A NEW APPROACH TO RIVER NAVIGATION IN ICE CONDITIONS

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Abstract: *Ice navigation represents a difficult challenge for every Navigation Officer, irrespective of their training level. However, it is possible for ships with strengthen structure in capable hands to navigate successfully through ice-covered waters.*

One of the problems concerning sailing in such areas is the detection of ice hazards early enough to avoid a collision. Although a rigorous watch keeping will help the ship to pass by large ice floes, there is still a need for the close-range detection of small icebergs and ice packs. A solution for this issue can be an enhanced ice detection radar.

This paper presents some ship handling techniques in ice, the advantages of the improved radar and the benefits of an eventual implementation aboard ships navigating on rivers.
Keywords: *ice navigation, river, radar, detection, high-speed scanner, ice jam*

1. INTRODUCTION

Winter conditions met on rivers can bring various problems for mariners having little or no experience in such circumstances. Ice navigation calls for special knowledge and precautions for every ship types. Now vessels frequently cross river areas usually closed to normal navigation during winter months.

Improved icebreaker assistance and ice observation are factors that have reduced the risk of ice damage, provided that the master acts in accordance with sound operating practice in relation to: speed in ice conditions; maneuvring; ice escort procedures; ice type reports and following recommended ice navigation routes [6].

One issue related to navigation in icy waters is that conventional marine radars cannot detect efficiently floes of ice or dangerous glacial ice at such distance that the vessels could avoid collision, especially in heavy sea conditions where these may be lost in the 'sea clutter'. Radar or visual detection can be as little as half a mile from the ship or less.

Hull damage may occur due to collision with ice, even for ice strengthened vessels. Also, fuel consumption increases for vessels transiting heavy ice conditions, therefore avoiding these areas is more efficient.

In 2004, the Climate Change Technology and Innovation Initiative (CCTII) developed a marine radar that could detect dangerous ice earlier and more accurately than a conventional radar and tested it aboard icebreaker vessels [3].

This enhanced radar integrates various advanced radar technologies developed over the years, such as:

- a modular radar interface (MRI) that captures improved radar images for advanced processing and display;
- a high-speed scanner which rotates at 120 rpm, to increase the chance of small targets detection in heavy seas;
- a cross-polarized system, which transmits radar pulses horizontally and receives them vertically and horizontally [4].

2. SHIP HANDLING TECHNIQUES IN ICE

In winter season a river channel can easily be blocked if the ice on each side of it, is drifted from the banks to which it is attached, either through natural causes or by the waves of passing ships. When the ice does break away, it is very probable to do it in layers that cross the channel and form an ice jam .

In this case, it is very important that the jam be broken and the channel restored to navigating purposes. This can only be done by attacking the jam from downstream, so that ice pieces may be carried away by the current. However, this procedure, which is the only way to clear a channel, can restore vessel traffic [6].

Time has shown that non-icestrengthened ships with a speed of about 12 knots can become trapped in relatively light ice conditions, whereas icestrengthened ships with proper power should be able to make progress through first-year ice .

The first rule of ice navigation is to avoid stopping or becoming trapped in the ice. In many cases a longer route around an ice surface whose limits are known proved to be the fastest and safest way to destination.

- **Before entering the ice**

For a non-icestrengthened ship, it is recommended to take other routes and go around the ice area even if the voyage is considerably longer.

The following requirements must be accomplished before a vessel enters an ice field:

- the speed must be reduced to a minimum to receive the initial impact of the ice;
- the point of entering the ice must be of low concentration and the entrance angle to the edge of the ice pack should be chosen wisely;
- the engine room personnel should be aware at any time that engine maneuvers will be frequent as speed is constantly adjusted [1].

- **Entering the ice**

The following notes on ship-handling in ice have proven helpful:

- enter the ice at low speed to keep the initial impact reduced; once into the pack, increase speed gradually to maintain ship's heading, but not over the point at which the hull might suffer ice damage;
- engines must be prepared to go 'Full Astern' at any time;
- navigation in ice areas after sunset is not recommended without good searchlights easily controlled from the bridge;
- propellers and rudders of every ship must be protected from ice; ships going astern in ice must proceed with extreme care [1].

