Document Revisions

**IALA Guideline No. ####**

**On**

**THE CHALLENGES OF PROVIDING ATON SERVICES IN POLAR REGIONS**

**Draft v4**

**Edition 1**

**[4 September 2013]**

**[Previous Edition; Date issued]**

***AISM***Association Internationale de Signalisation Maritime ***IALA***

International Association of Marine Aids to Navigation and Lighthouse Authorities

10, rue des Gaudines

78100 Saint Germain en Laye, France

Telephone: +33 1 34 51 70 01 Fax: +33 1 34 51 82 05

e-mail: [contact@iala-aism.org](mailto:contact@iala-aism.org) Internet: [www.iala-aism.org](http://www.iala-aism.org)

Revisions to the IALA Document are to be noted in the table prior to the issue of a revised document.

|  |  |  |
| --- | --- | --- |
| **Date** | **Page / Section Revised** | **Requirement for Revision** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

Table of Contents

[Document Revisions 1](#_Toc366050530)

[Table of Contents 3](#_Toc366050531)

[Index of Tables 4](#_Toc366050532)

[Index of Figures 4](#_Toc366050533)

[1 Introduction 5](#_Toc366050534)

[1.1 Emerging routes in polar regions 5](#_Toc366050535)

[1.1.1 Heading 3 5](#_Toc366050536)

[1.1.2 Heading 3 5](#_Toc366050537)

[1.2 Special features of AtoN in cold regions 5](#_Toc366050538)

[1.2.1 Heading 3 5](#_Toc366050539)

[1.2.2 Heading 3 5](#_Toc366050540)

[2 Background 5](#_Toc366050541)

[2.1 Heading 2 again 5](#_Toc366050542)

[2.1.1 Heading 3 again 6](#_Toc366050543)

[3 Scope / Purpose / Objectives 6](#_Toc366050544)

[4 Definitions / Acronyms, as required 6](#_Toc366050545)

[5 The need for AtoN in Polar Regions 7](#_Toc366050546)

[5.1 Traffic patterns 7](#_Toc366050547)

[5.2 User requirements for AtoN in polar seas 7](#_Toc366050548)

[5.3 Regulatory requirements 7](#_Toc366050549)

[6 Special features of working in remote in polar regions 7](#_Toc366050550)

[6.1 Special features of project management in polar regions 7](#_Toc366050551)

[6.2 Considerations for scheduling work in cold regions 7](#_Toc366050552)

[6.3 Communication with the site during construction 7](#_Toc366050553)

[6.4 Quality control 7](#_Toc366050554)

[7 SITE DESIGN AND EQUIPMENT SELECTION 8](#_Toc366050555)

[7.1 Foundations & Structures 8](#_Toc366050556)

[7.2 Safety considerations 8](#_Toc366050557)

[7.3 Energy generation and storage 8](#_Toc366050558)

[7.4 Visual Aids 8](#_Toc366050559)

[7.5 Electronic Aids 8](#_Toc366050560)

[7.6 On-demand AtoN 8](#_Toc366050561)

[7.7 Physical protection devices 9](#_Toc366050562)

[8 INSTALLATION AND CONSTRUCTION in remote regions 9](#_Toc366050563)

[8.1 Mobilization/demobilization 9](#_Toc366050564)

[8.2 Transportation of personnel and material 9](#_Toc366050565)

[8.3 Availability of manpower 9](#_Toc366050566)

[8.4 Availability of heavy equipment 9](#_Toc366050567)

[8.5 Personnel accommodation 9](#_Toc366050568)

[9 MAINTENANCE 9](#_Toc366050569)

[9.1 Specific maintenance plans and activities for cold climate 9](#_Toc366050570)

[9.2 Monitoring , measuring and control 9](#_Toc366050571)

[9.3 Repair strategies 9](#_Toc366050572)

[9.4 Preventive maintenance 9](#_Toc366050573)

[9.5 Corrective maintenance strategies 9](#_Toc366050574)

[9.6 Spare parts management 9](#_Toc366050575)

