Space services for arctic operations
Viking Ice Consultancy

- A Viking Group company
- Based in Kristiansand, Norway
- A part of the Viking Group with affiliated offices in Russia and Canada
- Offers services within marine operations in the Arctic and cold environments
- Knowledge and experience from Alaska, Canadian Arctic, Greenland, Barents Sea, Russian Arctic, Sakhalin and the Baltic
Where we have been

NE Greenland
Ice-breaking/seismic support 2012 & 2013, ice-mgt in 2008

Sea of Okhotsk
Ice-management and supply operations in ice 2012-2016

Alaska

The North Pole
Ice management and core drilling 2004

Baltic Sea
Seasonal Icebreaking since 2000.

Kara/Pechora Sea
Ice management 2014-2017

Northern Searoute
Passage of the Northern Searoute 6 times

Canada
Ice berg management Grand Banks Canada for Chevron and Husky Energy (2012 and 2013)

West Greenland
Moved more than 200 icebergs during 2010 & 2011

Barents Sea
Eni Norway, all duties 2011-2016
The Integrated Met ocean, Ice and Logistic services

Turnkey supply
Our Services

- Project management
- Turnkey supply
- Ice Management
- Ice Advisory
- Logistics & transportation
- Training
- Technology qualification
- Polar Code Compliance advisory
Dec 2015 NSR Transit

Why NSR instead of Panama from Seattle to Sweden

- Just finished seasonal work in Alaska Nov 15
- Shorter Distance 9500-7100 = 2400nm
- Be back in North Sea earlier for job opportunities
- Save Fuel?
- Good experiences with previous transits
- Increase Arctic in-house knowledge
- Good and reliable Ice and hydro-metological information from partners and suppliers
- Icebreaker from Rosatomflot in area

NSR Transit would not be started if Russian Icebreaker is not in area or poor availability of ice and met ocean information
### Viking Supply Ships – Fleet overview

12 of 18 vessels either high ice-class or ice-breaker

<table>
<thead>
<tr>
<th>Vessels</th>
<th>Design</th>
<th>Built</th>
<th>Ice-class</th>
<th>BP/ deck</th>
<th>NSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loke Viking class</td>
<td>VS-4622L</td>
<td>2010-2012</td>
<td>Ice 1A, deice C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tor Viking class</td>
<td>KMAR 808</td>
<td>2000-2001</td>
<td>Icebreaker Ice-10/ARC 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Odin Viking</td>
<td>Moss Mar 424</td>
<td>2003</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frigg Viking class</td>
<td>VS-470 Mk II</td>
<td>2003-2007</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMA Icebreakers</td>
<td>Icebreaker</td>
<td>1973-1989</td>
<td>1A Super – Polar 20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Details:

**Loke Viking class**
- With its high ice-class and winterization the Loke Viking class is the ideal vessel for sub-arctic operations.
- 4 vessels
- Built 2010-2012
- Ice 1A, deice C
- Bollard pull: 235-257 tonnes

**Tor Viking class**
- Combined Ice-breaker and AHTS suitable in harsh environment operations as well as the arctic
- 3 vessels
- Built 2000-2001
- Bollard pull: 202 tonnes

**Odin Viking**
- Medium sized AHTS suitable for world-wide operations, with a proven track-record in the North Sea
- 1 vessel
- Built 2003
- Bollard pull: 180 tonnes

**Frigg Viking class**
- Medium sized PSV vessels with DP-2.
- 5 vessels
- Built 2003-2007
- Bollard pull: 50-250 tonnes

**SMA Icebreakers**
- Icebreakers owned by Swedish Maritime Administration. VSS crewing and Technical management
- 5 icebreakers
- Built 1973-1989
- Bollard pull: 50-250 tonnes
High Data resolution needed to operate safe and economical

- Ice-statistics
- Optical sat. data
- SAR (Synthetic Aperture Radar) Sat. data
- Airborne SLAR
- Ship radar, IR, Visual

- Strategic planning (ashore)
- Metocean Weather Routing
- Hydrographic Data
- Education and training
- Real time evaluation (on board)
- GNSS

