Forum

Some Causes of Problems in the Observation of Standard Racon Marine Beacons when Observed by Means of Standard Marine Navigation Radars

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1. INTRODUCTION. Modern marine radar beacons (RACONS) are used widely for the marking of navigationally significant platforms such as lighthouses, buoys, etc. Occasionally, difficulties are experienced with the observation of RACONS by means of standard commercial marine navigation radars. The purpose of this note is to explore the causes for such losses of RACON visibility.

2. MARINE RACONS – PRINCIPLES OF OPERATION. Marine RACONS operating in the marine S-Band and X-Band, have been in use for many years. Until relatively recently, the most commonly used type has been the slow-sweep RACON, consisting of a crystal video receiver of wide instantaneous bandwidth whose output triggers a transmitter, radiating a pulsed signal whose frequency is swept slowly over the whole marine radar frequency band (2900–3100 MHz in the case of S-Band and 9300–9500 MHz in the case of X-Band).

The transmission takes the form of a signal which appears on the display of an observing radar as a morse coded radial 'flash', on the relative bearing of the RACON and originating in range at its relative position.

The purpose of the slow frequency sweep of the RACON reply transmitter is to ensure that any marine radar will, at some point in the sweep cycle of, typically, 90 seconds duration, obtain a signal from the RACON on its display, irrespective of where in the marine S- or X-Band the radar receiver is tuned. (The centre frequency to which a commercial marine navigation radar is tuned depends upon the centre frequency of the magnetron which happens to be fitted to it but, in any case, is within the band 2900–3100 MHz for S-Band radars and within 9300–9500 MHz for X-Band, although some older Estuary Surveillance radars have frequencies falling outside these limits).

More recent designs of RACON are of the frequency agile type, in which the centre frequency of each radar transmission received by the RACON is measured and the RACON transmitter tuned to the same frequency very rapidly so as to reply on the frequency to which the observing radar receiver is tuned. In this way, an observing radar receives a reply to each of its transmissions, providing it is within operating range of the RACON, thus avoiding the intermittent signals characteristic of the slow-sweep RACON.

Modern RACONS usually encompass both marine S-Band and X-Band and often have provision for interrogation path sidelobe suppression. Typical RACONS have receiver minimum trigger levels (MTL) of −40 dBm at X-Band and −33 dBm at S-Band with corresponding reply transmitter peak powers of 1 W and 0·5 W respectively. The frequency accuracy of the reply is normally within 3 MHz of the centre frequency of the

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transmission from the observing radar. The RACON reply usually takes the form of a morse coded pulsed transmission extending for some 25 μs, corresponding to 2 nautical miles.

3. SOME CAUSES OF DIFFICULTY IN THE OBSERVATION OF RACONS BY MEANS OF STANDARD MARINE NAVIGATIONAL RADARS. Since the reply from a RACON normally takes the form of a morse keyed carrier on–off sequence, should the observing radar receiver only pass the RACON carrier on–off transitions then, because they are so brief, it will be virtually impossible to observe them against clutter or radar target echoes. This condition can arise if the receiver video is, in effect, 'differentiated'.

The signal is deliberately differentiated in the case of the anti-clutter-rain facility, which operates by breaking up blocks of rain or snow clutter which could otherwise mask wanted targets. When anti-clutter-rain is in operation, it is usual for RACON responses to disappear.

A second cause of radar received-signal differentiation can occur if the receiver is badly mistuned relative to the magnetron centre frequency since, under these circumstances, only the sidebands which occur when the RACON transmitter is being switched on or off, fall within the radar receiver passband.

A third and very important cause of radar received-signal differentiation arises if a widely used form of automatic anti-sea-clutter signal processing is employed. When such automatic sea clutter suppression facilities are in operation, the gain level applied to the radar receiver video amplifier has an adaptive signal superimposed upon it which, while slow-acting, generally follows the shape of the clutter returns on the received-signal video, while being largely unaffected by the wanted echo returns such as those from ships, navigation marks, coastlines, etc. This effect may be reduced in the case of the very latest radar designs.

