BlueTraker®

WHITE PAPER: Challenges of vessel tracking in the Sea Area A4

Abstract

The seas in which the ships operate are divided into four areas (A1, A2, A3, A4) which all have some sort of communication limitations. In first part of the document, we present the challenges that a ship tracking device face in demanding Sea Area A4. In other part of this document, we share the solutions on how to efficiently report vessel status and location without any interference caused by weather related factors.

To understand the nature of this document, lets first describe what is Sea Area A4. The Sea Area A4 is the sea area of the world not being part of any seas area A1, A2 or A3 and it covers all of the remaining sea areas that A1, A2 and A3 don't cover. For ships it is bay far the most difficult area to navigate in of all the four areas.

When a ship navigates through Sea Area A4 it needs a reliable tracking device so that reporting to monitoring center is uninterrupted. It is crucial, that monitoring centres know the exact location and status of the vessels that they monitor, regardless of their location on the Globe.

In demanding areas, such as Arctic or Antarctic the electronic equipment needs to be robust due to the extreme weather conditions. It is crucial, that the crew and the monitoring centres are assured that the tracking device is operating normally. The electronic components from which the tracking device is constructed, are selected in a way that the fabricated device works properly in all weather conditions.

Purpose

The objective of this document is to present solutions to the difficulties faced by a ship's equipment while navigating through the Arctic and Antarctic regions. For the safety of both ship and crew, it is important that the fleet operators know the exact position, speed and bearing of their vessels, especially in regions where temperatures are extremely low and incidents at sea would be particularly hazardous. The most vulnerable part of maritime equipment are the electronic components. Problems with the device's operation can arise especially if the equipment is mounted outside therefore exposed to low temperatures and other weather factors. No challenges are present if the device is packed in housing and if it runs continuously with no power interruptions. When the power supply for any reason shuts down the temperatures of electronics often go below recommended temperature. At that point, if the device is powered and started up again, major damage to components and circuits can occur.

BlueTraker offers an arctic version VMS, LRIT and SSAS terminals which are designed specifically for operation in the Polar regions. These tracking devices can be cold started at temperatures as low as -50°C.

Further in this document we will describe how we accomplished this and what the benefits of such features are.

1 Challenges

When ships are navigating through the Arctic and Antarctic regions they encounter many challenges which are primarily related to the extreme weather conditions. Wind chill, humidity, changes in air pressure, temperature fluctua-

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tions and other non-weather related challenges like communication availability in remote areas of the Earth (e.g. Sea Area A4) are everyday hardships for the ship's crew and its equipment. Over the next 10 years there is expected to be a rise in shipping within the Arctic and Antarctic regions (read more: http://www.arctis-search.com/2020+Future+Scenario+for+the+Northwest+Passage). Ships navigating the remote waters of the Arctic and Antarctic face some unique risks and challenges.

A ship's equipment can often be compromised by cold temperatures and harsh weather conditions in addition to the stresses imposed on the hull and propulsion through polar ice fields.

1.1. Geostationary satellite limitation

Sea Area A4 is located around the Polar regions above 70° latitude as presented in Figure 1 and more exactly in Figure 2. Geostationary satellites, which are positioned above the equator, cannot reach this far or experience gaps in coverage at lower latitudes already, which is normal and relates to terrain configuration (mountains, valleys, fjords).

