

The Modes of Radar Presentation of Situation in Inland Navigation

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ABSTRACT: The use of an Analogical Simulator in shiphandling-manoevr tests (SIAMA) in waterways constitutes a useful tool for providing improvements in port design and manoeuvring rules, which, when enhanced with other relevant hydraulic studies of Froude scale models, is a source of valuable statistical information. The time-scale of physical models fast-time runs comply with the square root of the linear scale, in this study-case the model time was 13.04 times faster than prototype. More than 1500 official tests having been undertaken since 1993 by 13 official pilots of three harbours, for manoeuvring and project optimization in 7 piers, with 10 berths, and radio-controlled ore carriers of 75,000, 152,000, 276,000, 365,000, 400,000 and 615,000 dwt. The laboratory facilities belong to the Escola Politécnica of Sao Paulo University, Brazil. The port area studied comprised fairways, turning basins and berths. The ships and tugs were unmanned, with tug performance exerted by air fans.

1 INTRODUCTION

The main goal of navigation is to handle the ship in accordance with aim of their movement when required parameters of this process should be retained. The inland shipping requires the proper knowledge of navigators and adequate of navigation bridge equipment. The process of ships movement in water area should be safely. Its estimation is executed by means of notions of safety navigation. It may be qualified (Galor W. 2009) as set of states of technical, organizational, operating and exploitation conditions and set of recommendations, rules and procedures, which when used and during leaderships of ship navigation minimize possibility of events, whose consequence may be loss of life or health, material losses in consequence of damages, or losses of ship, load, port structures or pollution of environment. Very often, the sea-river ships move on waterways (natural and artificial) inside of land for hundreds kilometres. The manoeuvring of ships on each water area is connected with the risk of accident, which is unwanted event in results of this can appear the losses. There is mainly caused by unwitting contact of ship's hull with other objects being on this water area. The safety of ship's movement can be identified as admissible risk, which in turn can be determined as combination of probability of accident and acceptable losses level (Galor w. 2009).

As a result, a navigational accident may occur as an unwanted event, ending in negative outcome, such as:

- loss of human life or health,
- loss or damage of the ship and cargo,
- environment pollution,
- damage of port's structure;
- loss of potential profits due to the port blockage or its parts,
- cost of salvage operation,
- other losses.

The inland waterways are restricted areas those where ship motion is limited by area and ships traffic parameters. Restricted areas can be said to have the following features:

- restriction of at least one of the three dimensions characterizing the distance from the ship to other objects (depth, width and length of the area),
- restricted ship manoeuvring,
- the ship has no choice of a waterway,
- necessity of complying with safety regulations set for local conditions and other regulations.

The floating craft (ship) during process of navigation has to implement the following safety shipping conditions:

- keeping the under keel clearance
- keeping the safety distance to navigational obstruction
- avoid of collision with other floating craft.

Thus the navigation on such waterways is different than on approaching waterways and coastal water areas. The realization of navigation on limited water areas is consisted on:

- planning of safety manoeuvre,
- ship's positioning with required accuracy on given area,
- steering of craft to obtain the safety planned of manoeuvre.

The leading of safely navigation requires first of all the high accuracy ship's positioning to avoid the contact with other ships and fixed objects. It can be natural objects (coast, water bottom) and artificial (water port structures-locks, bridges etc.) obstructers. Such kind of shipping is called as pilot's navigation. It necessitate the proper. The main elements of Integrated Bridge System are navigational systems-satellite, radar, electronic charts ECS/ECDIS. Navigation Integrated Bridge contains the devices of sips positioning (radio navigation systems including satellite) and presentation of situation (electronic charts system ECDIS, radar/ARPA) (Opracowanie...2009). A vessel's position in a restricted area should be considered as the position of its entire waterline area in the waterway. If the position of a manoeuvring ship is not known with required accuracy, there is a risk of navigational accident.

The distance between the hull and another object depends on the dimensions of required manoeuvring area within the waterway. For fairways the manoeuvring area is considered to be the width of vessel's swept path:

The navigational component of swept path width depends on:

- position determination accuracy,
- position determination frequency,
- methods of converting a position into the waterway coordinates.

