New Technology Radars and the Future of Racons

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BIOGRAPHIES
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ABSTRACT
IMO MSC79 resolution 192(79) removed the requirement, from 1 July 2008, for S-band radar to trigger Radar Beacons. This was intended to encourage manufacturers to develop new types of radar; known as New Technology (NT) radar.

The GLAs have conducted racon trials with an NT Radar fitted to CIL Tender Granuaile. The trials were conducted in the Dublin Bay, Codling and Arklow areas of the Irish Sea, where there are a number of fixed and floating CIL AtoNs fitted with different types of racon.

Trial results showed that:
the NT radar tested did trigger racons but at a significantly reduced range;
there were gaps in the racon responses;
responses at S Band can be obscured by land clutter;
some anomalous responses were observed with the NT radar;
responses were much clearer on an X band conventional magnetron radar than on the NT radar, except at close range;
increased racon receiver sensitivity appears to restore much of the lost range with the NT radar.

This paper concludes that consideration should be given to modifying existing racons to improve their response to NT radars. This would need to be done in consultation with racon manufacturers. Further trials should also be carried out to confirm that the results obtained apply to other types of NT radar.

The results are made available to IALA, so that there is general awareness of the potential effect of NT radars on racon performance and so that the strategic options can be discussed.
INTRODUCTION
IMO MSC79 resolution 192(79) (IMO, 2004) removed the requirement, from 1 July 2008, for S-band radar to trigger radar beacons (racons). The removal of this requirement was intended to encourage the development of low power, solid-state, cost-effective radars which used digital signal processing techniques to mitigate display clutter associated with high-power magnetron based radars. These radars have become known as “new technology” (NT) radars.

NT radars have become available which claim to trigger racons (Wade 2008), even with considerably reduced output power. Such a radar has been fitted to the Commissioners of Irish Lights tender “Granuaile” (CILT Granuaile)

In an earlier study (Norris, 2006) carried out on behalf of the General Lighthouse Authorities of the UK and Ireland (GLAs), it was recommended that trials be conducted to establish empirically NT Radar performance using currently available racons. The GLAs have conducted trials using Granuaile’s NT radar with a sample of their current racon fit, which have a current nominal range of around 10-12 NM. This paper describes the outcome of those trials.

OBJECTIVE OF TRIALS
The purpose of the trials was to determine the performance of S band racons (2.9-3.1 GHz) with a commercially available NT radar, compared with a conventional, magnetron-based X band radar (9.3-9.5 GHz).

TRIALS METHOD
The trials used different manufacturers’ racons, which exhibited different characters and were fitted on both fixed and floating Aids-to-Navigation (AtoNs).

Two sets of trials were carried out, in March and December 2009. Some anomalous results observed in the first trials were investigated and mostly eliminated in the second trials.

The stations observed were the Arklow Buoy, the Codling Lanby, the Kish Bank Lighthouse and the Dublin Bay Buoy. In addition, racons were set up for the trials on the pier heads at Dun Laoghaire for the first trial and at Wicklow for the second trial.

Where time allowed the racons were observed as the vessel approached and departed from them up to their maximum operational ranges.

Performance in terms of clarity of response and ability to identify codes were recorded at approximately 1 NM intervals on both NT S Band and conventional X Band radars.

RACONS TESTED
Racon A on the Dublin Bay Buoy, was a relatively modern, integrated, solid state design.
Racon B on the Kish Lighthouse, was an old design, widely used, but no longer produced.
Racon C installed at Dun Laoghaire for the first trial and at Wicklow for the second was a more modern solid-state version of B, but also no longer in production.
Racon D on the Codling Lanby was an old version (18 years old) of a racon still in production.
Racon E on the Arklow buoy was a relatively new design, not in general use by the GLA.
Racon F installed on Wicklow pier for the second trial was the modern version of D, with an expected 10 dB improvement in receiver sensitivity.

All were frequency agile, dual band X & S racons, with side-lobe suppression enabled and proportional response, where available.

ENVIRONMENTAL CONDITIONS
The weather during the first trial was generally clear, with light winds and sea-state 2-3, rising to 3-4 later. In the second trial, winds were fresh to strong with sea state 5 and visibility reducing to 1-2 NM in frequent rain showers.

RESULTS
In the first trials it was shown that the NT radar did trigger racons but at a significantly reduced range when compared to the Granuaile’s magnetron-based X-band radar. This triggering distance was typically 4-5 NM compared with 10-12 NM for the X-band.

It was noted that there were gaps in the coverage. If an initial response was obtained at say 5 NM, this might continue to be satisfactory until a distance of between 3 and 4 NM when the response disappeared. Then at a distance of between 2 and 3 NM, the response was once again satisfactory. This was assumed to be the result of interference between the direct and reflected signal from the sea surface (multipath) and is in line with theory, but reduces the reliable range of the racon response to 3 NM. Although this is a known problem, it did seem to be exacerbated in these trials.

The racon interrogating pulse of the trial NT radar is very short (typically 0.1μs) and the paint of some proportional response racons was correspondingly short (typically 0.5 NM). This could lead to the racon response being lost in clutter.

Some racons responded with a portion of the “paint” in front of the actual position of the racon.
This could mislead the mariner into thinking that the Racon is closer to the vessel than it actually is; therefore giving potentially hazardous and misleading information.

One particular racon (Racon “D” at the Codling LANBY) gave a response which was offset in azimuth by approximately 10° from the actual racon position. At other times, the response was radially displaced by 10 NM beyond the actual racon position. This particular racon gave its first correct response at only 2.5 NM. Subsequent discussions with the manufacturer of this racon revealed that this unit was 18 years old and not up to the latest specification. Therefore these results could not considered representative of this racon type.