- **After entering the ice**

Once the ice is entered, speed of the vessel must be increased slowly, depending on the ice conditions and the ship's hull strength. If visibility decreases, speed should be reduced until the vessel can be stopped safely, if necessary. When stationary, the ship's propeller(s) must rotate at low speed to prevent ice from building up around the stern.

When navigating in ice, the following recommendation should be applied:

- ships should follow open water areas and lighter ice zones even if it involves large swerves from the route;

- in restricted visibility, speed must not exceed safety limit when in open areas within an ice field, or when navigating in open pack conditions [1].

- **Turning in ice**

Course changing occurs often in ice navigation. When possible, these changes must be carried out in open water or light ice conditions, because turning in ice requires more engine power. When turning, the ship breaks ice with its side rather with its bow, therefore the maneuver should start early and as wide as possible.

Ships equipped with twin propellers should use them to assist in the turn. In harsh ice conditions, a ship can maneuver better by applying full power and leaving the rudder at center. This allows her to find the least resistance without any drag from the rudder in trying to maintain a straight course by steering [1].

3. ICE HAZARD RADAR SYSTEM

Radars can be very helping tools in ice navigation during periods of restricted visibility, but only if the display is correctly interpreted.

Smooth ice, like sea surface, returns little or no echo, but small floes of rough ice capable of inflicting damage to a ship can be detected at a range of about 2 to 4 miles. Experience in interpretation is obtained through comparing various radar shadows with real observations.

Combining a high-speed marine radar with advanced digital processing there can be obtained high resolution images. Therefore, the user can identify hazardous ice features which are nearly impossible to see with a conventional radar.

The Ice Hazard Radar was installed in the navigation console of a T1200 Class Medium Arctic icebreaker and consists of a monitor, a computer, the ’*sigma S6*’ MRI and a radar software produced by Rutter Technologies Inc. (Figure 1). The radar display was connected to the ship’s BridgeMaster II X – band radar in slave mode [4].

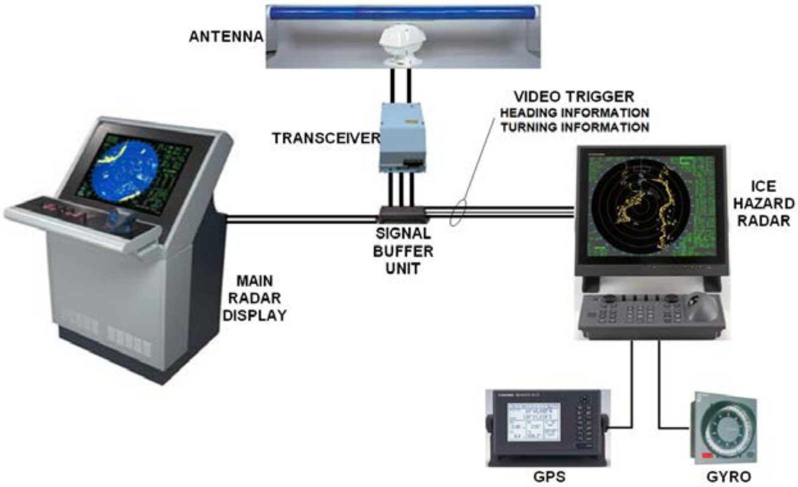

Figure 1. Ice Hazard Radar configuration

The signal from the conventional radar is processed by the ’*sigma S6*’and displayed as a 1024 by 1024 pixels digital image. Figure 2 represents a comparison between a photo of the BridgeMaster II X – band radar and the image taken from Ice Hazard. With the ice radar, the coastline is more clearly defined; icebergs, bergy bits and growlers are visible at greater distances.

While large icebergs may be detected initially at ranges of 15 to 20 miles in a calm sea, the strengths of echoes returned from icebergs are only about 1/60 of the strengths of echoes which would be returned from a steel ship of equivalent size. Generally, icebergs will be detected at ranges not less than 3 miles because of the irregularities in the sloping faces.