Safe Operation and Station keeping (Experienced crew, equipment and decision support)
Ice and Met Ocean Products, Services and Delivery/Viewer used

- Arctic and Antarctic institute
  - Soumi NPP VIIRS (IR Sat) res 750 m
  - IceAnalysis daily
  - Ice Forecast 24, 48, 72
  - Ice Pressure Forecast
  - Recommended Route
  - Metocean forecast
    - E Mail
    - Transas NaviSailor
    - Pdf, GeoTiff
    - Google Earth

- StormGeo
  - Fleet DSS, Vessel tracking and large area weather info
  - Icing Warning Forecasts
  - Online COPD Portal including daily high res weather routing
  - Point Forecasts (Vilkitsky)
    - E Mail
    - Installed SW
    - Online Portal
    - Pdf

- Kongsberg Satellite Services
  - Syntetic Aperture Radar Imagery:
    - Scheduling/Portal
    - Sentinel 1A
    - Radarsat 2
    - Risat 1
    - ftp
    - Portal
    - GeoTiff
    - Google Earth

- Polar View Ice/VTT/FMI
  - Polar View Ice onboard/onshore client
  - Sentinel 1 EWS
  - Barents and Kara Ice Thickness
  - PolarView Ice SW

- Viking Ice Consultancy
  - Daily operational ice products (GiS)
  - Ice advisory and daily teleconference
  - E-Mail
  - Pdf
  - GeoTiff
  - PolarView Ice SW
<table>
<thead>
<tr>
<th>Bird/Mode</th>
<th>Coverage</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radarsat-2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ScanSAR Narrow</td>
<td>300x300 km</td>
<td>50 meters</td>
</tr>
<tr>
<td>Standard</td>
<td>100x100 km</td>
<td>30 meters</td>
</tr>
<tr>
<td>Ultrafine (Growlers)</td>
<td>20 x 20km</td>
<td>3 meters</td>
</tr>
<tr>
<td><strong>CosmoSKY-med</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ScanSAR Huge</td>
<td>200x200 km</td>
<td>100 meters</td>
</tr>
<tr>
<td>ScanSAR Wide</td>
<td>100x100 km</td>
<td>30 meters</td>
</tr>
<tr>
<td>HIMAGE</td>
<td>40 x 40 km</td>
<td>3 / 5 meters</td>
</tr>
<tr>
<td><strong>TerrasarX</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ScanSAR</td>
<td>100x150 km</td>
<td>20 meters</td>
</tr>
<tr>
<td>StripMap</td>
<td>30x50 km</td>
<td>3-5 meters</td>
</tr>
<tr>
<td>Spotlight</td>
<td>10x10 km</td>
<td>1-3 meters</td>
</tr>
<tr>
<td><strong>Sentinel-1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EWS (Extra wide Swath)</td>
<td>400x400 km</td>
<td>40 m</td>
</tr>
<tr>
<td>IWS (Interferometric Wide Swath)</td>
<td>250x250 km</td>
<td>20 m</td>
</tr>
<tr>
<td>Stripmap</td>
<td>80 km</td>
<td>5 m</td>
</tr>
<tr>
<td><strong>RISAT-1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRS (Coarse Resolution ScanSAR)</td>
<td>223x223 km</td>
<td>50 m</td>
</tr>
<tr>
<td>MRS (Medium Resolution ScanSAR)</td>
<td>115x115 km</td>
<td>25 m</td>
</tr>
<tr>
<td>FRS (Fine Resolution StripMap)</td>
<td>25x25 km</td>
<td>3 m</td>
</tr>
</tbody>
</table>

**Polarization**
The electromagnetic waves transmitted from a SAR antenna is oscillating in a certain direction. Polarization indicates the orientation of the oscillating EM waves. Different materials can reflect polarization in different ways. Polariometry can therefore be used to extract extra information from SAR imagery. It is also important to choose the right polarization for specific applications.

