RADAR IMAGE OVERLAY IN ECDIS DISPLAY VERSUS ELECTRONIC NAVIGATIONAL CHART OVERLAY ON RADAR SCREEN

The paper presents radar image overlay in ECDIS (Electronic Chart Display and Information System) display and ENC (Electronic Navigational Chart) overlay on radar screen. The purpose of this paper is to assist in optimising the navigation operation and the information display. The introduction of AIS and ECDIS is changing maritime navigation drastically. In 2004 IMO adopted new revised performance standard for radar equipment. The value of radar information can be increased by correlation of radar target data and AIS target data to provide the mariner with all relevant information needed for collision avoidance and participation in traffic management systems and by correlation of radar target data and chart (ENC) data to provide the mariner with a second independent position fixing system which, in essence, is an effective position monitoring system, potentially an EPFS and ECDIS back-up.

Keywords: ECDIS, Electronic Charts, Maritime Radars.

INTRODUCTION

ECDIS is a real-time navigation system that integrates a variety of chart and navigation-related information. More than simply a replacement for a paper nautical chart, ECDIS is capable of continuously determining a vessel's position in relation to land, charted objects, aids-to-navigation, and unseen hazards. Increasingly, ECDIS is being used for both navigation and collision avoidance tasks. In this regard, there is growing concern about the display of ever-increasing amounts of chart and navigation-related information. When it comes to using ECDIS, more information is not necessarily better. Too much information can clutter the display and confuse the user. In this regard, there is a need to “harmonize” the simultaneous display of both chart and navigation-
-related information. The ECDIS display may also be used for the display of radar, radar tracked target information, AIS and other appropriate data layers to assist in route monitoring.

1. RADAR IMAGE OVERLAY (RIO)

Maritime radar has been a powerful and indispensable tool for both navigation and collision avoidance. In essence, radar allows to detect targets and to provide an overview on own ship’s situation and surrounding objects. Nevertheless, radar has to cope with many limitations. The radar picture shows generally poor similarity to reality, like a photography does. Moreover, radar has to cope with many performance compromises, e.g.:
- larger coverage versus better discrimination,
- improved clutter reduction versus risk of target suppression,
- true motion overview versus relative motion risk assessment,
- head-up presentation versus north-up presentation,
- ground stabilisation versus sea-stabilisation,
- integration of chart information versus information overload,
- high functionality versus high operational load.

Today’s radar operation includes a large variety of user functions. Within the decades, new functions have been added to improve performance. Today, some functions have only historic and „we-always-used-radar-this-way” meaning. In particular by the introduction of satellite position fixing, ECDIS and AIS, the role of radar has changed, and there are two basic consequences for the user:
- all relevant data of own ship and targets must be correlated to allow an unambiguous and easy situation analysis;
- a number of conventional functions and display mo-des may be dropped to make the use of radar easier.

Radar, AIS information or other navigational information may be added to the ECDIS display. However, it should not degrade the SENC information and it should be clearly distinguishable from the SENC information. ECDIS and added nav. information should use a common reference system. If this is not the case, an indication should be provided.
- Transferred radar information may contain a radar image and/or tracked target information.
- If the radar image is added to the ECDIS display, the chart and the radar image should match in scale, projection and in orientation.
- The radar image and the position from the position sensor should both be adjusted automatically for antenna offset from the conning position.
It should be possible to adjust the displayed position of the ship manually so that the radar image matches the SENC display.

It should be possible to remove the radar and other navigational information by single operator action.

2. RADAR AS POSITION BACK-UP BY ENC OBJECT CORRELATION

It is essential that not only ARPA data, but raw radar data are integrated with chart data. Integrating an electronic chart with radar, or at least enabling the user to overlay some selected SENC information, provides a system which can be used for grounding and collision avoidance. The mariner receives the following relevant information in one display: own ship’s position, all other vessels in the sea area and all charted objects and obstacles. The outstanding benefits of the ENC-radar overlay are listed in Table 1.

The radar-ENC overlay and object correlation are of particular value:

- for position fixing because, in essence, the overlay provides a permanent radar-fix without the mariner having to do one single action,
- for real-time position monitoring by checking the ship’s Electronic Position Fixing System (EPFS), e.g. GPS.

