Communication challenges in the Arctic
- Utfordringer ved satellittkommunikasjon i nord

Kay Fjørtoft
Department of Maritime Transport Systems
Presentation overview

- Drivers for Arctic communication needs
- Arctic challenges
- Results from the projects
  - MarSafe
  - SARiNOR
  - MARENOR and COINOR
- APNorway, Norwegian possibilities within SatCom
Norwegian Marine Technology Research Institute (MARINTEK)

- Develop and verify technological solutions for the shipping and marine equipment industries, for offshore petroleum production and renewable energy.
- 165 employees from 26 countries
- Headquarters in Trondheim
- Our owners: SINTEF, the Norwegian Shipowners' Association, DNV GL, Federation of Norwegian industry, Norwegian Maritime Directorate, Ship owners national federation
- SINTEF is the largest independent research organization in Scandinavia
The Marine Technology Centre

Velkommen til Marinteknisk senter

The Marine Technology Centre
Ocean Basin Laboratory

Ocean basin laboratory data:
- Length: 80 m
- Width: 50 m
- Depth: 0-10 m
Ship Model Tank

Ship Model Tank

I-III data:
- Length: 260 m
- Width: 10.5 m
- Depth: 5.6/10.0
First full scale floating wind turbine

Ground-breaking concept for floating production

World's tallest concrete platform

The world's most powerful ship (towing)

Revolutionary ship design

Technology development
(Spar-plattform, Aasta Hansteen-feltet)
Ocean Space Centre in 2022?
Hypothesis for activities in the Arctic

1. There will come more activities in the Arctic?
   - Do we have sufficient infrastructure?
   - Sea, aircraft, tourism, commercial, environmental research

2. There will be some "stops" for the Arctic adventure?
   - Less sailings NSR, Political issues
   - More ice
   - Financial down period

3. Norway will invest in a robust infrastructure?
   - Investment of new HEO's
   - CybSat/SmalSat development
   - AISSAT, NorSat, …

4. We do not know enough about challenges?
   - MetHyd forecast
   - Space Weather forecast
   - Satellite operation
   - Ice monitoring

User group

- O&G
- Fisheries
- Aeronautical
- Arctic environment
Challenges

The objective is to provide recommendations that will contribute to increased maritime safety in the High North, equivalent or better than the safety level in the North Sea.
Communication, Navigation, Observation

- Technology for communication and navigation
  - Satellite
  - Sensors
  - Radar
  - Drones
- Technology for observation
  - Satellite
- People and organizations
  - Internal
  - External
  - Rumors

Arctic User Groups
- Maritime
- Aeronautilcal
- Governmental
- Local population
- Energy and natural resources
- Research
Bandwidth requirements

- **Emergency messaging** (Search&Rescue, distress, positioning...): Normally voice communication, low (≤ ~10 kbps).
- **Mandatory reporting** (Factual reports, arrival info., ship and load data): Low (≤ ~10 kbps) to medium.
- **Operation & navigation reporting** (ship-shore status reporting...): Normally simple data messaging, low (≤ ~10 kbps) to medium.
- **Technical maintenance** (technical status, alarm and sensor reporting): Low (≤ ~50 kbps) to medium.
- **Training and qualification** (Data exchange ship-shore for training purposes, often real time...): Medium (≤ ~1 Mbps) to low.
- **Reporting and general information exchange** (Information interchange ship-shore, often real time, teleconferencing...): Medium (≤ ~1 Mbps) to low to medium.
- **Safety & technical monitoring** (Safety critical data): Medium (≤ ~1 Mbps) to medium to high.
- **Infotainment** (Crew and passengers: (HD)TV, Internet): High (≤ ~10 Mbps) to medium to high.
- **Special purpose applications** (Advanced O&G explorations, demanding unmanned (surveillance) operations...): High (≤ ~20 Mbps) to high.