[10 e-Navigation in Polar Regions 9](#_Toc366050576)

[10.1 Shortcomings of GNSS in polar regions. 10](#_Toc366050577)

[10.2 The maritime cloud in e-Nav and the artic web 10](#_Toc366050578)

[10.3 The use of Virtual AtoN in polar navigation 10](#_Toc366050579)

[10.4 Use of AIS in polar region and VDES (VHF data exchange system) 10](#_Toc366050580)

[11 Reference 10](#_Toc366050581)

[11.1 Manuals on construction in cold regions 10](#_Toc366050582)

[11.2 Applicable IALA Guidelines and Recommendations 10](#_Toc366050583)

[ANNEX A Annex Title 11](#_Toc366050584)

[APPENDIX 1 Appendix title 12](#_Toc366050585)

Index of Tables

[Table 1 Title required 3](#_Toc216488847)

Index of Figures

[Figure 1 Title required 3](#_Toc216488874)

**IALA Guideline No. ####**

**THE CHALLENGES OF PROVIDING ATON SERVICES IN POLAR REGIONS**

# Introduction

In view of the recent opening of shipping routes across the arctic and the increase in number of voyages in polar regions, it is clear there is a need to provide guidance on the special challenges of providing AtoN services in polar regions. This Guideline deals with the special challenges of providing Aids to Navigation (AtoN) services in polar regions and it is assumed that all other aspects of AtoN provision are dealt with in existing IALA documentation.

Information that is used to introduce the document, including reference to lead-up to the creation of the document. This should also include references to any IALA Conference or Symposium recommendations that led to the document creation.

All text should be English UK

## Emerging routes in polar regions

Followed by Body Text

### Heading 3

Followed by body text Indent

### Heading 3

Followed by body text Indent

#### Heading 4

Followed by body text Indent 2

It should not be necessary to go to more than 4 levels of numbering and it is preferable to keep to 3.

## Special features of AtoN in cold regions

Followed by Body Text

### Heading 3

Followed by body text Indent

### Heading 3

Followed by body text Indent

#### Heading 4

Followed by body text Indent 2

It should not be necessary to go to more than 4 levels of numbering and it is preferable to keep to 3.

Above gives rise to the need for guidance on provision, operation and maintenance of AtoN in cold climates.

# Background

Followed by body text

Background would be a section of the introduction, if required. It could refer to previous editions or other IALA documents that have been used / are superseded by this document.

## Heading 2 again

1. List 1

Can be followed by List 1 text

* 1. List 1 indent

Can be followed by List 1 indent text

* + 1. List 1 indent 2

Can be followed by List 1 indent 2 text

Followed by body text

* Bullet 1

Can be followed by Bullet 1 text

* Bullet 2

Can be followed by Bullet 2 text

* Bullet 3

Can be followed by Bullet 3 text

### Heading 3 again

Can be followed by followed by Body Text Indent 2

#### Heading 4 again

Can be followed by followed by Body Text Indent 3

#### Heading 4 again

Followed by Body Text Indent 3

# Scope / Purpose / Objectives

Body Text

1. Title required

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Note. Titles of Tables go above them. This example has font size 10 with 3 pt above and below text and with the text centred vertically

# Definitions / Acronyms, as required

Definition of terms used in the guideline are contained in the IALA Dictionary which is available on the IALA web site.

AIS Automatic Identification System

VDES VHF Data Exchange System



1. Title required

Figure titles come after the figures. Graphics should, preferably be inserted at a text point and then centred.

# The need for AtoN in Polar Regions

Body Text

## Traffic patterns

Body text

## User requirements for AtoN in polar seas

Body text

## Regulatory requirements

Body text

# Special features of working in remote in polar regions

## Special features of project management in polar regions

## Environmental considerations

* 1. Visibility

At high latitudes it is dark for all or most of the day for half the year, which will affect visual navigation. It is light for all or most of the day during the summer months, affecting celestial navigation.

* 1. Temperature

Extremely low temperatures can affect the performance of external equipment. Icing on antennas and snow build-up can cause problems for many different systems.