**Ascending/descending**
The current commercial SAR satellites are all polar dusk/dawn orbits. They will complete approximately 14 orbits around the earth during 24 hours. When the satellites are travelling north, it is in an ascending pass. When it travels south it is in a descending pass.
Satellite Imagery Scheduling with assistance of KSAT/Savoir SW

- Started Planning on Dep Seattle approx 10 days before reaching Ice Edge
- See availability of free SAR imagery (Sentinel 1)
- Then fill in gaps with Commercial products (Radarsat 2, Risat1)
- Challenges to know exact ship speed for tasking (Weather, Ice conditions operational delay)
- Freshness is crucial 1-6 Hours optimum
- To slow delivery time or tasking, vessel have passed the scene
- Will the ordered product cover your route?

Blue frames, Sentinel 1 EWS 40 m resolution Coverage from 30 nov-5 dec 2015
Optimal scheduling delivery, vessel in this pos scene is ready 1-6 hours age.
Freshness is essential
How to use onboard

- Methodology was to download satellite imagery to ECDIS system from PolarView Ice or KSAT Portal.
- Stop in Ice to identify ice drift and offsets from time of scene acquisition.
- Identify leads and cracks with light ice.
- Then use ice radar to do the local area fine navigation.
- The ship could increase speed from 5 to 12 knots using 3 (of 4) engines finding those areas with lighter ice.
How to interpret SAR imagery onboard.

151201 1951 UTC Sentinel1 HH 40 m Res SAR Image trough PolarViewIce and KSAT

Tor Viking intersects Icebreaker Vaycach ice channel and follow the track to west

Track of Vaygach, possible to follow for 19 hours

Track of Tor Viking

Areas of New Ice Snow flowers

Track of Nuclear Icebreaker Vaygach assisting to the east with Tanker in notch
Using Satellite AIS directly as WFS (Web Feature Service) in GIS/Ice charting tools to monitor vessels
Operational Ice and situation awareness Charts delivered on daily basis.
Communication

As expected VSAT communication coverage was kept to the middle of Laptev Sea on satellite Eutelsat 172 NP and no coverage until online on Thor V in the Barents sea. In the middle of the beams we had to change over to Iridium Pilot system where we had ordered a package of 1000 MB. Total Use in Iridium was 500 MB for this period of 5 days. Additionally Iridium voice 523 minutes.
PolarIce – ViewIce & ICEMAR how to order and upload

Catalouge showing available products and age for your area
Order/download and then transfer to ECDIS
Viking Use inhouse developed together with partners Common Operational Picture display (COPD) solutions for its operations.

- Both stationary and web based - laptop versions
- Philosophy: Everyone Sees Everything
- Strategic and Tactical planning tool
- Partners with weather, multi mission satellite data, ice information and communications service providers
Metocean and Ice Portal for Marine Operations (COPD)

Combined mode Ice Concentration/Drift Prediction/Actual Drift (Beacons)/ SAR/Optical

Presentation High Res SAR and AIS tracking

Drift Calculation based on multiple SAR/Optical images

Polar low Risk forecasting and real time tracking
MULDIARCOS - Multimission Data and Information services for Arctic Operations

• ESA ARTES IAP demonstration project – Integrated Application Promotion:
  – «The development of operational services for a wide range of users through the Integration of different space assets»

• Project Objective: Establish *ready-for-operations* service where a user on-board a vessel shall obtain access to multi mission Earth observation data and relevant information. The service shall be demonstrated in operational activities in the arctic (in or near ice).
Muldiarcos Project concept

Operational challenges:

- Different data access points
- Satellite data planning and ordering
- Timely status information
- Data access, interface and applications
- End-to-end satellite imagery delivery chain and user interface for arctic maritime operations.
- Order new acquisitions and access to pre-planned imagery and archived imagery
- Relevant met ocean and ice products
- Easy access to relevant information such as overview of ordered imagery, status information and possible acquisitions
- User interface with all relevant information
Muldiarcos Project, Users visions

Coms, Data Handling, automatic reporting of Met ocean Parameters and Ice ground thruthing for database and forecast improvement in low bandwidth mode

3G/4G cellular GSM
MBR/Wimax
Ice/NET1 long-range CDMA
VSAT satellite
Iridium satellite
Will future Navigation System will be a fusion of Integrated Navigation System and Geographical Information System?
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