Racon “E” (unused by the GLAs before this trial) gave inconsistent responses to the radar’s interrogations. For instance, an incorrect Morse code followed a “no response” condition after a power reset. A further power reset affected the correct response form the racon. It was not considered that this response was typical of the racon and CIL have now investigated power supply problems with the buoy and concluded that these were the cause.

In the second trial two racons (F & C) were set up on the East Pier at Wicklow and were powered up alternately for 3 minutes at a time. The Granuaile steamed eastwards to allow a clear view of the racons.

On the S Band NT radar racon F gave good returns out to 10 NM, apart from an apparent null at around 1-2 NM. However, the paint was spread out and sometimes hard to distinguish in the land clutter. There were also some spurious responses, displaced by about 180° and some spooking at close range (0.5 NM) possibly caused by reflected signals from the pier wall. The racon was picked up again at 10 NM on the outbound leg from the Arklow, so this range seems to be repeatable. This compared with clear and consistent returns on the X Band to 10 NM on the inbound leg, with a maximum range of 12 NM on the outbound leg.

Racon C gave returns at S Band out to 5 NM, again with a null at 1-2 NM. The paints were also hard to distinguish against the land clutter. On the X Band the returns were clear and easily distinguishable out to 10 NM and then again from 12 NM down to 9 NM (the closest point) on the outbound leg.

The Arklow buoy was fitted with the racon E, which had given incorrect responses in the previous trial. The suspected power supply problems had been fixed and the returns on S Band were clear from 3 NM on the approach and out to 3 NM on the outbound leg. This compared with clear and consistent returns on X Band from 9 NM on the approach. On the outbound leg returns became faint at 5 NM, possibly as a result of shadowing by the superstructure.

Racon D on the Codling Lanby had given returns displaced in both range and azimuth in the previous trial. This time the S Band returns were picked up at 5 NM, but then lost again until 3 NM, after which they were clear. On the outbound leg they were lost at 2.5 NM. The X Band was picked up at 7-8 NM, but there was a null at 5-6 NM and returns were lost in clutter below 2 NM. On the outbound leg returns were good, once free of clutter, out to 8 NM.

The next racon observed was B on the Kish Lighthouse. This was visible on S Band at 5.3 NM, with a null at 3-4 NM, then visible again down to 2 NM, when the vessel headed away. Returns disappeared at 3.5 NM on the outbound leg. On X Band returns were clearly distinguishable from 14 NM down to 3 NM when they disappeared in clutter.

The last racon observed was A on the Dublin Bay Buoy. This came in at 4.5 NM on S Band and was clear down to 2 NM, the closest point. On X Band returns were clearly distinguishable from 12 NM down to 2 NM.

DISCUSSION

Ideally racons should be able to respond at range at least equal to the primary AtoN; indeed, for buoys, the racon range is generally greater than that of the light. In these trials, the Racon failed to do this at S Band, presumably because of the low power of the radar. Even though a response was present, it was typically 25-30% of the currently published ranges for Racons.

Earlier manufacturers’ predictions indicated that the maximum range of Racon responses “is approximately 7NM” (Wade, 2008). The GLA trials show shorter ranges than predicted.

A Racon Plan prepared for the GLA (Ward, 2009) and an earlier GLA report on the future of Racons (Norris, 2006) set out options for the future of racons. Amongst these are modification of existing racons, development of NT racons and replacement of racons by AIS. AIS has the drawback that it relies on Global Navigation Satellite Systems (GNSS) for position reporting, whereas racons currently provide an independent alternative to GNSS in providing identification of AtoNs. If AIS was used as a replacement for Racons, then a suitable complementary, diverse and resilient back-up to GNSS would be required in times of GNSS service denial. The GLAs maintain that the only way to provide resilient and robust positioning systems is through the employment of a back-up to GNSS, using eLoran.

Modification of existing Racons would be the lowest cost option (Norris, 2006) and should be
investigated first. Development of NT Racons would be very expensive and would have to be carried out in conjunction with industrial partners.

The performance of all the racons was much better on X Band than S Band, not just in terms of range, but in clarity of response. The display of returns on the NT S Band radar was spread out and this made the racon paints more difficult to distinguish and identify, particularly in land clutter. The only exception was at close range, when the X Band response tended to be lost in sea clutter. Rain clutter also obscured the X Band returns.

The ranges at S Band were generally 5 NM or less, with the exception of the racon F, a new version of racon D, which gave 10 NM. This is consistent with the manufacturers estimate that the receiver sensitivity of the new version would be 10 dB greater than the older version. Ranges on X Band were generally 8-12 NM, depending to some extent on the height of the platform.

The anomalies experienced in the earlier trials appeared to have been largely resolved in the later trial.

However, it should be emphasised that these results were obtained with one particular type of NT radar. There are others on the market and these could give different results. Trials would be needed with other types to determine whether the conclusions drawn can be applied generally.

CONCLUSIONS
1. The NT Radar tested did trigger racons, but at substantially reduced range (less than 5 NM).
2. A new version of one of the racons tested did give up to 10 NM range at S Band, almost certainly because of its improved receiver sensitivity (+ 10 dB).
3. The inconsistencies in responses of some racons in the first trial were resolved.
4. The ranges with a conventional X Band radar were generally much better, around 10 NM and clarity of response was much greater, except at close ranges in clutter.

RECOMMENDATIONS
1. Modification of existing racons to improve their response to NT radars should be considered in consultation with racon manufacturers. Modifications could include: increasing the receive sensitivity, removing the scalable response, designing the racon to detect, and respond differently to NT radar.
2. The differences in racon performance during these trials indicate that better standardisation of racons should be considered.
3. IALA should be invited to consider the results of these trials when discussions its strategy for the future of racons.

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REFERENCES