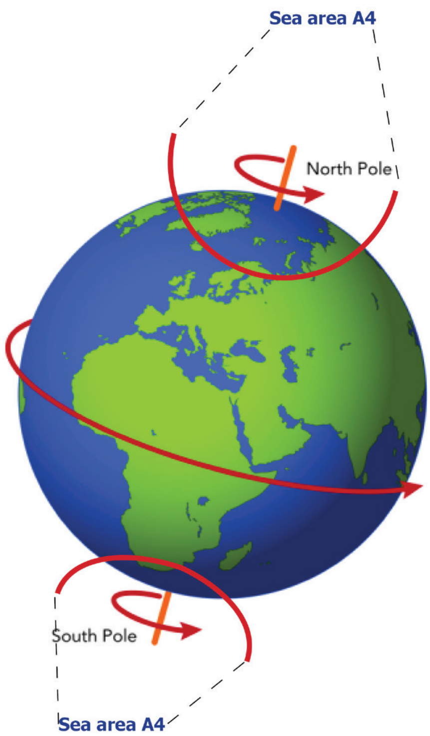

Figure 1: Sea area A4 coverage

A more detailed view of Sea Area A4 is seen in Figure 2, where the Sea Area A4 is displayed with a red circle, so we can locate the sea and offshore area which is not covered by geostationary satellites.

Any equipment used for vessel tracking in these remote areas needs to be capable of sending and receiving a signal from satellites in these remote areas.

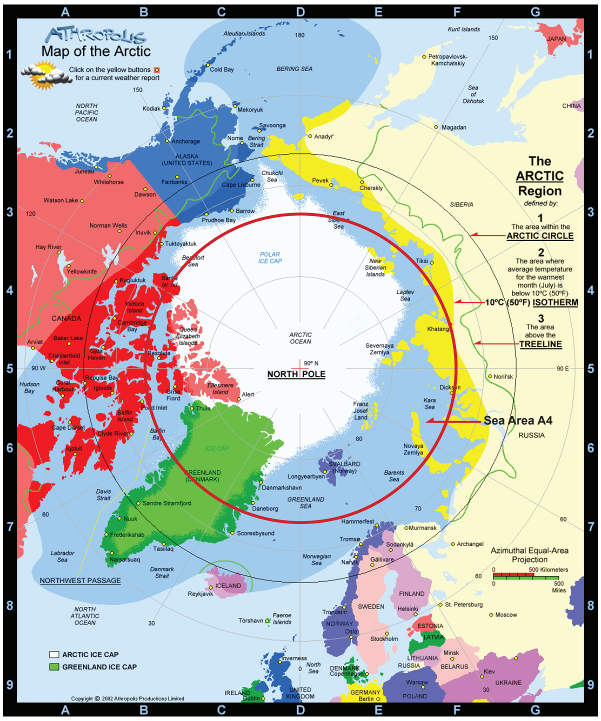

Figure 2: Arctic region
Source: http://www.athropolis.com/map2.htm

1.2. Temperature grades

Electronic devices are manufactured in different temperatures grades. The broadly accepted grades are commercial, industrial and military. These grades ensure that a device is suitable for its application and that it will withstand the environmental conditions in which it is used. The electronic components which make up the device also have particular temperature thresholds to which they work. For most electronic devices the temperature range is between 0°C and 70°C. Industrial temperature grade for devices are between -40°C to 85°C and military which is -50°C to 125°C.

1.3. Humidity and air pressure interferences

Excessive humidity can also exaggerate the effect of extreme temperatures on electronic components; short circuits can be created when humidity create condensation, which can affect or even damage electronic components. So any housing must be adequately constructed to prevent these external weather influences. However, this presents another problem as devices with a firmly closed housing face changes to the internal pressure of the device. When a device is cooled way below 0°C and after that get warmer, the device experiences pressure changes which can seriously damage the device.

If a device is sealed too tightly, then over time cracks can appear due to pressure changes from the high-low pressure cycle. So a device must be equiped with a system, specifically the housing of the device, that can not only equalize the outer and inner pressure but also needs to prevent moisture from entering the device.

1.4. Material expansion related to temperature

If a device is left powerless in polar regions for any reason, the circuit board and other electronic components get too cold and can be damaged upon reboot. When electricity flows through a circuit, the circuit is heated and that assures that the device is operating normally. If the power is cut off, a circuit will cool down to surrounding temperature which in polar areas it can as low as -50°C. When power is restored, and electricity passes through the circuit it then heats up the circuit and causes the material such as copper to expand. The rapid expansions of metal when close to other material (e.g. pertinax) which remain the same size, will distort it and bend or break parts of the components.

