e-NAV10 Input paper

Agenda item 8.7

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Future Strategy for Racons

# Introduction

This strategy deals with the anticipated developments in radar over the next decade (NT Radar), the consequences for racons and the possible options for meeting these challenges. The strategy reflects discussions in IALA and consultation with other bodies such as CIRM. Any regulatory changes considered necessary will need to be coordinated through IALA and progressed in IMO, ITU and IEC, as appropriate.

# Present situation

The advent of new technology (NT) radar, with low power, solid-state transmitters introduces uncertainty about the future of racons.

In 2004, IMO MSC79 approved new radar performance standards in Resolution 192(79), which from 1 July 2008 removed the requirement for new S-Band radars to trigger racons. This was intended to facilitate the introduction of cost effective coherent processing techniques that would enable future radars to have an improved performance in sea and rain clutter. Potentially, it also allowed more stringent limits to be considered by ITU on spurious and out of band emissions of marine radars in order to improve the utilisation efficiency of the radar spectrum.

S-Band radar is normally the preferred choice by users when operating in adverse conditions, particularly in open waters, when the extra angular resolution of X-band radar is not so important. S-band is much less affected by precipitation clutter than X-band. IMO saw that the potential performance improvements that could be obtained by using new technology (NT) would therefore be particularly beneficial at S-band. The requirement to trigger racons was dropped in order not to limit the possibilities of improving radar performance in clutter. However, IMO continues to recognize the importance of racons as an aid to navigation, since they provide a means of identifying and locating navigation marks in poor visibility without reliance on GNSS or other electronic position fixing systems. For this reason the requirement at X-band on racon compatibility has not been altered.

Prior to IMO’s decision, the Nautical Institute carried out a survey of bridge officers and established that there was a consensus on an approach that effectively trades S-band racon compatibility for improved radar detection in conditions of heavy clutter. New systems and services provide an ever-increasing array of options through which to optimise service levels and reduce risk and cost. At the same time, the need for co-ordination through IALA and key stakeholders such as IMO and CIRM has never been more important in the endeavour to ensure consistent levels of service provision on an international basis.

# Technical Background

It is likely that several S-band NT radar solutions will emerge over the next few years and that these will rapidly be adopted by users and manufacturers. These may include solid state amplifiers, pulse compression, Travelling Wave Tube, Frequency Modulation Carrier Wave. Target and clutter Doppler information may be used to enhance target visibility, in fact these techniques may also be used with magnetron radars. There are however, several benefits with the low peak powers obtainable from pulse compression techniques, which enable solid-state transmitters to be used. The required technology has become increasingly affordable because of the escalating market for mid-power microwave digital communication systems.

Solid-state transmitters also allow the easy use of frequency diversity techniques, giving a further significant boost to target detectability. They offer good benefits in improving the reliability of radar systems compared to magnetron based systems. Magnetrons have a limited in-service life (c10,000 hours) and require very high voltage power supplies that limit reliability.

**Comparison of characteristics of existing and NT radars**

|  |  |
| --- | --- |
| **Conventional Radar** | **New Technology Radar** |
| non-coherent | coherent |
| pulsed | CW/FM |
| high peak power (3-30 kW) | low peak power (10-500 W) |
| magnetrons | solid-state |

# The Role of Racons

This Racon Strategy is set in the following context:

* radar will continue to be the primary tool for collision avoidance for the foreseeable future;
* radar will continue to have an important role in hazard warning, spatial awareness and confirmation of position;
* anticipated continuing requirement for racons in the e-Navigation era;
* the navigational requirement for racons in the future is expected to be as set out in Annex 1;
* there is a need to respond to the proliferation of other radar targets, such as wind farms;
* increasing congestion in some areas is making greater demands on AtoN;
* radars may be introduced over the next decade that will not trigger existing racons, or will do so at significantly reduced range .

Mariners have access to a rapidly increasing amount of information, bringing with it a risk of information overload. This necessitates an ability to interpret and discriminate between individual aids to navigation in an environment with an increasing amount of radar clutter.

There is a potential single point of failure with both the navigation and surveillance functions of future systems relying solely on GNSS. The role of radar aids to navigation as part of the GLAs’ approach to risk mitigation will be a key element of future operational strategy.

The removal of the requirement to trigger racons does not necessarily mean that racons will not work with NT Radars. They may work, but at a reduced, but acceptable range; NT Radars could be designed to trigger racons, whilst retaining their other performance advantages; alternatively existing racons could be modified to work with NT Radars or new racons designed to do so. Calculations of performance with the first of the NT Radars (Kelvin Hughes SharpEyeTM) indicate that existing racons will perform, but with reduced range.