<table>
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<tr>
<th>FEATURE</th>
<th>CORRELATION</th>
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<tr>
<td><strong>Navigation assistance:</strong></td>
<td>Radar and ENC</td>
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<td>- Position monitoring (continuous radar fix)</td>
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<td>- Targets and manoeuvring space in one display</td>
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<td><strong>Detection of problems and failure by discrepancies:</strong></td>
<td>Radar and ENC position error gyro error</td>
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<td>- Mutual operational monitoring</td>
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<td>- Objects out of position</td>
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<td>- ECDIS and radar “North”</td>
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<td><strong>Target identification:</strong></td>
<td>Radar and ENC</td>
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<td>- Vessels and buoys; vessel in wrong traffic lane</td>
<td>Radar and AIS</td>
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<tr>
<td>- Targets near-by, obscured by bridges/bends, non-conspicuous</td>
<td>Radar and ENC</td>
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<td><strong>Redundancy:</strong></td>
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<tr>
<td>- Radar as ECDIS back-up; flexibility</td>
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<td><strong>General:</strong></td>
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<td>- One workstation for navigation and collision avoidance</td>
<td>Radar and ENC</td>
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<td>- Increase of safety; reduction of workload</td>
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As long as the radar echo paints and corresponding ENC objects match, own ship’s EPFS (GPS) is reliable. However, if the radar echoes of fixed objects do not match the ENC objects, but are shifted for some distance, there is obviously an error in the EPFS, potentially in the geodetic datum. Moreover, if the radar
picture and the ENC picture are rotated against each other, there is obviously a gyro error.

Thus, radar may serve as second and independent position fixing system, i.e. the display of ENC objects in the radar picture is a potential position-fixing system back-up. In particular, when appropriate reference objects such as racons are available, there will be no need for the ship carrying other EPFS equipment such as LORAN-C as alternative. The ECDIS-radar overlay is particularly safety-relevant in automatic track control mode (TC) where - due to the task of the controller - the current GPS position is always displayed on the planned track, independent of the actual GPS error. This might seduce the mariner to over-rely on the system. A radar overlay showing discrepancies between radar and ENC objects will immediately indicate the danger.

3. ACCURACY LIMITATION

For large commercial vessels, a scaled outline of the vessel should appear on the ECDIS screen and the vessel's display size should adjust with operators' changes in display scale. This will maintain the navigator's perspective of his/her vessel with respect to the surrounding navigational attributes.

The radar display must automatically adjust its presentation to the scale of the ECDIS display in order to prevent misinterpretation. Radar beam width and pulse limitations could limit the ECDIS accuracy.

4. WGS-84 – COMMON REFERENCE SYSTEM FOR ECDIS AND RADAR

The Electronic Chart Display Information System has emerged as a promising navigation aid that will result in significant improvements to maritime safety and commerce. As an automated decision aid that is capable of continuously determining a vessel’s position in relation to land, charted and tracked objects, aids to navigation, and unseen hazards, ECDIS represents an entirely new approach to maritime navigation and piloting.

It is expected that ECDIS will replace the need to carry paper charts. As specified in the IMO Performance Standards [3], the primary function of ECDIS is to contribute to safe navigation. ECDIS must be capable of displaying all chart information necessary for safe and efficient navigation organized by, and distributed on the authority of, government-authorized hydrographic offices. With adequate backup arrangements, ECDIS may be accepted as complying with the up-to-date charts required by regulation V/27
of the Safety-of-Life-at-Sea (SOLAS) Convention of 1974. In operation, ECDIS should reduce the navigation workload compared to using the paper chart. It should enable the mariner to execute in a convenient and timely manner all route planning, route monitoring, and positioning currently performed on paper charts. ECDIS should also facilitate simple and reliable updating of the electronic navigation chart. Similar to the requirements for shipborne radio equipment forming a part of the global maritime distress and safety system (GMDSS), and for electronic navigation aids, ECDIS onboard a SOLAS vessel should be in compliance with the IMO Performance Standard.