Bergy bits, extending at most about 4 meters above the sea surface, usually cannot be detected by radar at ranges greater than 3 miles. Because their echoes are generally weak and may be lost in sea clutter, bergy bits can impose considerable hazard to ships.

Growlers, extending at most about 2 meters above the sea surface, are extremely poor radar targets. Being smooth and round because of wave action, as well as small, growlers are recognized as the most dangerous type of ice that can be encountered. In a rough sea and with sea clutter extending beyond 1 mile, growlers, large enough to cause damage to a ship, may not be detected by radar. In a calm sea growlers are not likely to be detected at a range exceeding 2 miles [2].

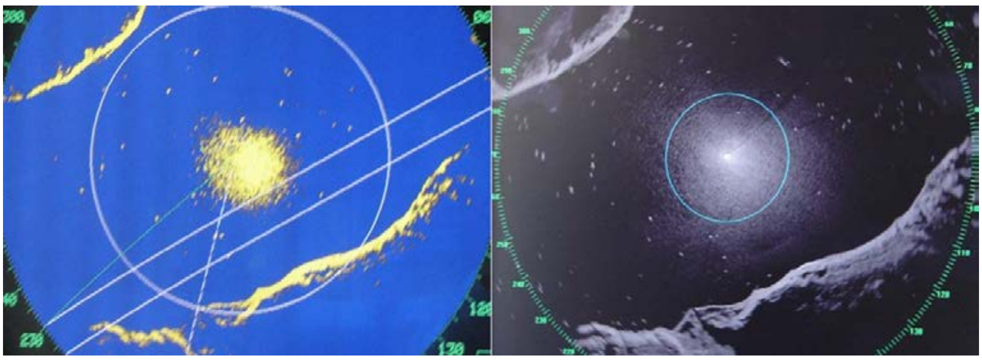

Figure 2. Comparison between a standard X – band radar image and Ice Hazard Radar image of Thule Harbour, Greenland [1]

Marine radars were developed with a typical scanner rotating at 25 to 30 rpm and used for detecting other ships, coastlines and hazards. Small floes of ice and fragments of icebergs may not be detected by these radars in the sea clutter. Combining a higher speed radar with a digital radar processor the probability of the detection of such targets is increased.

The high-speed radar scanner improved the detection range, being able to ’*see*’ large targets such as vessels and icebergs. Rotating with speed of 120 rpm, the scanner detected bergy bits and growlers at more than three nautical miles.

After two years of using the system, it was clearly evident that the Ice Hazard Radar had become an integrated system for the bridge navigation team operated with ease and confidence [5].

4. CONCLUSIONS

Navigating through ice can be very demanding for mariners, especially when the lack of experience is present. Ice floes can become great hazards to ships if not avoided. Although detecting them is crucial to the safety of navigation, it is also important to know how to maneuver the ship in ice areas.

The effectiveness of marine radar systems varies with power and wavelength. The normal radar settings will be different for ice navigation than for open water. In general, powerful radars are preferred because those with 50 kW output provide a better ice detection than 25 kW radars. Similarly, X – band radars provide better ice detail while S – band radars show the presence of ice and its ridge at a greater distance. Therefore, it is recommended that both wavelengths be used.

The Ice Hazard Radar ensures highly detailed images of sea ice in the close area of the vessel, enabling it to manoeuvre around difficult area, thus minimizing the potential of ice damage.

The high-speed scanner of the Ice Hazard Radar system can detect small ice objects in various sea states at greater ranges than usual radars or visual detection.

The following area charts (Figure 3 and 4) indicate the distance visible on the standard and enhanced radars, in winds of 10 to 15 knots.

