and the Arctic

Accompanying the document

JOINT COMMUNICATION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Developing a European Union Policy towards the Arctic Region: progress since 2008 and next steps

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This document is a European Commission and EEAS staff working document for information purposes. It does not represent an official position of the Commission and of the EEAS on this issue, nor does it anticipate such a position.

1. INTRODUCTION

The remoteness, low population density, marked seasonal variability[1] and harsh meteorological conditions in the Arctic mean that Earth-orbiting satellites are essential tools for communication, navigation and observation in the region.

With the entry into force of the "Lisbon Treaty", article 189 of the Treaty on the Functioning of the European Union confers to the European Union a shared space competence which it pursues alongside that of the Member States. It is the basis for the definition of a EU Space policy[2] of which the two flagships are Galileo, the European GNSS, and GMES, the European Earth monitoring programme. Space research and developments activities are funded under the space theme of the Seventh Framework Programme for research.

The European Space Agency (ESA), established in 1975, is an intergovernmental organisation currently with 18 member states. Its purpose is to provide for, and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems

A Space and the Arctic workshop was organised on 20 to 21 October 2009 in Stockholm, Sweden by the Swedish National Space Board and the Swedish Meteorological and Hydrological Institute together with the European Space Agency (ESA), EUMETSAT and the European Commission.

The workshop was held under the auspices of the Swedish Presidency of the Council of the EU as part of a commitment to face the challenges of climate change and increased human activity. It focused on three themes: climate change and environment; transport safety and security; and sustainable exploitation.

The aim of the workshop was to identify the needs of those working and living in the rapidly changing Arctic and explore how space-based services might help to meet those needs. Increased activities in these northern areas are expected as a consequence of climate change, technological progress and shortages of resources. Oil and gas production, fisheries and shipping are expected to move further north. The workshop investigated how space infrastructures could facilitate communication, environmental monitoring, early warning, navigation and vessel tracking.

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[1] The sea-ice cover varies considerably between summer and winter

[2] See conclusions of the 4th Space Council meeting

At the end of the workshop, participants agreed a set of conclusions and recommendations as to how space technology could help Europe meet its objectives in the Arctic[3].

This document is a European Commission interim report, prepared together with the European Space Agency, taking stock of current and future space programmes relevant to the Arctic region and assessing to which extent actions have been addressed following the workshop. It is a factual account showing that progress has been made in meeting these challenges and that considerable benefits to the many interests in the Arctic have accrued through collaborative programmes involving both EU and non-EU Member Statres.

2. NAVIGATION

Global and regional satellite navigation systems (GNSS) for accurate positioning are now fundamental tools for safe transport on land, in the air and on the sea. This is particularly true for the cold, dark, snowy Arctic which has few other navigation and positioning tools. Positions and timings derived from GNSS can also contribute significantly to observations of the Arctic for scientific purposes.

The further implementation of the European satellite navigation programmes (EGNOS and Galileo) was established by the regulation (EC) No 683/2008 of the European Parliament and of the Council of 9 July 2008. The system established under the Galileo programme is an autonomous global navigation satellite system (GNSS) infrastructure consisting of a constellation of satellites and a global network of Earth stations. The objectives of the Galileo programme are to ensure that signals emitted by the system can be used to fulfill the following five functions : Open Service, free to users, a Safety of Life Service aimed at users for whom safety is essential, a Commercial Service with improved performance, a public regulated service for government-authorised users and a search and resque support service.

Galileo is a global system which will cover also the Arctic. The Galileo services will facilitate safe navigation in the Arctic, support search and resque activities and any activity requiring positioning.

The European Geostationary Navigation Overlay Service (EGNOS) is an infrastructure for monitoring and correcting signals emitted by existing global satellite navigation systems. It is EGNOS that will provide the Safety of Life function for Galileo by providing warnings when the signals fail to provide acceptable margins of accuracy. EGNOS relies on a system of 40 ground stations in Europe and North and three geostationary satellites above the equator to Africa to assess the accuracy of positioning signals and transmit them to users. Since there are no ground stations in the Arctic and since users above about 75ºN cannot receive signals from geostationary

[3] http://esamultimedia.esa.int/docs/EarthObservation/Statement_final.pdf

satellites, EGNOS does not work in the Arctic. This will mean that, under current plans, satellite information cannot be certified for safety-critical applications such as aircraft landing in the Arctic.

The European Space Agency's GNSS Evolution Programme's Arctic Testbed[4] will explore how EGNOS augmentation services can be extended to the Arctic. Broadcasting via other satellite systems, including non-European ones, is an option and will be explored in the years to come. The Arctic Testbed may later also analyse the requirements of scientific applications, including those related to climate change, mainly for more positional accuracy.

3. MONITORING

The Arctic sea-ice is being monitored by both European and non-European satellites. Various providers use measurements from these satellites to support navigation within their own national waters. However no single provider is yet capable of providing satellite based near-real time sea-ice information to ships in all Arctic waters[5]. Ships' masters must therefore switch between different presentations of satellite-based ice maps as they move from one zone to another.

3.1. Global Monitoring for Environment and Security (GMES)

Workshop Recommendation: "The European Commission to ensure that proposals for future operational GMES satellites and services, address the special needs of the Arctic (sea ice, icebergs, snow, glaciers, ice sheets and permafrost"

GMES is the EU's Earth monitoring programme. It is a long-term programme built on partnerships between the Union, the Member States, the European Space Agency (ESA) and other relevant European stakeholders. It is also a programme where the EU plays an important role in international cooperation through bilateral collaborations with other space faring nations or participation to global efforts in the field of Earth Observation (e.g. the Group on Earth Observations).

Since its beginning in 1998 the overall funding allocated to GMES until 2013 by the EU and ESA has reached over €3.2 billion for the development and initial operations of the services, and of the space and in situ infrastructures.

The GMES architecture is based on three components: a service component that delivers information in support of environment and security policies, and two observation components (space-based and in-situ) that provide the data needed for operating the services.