Consistent cold temperatures can reduce the expected life of equipment. Also consideration should be given to selection of lubricants used on moving parts.

* 1. Moving landscape

Ice sheets grow and shrink with the seasons and ice-charts may need to be updated frequently. Consideration should be given as to how this information can be managed in an efficient and cost-effective manner to ensure the mariner uses the most up to date information.

The growth and reduction of the ice sheet can also result in land based systems having to be installed at permanently stable ground which may potentially be at sub-optimal locations, distant from the area of navigable waterway being served.

* 1. Natural resources

It is expected that this area will observe a growth in off shore industry as approximately 25% of undiscovered oil and gas resources are believed to be within this region. As such, navigable space may become restricted.

* 1. Hydrography

Given the rapid changes expected to navigable areas due to moving ice and the ice shelf, the mariner will need up to date charts. For example, it is estimated that only 20% of the sea area around Greenland is surveyed.

1. Space Weather

The Earth’s magnetic field helps protect the planet from the effect of some space weather effects. Energised particles are directed towards the pole as they are deflected around the Earth, which can result in greater ionospheric disturbance in Polar Regions.

Space weather forecasts are provided by a number of bodies, for example, the North American Oceanic and Atmospheric Administration Space Weather Prediction Centre ([www.swpc.noaa.gov](http://www.swpc.noaa.gov)) and mariners are invited to be aware of such effects.

* 1. Geomagnetic Storms

Geomagnetic storms can induce changes to the Earth’s magnetic field which can introduce a deviation to the vessels’ magnetic compass.

* 1. Ionospheric effects

Space weather can lead to charging of the atmosphere and small areas of highly charged particles. These areas can lead to phase and signal scintillation in satellite signals as they propagate through the atmosphere, which can result in large position errors or ultimately prevent satellite signal reception.

Leading Lines (lighted or unlighted)

Lighted or unlighted sites

Passive AtoN (Visual, Radar)

AIS

The installation of ground based AIS transponders require firm, stable, ground on which to position the reference station. As like other radio systems, this can result in the station being positioned away from the navigable area due to ice.

Satellite AIS is available in the Polar Regions, however this may be limited to AIS tracking rather than two way information exchange.

e-Navigation solutions

* Equipment redundancy requirements for remote regions

## Considerations for scheduling work in cold regions

Working on Permafrost

Transportation during winter season

## Communication with the site during construction

Body text

## Quality control

Body text

# SITE DESIGN AND EQUIPMENT SELECTION

## Foundations & Structures

* Soil surveys
* Land surveys
* Environmental conditions
* Ice conditions
* Accessibility

## Safety considerations

* Safety plan
* Medical evacuation

## Energy generation and storage

* Solar
* Wind
* Fuel cells
* Primary batteries
* Hybrid systems
* Energy storage

## Visual Aids

* + 1. Physical AtoNs

Floating aids are generally not used in this area due to moving ice, high currents and the increased maintenance due to ice loading.

Fixed aids such as Lighthouses and Beacons are used in these areas, such as the Beacon shown below provided by the Danish Maritime Administration. These are subject to high winds and icing



*Numbered beacon*

These aids are powered by solar power with battery capacity sufficient to supply the lamp during the winter.

Power consumption

Transmissivity

Low temperature performance

Durability

Ice build-up on lanterns

Maintainability at low temperatures

## Electronic Aids

* RACONS

Performance at low temperature

It is likely that Racons will be able to operate in low temperatures[[1]](#footnote-1) and their shape will help prevent snow build up, to some extent, however it is not expected to prevent it.

Racons are used in the vicinity of Greenland and Svalbard Islands and have operated with no problems for many years.

These Racons are powered via solar panels and battery banks, the power consumption is very low due to the limited number of passing vessels.

* AIS-AtoN

AtoN AIS could be used on fixed infrastructure as long as the power and coverage area requirements are met. As noted above, floating aids are generally not used.

power consumption

durability of equipment

performance at low temperatures

* Radar reflectors

It is believed that radar reflectors may become less effective if they are covered by snow and ice, however it is expected to be a small degradation in performance.