The manoeuvring component depends on a number of factors. One of them is the time of the navigator's, i.e. pilot's or captain's response to observed movement off the fairway centre line, its analysis and giving a relevant command. The response time is affected by the same factors as those affecting the navigational component (mentioned above). The swept path reserve allows for hydrodynamic phenomena of bank effect or another object on vessel hull (mainly suction forces).

In the case of a system of continuous position determination, position determination accuracy is the basic element affecting the swept path width. That is why it is important to ensure that position determination is performed with appropriate (possibly highest) accuracy.

2 THE MODES OF RADAR PRESENTATION OF SITUATION

The radar is one of the basic devices which facilitate safe navigation in various conditions – both reduced and good visibility. The radar as a technical device significantly helps conducting a vessel by presenting a proper image of a situation around the vessel. The use of radio waves for presenting imaging objects enables a display of a situation that would be particularly difficult in poor visibility (fog, precipitation, night). In this way the radar facilitates steering a vessel in conditions in which human observation is much hampered, if not impossible (Fedorowski J. & Galor W. & Hajduk J. 1998). Nevertheless, radar observation also has some limitations resulting from the manner radar operates.

The use of radar for navigation can be said to have two basic goals:

- avoidance of collisions with stationary objects (natural objects such as the shore or bottom, and artificial objects such as port or other structures),
- avoidance of collisions with other vessels.

In both cases the operation of the radar can be divided into the following stages:

- detection of an object that results in a graphic presentation on the radar screen,
- object identification on the radar screen by the navigator,
- measurement of the detected and identified object (its position, movement parameters etc.).

The basic information for the navigator is presented on the display screen (Galor W. & Galor A. 2008). Presently, the display commonly used on board sea-going ships and other sailing craft is the type P display (called panoramic display). The display, showing a radio-located chart which illustrates the area surrounding the vessel, makes it possible to read out the range and direction (heading or bearing). Target echoes are displayed as spots displayed on the radar screen. Due to easy transformation of the polar coordinate system of the display into the Cartesian coordinate system of marine charts plus 'bird's eye view' imaging, the image interpretation is generally simple, except for a few particular situations. In spite of all the advantages of the panoramic display that make its use quite common, it should be noted that there are a number of shortcomings that limit substantially its range of applications. These are situations where navigation takes place in restricted areas, mainly rivers and channels or canals. When the range scale of observation is the same for the entire displayed area around the vessel, it often happens that the useless part of the screen (land beyond the shoreline) makes up 70% or more of the observed screen. Taking into account the width of a restricted area, the screen diameter (width) and the

minimum operating range scale, it may turn out that using radar in such a situation is much more difficult.

The faults of that panoramic display may be largely eliminated by the method that presents the situation around the vessel as perspective display also known as type B (U.S. Radar...2006) perspective called sometimes also cineramic presentation (Brożyna J. 1984).

3 PANORAMIC PRESENTATION

Modern shipboard radars use mainly type P panoramic displays (PPI-Plan Position Indicator) for imaging information on the position of detected targets. Imaging on such a display resembles a chart and is 'drawn' in the polar coordinate system. Figure 1 presents a real image seen on the radar screen with the type P display recorded during a voyage of a vessel on the River Odra (Poland).

Each detected target is presented in position depended on its real distance (D) and bearing (NR). Formerly the radial –scan cathode tube ray was used. Than the co-ordinates of target position on screen were defined by distance and angle. Presently radars used screen where the picture is projected in raster –scan method. It means that position of targets is positioned in orthogonal co-ordinates XY . Thus the target dates achieved from radar sensor is transformed to these systems. The position of target A has a linear co-ordinate:

$$X_A = D \cdot \sin NR \quad (1)$$

$$Y_A = D \cdot \cos NR \quad (2)$$

where D = distance of target, NR =, bearing of target, X_A = linear horizontal co-ordinate, Y_A = linear vertical co-ordinate.

