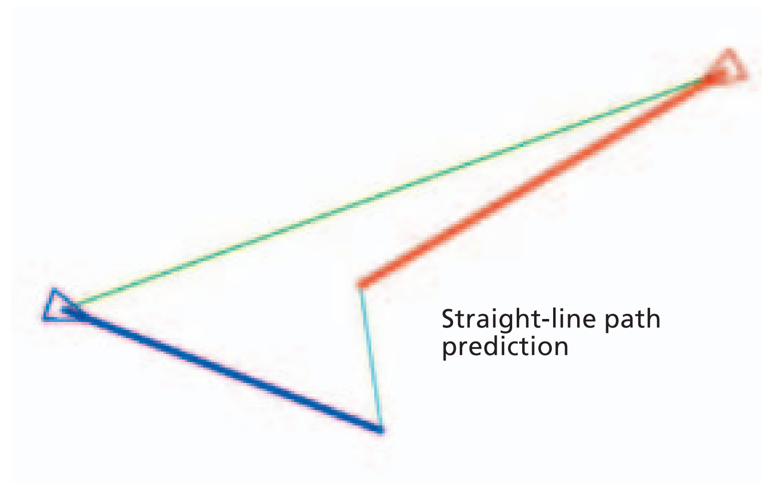
Radar: The Evolution to Digital

By Fred Pot

Operators are now installing AIS on their ships in order to comply with IMO and USCG requirements, and rather than setting up a transponder as a little black box somewhere on the bridge and letting it do its own thing, most feel it is worthwhile to connect it to the radar or the electronic chart, or both. Connecting a transponder to radar takes it another step to becoming a purely digital device.

Over the years, radar has become more and more digital. While the analog element isn't going away, it is constantly being enhanced with more and more digital information. Pure old-fashioned analog radar gave us a picture of what was ahead. Then radar was enhanced with an automatic radar plotting aid (ARPA) that calculated the relative course and speed of a radar target and displayed them as a vector. This information, in turn, was used to predict the closest point of approach (CPA) and the time of the closest point of approach (TCPA).



In the crossing situation shown above, the blue line represents the straight-line predicted path of the own ship making 12 knots on a true course of 110° and a target ship (red line) making 15 knots on a true course of 240°. The target initially is on a true bearing of 70° with a range of 2 NM (green line). With straight-line projection, the CPA of .4 NM will be reached in 4.8 minutes (light blue line).

Later, GPS was connected to radar. Doing so allowed showing the traffic situation in absolute rather than relative terms by calculating a target's 'absolute' course over ground (COG) and speed over ground (SOG). Next, it became possible to enhance echoes of fixed features by overlaying them with an electronic chart.

What AIS Does to Radar

With the advent of AIS, ships are starting to exchange navigation information directly with each other. Rather than having to derive a target's COG and SOG from own ship GPS data and the range and bearing to a target, a target sends its GPS information (and then some) directly, even if it is hiding behind a cape or an island. Ships can do that because VHF, too, is going digital. First came digital selective calling (DSC) on channel 70 that made it possible to broadcast your position in an emergency (via GMDSS) and establish contact with a particular station using its MMSI number. Now AIS takes that a step further and turns a VHF radio into a regular, albeit somewhat slow, modem. It sends and receives data just like any other modem.

Apart from GPS information, what other information could ships exchange with each other that would enhance the awareness of the traffic situation by the officer of the watch (OOW) without causing information overload? Transponders are programmed to exchange lots of information, but only some of it fits the

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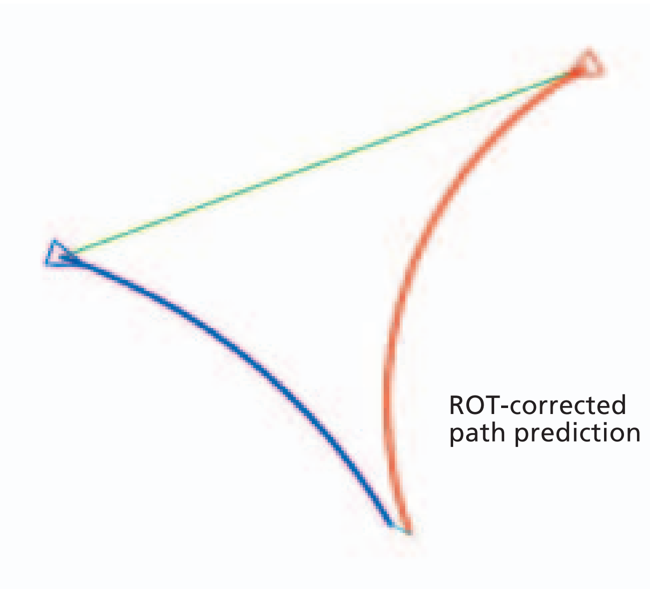