## On-demand AtoN

* AIS triggered AtoN
* VHF triggered AtoN
* Equipment specification and procurement

Durability

Ice effect

## Physical protection devices

Vandalism / theft

Animals

Lightning protection

While lightning may be unusual, if it does occur the effects can be significant. Therefore grounding of equipment is important.

# INSTALLATION AND CONSTRUCTION in remote regions

## Mobilization/demobilization

Body text

## Transportation of personnel and material

Body text

## Availability of manpower

Body text

## Availability of heavy equipment

Body text

## Personnel accommodation

Body text

## Planning restrictions

Remote locations may have particular planning requirements that may affect the I nstallation of new AtoNs.

# MAINTENANCE

## Specific maintenance plans and activities for cold climate

Body text

## Monitoring , measuring and control

Equipment

Transmission of information

## Repair strategies

In-house

Contract

## Preventive maintenance

## Corrective maintenance strategies

Repair by replacement

Field repair

Other

## Spare parts management

# e-Navigation in Polar Regions

General comments, opportunities, benefits and use of e-Navigation in polar regions.

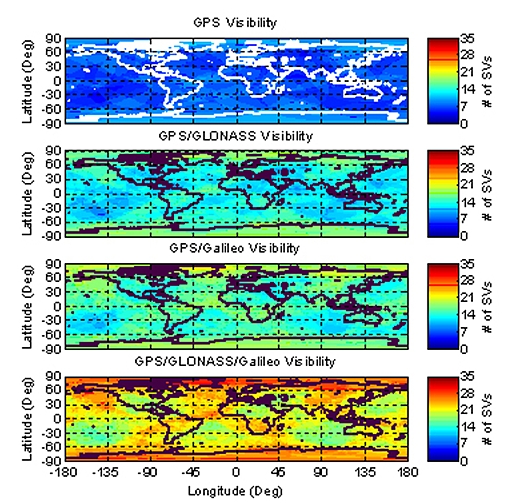
Body text

## GNSS in Polar Regions.

* + 1. Global Navigation Satellite Systems (GNSS)

GNSS is usable in the Polar Regions, however the satellites appear low in the horizon, due to the use of medium earth orbits, although more satellites may be visible than at lower latitudes. Due to the low elevation, users will experience a lower signal to noise ratio, a shorter visibility period and could be obstructed by the ship infrastructure or terrain.

The use of more than one constellation is recommended.



### Figure 1: Expect satellite visibility (from New Global Navigation Satellite System Developments and Their Impact on Survey Service Providers and Surveyors, Rizos et al, FIG article 2005)

### GPS

The GPS constellation uses six orbital planes with a 55o inclination. As such satellites are low in the sky when observed from Polar Regions. The plot below shows the expected GPS satellite visibility from the North Pole, from which it can be seen that most satellites are below approximately 450 elevation from the horizon, however this is considered the worst case, satellites will appear slightly higher in the sky at lower latitudes.



Figure 2: Expected GPS Satellite visibility as seen from the North Pole (Aarmo, GNSS positioning for the future workshop, Denmark, Sept 2012)

Low satellite elevations can result in increased satellite obscuration, increased multipath and poorer vertical accuracy, as there are no satellites directly overhead.

GLONASS

The GLONASS constellation uses three orbital planes with an inclination of 64.8o of the horizon, which results in greater satellite visibility in Polar Regions. The plot below shows the expected satellite visibility from the North Pole when GPS and GLONASS satellites are observed.

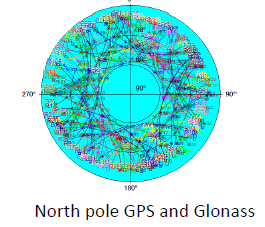


Figure 3: Expected GPS & GLONASS Satellite visibility as seen from the North Pole (Aarmo, GNSS positioning for the future workshop, Denmark, Sept 20120

Galileo

The Galileo constellations will consist of 30 satellites arranged in three circular Medium Earth Orbit at an inclination of 56o to the equator. Galileo is reported to provide good coverage up to 75 degrees north (ref ESA[[2]](#footnote-2)).