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4 Budget €4.5 million

5 Global pictures provided by EUMETSAT Ocean and Sea Ice Satellite Application Facility are of very low resolution and not intended as an aid to navigation.

The satellites under the GMES umbrella that are most useful for the Arctic are:

(1) Sentinel-1A is planned for launch end 2012, Sentinel-1B 2 years later. These satellites have been developed to ensure operational monitoring of sea-ice extent and icebergs within the GMES framework. Snow, glaciers and permafrost were not considered within the original design specifications for Sentinel-1 which will nonetheless contribute towards their monitoring.

(2) The Sentinel-3 constellation will provide useful monitoring capabilities for the Arctic, providing global land and ocean observations of parameters relevant to the Arctic such as sea-surface temperature and topography, snow extent and sea-ice thickness. The capability to monitor sea-ice thickness will be based on experience from the CryoSat research satellite (see below) and, providing the appropriate infrastructure is set up, will allow near real time monitoring of this parameter for the first time. The first of the two Sentinel-3 satellites is planned for launch in 2013.

GMES services can be divided between core services and downstream services that add value to the core services. It is intended that there should be six core services - emergency management, land, marine, atmosphere, climate change and security.

The MyOcean project, funded under the Seventh Framework Programme, is delivering a prototype marine core service. It includes an 11-16km resolution model providing forecasts 10 days ahead.

Other components of GMES, whilst not particularly developed for cold regions, nevertheless contribute to understanding the Arctic. The Sentinel-4 and Sentinel-5 missions are dedicated to monitoring the composition of the atmosphere for GMES Atmosphere Services. Both missions will be carried on meteorological satellites operated by Eumetsat and could contribute to monitoring the trans-boundary pollution that affects the Arctic. During winter 2009-2010 the near real time analysis and forecasting system of the GMES Atmosphere monitoring pilot service provided in depth analysis of low ozone values including a comparison to previous years.

3.2. Climate

Workshop recommendation "The European Commission, ESA, and Member States to sustain continuous observations ensuring long term data records to support climate monitoring. The European Space Agency and EUMETSAT should discuss the possibility of joint programs with international partners."

A new ESA programme, "Global Monitoring of Essential Climate Variables[6]" has been set up to extract measurements from satellite data

6 Also known as CCI (Climate Change Initiative)

archives in order to produce the long time series of climate-relevant variables requested by the Global Climate Observing System (GCOS), the Committee on Earth Observation Satellites (CEOS) and the United Nations Framework Convention on Climate Change, UNFCCC. Spatial and temporal data for 13 essential climate variables will be delivered in the first phase. This €72 million programme is expected to provide a significant contribution to the understanding of Arctic climate change issues, including measurements of glaciers and sea-ice. At least 3 out of the 13 variables (sea-ice, ice-sheet and glaciers) are particularly relevant to the Arctic although sea-surface temperature and sea-level are also useful. There are also a number of EU research projects on climate variables (see section 4.8)

A conference[7] was held in Helsinki, Finland on 16-17 June 2011, organised by the European Commission, involving ESA, EUMETSAT and several national agencies to consider what a GMES climate service could do over and above the GMES Sentinel satellites, the GMES land, ocean and atmosphere services and the ESA programme on Essential Climate Variables. A User Forum has debated the matter. The consultation should lead to an operational capacity for Climate Change monitoring.

A renewed cooperation agreement between ESA and Canada provides the continuation of a framework allowing inter alia coordination of satellite based facilities for the Arctic, including climate monitoring capabilities. Examples are Canada's current Radarsat missions and the future Radarsat constellation.

ESA and EUMETSAT both support a request from the Secretary General of The World Meteorological Organisation (WMO) to establish a Polar Science Space Task Group. This will ensure the legacy of coordinated observations performed during the International Polar Year. The Director Generals of ESA and EUMETSAT have nominated candidates accordingly[8].

The group is being formed with the support of the Secretary General of WMO, and under the auspices of the WMO Executive Council Panel of Experts on Polar Observations Research and Services (EC-PORS) - with a secretariat to be provided by WMO Space Office. The group will have a mandate to respond to requirements to support the WMO Global Cryosphere Watch Program, to contribute to the Sustained Arctic Observing Networks (SAON) initiative in the context of space-borne measurements, and to respond to the need for sustained observations in support of climate monitoring requirements originating from the GCOS Requirements and the IGOS Cryosphere Theme reports.

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7 See http://ec.europa.eu/gmes

8 M. Drinkwater - ESA; and K. Holmlund - EUMETSAT

3.3. Monitoring - meteorology

Workshop Recommendation: "ESA and EUMETSAT to review the coverage of meteorological missions and to identify the necessary priorities and technical solutions for weather forecast"

Both EUMETSAT and ESA are monitoring closely the Canadian Space Agency work on the Polar Communications and Weather (PCW) mission. Following this programme from development through to operations will provide Europe valuable insight into the benefits and opportunities resulting from such a mission concept for providing meteorological observations over the Arctic. EUMETSAT is not presently considering specialist satellite missions of its own but may consider distributing products from PCW. Studies are ongoing with ESA to determine whether monitoring stations for an EGNOS extended to the Arctic could deliver atmospheric water vapour concentrations.

3.4. Monitoring - vessels

Workshop Recommendation: "The European Commission to consider the needs of the Arctic when assessing the results of the preparatory action on receiving Automatic Identification Systems from space".

3.4.1. ESA EC coordination

The European Commission and ESA set up a Steering Committee that regularly reviewed the results of the PASTA-MARE project, was informed of the results of the ESA projects and checked the user requirements that ESA had used as a basis for their design studies. The Committee was dissolved at the end of 2010 following the successful completion of the PASTA-MARE project and a follow-up began work at the beginning of 2012 to examine new issues. examine new issues, such as the planned initiative of ESA and EMSA.

3.4.2. Preparatory Action for Integrated Maritime Policy

The project PASTA-MARE, was a preparatory action of the integrated maritime policy. The objective was to assess the performance of AIS sensors mounted on satellites.