In the same crossing situation shown here, the blue arc represents the predicted path of the own ship again making 12 knots on a true course of 110° and a ROT of +5° per minute (starboard). Again, the target is initially on a bearing of 70° at a range of 2 NM (green line) making 15 Knots on a true course of 240° with a ROT of –10° per minute (portside). The red arc shows its predicted path. The CPA is now only 380 feet after 7.9 minutes (light blue line).

above criterion. First, lets look at five major areas where AIS can be used to further enhance radar:

• AIS can identify targets on the other side of a cape. The range between ***Regal Princess*** and ***Sea Princess*** was only 6.3 nautical miles during a test of AIS, in 2000, near Juneau, Alaska, or well within radar range, except that there was a 2,500-foot tall island (Douglas Island) between them… AIS easily scaled that mountain, thus confirming that it can help the OOW to anticipate a traffic situation earlier.

• AIS translates radar echoes into ship names. Being able to hail "***Nordic Venture***" on VHF by its name avoids potentially dangerous confusion about which ship is responding to "Ship off my starboard bow". AIS allows radar (and ECDIS) manufacturers to label a target with (an abbreviation) of its name or show its name when it is selected.

• AIS improves prediction of a target's path. Knowing a target's rate of turn (ROT) improves the OOW's ability to anticipate a traffic situation more accurately, as shown by the two examples on pages 32 and 34.

• AIS extends radar's range. This is useful when approaching features like a bridge, a point or a narrows. The extended range and target identification that AIS provides, allows the OOW to identify other ships with a similar ETA to the same feature, even if they are approaching it from the opposite side and are still some 40 NM away. This allows the OO W to anticipate a traffic situation earlier and make passing arrangements well over an hour in advance via VHF, or, if the other ship is still beyond VHF range, via an AIS instant message.

• AIS clarifies a target's intentions. If the OOW, for whatever reason, scrutinizes a target, AIS will provide not only its destination but also its intended route. This route can be temporarily displayed to anticipate a target's intentions. If a target has limited maneuvering capabilities, for instance due to its draft, AIS will provide such details too.

Connecting AIS to radar can also complicate matters. An AIS target's GPS information may, for various reasons, not be accurate. A target's AIS position may be different from the position of its echo on the radar screen. ROT-corrected (T)CPA calculations are difficult.

• Accuracy of AIS positions. The OOW will know when an AIS target is no longer sending position updates, because its icon will be crossed-off with a flashing line. If a target continues to send out AIS position updates but its GPS is not working properly, the OOW can only find that out by comparing AIS and radar (ARPA) positions (assuming it is clear which radar and AIS icons are associated with each other).

• Target Icon Consolidation. If a nearby ship has both an AIS and a radar icon on the screen and the two do not overlap, the software in the radar (or ECDIS) will try to decide whether the two separate icons should be replaced with a single consolidated icon and where to place that icon on the screen. The software bases this decision on a comparison of each icon's range, bearing, relative course and relative speed. If they pass this test, the target's radar icon is dropped from the screen.

• ROT-corrected (T)CPA predictions are difficult. While (T)CPA predictions that take ROT into account are preferable, there is no readily available algorithm to make such predictions. Fourier-LaPlace transformations of the necessary equations have to be used to solve them for CPA. Until such an algorithm has been developed, once per second recalculation of ROT-corrected (T)CPA of all selected AIS targets remains impractical.

Even without (T)CPA predictions, the OOW will have a more complete representation of the traffic situation if the predicted path of a target is shown on-screen as an arc that reflects its ROT.

It will take some time for all these benefits to become readily available, but connecting AIS to radar will significantly improve the ability of the officer of the watch to anticipate and avoid potential collisions. Anticipation will be improved primarily by the extended range provided by AIS, its ability to see around a point and by improving target's path predictions. Avoidance will be improved by clearly identifying targets for hailing purposes via VHF or instant messaging.

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