As temperatures decrease, changes can also occur in the resistance and capacitance of the elements resulting in timing changes on integrated circuits, waveform changes, and other electrical properties, so, therefore, electronic components can operate with some disturbance.

1.5. Freeze-out

The lower temperature limit is typically determined by the ionization energy of the dopants. Dopants usually require some energy to ionize and produce carriers in the semiconductor. This energy is usually thermal, and if the temperature is too low, the dopants will not be sufficiently ionized so there will be insufficient carriers. The result is a condition called "freeze-out." (Source: http://www.extremetemperatureelectronics.com/tutorial3.html).

1.6. Overheating

Another temperature challenge that electronic devices face is due to overheating of the electrical components. The electronic components need to operate at a specific temperature for preventing the damage to sensitive parts of the circuitry. The term "sensitivity of the components" explains that even a small fluctuation in device voltage is dangerous. Excessive heat in wires increase the electrical resistance of copper and other metals, therefore decreasing the current in the circuit board and the byproduct of this is overheating of the elements and fluctuations in power supply which can create signal interference.

1.7. Wind Chill

When a device is mounted outside exposed to weather conditions, the wind is one of many weather factors that has an impact on the electronic device. In low-temperature areas, the effect that the wind has on objects is called wind chill. When the wind blows across the surface of an object, it draws heat away from it. When the wind picks up speed, it draws more heat away, so if the object is directly exposed to the wind it cools more quickly than it would on a still day. The surface will cool down to exact temperature that is measured in a non-windy area but the time period of surface cooling is significantly faster. In Figure 3 we see object surface temperatures (the apparent temperature) which depend on the outside temperatures and wind speed. The purpose of the graph in Figure 3 is that the reader gets a sense of how wind speed in low temperatures affects the surface of the object. If outside temperatures are for example

-20°C and the wind is blowing at 20mph the heat on the surface of the object is drawn away as it would be -45°C.

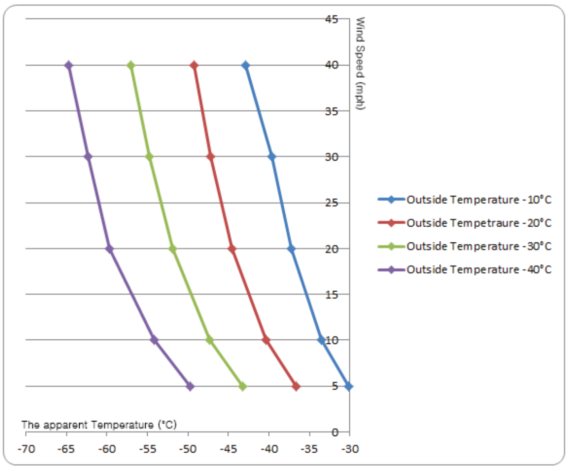

Figure 3: Effect of wind chill on an objects surface

1.8. Power dissipation

Normal operating temperature ranges are affected by several factors, such as the power dissipation of the device. Power dissipation is the process in which an electric or electronic device produces heat as an unwanted byproduct of its primary action. If the average power dissipated is more than resistor can safely dissipate, the resistor may depart from its nominal resistance and may be damaged by overheating.

Excessive power dissipation may raise the temperature of the resistor to a point where it burns out, which could cause a fire in adjacent components and materials. Also as discussed before, if the temperature is lower than the devices' range, freeze-out can occur.

2 BlueTraker Response

2.1. Use of Iridium Satellite Constellation

It's clear that full satellite communication coverage is required to cover all sea areas. Currently, there is only one satellite commercial solution on the market that can deliver that: the Iridium satellite network. Full global coverage is achieved with a constellation of 66 active satellites traveling in low earth orbit that has 6 orbital planes spaced 30 degrees apart as presented in Figure 4, with 11 satellites in each plane. EMA hardware uses the latest technology available on the market and we united that technology in a product that can cope with all challenges that are set upon it.