The PASTA-MARE project produced a global map of traffic density which is publicly available. However, since none of the satellites involved in the project delivered sufficient data on the Arctic no actual vessel density data plots are available.

The project assessed performance of sensors by comparing signals with signals from other satellites passing at the same time and with ground stations. This was not possible in the Arctic because no concurrent satellite passes were found and there are very few ground receiving stations in the region. The project ended in 2010 before the data from other satellites came on stream.

4.4.3. 3.4.3. Possibility of mounting AIS receivers on medium orbit satellites

ESA recently concluded a study on a cooperative surveillance system for ships based on a piggyback GNSS payload as part of its European Global Navigation Satellite System (GNSS) Evolution Programme.The study concluded that a system for supporting the surveillance of ships could be possible with payloads embarked on medium Earth orbit satellites. However the large size of the payload means that a larger satellite platform would be required and there are currently no plans to go further with this concept.

3.4.4. European Space Agency Programmes

ESA in cooperation with the European Maritime Safety Agency, EMSA, has established a SAT-AIS work plan which includes developments of key technologies, the setting up of a Data Processing Centre Demonstrator and continuation of system design activities. It was approved in 2010 by the ESA Programme Board responsible for Telecommunications and Integrated Applications.. An operational demonstration mission may also be launched, possibly for a limited geographical area. At the same time ESA is assessing possible schemes for establishing a Public Private Partnership (PPP) for the development/deployment and/or operation of the infrastructure and provision of SAT-AIS data to institutional and, possibly, private users. EMSA have completed a study on "Space-based AIS User Benefit Analysis”.

3.4.5. Possibility of mounting AIS receiver on Sentinel-1B

It is planned that automatic identification system receivers be mounted on board the Candian RADARSAT Constellation Mission and the Spanish /PAZ together with synthetic aperture radar. This would allow simultaneous correlation of ship positions with observations from the radar images - the only waty to reliably find ships that have disabled their AIS transmissions.

Studies are ongoing to determine whether an satellite AIS receiver can be accommodated on the GMES Sentinel-1 satellites. While the development of the first satellite (“A-unit”) appears too far advanced to accommodate an AIS receiver, this might still be possible for the second satellite (Sentinel-1 “B-unit”), provided funding would become available in time.

3.4.6. Increase of AIS offer

A number of companies including Orbcomm, Comdev/ExactEarth and LuxSpace are already offering a commercial service with AIS. Furthermore the experimental Norwegian AISsat-1, launched in July 2010, was specifically designed for the high north. Between them these satellites cover the whole Arctic. Because of the relatively low cost of the technology and the low shipping density in the Arctic, and because revisits are frequent at these high latitudes, the accurate (e.g. decollision issue) and timely regular monitoring of Arctic traffic looks assured. However the performance still needs to be checked.

3.5. Monitoring –contribution to Sustained Arctic Observing Networks (SAON)

Workshop recommendation "ESA to check the requirements of the Sustaining Arctic Observing Networks (SAON) for measurements from space.

The newly established Polar Science Space Task Group will have a mandate to contribute to the Sustaining Arctic Observing Networks (SAON) initiative in the context of space-borne measurements, and should therefore be concerned with collecting their requirements.

The Svalbard Integrated Arctic Observing System will also contribute.

3.6. Monitoring - data access

Workshop recommendation 'The EU, ESA, EUMETSAT and their Member States as well as other involved parties to support and implement a fully open and "obstacle" free data access policy and infrastructure.

The "marine knowledge 2020" Communication[9] confirms the Commission's policy:

The ultimate aim is to provide free access without restriction of use

The GMES programme, once in operational mode, will provide users with access to data and information from the dedicated Sentinel satellite instruments as well as from GMES services. EU Regulation 911/2010 for the initial operations of GMES[10] foresees full and open access to GMES data and information subject to international agreements, licensing conditions and security restrictions, The GMES policy on data and information will be compliant with the EU's legislative framework governing the availability of public and environmental information (access to environmental information, PSI and INSPIRE directives[11]).

ESA has revised its Earth Observation Data Policy[12]. The revision intends to adapt the existing ESA Data Policy to the "Joint Principles for a Sentinel Data Policy"[13], as approved by ESA member states in September 2009. The revision of the ESA Data Policy aims to provide open and free of charge access to the majority of the EO data provided by the ERS, Envisat[14] and Earth Explorer missions.

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9 "marine data and observation for smart and sustainable growth", Brussels, 8.9.2010, COM(2010) 461 final

10 Regulation 911/2010 of 22 September 2010 on the European Earth monitoring programme (GMES) and its initial operations (2011 to 2013

11 Public access to environmental information directive 2003/4/EC, PSI directive 2003/98/EC, INSPIRE directive 2007/2/EC

12 Earth Observation Programme Board paper (ESA/PB-EO(2010)54)

13 ESA/PB-EO(2009)98, rev. 1

14 ENVISAT's mission ended on 9 May 2012. However its rich archive of past images will continue to provide material for understanding the Arctic for many years to come.

Data access to EO data provided by the ERS, Envisat and Earth Explorer missions has significantly progressed from the data policy principles laid out in the original data policy almost a decade ago. The evolution of information technology systems supporting the data access, particularly in recent years, has rendered the increased uptake of Earth observation data possible. A growing number of Earth observation data sets are available on-line and provided free of charge. Only a subset of data, for technical or financial constraints, remains accessible in limited fashion.

This development reflects a common trend to make environmental Earth observation data more easily accessible and freely available subject to unavoidable restrictions, which is actively supported by international initiatives such as GEO Data Sharing Principles)and CEOS. It also reflects evolving user expectation as to the accessibility of Earth observation data and the increasing demand for them.