The diagram illustrates the relationship between bandwidth requirements, integrity levels, and various applications.
Satellite communication, MF/HF, AIS, Global Navigation Satellite Systems (GNSS)

- **LEO**: Low Earth Orbit (Height: 200 - 2000 km)
- **MEO**: Medium Elliptical Orbit (Height: 2000-GEO, normally: 10.000-20.000 km)
- **GEO**: Geostationary Orbit (Height: 35.786 km)
- **HEO**: High Elliptical Orbit (Height: 500-50.000 km)
SatTracker - MARINTEK

Astra 4 - GEO

Iridium - LEO

Molniya - HEO

Vessel position

Vessel SatView
The Earth seen from satellites

GEO

HEO
Propagation impairments over the Earth - satellite slant path

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<th>Band designation</th>
<th>Frequency range</th>
<th>Description</th>
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<td>High Frequency</td>
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<td>Very High Frequency</td>
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<td>0.3 to 1 GHz</td>
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<td>Kurz-above</td>
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Degradation factors:
- Ionosphere
- Atmosphere
- Metocean – ship movements
- Position
- System performance
- Icing on antennas
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<th>System</th>
<th>Characteristics</th>
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<td>Unsuitable for digital communications</td>
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<td>No base stations</td>
<td>Few base stations</td>
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<td>GSM, 3G</td>
<td>Line-of-sight voice and narrowband data</td>
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<td>LTE/4G, WiMAX</td>
<td>Line-of-sight voice and broadband data</td>
<td>No base stations</td>
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<td><strong>SatCom systems</strong></td>
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<td>GEO (Inmarsat, VSAT)</td>
<td>Medium capacity - low to moderate latency</td>
<td>Unavailable</td>
<td>Limited availability and quality</td>
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<tr>
<td>LEO (Iridium)</td>
<td>Narrowband data communications – high and variable latency</td>
<td>Potential problems with capability/ quality</td>
<td>Potential problems with capability/quality</td>
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<td>HEO</td>
<td>Properties comparable with GEO</td>
<td>Currently unavailable, but expected to provide good coverage and properties comparable to LEO systems at lower altitudes (&lt; 60°N).</td>
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The MARENOR project
(Maritime Radio Performance in the high North)

- EMGS – Project Owner
- MARINTEK – Technical Coordinator
- Duration Feb 2012 – Jan 2015
- Supported by NRC

MARENOR will quantify the system performance of the most common navigations and communications systems by maritime users in the Arctic.

1 year period
Message every 5 minutes
>90,000 exchanges

Svalbard, Mexico and North of Svalbard

Prognoses on system failures
Delays and occasional losses
Understand and learn weaknesses
In-situ measurements of satellite performance

MV Atlantic Guardian
Mexican Gulf
Norwegian Sea

FV Remøy
Greenland Sea
Barents Sea

Kjell Henriksen Observatory
Svalbard
VSAT Data recorded from Remøy

- Using ASTRA 4A (4.8°E)
- Ku-band
Results of measurements

- Good performance up to 78°N
- Intermittent communication breaks above 78°N, sometimes up to 82°N
- No statistically significant degradation below 78°N

- Expected round-trip time (RTT) is 700ms
- Not significant different between messages initiated from ship or shore
- 14% more than 1.4 seconds
- 1.4% more than 7 seconds.
Main measurements on Svalbard, but also elsewhere
Results of Iridium measurements (on Svalbard) - 1

- Expected RTT is 1.5s for the messages from the ship
- ... and for the messages from shore, RTT is about 15s
Results of Iridium measurements (on Svalbard) - 2

- A relatively high incidence of connection breaks over the four month period.

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<th>Numbers over 4 months</th>
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<td>&gt; 2800 seconds</td>
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Iridium: Similar results from other areas

- Svalbard
- Barents Sea
- Mexican Gulf

NOT identical conditions for measurements. BUT similar patterns were observed!
Conclusions

• Navigations in the Arctic rely on general communications

• VSAT over Ku-band works well up to fairly high latitudes
  – Variance in RTT may have an impact on some critical applications
  – East/west longitude will reduce the maximum of workable latitudes

• These characteristics might be varied and needed to examine with each satellite and service provider

• Iridium over L-band works fine in the Arctic region, but with limitations:
  – Limited bandwidth
  – Relatively long RTT
  – Very high variance in RTT
  – Some drop-outs
Data analysis

- Basic map
- Radio stations and coverage
  - VHF/MF/HF public
  - DSC watch VHF/MF/HF
  - Coverage DSC VHF/MF
- Navigational aids
  - LORAN-C transmitters
  - CHAYKA transmitters
  - NAVTEX transmitters
- Vessel density
  - Month, type, zone
- Vessel accidents
  - Type, zone
- Combination
- Reports