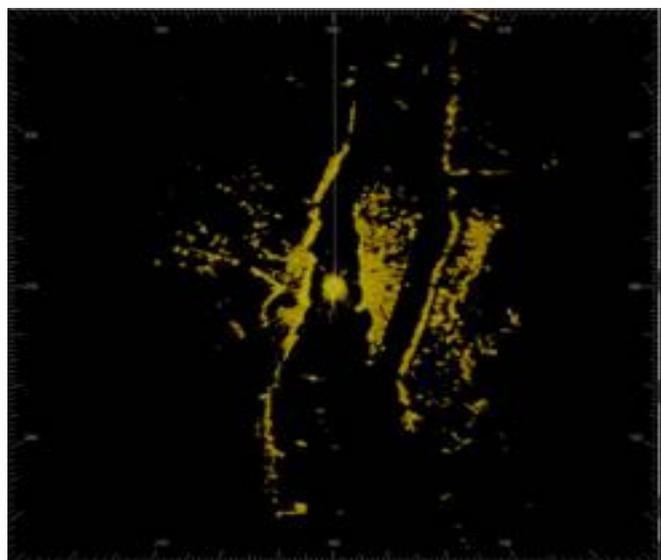


Figure 1. Real radar screen image with type P display

4 THE ASSESSMENT OF NAVIGATION BRIDGE OBSERVATION

In navigational practice there is often a need to compare a situation detected by the radar and displayed on the screen with a situation seen by the human eye. In this case the perceived image has geometry than that describing distance relation on a chart. How a picture observed by the human eye is created is shown on fig. 2 (Galor W. 2007), where A is an apparent plane of the image, while the observer's eye can be seen on the left side of the diagram. The object O located at the distance $A0$ (section a can be neglected here as very small in comparison to $A1$) will be displayed as the point O_1 . The farther objects lie, the closer to each other and to the point H their images are seen, where the point H represents a point lying far away on the horizon. Therefore, comparison of the results of the eye perspective observation with a radar display image in the polar coordinate system calls for the transformation of the coordinate system. Then further actions can be performed, such as the object identification. From the navigator this transformation requires the capability of abstract thinking, which not always is possible, and is always an extra burden for navigator's mind, already loaded with a variety of duties. Besides, there is a risk that such transformation will be incorrect. The importance of this problem gets even greater if we realize that in practice navigators often has no time to analyze a situation with a pencil in their hand; then they make an overall estimation taking advantage of their experience and knowledge; on this basis navigational decisions are made. It is important that this experience is connected with the situation assessment in the display explained in figure 2. These factors are often a cause of frequent wrong interpretations of radar images; this, in turn, has resulted in a fact that in spite of placing fully operational radars on board ships the number of collisions has not been reduced.

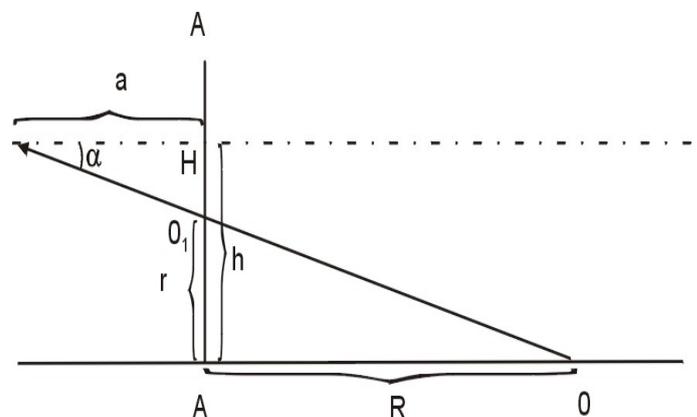


Figure 2. Visual assessment of a situation from the bridge.