3.7. Monitoring- pollution

Low temperatures and light-level mean that ecological damage from any oil spill in the Arctic Ocean is greater than that that would result from spills at more temperate latitudes. CleanSeaNet is the European Union's satellite based oil spill monitoring and vessel detection service operated by the European Maritime Safety Agency (EMSA). It is available to all EU Member States, European Free Trade Association (EFTA) States, Acceding Countries and the European Commission. Satellite detection of oil-spills requires short scale surface roughness The relatively flat Arctic waters and the ice would make extension to the Arctic difficult..

3.8. Monitoring - research

Workshop recommendation "All partners concerned with Research and Development efforts to address issues such as monitoring of ice features, permafrost, biodiversity etc"

The CryoSat mission, launched by ESA in April 2010, is assessing the ability of satellites to measure ice thickness. Its Synthetic Aperture Interferometric Radar Altimeter (SIRAL) has been specifically designed for measuring ice thickness changes over time. CryoSat measures the height of the sea ice above the water line, known as the freeboard, to calculate the ice thickness. The first CryoSat ice thickness map of the Arctic was generated from January and February 2011 data, as the ice approaches its maximum. CryoSat provides multi-year elevation data at latitudes never reached before by a satellite altimeter, determining changes in the thickness of marine ice floating in the polar oceans and monitoring changes in the vast ice sheets that overlie Greenland and Antarctica, particularly at the margins where icebergs are calved

Although it is not known exactly how much has been spent, successive EU Framework Programme projects have not only enlarged our understanding of Arctic processes but also helped create a coordinated community of researchers who share effort on common challenges. The ALOMAR project which finished in 2008 provided access to a worldwide unique ensemble of sophisticated ground-based instrument and a new service of in-situ measurements through a rocket-launch "Hotel Payload" (HotPay). The project DAMOCLES, which focused EU efforts on monitoring the Arctic, closed in 2010. The ACOBAR project is developing an observing system for the interior of the Arctic Ocean based on underwater acoustic methods and the ICE2SEA Project will improve projections of the contribution of continental ice to future sea-level rise. The ACCESS project which started in March 2010 will provide access to information on the current status and changes of the Arctic sea ice including use of CryoSat information). This is meant on one hand as a baseline against which to compare projected future changes and to maintain the critical measurements that are needed to confirm and determine the trends in ocean, ice and atmospheric change[15] .

A number of new Seventh Framework Programme projects have started since the Stockholm conference. For instance the ACCESS project will provide access to information on the current status and changes of the Arctic sea ice (including use of CryoSat information). This is meant on one hand as a baseline against which to compare projected future changes and on the other to maintain the critical measurements that are needed to confirm and determine the trends in ocean, ice and atmospheric change.

Other projects are devoted to testing and implementing methods for calculating parameters based on the satellite measurements.

3.8.1. Sea ice

The MyOCean project delivers near real-time, forecasts and archived sea ice concentration, edge, type and drift at (10km and 60km resolution), surface temperature (1km resolution) and 3 dimensional circulation parameters (12.5km resolution) for all of the Arctic ocean. It delivers iceberg maps from the gulf of Boothia in northern Canada in the west to Svalbard in the east

MONARCH-A[16]will provide seasonal to interannual changes in sea-ice since 1980

SIDARUS will develop new methods for determining sea ice classification, albedo and thickness for selected regions in the Arctic as well as forecasts for the Barents Sea.

MAIRES on developing algorithms for ice classification, drift, thickness and icebergs for the Barents and Kara seas.

The NEWA project which is concerned with European reconnaissance and surveillance capacities in Moving Target Identification (MTI) has assessed the feasibility of a possible constellation of satellites to support the. "Iceberg Monitoring and Surveillance of the north Atlantic shipping lanes".

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15 www.ice2sea.eu

16 See http://www.nersc.no/project/monarch

ESA's Polar View delivers near real-time sea ice products at a range of spatial scales. High-resolution (100 to 500 metres) ice charts are provided for the Baltic Sea, the Barents Sea and Svalbard areas. Medium-resolution (1 km) ice products are provided for Greenland waters, while low-resolution (3 to 15 km) global sea ice extent and concentration are available for the northern and hemisphere.

3.8.2. *Snow cover*

The MONARCH-A project aims to provide seasonal to interannual changes in snow cover since 1980 whilst Cyoland will test methods for measuring snow extent, snow cover, and snow properties at 500m-1km resolution in selected European areas. Polar View provides snow extent and fractional snow cover products in near real-time for major catchments in Scandinavia at a spatial resolution of 500 to 1000 metres geared towards flood forecasting centres and water management authorities.

3.8.3. *Glaciers*

MONARCH-A will deliver changes in glaciers (including the Greenland ice sheet) over interannual time scales since 1992 whilst Cryoland will provide more detailed estimates glacier areas and movement of selected glaciers in the Alps, Greenland, and Svalbard. MAIRES will assess glacier extent and velocity and intereannual variability for Russian glaciers. Polar View provides maps of glacier extent, topography and velocity. estimates yields from glacial runoff and model expected yields under different climate scenarios.in northern Europe and Canada.

3.8.4. *Lake snd river ice*

MONARCH-A will estimate snow burden and freshwater runoff to the Arctic Ocean whilst Cryoland will deliver lake and river-ice extent on selected areas in Northern Europe and Russia. Polarview generates products on ice-type, extent, break-up and freeze-up dynamics on Canadian rivers at a spatial resolution ranging from 10 to 100 metres

3.8.5. *Permafrost*

The extent and changes of permafrost from 1950 to present in Siberia wil be estimated in the MONARCH-A project

3.8.6. *Svalbard*

The preliminary phase of a Svalbard Integrated Arctic Observing System (SIOS) was launched in October 2010. It is an upgrade of the present infrastructure on Svalbard. that integrates the studies of geophysical, chemical and biological processes from all research and monitoring platforms. in and around Svalbard - land, sea, ice/glacier and atmosphere/space base

3.9. Communication

Workshop Recommendation "ESA to review communication satellite coverage and determine solutions that can improve the situation following priorities identified with all involved parties."