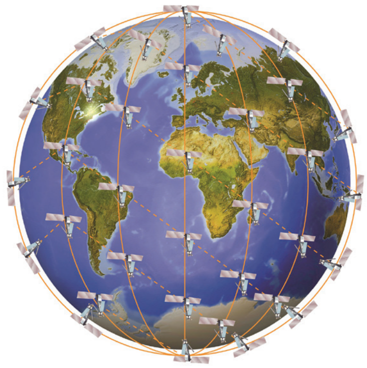

Figure 4: Iridium satellite constellation.

2.2. Embedded heater

BlueTraker Arctic devices can cope with extremely low temperatures because of the unique heat element that is built into the device. This element continuously provides sufficient heat so that the device can operate without disturbance due to weather conditions.
Inbuild regulation control measures the temperature and and keeps the inner temperature is kept at a safe operating range for normal operation of the electronic components. For the embedded heater to be operational and provide enough heat to the device, it needs constant 24 V power supply.

2.3. Equalizing valve with Teflon foil

Devices need a way to equalize the pressure while at the same time prevent humidity entering inside the device. BlueTraker engineers came up with an ideal solution using a Teflon foil to prevent the ingress of moisture and to equalize the pressure.

In Figure 5 you can see pressure release valve used inside every BlueTraker terminal.

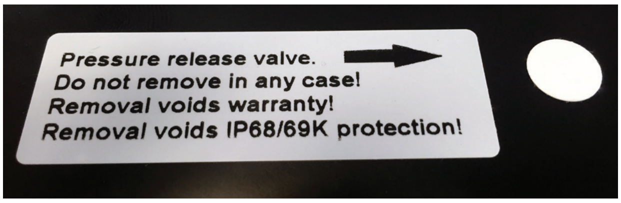

Figure 5: Pressure release valve

During the assembly process humidity will enter the device which can cause issues as previously mentioned.

When assembling BlueTraker devices, silica gel (see Figure 6) is inserted into the device. It absorbs any moisture which is inside the device and could later present operating problems.

Figure 6: Silica gels

2.4. Double shell housing

One of the solutions for BlueTraker devices smooth operating lies in the double shell housing which all BlueTraker devices are constructed with. The unique double-shell housing with a ventilated layer between (see Figure 8) is one of the solutions to the challenge imposed by different weather conditions. Two shells give the device added protection against low and high temperatures and wind chill in low temperatures.
The color of the housing used for BlueTraker devices visible in Figure 7 is also important because the white area reflects UV radiation. If an object is darker, the object temperature rises when hit by sunlight but if the object is whiter, the device temperature is not significantly increased because the white surface does not absorb as much sunlight.

Figure 7: White outer shell reflects UV radiation

2.5. Ventilating gap

The gap between the two housings acts like a thermal bridge which works as a vent when there are excessively high temperatures (when exposed to heat caused by sunlight). It also preserves the heat when a device is starting up after shut down (e.g. cold start) and when internal heating is enabled (if temperatures drop down to -20°C). The outer shell prevents fast moving cold wind from hitting the inner shell housing, thus eliminating any wind chill factor. The result is that the BlueTraker is not affected by external weather related factors.

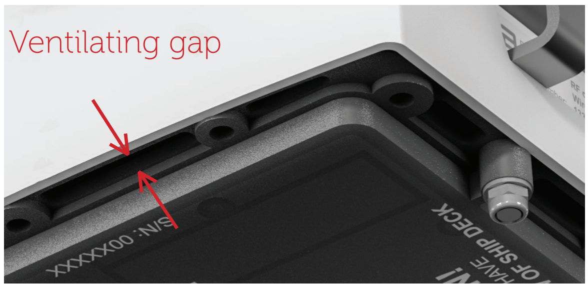

Figure 8: Ventilating gap on BlueTraker terminal

2.6. IP68 dust and water protection

BlueTraker devices unique housing is rated to IP68. Devices with IP68 are completely protected from dust ingress and also protected from water ingress during long-term immersion up to a specified pressure (in the case of BlueTraker a depth of 2m). The housing has also been approved and certified by GL Type Approval System.

2.7. Block diagram

We have presented the solution and described the different conditions that BlueTraker terminal devices can withstand, now we would like to share the engineering solution invented by EMA.