Trials have now been carried out with the SharpEyeTM NT radar, which have indicated a serious reduction in range with most existing racons (Refs 3 & 4). These trials have provided firm guidance for future racon strategy.

NT radars are only being introduced at S Band at present, for SOLAS vessels, although there is are X Band NT radars available for non-SOLAS vessels. If they are effective in achieving their aim of improving small target detection in clutter it is likely that demand will grow for development of NT radars at X Band and their application to SOLAS vessels.

Therefore the important role of racons could be challenged in the medium term at S Band and in the longer term at X Band.

# Options for Racons

## Use Existing Racons

In principle, existing racons can respond to pulsed NT radars, if certain constraints are placed on the radar design. However, these constraints may be unacceptable to the radar manufacturers. The distance at which such radars can potentially trigger a racon depends on the peak power of the pulse. Furthermore, an NT radar can be designed so that it would properly process and display the received pulse from the racon, even though the racon’s response would not reflect the modulation on the radar transmitted pulse. This is a low cost and apparently low risk option for the racon provider and it would be compatible with a large range of possible NT radar solutions, but only if they generate a racon interrogation signal and have racon detection algorithms within the radar’s digital signal processing (DSP).

## Modify Existing Racons

The second option is to examine the possibility of increasing the effectiveness of racons with future coherent radars, with various levels of changes to the present racon requirement specification. This might provide an acceptable way forward, assuming costs are acceptable - all existing racons would have to be modified or replaced. Unchanged compatibility with existing conventional radars would also be essential. An outline technical specification for racons in the short to medium term is set out in Annex 2.

## Universal Radar Beacon

The third option is to consider the design of a racon that would be compatible with all types of coherent and non-coherent radars. In principle, this is possible using main-stream advances in digital microwave techniques, digital RF memory and fast DSP. Although it stretches today’s technology it is likely that future advances will make this approach affordable. Its main advantage is that it is potentially compatible with all present and future radars. Beacon power consumption would be a major consideration.

## Secondary Radar

There is also the possibility of using non-primary radar techniques in order to determine a ship’s relative position to one or more navigation marks. This can be readily performed with today’s technology, using transponders in another band, but requires extra shipborne equipment, new standards and a racon replacement programme. It would therefore be costly and politically very difficult to implement.

## Non-radar technology

If the preceding options prove technically, politically or economically too difficult, then non-radar alternatives would have to be considered as a replacement for racons. AIS is the obvious choice, although it has two major drawbacks: first it is dependent on GPS and therefore does not provide redundancy of position-fixing; second, few vessels have onboard equipment that can display AIS AtoN. Until both these problems are resolved (by an alternative position sensor and by modernised display equipment) AIS will not provide an adequate replacement for racons.

# The Strategy

The specification in Annex 2 takes account of the results of trials carried out by the GLA in 2009 (Refs.2 & 3) on the effectiveness of existing racons with NT Radar. It was concluded that there was significant loss of performance, with current racons, except for the most modern design. The option of modified racons (5.2), in accordance with Annex 2 should be pursued in the short to medium term, with the possibility of a Universal Radar Beacon (5.3) or non-radar alternatives (5.5) in the longer term.

IALA may wish to encourage liaison with Radar manufacturers to confirm that other NT Radars have the capacity to trigger Racons and work with Racon manufacturers to identify possible modification to improve triggering range.

# References

1. RPT-15-NW-08 Racon Plan 05, GLA R&RNAV 2010
2. RPT-06-MB-09 Racon Trials, GLA R&RNAV 2010
3. RPT-07-NW-10 Second Racon Trials, GLA R&RNAV 2010

# Action requested

The Committee is invited to consider this input from the General Lighthouse Authorities as an updated contribution to a possible IALA Strategy for racons.

1. Proposed Navigational Requirement for Racons
2. Background

Racons are an important element of the present and future AtoN mix.

IALA Recommendations / Guidelines and the NAVGUIDE set out the following typical uses of Racons:-

* Inconspicuous coastlines
* Ice conditions
* Identification of AtoN at long range
* Landfall identification
* Traffic Separation Scheme / precautionary area
* Hazard marking
* Navigable spans under bridges
* Leading lines
* Short range Racon identification of a local feature (e.g. a harbour entrance)
* New Dangers (Morse D)
* Offshore structures
* Turning Marks

In the absence of any specific considerations IALA recommends that the availability of a Racon should be at least 99.6%, however many authorities treat all Racons as Category 1 AtoN with an availability target of 99.8%.

1. AIS and Racons

The IALA NAVGUIDE envisages the possible replacement of Racons by AIS, however Racons and AIS are different technologies and most authorities have no intention to phase out Racons in the foreseeable future. While AIS requires GNSS for position and timing (albeit with the possibility of semaphore for timing) Racons provide an independent source of position data and target identification. Subject to the Racon being triggered successful reception depends on shipboard equipment under the control of the user.