3.9.1. Demand

The demand for data communications at higher latitudes is following the increase of activities related to oil and gas surveying and exploration, maritime activities, arctic shipping, search and rescue, air traffic management, environmental management, tourism, surveillance, security and safety. Data communication can also support applications for navigation and positioning, as well as scientific purposes. A number of user studies, including the Arctic Shipping and Marine Assessment report[17] from the Arctic Council have confirmed these developments.

3.9.2. Current capacity

Geostationary telecommunication satellites do not cover the Arctic region at all or only partly with reduced efficiency. A number of satellite constellations that are in a low-Earth orbit such as Iridium, Globalstar, OrbComm and Gonets, are serving the Arctic with low data-rate and/or messaging services.

There are presently no broadband communications solutions available for defence or military users: all European forces currently use U.S. systems.

3.9.3. Ongoing initiatives in the United States, Canada, Russia and China

Due to the need for general broadband access and government needs (security, search and rescue, safety, aviation), the Governments of Canada, Russia and the US are currently carrying out definition studies for their own dedicated Arctic satcom public and government broadband services.

3.9.3.1. United States

Constellations owned by U.S. companies such as Iridium and Globalstar are currently being upgraded to their second generation. Iridium NEXT will allow subscriber data rates up to 1 Mbps (contended) and provide complete Arctic coverage. Furthermore, Iridium NEXT is planning to offer high-speed Ka-band “opportunity” services.

Globalstar 2.0 is not sure to cover the complete Arctic with their currently planned inclination. Like Iridium, the system is U.S. owned, with a strong defence and government usage in mind. The U.S. OrbComm system is also being upgraded with increased messaging capabilities.

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17 Arctic Council Arctic Marine Shipping Assessment 2009 Report

A highly elliptical orbit satellite system offering broadband in the Arctic has so far only been considered at the level of feasibility studies by the U.S. Air Force.

3.9.1.2. Canada and Russia

An upgrade of the current Russian Gonets ("messenger") LEO system is being designed and would offer medium data-rate communications to the Arctic, with low latencies enabled by inter-satellite links. Furthermore, a new generation system called KOSMONET is on the drawing table. This system can be seen as the Russian Iridium NEXT version.

The Canadian and Russian governments have started to design their respective PCW (Polar Constellation for Communication and Weather) and ARKTIKA systems. The Canadian PCW system will offer broadband services only to the regions of Canadian interest in the Arctic, and moreover to government users only. The Russian ARKTIKA system will offer low data rate communications for government and aeronautical communications with a navigation signal overlay, and broadband communications. The coverage is more extensive than the Canadian, but for the moment mainly targeting government and institutional use.

The Canadian and Russian systems enjoy support from their respective governments, although the financing has not yet been secured. There are indications that private funding could support an Arctic initiative in both countries. The Canadian Space Agency has commissioned a study to analyze the socio-economic benefits of PCW, which will inform Canada's final decision on the mission. Russian state companies from the oil and gas sector are considering public-private partnerships with ROSKOSMOS to move the Russian system forward.

Discussions between Canada and Russia on the possible interoperability and harmonization between their systems have not been successful so far.

3.9.3.3. China

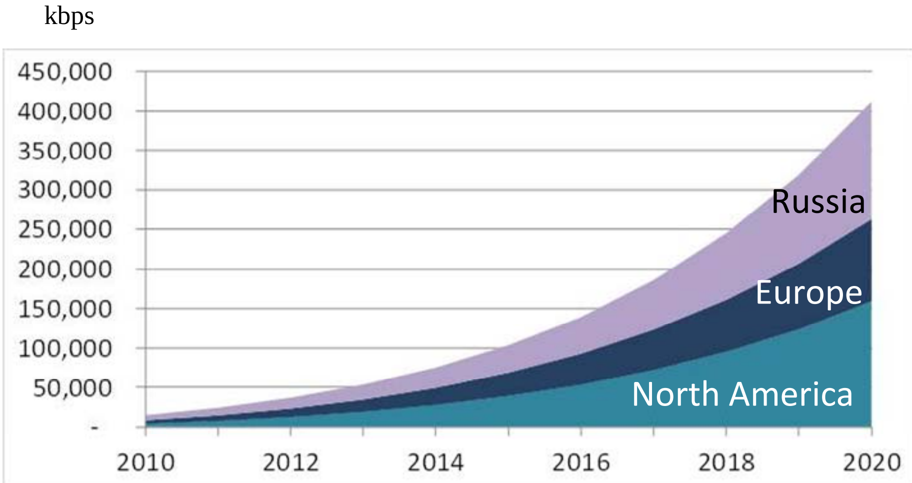
The next generation of the Chinese satellite navigation system BeidouCompass-2 II system will have consist of 5 GEO, 3 IGSO and 4 MEO satellites by 2012. To what extent Compass-II and/or Compass-III (extension to a global system) may offer additional communication capabilities, is not known at present.

3.9.4. European needs

Taking into account the developments sketched above, it is therefore likely that a number of low and medium data-rate and messaging satellite communication services offered by non-European entities will be available to European users in 2015-2016.

None of the proposed Canadian, Russian and Chinese systems are planning to offer broadband communication capabilities to the EU area of interest, mainly because these systems are driven by their respective government needs and have not taken into account European user requirements.

A recent study from the European Space Agency (ESA) on "Future Arctic Communications Needs" has concluded, based on consultations with various stakeholders, that in the European Arctic the demand for broadband communications could extend over 100 Mbps in 2020. Maritime activities are considered one of the main drivers of the demand. The supply is virtually non-existent, i.e. there is an considerable capability gap.



Demand in kbps in Russian, North American and European Arctic (above 75 N). Source: ESA/Euroconsult

In summary, taking into account all planned developments, these will not fulfil the broadband communication requirements for the EU area of interest, or allow independent European communications capabilities at the higher latitudes.

3.9.5. *European options*

The ESA Directorate for Telecommunications is investigating how inclined-orbit satellites could meet European needs for communication facilities in the Arctic.

One option is to push end-of-life commercial telecommunication satellites into orbits that would allow coverage of the European Arctic. Initial findings indicate that too much fuel needs to be reserved to be able to raise the satellite to the appropriate orbits.