Increasingly, commercial marine navigation radars are fitted with Automatic Frequency Control (AFC), so that the possibility of receiver mis-tuning will not arise except under fault conditions. Also, performance monitors are often fitted to deep sea radar installations so that the possibility of the radar receiver being badly mistuned is greatly reduced. The problems with anti-clutter-rain operation and with automatic CFAR signal processing remain, however.

It is important that the radar operator understands that, where the presence of RACONS, whose responses are to be observed, is expected, the anti-clutter-rain and automatic anti-clutter-sea signal processing should be switched off (most radars have front panel switches for this). Under conditions of very heavy precipitation or sea clutter, it may be difficult to see the RACON signal against the clutter background with clutter suppression removed.

An advantage of the fast-sweep RACONS used at some points on the French Coast is that their visibility is much less affected by anti-clutter-rain and anti-clutter-sea signal processing, since the signals are of short duration and form a radial series of dots on the radar display which facilitates observation. However, since the response appears on the radar display as a series of dots, it is more difficult to make it appear as a morse-coded letter for the positive identification of the RACON.

A further cause of loss of visibility of the RACON reply which is occasionally encountered, is that of excessive residual error in the frequency agile tuning of the RACON to the observing radar.

It is common practice for radar receiver bandwidth to be switched depending upon the display range selected. Thus, in the case of one widely used series of deep sea radars, for the short-range scales, the receiver bandwidth is 20 MHz, while for the longer-range scales, a bandwidth of 3–4 MHz is employed.

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On the other hand, some other manufacturers use receiver bandwidths considerably less than these values which, while it confers benefits in terms of target detectability (lower KTB noise), may also lead to failure to observe frequency agile RACONS due to the RACON reply frequency error causing the reply to be outside the radar receiver passband for longer displayed range scales.

Reflections from the surface of a smooth sea can also cause the fading of RACON responses. This effect, which can also adversely affect radar echoes and is known as Lloyd's Mirror, is dependent upon the range of the RACON from the radar and also upon the heights of the antennas of the radar and RACON above the sea surface.

The visibility of RACON responses at closer range can be affected by the improper setting of the radar anti-clutter-sea (STC) controls, since, if the sea clutter suppression threshold is set too high, it may also suppress RACON or other beacon replies.

4. FUTURE DEVELOPMENTS. A new development in marine navigation radar technology which has implications for operation with standard RACONS, is the Signaal SCOUT radar, now being tested by the Dutch and Canadian navies. SCOUT is a CW radar having a peak transmitted power of 1 W compared with the 25 kW of a standard marine navigation radar. The low transmitted power, together with the FM–CW mode of operation, means that standard marine navigation RACONS, which require a pulsed signal, will not be triggered.

Low peak transmitted powers are environmentally attractive and it seems likely that SCOUT points the way for the future evolution of commercial marine navigation radar, provided that the problem of incompatibility with RACONS and Search and Rescue Transponders (SART), can be overcome.

KEY WORDS

1. Radar. 2. Radar Beacons.

A Step by Step Method of Computing Points Along the Arc of a Great Circle

Roy Williams

1. INTRODUCTION. On any surface with suitable continuity properties, the shortest distance between two points on the surface is along the arc of a geodesic curve. A geodesic curve on such a surface is defined as a curve on the surface along whose length, at any point, the normal to the curve is also the normal to the surface at that point. On the surface of a sphere, the geodesic arcs are the great circles and, except when the two points are antipodean, the arc of the great circle joining them is unique.

In navigation the standard procedure for computing great circle course and distance, and any intermediate points along the path, employs the methods of spherical trigonometry. These methods, which usually involve the haversine formula and the spherical cosine formula, are well tried and tested and give accurate results but they are not sufficiently general and cannot be applied to surfaces other than the sphere. They can be used to provide first approximations to the path of the geodesic on the surface of the

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