* 1. BeiDou

The BeiDou constellation has been designed with a constellation of 5 geostationary satellites, 27 medium earth orbiting satellites and 3 inclined geosynchronous satellites. The geostationary satellites and medium earth orbit satellites will also appear at low elevations. The inclined geosynchonous orbits are positioned to maintain satellite availability over the intended service area and may not be visible from the Polar Regions.

QZSS

Whilst not a Global system in itself, QZSS can be used with GNSS. Due to its design, it is unlikely to benefit users in the Arctic region, but may provide additional ranging information to users in the Antarctic region.

1. Augmentation Systems
   1. Ground Based Augmentation Systems (GBAS)

Marine radiobeacon DGPS

Marine radiobeacon Differential GNSS services provide corrections to GNSS over a 300kHz radio link. These systems are not developed in the southern polar area and are only sparsely developed in the northern polar areas. Radiobeacon signal attenuation is greater over ice which results in reduce coverage in Polar Regions.

It should be recognised that along with the potential for a smaller coverage area, it may not be possible to site the reference station infrastructure near to the intended service area due to available land and ice sheets. This may lead to greater spatial decorrelation and reduced accuracy.

Ionospheric effects can also be greater in these regions and may affect performance.

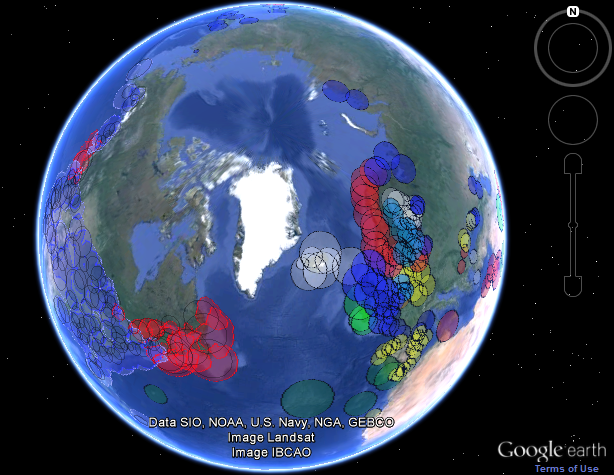


Figure 4: Indicative location of marine DGPS stations in the northern hemisphere[[3]](#footnote-3). Note that this does not show all stations and that the circles shown relate to nominal range, rather than usable coverage.

DGPS via AIS

Due to the potential for shore based infrastructure to be positioned some distance from the main waterway, due to positioning on permafrost or solid land, it may result in limited coverage.

* 1. Satellite Based Augmentation Systems (SBAS)

SBAS systems generally use satellites in geostationary earth orbit, which is a circular orbit above the Earth's equator and rotates at the same speed as the earth’s rotation. Because the satellite remains over the equator, it tends to appear low in the sky and may not be visible at high latitudes (approximately over 70-75 degrees latitude).

SBAS models the ionosphere based on information collected at ground reference stations. These reference stations are located throughout the SBAS service area but are limited in number at higher latitudes. This affects the performance of SBAS corrections at high latitudes as the model is less accurate in those areas.

The coverage regions of existing and planned SBAS systems are shown below.