Another option is to combine forces with an Arctic partner:

(1) The Canadian PCW system might allow the embarkation of a small European communication payload that could serve the European Arctic. The ESA Directorate for Navigation (in cooperation with the ESA Directorate for Telecommunications and the Canadian Space Agency) is currently investigating the embarkation requirements for such a small piggy-back payload by means of an industrial study.

(2) The Russian ARKTIKA system – which is built around larger satellite platforms - would also allow for the embarkation of additional payloads that could provide European coverage and serve European requirements. The Russian system will also support a mission for Air Traffic Management Communications. The ESA Directorate for Telecommunications is in continuous exchange with ROSKOSMOS to identify possibilities for cooperation in this area.

(3) Within the EC Russia Space Dialogue, ROSKOSMOS has offered cooperation in the area of a new low-Earth orbit system, meant as an upgrade of the current Gonets system. The new Gonets system would use inter-satellite links like Iridium, as would the follow-up KOSMONET system.

(4) ESA is in contact with Iridium NEXT to understand better the hosted payload possibilities and the Ka-band opportunity service.

The satellites in the Canadian and Russian systems will need to be replaced every 10-12 years, and the constellations foreseen are in addition each not fully redundant, i.e. Europe could offer to complement or make these constellations redundant, or offer replenishment with European-manufactured satellites.

Navigation satellites in medium Earth orbit might also offer a platform for Arctic Communications. In case the European Union would embark on inclined geosynchronous orbits for navigation satellites (making EGNOS similar to the Indian or Chinese regional satellite navigation systems) a telecommunication payload could be added to provide coverage in the European Arctic. A combined system could be proposed that serves multiple missions.

In the very long-term, a new type of highly inclined satellite orbits – possibly enabled by the use of solar sails – could prove to be an interesting solution for covering the Arctic. Continuous research is required in this area.

ESA is currently running a study that will consolidate the user requirements for telecommunications in the Arctic for 2015-2020. ESA has also initiated a feasibility study for a navigation and a communications payload as a piggy-back on the planned Canadian PCW satellite mission. At the same time the ESA Iris Programme will assess whether satellite communications for aeronautical safety systems based on geostationary satellites are interoperable with systems based on highly elliptical orbits

3.10. Decision support and early warnings

Workshop Recommendation "Scientists and operational users to continue dialogues in order to accelerate the development of operational decision support and early warning systems"

In the field of crisis response (relevant to accidental pollution, search and rescue and security crises in the Arctic), both the European Commission and

ESA are presently investigating future solutions in terms of services and infrastructures for European security actors in a multidisciplinary approach. This work might contribute to the development of new operational services and systems in the Arctic in the fields of Earth observation, telecommunications and navigation. This includes the emergency managament service planned for GMES that will contribute to European structures such as the Commission's future Emergency Response Centre (currently DG ECHO/MIC), EMSA, the EEAS and the EU Satellite Centre.

The €600,000 PRETEAR project co-funded by the EU's Civil Protection Financial Instrument started in October 2009 and is co-ordinated by The Norwegian Fire Protection Training Institute (NBSK) in Fjelldal. PRETEAR will review the specific challenges faced by the region and will compare these to the capabilities currently in place. It will simulate and model critical scenarios and review regional compatibility. It will also identify developments needed in training, mobility and cross-border collaboration.

The European GNSS Evolution Programme's Arctic Testbed will test whether EGNOS can be extended to the Arctic and thus extend the safety of landing sites used in rescue operations.

3.11. Standards

Conference Recommendation "Industry to establish and adopt common guidelines and best practices to improve safety, security and manage the environmental impact of their activities in the Arctic by making further use of satellite-based geo-information products to monitor operations in the fields of oil & gas, shipping and tourism.'

ESA organized a workshop on September 14-15 2010 for the Oil & Gas industry[18] which addressed the need for a common set of industry guidelines and best practices in order to take further advantage of satellite based monitoring capabilities. And even though the workshop had no geographic focus, the Arctic was highlighted as one of the next frontiers, representing huge challenges both with respect to operational support and environmental monitoring. The recommendations for actions can be found at the workshop website [19] at

An ESA study to investigate how satellite based monitoring can be used for tactical navigation of ships in ice-infested waters will also address the need for adopting the EO based products to international standards for navigation like Electronic Chart Display and Information System (ECDIS)[20].

An EU preparatory action under GMES, ICEMAR, will implement a pre-operational service to deliver ice charting products to the bridges of vessels.

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18 Presentations can be found at http://earth.eo.esa.int/workshops/gasoil2010/)

19 http://earth.eo.esa.int/workshops/gasoil2010/Final_Report.html

20 http://www.eomd.esa.int/contracts/contract325.asp

ESA is continuing its work to investigate the need for an EO based product certification scheme. The aim of such a scheme would be to ensure that products based on satellite derived information is produced according to a standardized set of procedures. A draft set of documents for an EO product certification scheme has now been drafted and will be discussed with the European Association of Remote sensing companies (EARSC).

4. CONCLUSIONS

Three years that have passed since the Commission Communication on "The EU and the Arctic Region[21]" defined the objectives for EU policy and two years since delegates to the Swedish presidency event on "Space and the Arctic" made a number of recommendations as to how space assets could help to achieve those objectives.

Tentative conclusions are that certain objectives can probably be met with existing or planned programmes:

(1) Measurements of sea-ice extent, useful for supporting human activities and monitoring climate change, are assured through the Sentinel satellites of the GMES Space Component.

(2) Earth Observation based services providing sea-ice information for navigation are being provided by a multitude of European national and private entities. A number of new services are also being tested under research programmes. However these currently only covering discrete national areas of interest.