Figure 9 is a block diagram where different blocks contain different electronic elements which form the solution.

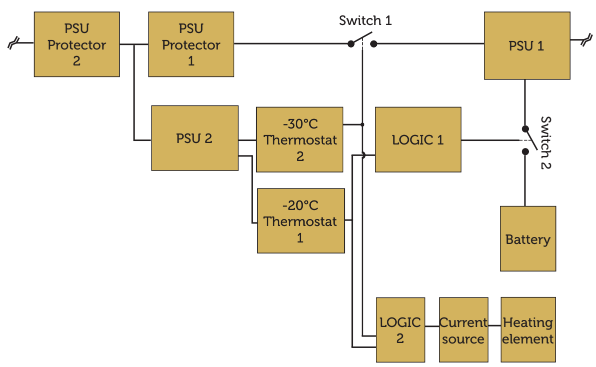

Figure 9: BlueTraker block diagram for low temperature operation ability

Circuit protectors

In the block diagram, there is PSU 1 and PSU 2 which are primary the source units and they power up different parts of the device. PSU protector 1 and 2 are used to protect the device. PSU protectors prevent polarity change when connecting the device. The PSU also contains ESD (electrostatic discharge circuit protection) and other features. The current source provides enough power for the heater to produce a sufficient amount of heat for the device in case of a cold start and for further normal operation in low temperature.

Battery charging and discharging protection

The circuit contains two thermostats (1 and 2). Thermostat 1 is designed to operate the conditions for LOGIC 1. It sets the conditions when the battery can be charged or discharged by controling switch 2.

To prolong the battery life, the circuit protect the battery with the conditions when the battery can be charged. For battery safety, the charging limits are set to allow charging from 0°C to 45°C. Limits for discharging the battery are set to allow the battery to be discharged from -20°C to 60°C (see Figure 10). It also provide the condition for LOGIC 2 which enables the heating element in the case of cold start and disable it when the temperature inside the device rises above -20°C.

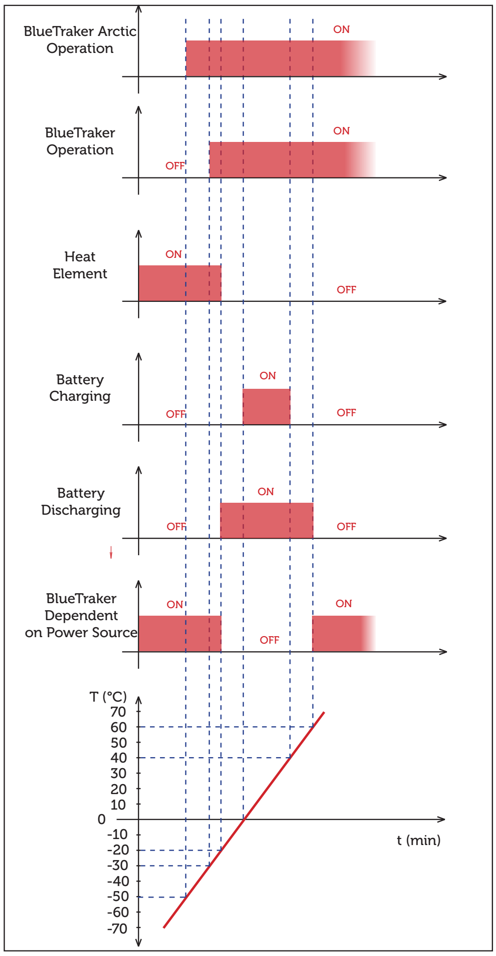

Figure 10: Block operation independence of temperature fluctuations

Regulating heating element

Thermostat 2 is used to set the conditions for LOGIC 2 and it turns on and off the heating element if the temperature drops below -20°C. Switch 1 is controlled by thermostat 2 and its function is to turn PSU on and off. Figure 10 shows the operation of different functions as an interdependence of temperature fluctuations.