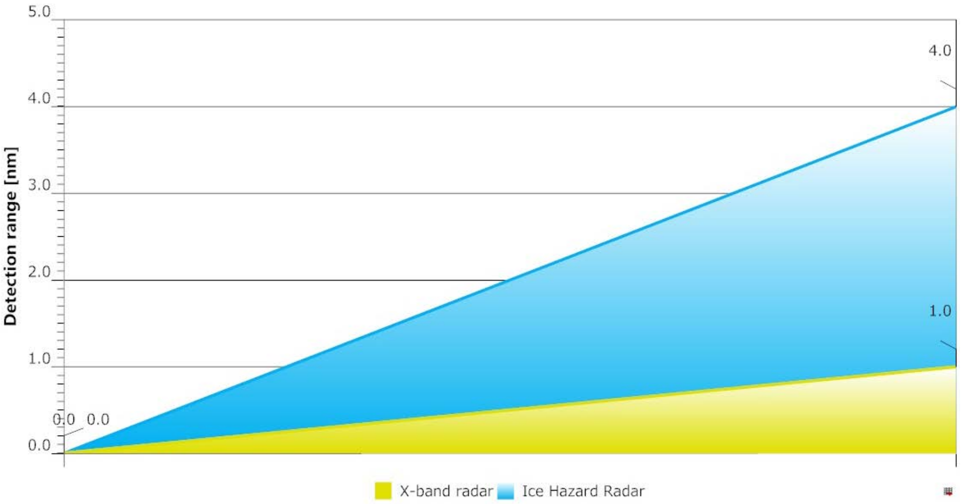

Figure 3. Detection range increase for bergy bits

Bergy bits, extending from 1 to 5 meters above the sea surface, were detected by conventional radar at ranges between 0.5 and 1 nautical mile. With the enhanced radar, they were visible from more than 4 nautical miles, increasing the detection range four times.

The visual sighting of bergy bits is influenced by visibility and surrounding conditions of sea state or smooth sea ice. The difference between bergy bits and an open water area or a smooth first-year ice cover can be seen relatively easy with radar, if the height of the bergy bit is sufficient for its return to be differentiate from the ice or water returns. The radar display should be checked carefully for radar echoes which may identify bergy bits with less height differential, or when the ice or water background is more cluttered.

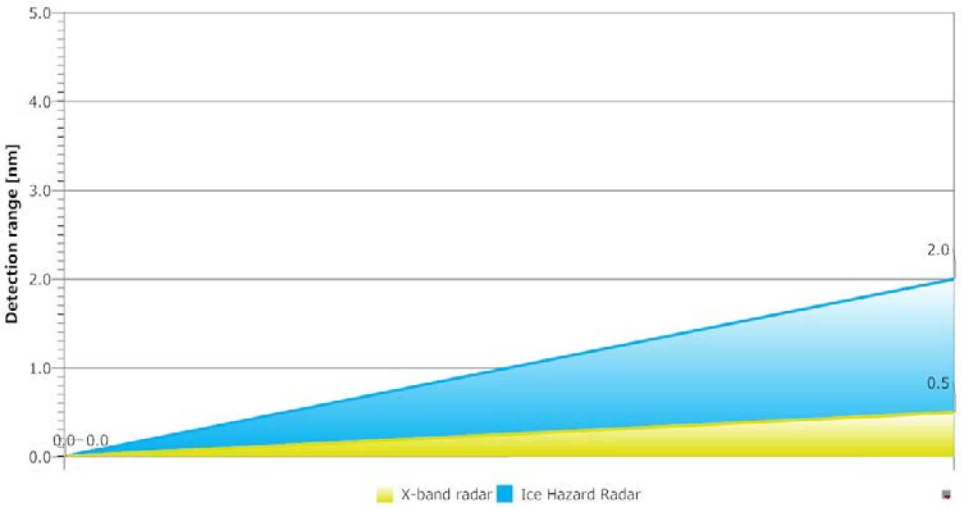

Figure 4. Detection range increase for growlers

The size (height above sea level) of the growlers is merely 1 meter. Therefore, the BridgeMaster X – band radar could not detect them further than 0.5 nautical miles, while the Ice Hazard Radar increased detection range four times at 2 nautical miles. This distance allows ships to maneuver early enough to avoid collision with such hazards.

An eventual implementation aboard ships navigating on rivers of such enhanced radar might have some advantages, such as:

- early detection of ice floes;
- reduced risk of trapped ships in ice;
- better localization of ice jams for icebreakers attacks.

The trials made between 2006 and 2008 demonstrated the performance and robustness of the software and hardware in actual operating environments. This technology proved to be a significant improvement over the conventional marine radar.

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