(3) Up to now satellites have not been able to measure ice thickness accurately enough for safe operations on multi-year sea-ice. The experimental satellite, CryoSat-2, launched in 2010, is now able to measure changes in the thickness of the polar ice sheets and floating sea ice for Earth sciences more accurately. Its Synthetic Aperture Interferometric Radar Altimeter (SIRAL) has been specifically designed for measuring ice thickness changes over time. As of June 2011, the first maps of ice thickness from January and February 2011 - as the ice approaches its annual maximum – were produced. The altimeter on GMES Sentinel-3 will build on the lessons learnt from Cryosat-2 in order to provide a long-term monitoring of ice-thickness.

(4) Low and medium data rate communications should be assured through commercially-operated systems.

(5) Because of the low traffic density in the Arctic, effective monitoring of vessel traffic should be assured by present or planned commercially operated satellites carrying AIS receivers. However, this should be checked.

[21] The European Union And The Arctic Region Brussels, 20.11.2008, COM(2008) 763 final

However, a certain number of gaps have been identified:

(1) High bandwidth communications will not be available without further action. To address this in the near/medium term some buy-in to Russian, Canadian or United States programmes is being investigated.

(2) High reliability navigation through the European Geostationary Navigation Overlay Service (EGNOS) is presently not possible in the Arctic because of the inability of geostationary satellites to reach above 75ºN. Broadcasting of the Safety of Life Service through other channels is under investigation.

(3) GMES services for ice extent have been developed and demonstrated involving some Arctic user communities and national areas of interest but have not yet achieved a complete circumpolar uptake. Services supporting international trans-Arctic vessel traffic are still under development.

(4) The Sentinel-3 satellite will provide more accurate monitoring of ice thickness than has been hitherto possible in order to meet the needs of science. However ground infrastructure and systems need to be developed to ensure that the data can be downloaded and processed in time to also serve the operational needs of those living or working in the Arctic.

(5) The relatively still waters and ice cover make an extension of the operational European satellite oil-spill monitong programme CleanSeaNet to the Arctic challenging.. Further study would be necessary before extending the sevice to this region.

5. NEXT STEPS

The EU is fully committed to its Arctic policy. The flagship programmes of the European Union, Galileo and GMES, the EU Framework Programmes, and a number of space programmes carried out in the European Space Agency will contribute to meeting EU objectives for the Arctic. Climate research and environmental protection in the Arctic, monitoring of the ocean and ice, provision of satellite navigation in order to ensure safer modes of transport in the Arctic all rely heavily on space systems

Not all space systems cover the Arctic, and some monitoring requirements are specific to polar regions. This region therefore requires special attention. In view of the high costs and long lead times for deployment of space systems, it is important to continue a targeted collaboration between the European Commission, the European Space Agency and Member States space agencies and to continue a dialogue with third countries in order to identify capability gaps, establish synergies and identify potential areas of cooperation.

This working paper can contribute to discussions within the Arctic Council and amongst coastal States whose prerogatives are recognised by international law as to how best to ensure that the Arctic environment remains protected and that those living and working in the Arctic can cope with inevitable future changes.

A follow-up to the Arctic Space conference organized by the Swedish Presidency in 2009 was held in Copenhagen on 13 March, 2012. The recommendations were along the lines presented in this document[22].

6. GLOSSARY

ARKTIKA	A proposed Russian satellite system purpose-built to provide observation and communication services to the Arctic
COMPASS	COMPASS is the Chinese satellite navigation system that is expected to be operational by 2012
Cryoland	CryoLand is a seventh framework programme project aimed at developing, implementing and validating a standardized and sustainable service on snow and land ice monitoring
Cryosat	A research satellite operated by the European Space Agency and launched in April 2010, that monitors variations in the extent and thickness of polar ice.
EGNOS	The European Geostationary Navigation Overlay Service (EGNOS) system is an infrastructure monitoring and correcting signals emitted by existing global satellite navigation systems. It consists of Earth stations and several transponders installed on geostationary satellites It reports on the reliability and accuracy of signals.
EMSA	European Maritime Safety Agency. EU Agency based in Lisbon. Portugal
EO	Earth Observation; measurements taken from remote sensing satellites, airborne and in situ monitoring systems.
ESA	European Space Agency The European Space Agency (ESA), established in 1975, is an intergovernmental organisation currently with 18 member states. Headquartered in Paris, ESA has a staff of more than 2,000 with an annual budget of about €3.99 billion (2011) ESA's purpose is to provide for, and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific

22 http://www.esa.int/esaEO/SEM1WRAYLZG_index_0.html

	purposes and for operational space applications systems
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites Its objective is to provide, from space, information that can be used in weather forecasting and climate applications
FP7	The EU's Seventh Framework Programme for Research and Technological Development, covers the period 2007 to 2013. €1.43 billion is dedicated to space.
Galileo	The system established under the Galileo programme is an autonomous global navigation satellite system (GNSS) infrastructure consisting of a constellation of satellites and a global network of Earth stations.
GCOS	Global Climate Observing System. GCOS is an organization, co-sponsored by the World Meteorological Organization (WMO), Intergovernmental Oceanographic Commission (IOC) of UNESCO, United Nations Environment Programme (UNEP), and International Council for Science (ICSU), established with the aim of ensuring that observations and information needed to address climate-related issues are obtained and made available to all potential users.)
GEO	The Group on Earth Observations is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS.
GEOSS	The Global Earth Observation System of Systems (GEOSS) is a coordinating and integrating network of Earth observing and information systems, contributed on a voluntary basis by Members and Participating Organizations of the intergovernmental Group on Earth Observations (GEO). The vision for GEOSS is to realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information..
GLONASS	A satellite navigation system operated by the Russian Federal Space Agency,.
GMES	GMES (Global Monitoring for Environment and Security) is the European Earth monitoring programme for the collection, assimilation and production of information about planet Earth’s physical, chemical and biological systems.
GNSS	Global Navigation Satellite System. The generic term for systems such as GPS, Galileo, COMPASS and GLONASS.
GPS	The Global Positioning System (GPS) is the United States space-based global navigation satellite system (GNSS)