5 PERSPECTIVE PRESENTATION

The perspective (called also as type B) shows radar information to the navigator with such geometry that he or she has been accustomed to since childhood as a regular observer, with a produced image similar to a TV or film picture. This imaging has a rectangular shape, where the horizontal axis is the bearing axis, while the vertical axis is the distance axis. Unlike a typical type P display used for other radiolocation purposes, the perspective display has a linear graduation on the horizontal axis, while on the vertical axis the graduation adequately intensifies towards the horizon Galor W. 2008). The target's co-ordinations (D, NR) are transformed on perspective presentation as:

$$X_A = D \cdot \sin NR \quad (3)$$

$$Y_A = D \quad (4)$$

In the panoramic display the range and direction have a rectangular representation. Such arrangement of the coordinates is often used in various areas in order to enhance distinguishing small angles, e.g. radar radiation characteristics at the horizontal cross-section. The method used for the presentation of a radar image allows to 'extending' the waterway, which will automatically reduce the useless part of the image on the screen. Figure 3 depicts a comparison of two screens with two different displays of types P and B. The examples show a situation for the bow sector covering -30^0 , $+30^0$ areas. Naturally, the sector can be changed within the $0 - 90^0$ range. The 'O' marks heading line, 'A, B, C' indicate the different wide canals. It is evident that perspective presentation gives better relation of water area to total surface of radar screen.

Figure 4 shows a image of the same situation converted from P presentation into the type B display.

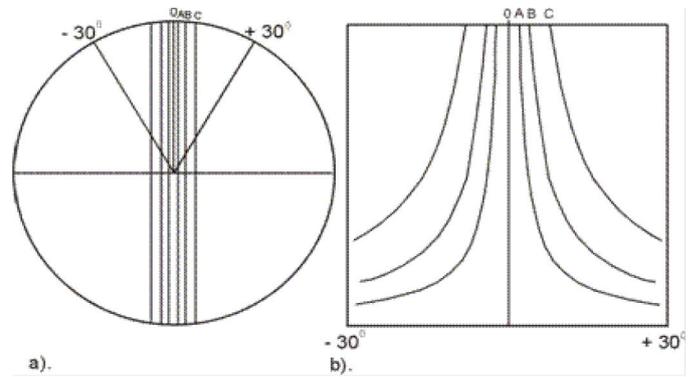


Figure 3. The radar screen: type P and B displays

The B display has much other beauty. One of them is easy and fast to detect of ships changing course from middle of the canal. In many cases the ships are going on axis of waterway. It is caused by hydraulic phenomena as suction by edge of canal (Projekt badawczy...2009). The B type display permits to fast positioning of ship in relation to the shore. Fig. 5 presents of such situation. The next beauty is fact, that the perspective presentation permits too much correction of angle's differentiation on the screen. It is correctly visible on fig.5 (right) for B display. The area near ship's position is stretched widely to P display. It highly permits for identification targets near the ship. Especially it respects the navigational marks (buoys, beacons), water structures (locks, bridges) and floating crafts (boats, yachts).

The above considerations on the method of presenting a situation of a vessel engaged in inland navigation justify the thesis that the method of vessel position determination (accuracy) and the mode of situation display are of major importance for navigators responsible for the process of navigation in inland waterways.