For the electronic navigation positioning system to be used with an IMO-compliant ECDIS, it is specified that:

- The vessel’s position should be derived from a continuous positioning system of an accuracy consistent with the requirements of safe navigation.
- A second independent positioning method of a different type should be provided; and, ECDIS should be capable of detecting discrepancies between the primary and secondary positioning systems.
- ECDIS should provide an indication when the input from a positioning system is lost or malfunctioning.

When ECDIS and radar/Automatic Radar Plotting Aid (ARPA) are superimposed on a single display, they provide a system that can be used both for navigation and collision avoidance. As specified in the IMO Performance Standards, radar information may be added to the ECDIS display, as long as it does not degrade the display and is clearly distinguishable from the electronic navigation chart. The IMO Performance Standard further stipulates that both the ECDIS and radar use a common reference system (e.g., WGS 84), and that the chart and radar image match in scale and orientation.

5. RADAR OVERLAY IN ECDIS NAVISAILOR – ADVANTAGES OF RADAR INTEGRATOR

Navi-Sailor 3000 ECDIS can be fitted with a dedicated Radar Integrator Board (RIB) from Transas. RIB is capable of converting the radar's video signal to digital form, which allows overlaying a radar picture on the electronic chart.

Advantages of Radar Integrator include:
- Unique combination of the electronic chart and radar image overlay on a single display,
- ARPA functions with the capability of tracking up to 500 targets simultaneously,
- Advanced voyage data recording,
• Brightness, gain, sea and rain clutter on-screen control,
• Full compatibility with all Navi-Sailor products,
• OEM toolkit.

6. RADAR/ARPA VECTORS

The mariner can set the vector length (usually from 1 to 24 min.) for the radar/ARPA targets and the own ship:
• to display vectors with length corresponding to the set value, the minute intervals marked with dashes,
• to display vectors of a fixed length proportional to the speed.

The mariner can turn on/off the display of vectors originating in the own ship symbol:
• vector of motion over the ground (COG),
• motion vector according to the gyro and log readings.

7. RADAR WITH CHART OVERLAY

According to new revised radar performance standards for radar equipment adopted in 2004 the radar system may provide the means to display vector chart information (ENC) within the effective display area to provide continuous and real-time position monitoring. It should be possible to remove the display of ENC data by a single operator action. The ENC information should be the primary source of information supplied in S-57 format. Unofficial information should be identified with a prominent indication. There should be a minimum set of SENC objects that should be displayed if chart data is available:
• a user selected own ships safety contour,
• an indication of isolated underwater dangers of depths less than the safety contour.

An indication of isolated dangers which lie in safe water defined by the safety contour, such as bridges, overhead wires etc and including buoys and beacons, whether or not these are being used as aids to navigation. In addition, coast lines should be made available. Means should be provided to enable the user to select parts of the available SENC information. Information should only be selected on a class or layer basis, not as individual objects. There should be an indication of the SENC status in terms of source, authorisation and update information. The chart information should use the same reference and coordinate criteria as the radar/AIS system. Means to align the radar and chart
information is permitted. The application of such alignment should be clearly indicated. A simple alignment reset facility should be available. The display of radar information should have priority. Chart information should be displayed in such a way that radar information is not substantially masked, obscured or degraded. SENC information should be clearly perceptible as such. A malfunction of the source of SENC data should not affect the operation of the radar/AIS system. Symbols and colours should comply with the IMO and the IHO standards.

8. CONCLUSIONS

Without doubt, radar is and will remain an extremely powerful tool for detecting objects and an extremely important component of grounding and collision avoidance. The introduction of AIS and ECDIS is changing maritime navigation drastically. As discussed above, the value of radar information can be increased

- by correlation of radar target data and AIS target data to provide the mariner with all relevant information needed for collision avoidance and participation in traffic management systems;
- by correlation of radar target data and chart (ENC) data to provide the mariner with a second independent position fixing system which, in essence, is an effective position monitoring system, potentially an EPFS and ECDIS back-up.

This progress of data correlation has started and will be intensified. Of course, other improvements of radar systems, e.g. higher target detection performance particularly in bad weather conditions and for fast moving targets, are strongly desirable. Moreover, the radar system can be simplified by omitting some conventional functions and modes, e.g. by using only a chart-like true motion display into which relative (for collision thread detection) or true (for situation overview) trails are incorporated.