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Data analysis
• The Ambassador Platform Norway is hosted by MARINTEK in Trondheim.
• The Ambassador Platform Norway addresses the interactions between relevant stakeholders in the field of maritime navigation, communication and earth observation:
  - Efficiency improvements of transport and operations in the maritime and oil and gas industry;
  - Exploiting integration potentials in utilizing technology to improve collaboration between people and organizations;
  - Monitoring of transport infrastructure to identify and/or predict problems caused by inadequate information on adverse conditions to navigators;
  - Improved situational awareness providing decision support during demanding maritime operations (harvesting, sea-farming, transport, oil & gas operations, search and rescue, etc.);
Example on space based services
ARTES 20 Integrated Applications Promotion (IAP)

- The ARTES 20 IAP programme is dedicated to the development, implementation and pilot operations of Integrated Applications. These are applications that combine (or 'integrate') data from at least two existing and different space assets, such as Satellite Communication, Earth Observation, Satellite Navigation, Human Spaceflight technologies and others.

- ARTES 20 Integrated Applications projects cover Feasibility Studies and Demonstration Projects. Any organisation can propose to develop a new commercially promising space-based application or service. It may be e.g. a federation of users, a commercial company, a public body or a non-governmental organisation.
FUNDING OPPORTUNITIES

ESA supports the development, validation and demonstration of viable operational applications and services, relying on space systems and having the objective to establish sustainable operational solutions, through two funding programmes: Integrated Applications Promotion (IAP - ARTES 20) and Satellite Telecommunications Applications (SATCOM - ARTES 3-1). Proposals can be submitted in response to Open Competition issued by ESA on specific subjects (fully funded by ESA) or at your own initiative through Direct Negotiation (50% funded by ESA). Depending on the level of maturity of your project, ESA programmes offer different funding schemes.

DIRECT NEGOTIATION:

**Feasibility Studies**

ARTES 20 – Feasibility Studies provide the preparatory framework to identify, analyse and define new potentially sustainable applications and services within the ARTES 20 IAP programme.

**Fast Track Feasibility Studies**

ARTES 20 – Fast Track Feasibility Studies: the ESA funding is limited to 50 kEuro, the duration should not exceed 6 months, and the content is expected to be focussed on a few specific, but critical elements of a regular Feasibility Study.

**Demonstration Projects**

ARTES 20 Demonstration Project: The output of ARTES 20 IAP Demonstration Projects shall be a pre-operational service responding to well identified user needs and requirements and should show a clear potential to become sustainable at the conclusion of the project with ESA.

**Satcom Applications Projects**

ARTES 3-4 Satcom Applications Projects: Aims to support design, development and demonstration activities of system and services making use of satellite telecommunications. The scope of the development can be any hardware, software, service or application item aligned with industry plans for future exploitation.

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300kEuro (100 or 50%)

50 kEuro (< 50%)

<50%
Waste Management

The objective of this ARTES IAP feasibility study is to develop a business case where space technologies enable services for Waste Management issues while assessing its feasibility / viability.

Big data applications to boost preparedness and response to migration

The objective of the feasibility study is to carry out an analysis of the technical feasibility and commercial viability of big data processing applications in combination with space-based services in order to support the identification of migration flows, and to propose a roadmap for their implementation.

Integrated applications using ADS-B

The objective of the feasibility study is to identify and characterize ADS-B based services addressing potentially interesting application domains, carry out the analysis of their technical feasibility and commercial viability, select the most promising ones for further development and exploitation, and propose a roadmap for the implementation and demonstration of the proposed services.

Assessing the Potential of Future Maritime Applications in the Context of VHF Data Exchange System

The purpose of this feasibility study is to identify and specify new viable and sustainable maritime services using VDES (VHF Data Exchange System) and combining space (minimum two space assets) and non-space assets. Consultation with relevant institutional and commercial user and stakeholder groups.

https://artes-apps.esa.int/
Nedskalering av romvirksomhet

- I forslag til statsbudsjett ligger det et kutt på 75 prosent i satsingen på de frivillige programmene hos European Space Agency (ESA). Samtidig kuttes nasjonale følgemidler med 40 prosent.
- Norsk romindustri omsetter for mer enn 7 milliarder kroner årlig og viser at målrettet satsing på høyteknologisk spisskompetanse er en god investering for Norge.
- En fersk, samfunnsøkonomisk analyse av deltakelsen i ESAs frivillige programmer viser at den norske investeringen gir en årlig gjennomsnittlig sosioøkonomisk avkastning på 40 %.

Land som Tyskland, Frankrike, Italia, Storbritannia, Spania, Belgia, Sveits, Sverige, Nederland og Luxemburg, prioriterer romsatsingen selv i tøffe økonomiske tider.
Thank you!

Questions?

Comments?

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