Extreme cold power-up

If for some reason a device is left without power in the area where the temperature are extremely low (e.g. -50°C), the heater stops working and the device cools down to outside temperature. When the power supply is turned on again the cold start function is enabled and the heat element inside the device start to heat up the electronic components (see Figure 10). The heater provides enough heat for device to reboot itself in 20-30 min after power outage and therefore tracking and monitoring can be established in just 30 min.

3 Demand of tracking per Industry in Sea Area A4

3.1. Ship security system

For cargo ships, there is a very real possibility of an attack by pirates and other threats as they navigate around the globe. Ship Security Alert System (SSAS) was developed, so navigation is safer for the ship's crew and cargo.

SSAS is an IMO regulated requirement. In the case of attempted piracy or terrorism or in need for help, a ship's SSAS beacon can be activated and an appropriate response can be initiated. The BlueTraker SSAS device is available in two versions (regular and arctic version), they differ by their relative capability of temperature resistance. A regular BlueTraker SSAS Terminal can withstand temperatures down to -40°C and BlueTraker SSAS Arctic (see Figure 11) can cope with temperatures down to -50°C, so it all depends where your vessel is likely to travel.

Each terminal has two or more alert buttons which are located in safe zones on board and in the case of an emergency situation one or both can be pressed to sound the alarm to an appropriate rescue service. In instances where there is a power supply failure the device will still operate for approximately 72 hours so an SOS message can be sent even if the ships power supply is cut off.

Figure 11: BlueTraker SSAS Arctic

3.2. Commercial vessel tracking

Long range identification and tracking (LRIT) was established as an international system on 19 May 2006 by the International Maritime Organization (IMO) for tracking positions of all passenger ships including high-speed craft, cargo ships including high-speed craft and vessels of 300 gross tonnage and above to their flag administration at least four times a day.

There are two version of LRIT and one is BlueTraker LRIT other is BlueTraker LRIT Arctic version seen in Figure 12. The main differences between them are their operating temperatures. Regular version operates down to -40°C and Arctic version operates down to -50°C which is ideal for devices mounted on ships that are set to traverse treacherous Northwest or Northeast passages.

Figure 12: BlueTraker LRIT Arctic

3.3. VMS for Fisheries

If a fishing vessel ventures into Arctic waters, for example, to fish for the northern shrimp (commercially exploited shrimp species in Atlantic Canadian waters) they use a demersal otter trawl. Ships equipped with fishing equipment as mentioned need to have VMS (vessel monitoring system) solution established on board. In winter time, temperatures can go way below zero so therefore operation of electronic equipment is not 100%.

As described before with LRIT and SSAS, EMA offers a solution for fisheries called VMS and in addition, we offer BlueTraker VMS Arctic (see Figure 13) that is capable of operating in extreme conditions with a regular version of BlueTraker VMS available. BlueTraker VMS Arctic, LRIT Arctic, and SSAS Arctic are the only devices on the market suitable to work and survive temperatures down to -50°C and in addition, if the power supply is cut off, the devices can cold start.

Figure 13: BlueTraker VMS Arctic

4 Conclusion

For an electronic device to operate in such extreme weather conditions such as in Polar regions and Sea Area A4, numerous challenges had to be overcome. In addition to the design challenges of making a device capable of surviving these difficulties, it was also necessary to obtain the necessary certification to prove that the devices are capable working under previously mentioned conditions.

BlueTraker is the worlds only device that is designed and fully tested for purpose of vessel tracking in all weather conditions, meaning they are the ideal choice for ships that travel through remote areas and 100% reliability is required.

About EMA

EMA, headquartered in Slovenia/EU, is a leading maritime tracking and traceability specialized company with 25 years of history. Its mission is to develop, manufacture and market a range of intelligent, remotely operable machine-to-machine equipment and systems.

BlueTraker® solutions are applicable to a broad range of industries, mainly using satellite communications technology to monitor remote stationary or moving objects.

EMA provides turnkey solutions to end customers, technology providers, product providers and system integrators on maritime markets worldwide.

For more information, visit www.bluetraker.com or contact us at sales@bluetraker.com.