Integration will continue. In the future, it may be taken for granted that radar will no longer exist as a stand-alone unit, despite its not decreasing importance:

- In the near future, the radar will still remain a “radar system” with radar as the prime component and additional display of GPS, AIS, ENC and EPFS data. The new Radar Performance Standards, based on changing user requirements and new technology, aim at such an improved system (revision in 2004) [2].
- In the more distant future, it may be expected that radar will only be part (a sensor) of a “composite system”. Function, integration and presentation requirements have to be considered for such a system.
The relevant standards „Performance Standards for INS” and „Presentation and Display of Navigation Information” are already adopted to prepare the future composite system. Finally, it has to be achieved that the integration of radar/ARPA, AIS, ECDIS, EPFS and other components form a system that can be used:

– as primary navigation system and (!)
– as primary collision avoidance system
to enhance the safety and ease of shipping.

There are two recommended solutions:

• Function 1: **Navigation**
  Main source of information: **ECDIS** with Radar overlay on demand.

• Function 2: **Anti-Collision**
  Main source of information: **Radar** with ENC overlay on demand.

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**Fig. 1.** Typical configuration of ECDIS [4]

**Fig. 2.** ECDIS connections with other navigational equipment [4]
Fig. 3. Integrated navigation system INS [4]

Fig. 4. Radar as integrator of navigational information [4]

Fig. 5. Electronic chart system ECS [4]
Fig. 6. Integration of various types of information [4]

Fig. 7. Various types of ECS/ECDIS systems with radar image overlay [4]

Fig. 8. Radar/ARPA display (left) and ECDIS display with radar image and ARPA information overlay (right) [4]
Fig. 9. ECDIS display with radar overlay [4]

Fig. 10. ECDIS display with radar/ARPA overlay – including table with radar reports [4]

Fig. 11. ARPA guard zone settled and presented on ECDIS display [4]
Fig. 12. Trial manoeuvre presented on ECDIS screen [4]

Fig. 13. Radar image overlay (RIO) [4]

Fig. 14. Data presentation displays [4]
Fig. 15. Transas NaviRadar 3000 and NaviSailor 3000 interface [4]

Fig. 16. Radar – ECDIS interface [4]

Fig. 17. Radar with electronic chart overlay – NaviRadar 3000 [4]
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PORÓWNANIE MOŻLIWOŚCI NAKŁADANIA OBRAZU RADAROWEGO NA ZOBRAZOWANIE SYSTEMU ECDIS Z MOŻLIWOŚCIĄ NAKŁADANIA ELEKTRONICZNEJ MAPY NAWIGACYJNEJ NA OBRAZ RADARU

(Streszczenie)

W artykule przedstawiono problemy związane z nakładaniem obrazu radarowego na obraz mapy w systemie ECDIS (Electronic Chart Display and Information System) oraz nakładaniem elektronicznej mapy nawigacyjnej ENC na obraz radaru. Celem artykułu jest próba zoptymalizowania prezentacji graficznej oraz alfanumerycznej informacji nawigacyjnej. Wprowadzenie do eksploatacji systemów AIS oraz ECDIS zmienia dotychczasowe sposoby prowadzenia nawigacji morskiej. Naprzeciwnym
zmianom wyszły znowelizowane w 2004 roku przez Międzynarodową Organizację Morską IMO standardy eksploatacyjne dla urządzeń radarowych. Wielość informacji prezentowanych na ekranie radaru może być zwiększona dzięki możliwości nakładania na obraz radarowy informacji o obiektach AIS – dostarczając nawigatorowi pełniejszej informacji niezbędnej do unikania kolizji oraz udziału w systemach nadzoru i kontroli ruchu statków VTS, a także możliwości nakładania obrazu mapy ENC na ekran radarowy – dostarczając nawigatorowi drugiego, niezależnego systemu pozycyjnego, który w istocie jest systemem kontroli pozycji EPFS (Electronic Position Fixing System), a zarazem układem back-up wobec systemu ECDIS.

Słowa kluczowe: ECDIS, mapy elektroniczne, radary morskie.