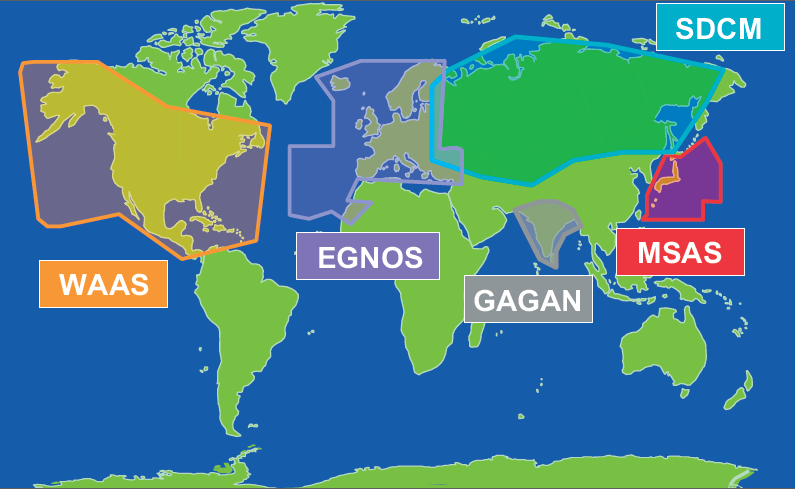


Figure 5: Existing and planned SBAS systems[[4]](#footnote-4)

1. Terrestrial navigation systems
   1. Radar
      1. Ice detection

Scan to scan clutter correlation techniques can be used to identify very slow moving or stationary boundaries in clutter returns. Such boundaries can indicate the edge of the navigable sea surface, coastlines etc. Slow moving sea ice (such as icebergs) of various sizes can also be extracted from radar clutter returns – potentially invaluable in poor visibility and extended periods of darkness.

* + 1. Ice thickness detection

The mean and statistical variation of signal amplitude of radar clutter returns can be used to indicate ice thickness (for example indicating a (potentially) navigable channel in a large expanse of ice).

Note that new technology radars incorporating Doppler processing can be used to provide radar data with enhanced clutter response. It is quite possible for such a radar to have two parallel processing channels providing a target detection channel in which clutter is suppressed and a clutter analysis channel in which clutter is enhanced (eg. for coastline, ice detection and ice thickness assessment).

* + 1. Ice loading issues

In extreme cold weather conditions, ice accretion can degrade both the mechanical and the RF performance of externally mounted rotating and non-rotating antennas. Mechanically, components should be adequately specified for these conditions (using low temperature greases and specifying motors and gearboxes for the addition weight due to ice). Heating elements are often included within component housings above decks.

* + 1. Calibration to north

The geomagnetic North Pole that the compass needle points towards is not the geographic North Pole. The former lies in the Canadian high arctic and is constantly undergoing a slow drifting motion. Depending on where you are, this may result in a compass error (declination) of anywhere from a few degrees up to 20-30 degrees or rarely even more. Calibration of this error is important in the extreme latitudes especially when GPS data may be affected. Accurate position and navigation data is critical to achieving correct registration of the radar data when overlayed on to the electronic chart.

* + 1. Influence of position and compass data on radar system

Some conventional radar functions such as scan-to-scan correlation, target trail, target tracking, etc., use the vessel’s position and compass data. Therefore should the accuracy of this information be degraded, the radar performance will also be affected.

* + 1. Radar overlay on an electronic chart

There may be a need to apply a transform when overlaying the radar image on an electronic chart at high latitudes. The IEC test standard[[5]](#footnote-5) requires shipborne radar to match the chart up to 70o. Above 70o there could be a mismatch between the radar image and the electronic chart. Similarly, AIS symbols could be presented off from radar echoes for the same reason in these latitudes.

* 1. Loran-C, Chayka & eLoran

There are existing Loran-C and Chayka stations in the northern parts of Russia and Norway, which are able to provide positioning in the Arctic region.

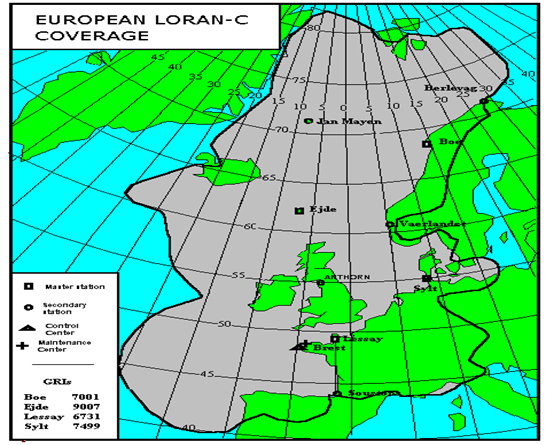


Figure 6: European Loran C coverage

Currently eLoran coverage is not available in the Polar Regions as it is currently limited to lower latitudes.