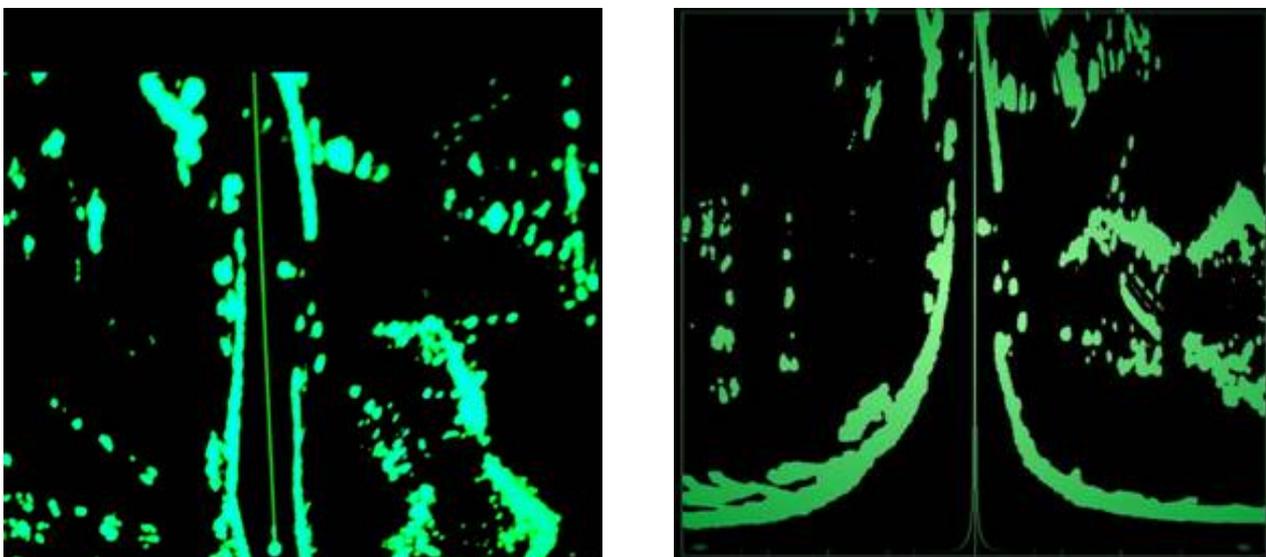


Figure 4. The real situation presented on screen radar - P (left) and B (right) displays

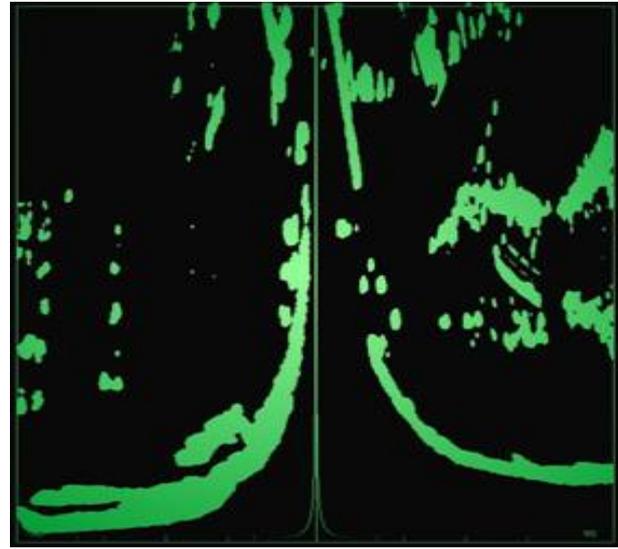
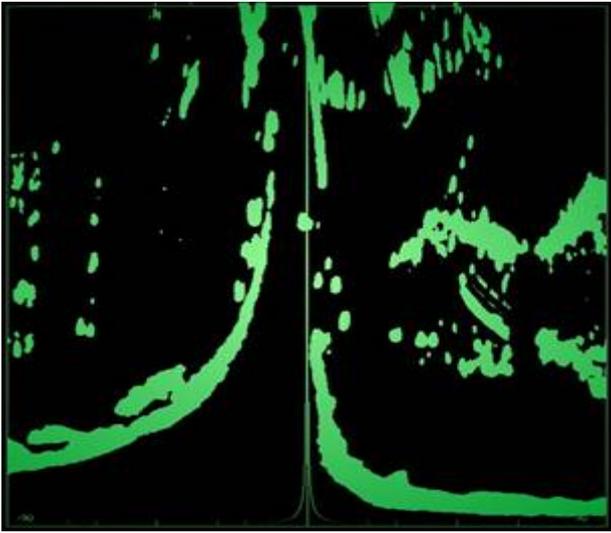


Figure 5. The presentation of ships course on right and left of axis waterway

6 SUMMMARY

The safety of navigation in restricted waters, particularly inland waterways, depends on the accuracy of determining the position of a vessel manoeuvring within such waters.

The radar is one of the devices for position determination. The most common mode of display showing the present situation on the screen is a panoramic display (bird's eye view) similar to that of a navigational chart.

This type of display does not fully satisfy navigators' requirements on fairways and rivers, because the water area perceived is small in relation to the surrounding land.

These shortcomings can be significantly reduced by applying a perspective display. Especially this kind of presentation of radar situation is useful in narrow water areas like canals, rivers in inland navigation.

The perspective presentation permits too much correction of angle's differentiation on the screen.

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