1. New Technology (NT) Radar

S Band NT Radars are not required by IMO to trigger Racons. IMO was prepared to trade off Racon response in favour of improved performance in clutter and small object detection and the opportunity for solid state radar development. The continued availability of Racons on X band was a significant factor in this decision. It is likely that, in time, there will be demand for NT Radar at X Band and at that time a further review of Racon requirements and technology will be required.

However, racons operating in the S Band are still a valuable AtoN, this being the preferred radar band in many operational conditions. Trials have investigated the extent of the loss of performance with NT radars and whether there are cost-effective measures that can be taken to mitigate this loss.

The trials showed that the NT Radar tested would trigger Racons but at far lower ranges than a conventional (magnetron) radar. The trials also demonstrated that relatively simple adjustments to the receiver sensitivity could make a significant improvement in triggering range.

1. Required Racon Range

Racon range will depend on a number of factors including transmitter power, height of the Racon and height of Radar. The Admiralty List of Radio Signals Volume 2 sets out the approximate ranges of Racons presently provided as well as some general information on Racon performance. At present Racon ranges are set out in two formats, in some cases a single range is given and in others a spread of ranges is given.

It is proposed that the navigational requirements for Racon range (regardless of radar type) should be a minimum of 5 nautical miles from a floating AtoN and 10 nautical miles from a fixed AtoN. These figures are based on a typical height of Racon of 5 metres for floating and 20 metres for fixed Racons and a Radar height of 20 metres.

1. References
2. IALA Guideline 1010 Racon range performance
3. IALA Recommendation R-101 Maritime Radar Beacons (Racons)
4. IALA Recommendation O-113 for the marking of fixed bridges
5. IMO Resolution MSC.192(79) – Radar Performance Standards
6. Proposed Technical Specification for Racons
7. Frequency Agile X (9300-9500 MHz) and S Band (2900 – 3100 MHz) Racon with ability to disable either band. Blocking period 100 µs after end of response. Response to radar of minimum pulse length 0.05 µs.
8. Suitable for mounting in marine environments to fixed and floating (including buoys) Aids to Navigation.
9. Receiver sensitivity to exceed -50 dBm X Band and -50 dBm S Band. These receiver sensitivities are required to improve the racon range response to NT radars. The requirement for Racon range (regardless of radar type) is a minimum of 5 nautical miles from a floating AtoN and 10 nautical miles from a fixed AtoN. These figures are based on a typical height of Racon of 5 metres for floating and 20 metres for fixed Racons and a Radar height of 20 metres.
10. Transmission should occur on the frequency of the interrogating signal with a frequency tolerance of ± 3.5 MHz for interrogating pulses with a duration of less than 0.2 µs or with a frequency tolerance of ± 1.5 MHz for pulses with a duration equal to or more than 0.2 µs.
11. Polarisation: Horizontal X Band, Horizontal and Vertical for S Band.
12. Input Voltage 10 – 36 VDC.
13. Lightning protection to address indirect strikes to the adjacent structure.
14. Temperature range - 40 to + 70 deg C.
15. Weight less than 15 kg.
16. Output Power X Band 1W and S Band 0.5 W.
17. Response delay ≤ 0.7 microseconds.
18. Vertical beam-width minimum of ± 10 deg between – 3dB points.
19. The racon should be programmable with a response duty cycle with an active period programmable between 5 and 30 seconds, and a quiescent period programmable from 10 to 60 seconds.
20. Low Power Consumption: less than 0.5 W with no activation (for solar applications), the power consumption when active/transmitting is to be less than 1.5 W.

Health Monitor with Volt Free Contact, a full description of how the monitoring is conducted is to be provided.

1. The duration of the response should be approximately 20% of the range requirement of the radar beacon, for example 1 nautical mile if the range required is 5 nautical miles, or 2 nautical miles if the range required is 10 nautical miles.
2. Side lobe suppression by dual token (frequency and pulse length).
3. Standard plug configuration and cable drawings to be provided, with any options available, for both communication and power interfaces.
4. Should be supplied with all operational and programming accessories, including mounting plates and vibration isolation devices.
5. Environmental protection to IP66, specifically due to the constant high humidity in buoy applications, details of any pressurisation of equipment areas or special protection to component boards utilised should be indicated.
6. Impact/vibration protection to be indicated, with respect to drop test onto hard surface and vibration/impact via mounting as per MILSTD 810D.
7. Mounting arrangement to be (typically) 4 No x 12 mm studs/bolts at 241 mm PCD, using a transfer plate if necessary.
8. Transmit codes: morse codes available and means of programming are to be provided in the tender return. One morse dash should be three times as long as one dot or space.