Installations would need to be robust due to high winds combined with risk of icing of the antenna structure. Ground wave signals are attenuated more over ice than other ground types and therefore coverage may be reduced.

## Communications

Communications systems

* + 1. Satellite communications

Satellite communications (broadband) generally make use of geo-stationary satellites positioned over the equator. Therefore, they have poor coverage above ~72oN.

* + 1. Shore based communications

Localised radio systems could be affected by greater radio noise experienced in the auroral zones.

Maritime Safety Information

MSI via SafetyNet is limited to the Inmarsat coverage around 76 deg North.

NAVTEX coverage in Polar Regions may be limited to latitudes up to 75-80o when using 518kHz. For example, coverage is limited to 78o to the west of Greenland. For higher latitudes NAVTEX information is available on 4209.5 kHz, but transmission on this frequency will from time to time be greatly affected by solar or magnetic storms.

* 1. Chart data
     1. Chart accuracy and updates

It is noted that chart data in Polar Regions will need to be reviewed and kept up to date. For example, there are currently unsurveyed areas and outdated paper charts for an area around Greenland which results in a difference of several kilometres between the charted position and the GPS position. Similarly, only one third of Svalbard Islands have been charted to sufficient accuracy for use in navigation.

* + 1. Chart provider
    2. Datum accuracy
  1. Emergency transponders
     1. SARTS

## The maritime cloud in e-Nav and the artic web

Body text

## The use of Virtual AtoN in polar navigation

Body text

## Use of AIS in polar region and VDES (VHF data exchange system)

Body text

# Magnetic and Gyro compass

Both magnetic and gyro compasses experience deteriorated performance near the poles. The magnetic compass due to reduced horizontal magnetic field strength near the poles and the gyro due to the angle between the gyroscope axis and the earth axis[[6]](#footnote-6). GNSS compasses are however not deteriorated by increasing latitudes near the polar areas.

# Reference

## Manuals on construction in cold regions

## Applicable IALA Guidelines and Recommendations

1. Annex Title

Guidelines should have Annexes. Appendices are attached to Annexes.

1. ANNEX HEAD1

Body Text

To restart the Annex Heading numbering at 1:

* Office 2003, go to Format / Bullets and Numbering / Restart numbering (lower left in the box)
* Office 2007, go to down arrow next to Numbering icon and select Set Numbering Value
  1. Annex Heading 2

Body text

Annex Heading 3

Body Text Indent

Annex Heading 4

Body Text Indent 2

1. Appendix title
2. APPENDIX Heading 1

Followed by Body Text

* 1. Appendix Heading 2

Followed by Body Text

* + 1. Appendix Heading 3

Followed by Body Text Indent

Resources of interest

<http://wwwx.dtu.dk/Subsites/iap/welcome%20to%20iap%20applications%20for%20the%20arctic/download%20of%20presentations.aspx>

1. http://www.tidelandsignal.com/web/information/Data%20Sheets/RADIO%20AIDS/SeaBeacon2\_Rev16.pdf [↑](#footnote-ref-1)
2. http://www.esa.int/Our\_Activities/Navigation/The\_future\_-\_Galileo/What\_is\_Galileo [↑](#footnote-ref-2)
3. <http://sxbluegps.com/technology/techno-1/> [↑](#footnote-ref-3)
4. http://ec.europa.eu/enterprise/policies/satnav/files/egnos/egnos\_os\_sdd\_v2.0\_en.pdf [↑](#footnote-ref-4)
5. IEC 62388 [↑](#footnote-ref-5)
6. E. W. Anderson (1957). Navigation in Polar Regions. Journal of Navigation, 10, pp 156-161. doi:10.1017/S0373463300016623. [↑](#footnote-ref-6)