ICEMAR	GMES preparatory action aiming to deliver ice maps to the bridges of ships
ICOS	ICOS is a new research infrastructure to decipher the greenhouse gas balance of Europe and adjacent regions. ICOS will provide the long-term observations required to understand the present state and predict future behaviour of the global carbon cycle and greenhouse gas emissions and to monitor and assess the effectiveness of carbon sequestration and/or greenhouse gases emission reduction activities on global atmospheric composition levels, including attribution of sources and sinks by region and sector.
IGOS	Integrated Global Observing Strategy. The objectives and activities of the IGOS theme teams are now being pursued within the framework of the Group on Earth Observations - and the various GEO Communities of Practice
IGSO	Inclined geosynchronous satellite orbit. An orbit that carries the satellite round then Earth once every 24 hours but the inclination means that it is not geostationary.
Iridium NEXT	Iridium is currently developing, and is expected to launch at the beginning of 2015, Iridium NEXT a second-generation worldwide network of telecommunications satellites, consisting of 66 satellites
KOSMONET	Proposed Russian satellite system for communications between satellites and with ground.
LEO	Low Earth Orbit (160 - 2,000 km above Earth's surface)
MACC	Monitoring Atmospheric Composition and Climate. FP7 project providing the pre-operational GMES atmosphere monitoring service.
MEO	Medium Earth Orbit (above low Earth orbit of 2,000 kilometres and below geostationary orbit of 35,786 kilometres
MONARCH-A	MONitoring and Assessing Regional Climate change in High latitudes and the Arctic - Seventh Framework Programme Project
MyOcean	GMES FP7 project providing athe pre-operational GMES service for marine environment monitoring service
PCW	Polar Communications and Weather satellite. A potential new Canadian space mission called which would provide 24/7 two-way communications capability to the Canadian north and near-real time meteorological information products about the north to government users throughout Canada

ROSKOSMOS	The Russian Federal Space Agency.
SAON	Sustained Arctic Observing Networks. A legacy of the International Polar Year. A process to encourage coordination and sustaining long-term observation.
SAT-AIS	A system that obtains information on ship positions by picking up signals from their anti-collision automatic identification system from sensors mounted on satellites.
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organisation

APPENDIX: COST OF EUROPEAN CONTRIBUTION TO MONITORING THE ARCTIC

European countries are making a significant effort to monitor the Arctic from space, largely under the auspices of the European Space Agency. Some of these satellites are multi-purpose, designed to fulfil a number of requirements, so it is hard to identify exactly how much is spent on the Arctic.

Envisat

Launched in 2002, Envisat is the largest civilian Earth Observation spacecraft ever built. It carries ten sophisticated optical and radar instruments to provide continuous observation and monitoring of the Earth's land, atmosphere, oceans and ice caps.

The instrument most useful for monitoring the Arctic is the Advanced Synthetic Aperture Radar (ASAR), operating at C-band which allows radar beam elevation steerage and the selection of different swaths, 100 or 400 km wide. This can measure the extent of Arctic sea ice.

The total cost of the Envisat for the initial 5-year operation was €2.3 billion. Yearly operation costs beyond this period amount to €50 million, with an expected lifetime extended to 10 years, giving an extra cost of €250 million. It is difficult to know how much of the cost to allocate to monitoring the Arctic since many of the costs are unknown.

A way to calculate the cost would be:

$$C_A = \frac{N_A C_T}{N_T Y}$$

Where

C_A	Cost of monitoring Arctic

C_T	Total cost of Programme
N_A	Number of images provided to users covering Arctic region
N_T	Total number of images provided to users
Y	Years of Envisat operation

These parameters, particularly N_A and N_T, are not readily available but it has been estimated that 30% of ASAR images are acquired over the Arctic. The cost would then be €70 million per year.

Cryosat

ESA's Earth Explorer CryoSat mission, launched on 8 April 2010, is dedicated to precise monitoring of the changes in the thickness of marine ice floating in the polar oceans and variations in the thickness of the ice sheets that overlie Greenland and Antarctica. Its total cost is €140 Million including development, launcher and operations (3 years) of which €75 Million is for procuring the satellite. This comes to about €47 million per year. Assuming that 70% of usage is for the Arctic, we arrive at a cost of €33 million per year.

GMES

Up to 2013 financial appropriations for the GMES programme have been € 3.2 bn. This is divided approximately as follows

	European Union	**European Space Agency**	**Total**
Services and in-situ components	€ 520 million	€ 240 million	€ 760 million
Space component	€ 780 million	€ 1 650 million	€ 2 430 million
	€ 1300 million	€ 1 990 million	€ 3 290 million

The services component has largely consisted of pre-operational research projects designed to develop and test solutions for using satellite data for purposes concerned with environment or security. Both "core" and "downstream" services have been tested. There are no estimates of how much of the services budget has been spent on the Arctic.

The space budget has been spent on designing and building the Sentinel satellites The space component of the Global Monitoring for Environment and Security (GMES) consists of six satellites. Four of these will be useful for the Arctic.

– The Sentinel-1 series of satellites will provide synthetic aperture radar data. Two are planned.

– Sentinel 3 will provide ocean colour and temperature and altimetry.Two are planned.

The total cost of these is:

Sentinel 1 A+B development + launch	€558 million
Sentinel 3 A+B development + launch	€637 million
Ground Segment development[23]* *	€191 million
Total one off cost	€1386 million

On top of that we will have the operations cost, which today are estimated at €138 million/year for the total operations of Sentinel 1+2+3. Assuming 10 years of operations, the total cost is in the order of €2.7billion.

Assuming that 30% of the imagery is used for the Arctic, the cost is €81 million per year.

Summary

Based on the above, a best estimate of annual costs for the three satellite systems is:

	total cost	**years**	**annual cost**	**Arctic use**	**Arctic cost**
Envisat	€2550M	10	€255M	30%	€76M
Cryosat	€140M	3	€47M	70%	€33M
Sentinel	€2700M	10	€270M	30%	€81M

23 cost for developing the whole ground segment not specific to any sentinel satellite