Active radar reflectors

HEAD-TO-HEAD TEST!

Being seen at sea is literally a matter of life and death, so it's hardly surprising that so much interest was taken in the questions raised by the Ouzo disaster and the subsequent Qinetiq report on radar reflectors. And one of the results of that report was a statement that 'The Sea-Me is the recommended product if power is available.'

The justification is clear: despite reasonable performance from some of the passive reflectors tested, mixed with disconcertingly poor results from other products, the Sea-Me was the only product which consistently met or exceeded the requirements set down by ISO8729. Although not a legal requirement, this international standard for radar reflectors provides a good benchmark to indicate how visible a small boat would be at sea when fitted with a reflector.

Sea-Me's success was down to one simple difference with the competition. Where the other reflectors are passive and just reflect part of an incident radar pulse, Sea-Me is active and sends back a stronger return.

Such devices are generically known as Radar Target Enhancers (RTEs). Several RTEs have been developed in the past (check www.theradarreflectorsite.org for a near-exhaustive list) but few seem to have been commercially successful. Sea-Me proved the pattern wrong and benefited from being the only RTE in the Qinetiq test, but now there's a new player. Echomax have a good reputation in the field of passive radar reflectors, so it's not surprising to see them launch a rival to the Sea-Me with their Active-X RTE.

What is an RTE?

The principle behind an RTE is that it collects an incident radar pulse and sends back a much stronger pulse at the same frequency, resulting in a stronger signal at the receiver. One fallacy that should immediately be laid to rest is that they make a small boat look like a container ship on a radar picture. Confusing a radar in this way is regarded as jamming, and is likely to fall foul of the law.

Instead, an RTE improves the vessel's radar cross-section (RCS), which is effectively how reflective a target is to radar pulses – not how big it is. As an analogy, imagine two identical objects at sea on a pitch-dark night, one painted white and the other matt black. If you pan across the horizon with a searchlight, you will certainly see the white one, but probably not the black, despite their being the same size and shape.

Yachts tend to be poor reflectors of radar, closer to the black than the white object in the analogy. To improve this, adding a conventional radar reflector is like adding a mirror to the black object. Most of it would remain dark, but when the searchlight passed over there would be a single, dazzling reflection, provided the mirror is at the correct angle.

Adding an RTE takes this one step further. Instead of a mirror, imagine a single, extremely bright bulb fitted to the black object so that it can shine out in all directions. Most of the time it is switched off, but as soon as it detects the searchlight it switches on. Unlike the mirror, it shines just as strongly whatever angle the light comes from. That's the true advantage of an RTE: even if the radar is only weakly received, the RTE will send a strong pulse back to the receiver, increasing the number of times the yacht is reliably 'painted' on the radar screen. And that has all sorts of additional benefits: you are not only more visible to a human radar operator, you are also more likely to be tracked by the ARPA (Automatic Radar Plotting Aid) systems fitted to ships, which tend to need a ratio of around 50% successful paints to reliably track a target.

Echomax or Sea-Me?

Visually, the Echomax and Sea-Me products are pretty similar: the Echomax antenna is slightly taller and thinner than the Sea-Me and has a slightly smaller control box. Both operate on the X-band of frequencies (9.32GHz – 9.5GHz) used by small boat radar and also by ships (who operate it in conjunction with the lower frequency S-band) and both offer the option to fit an external alarm which sounds when the unit detects a radar pulse, a useful feature on ocean passages when radar contacts are few and far between. This is backed up by a visual alarm in each case, and Echomax add an additional audible alarm in the control box with a built-in switch.

However, reading further into the specification sheet is like a game of top trumps. Where Sea-Me quote a radar cross section of 42.57m2 when the antenna is upright, Echomax quotes 111.36m2. At 20° heel, Sea-Me's RCS has dropped to 4.35m2, while Echomax claim 20.80m2. This exceeds ISO8729-2, which came into effect on 22 July, and requires a minimum RCS of 7.5m2 at 10° heel for motorboats and 20° heel for yachts.

The top trumps continue, with Sea-Me citing a standby current of 150mA, while the Echomax state a tenth of that at 15mA. And where Sea-Me say that their antenna emits a maximum EIRP (Effective Isotropic Radiated Power) of 630mW, Echomax claim a typical value of 1W, increasing its range.

On paper then, it looks like the Echomax should significantly outperform the Sea-Me, but the difference between paper and water is significant so we took both units out to test their maximum range and how they perform when heeled.

Echomax v Sea-Me

	Echomax Active-X	Sea-Me
RCS at 0° (m^2)	111.36	42.57
RCS at 10° (m^2)	78.96	24.87
RCS at 20° (m^2)	20.80	4.35
EIRP	1W typical	630mW max
Standby current (mA)	15 (spec) 14 (measured)	150 (spec) 90 (measured)
Transmit current (mA)*	290	350
Antenna size (mm)	478 x 40.5	416 x 50
Price	£???????????????	£????????????????
Website	www.echomax.co.uk	www.sea-me.co.uk

* this is the current drawn when the RTE is continuously transmitting. Where there are fewer radars, the current will be significantly lower – Echomax quote 23mA for five radars in the area and 32mA for 10 radars.

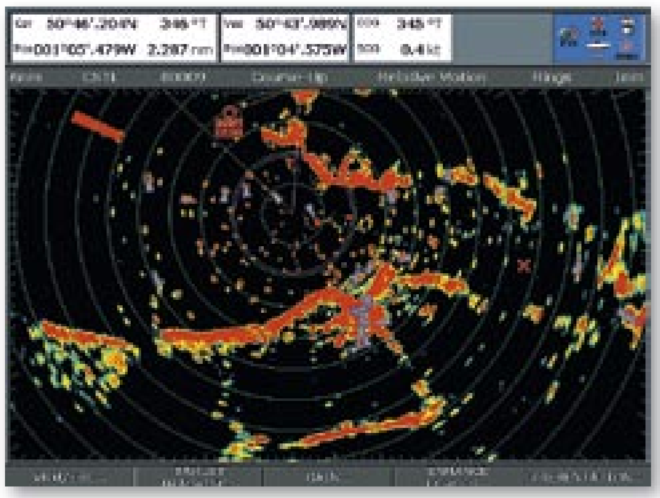
PBO's on water test

At close quarters an RTE often makes little difference, as the radar returns from a small boat are still consistent enough to paint regularly on the screen. Where an RTE starts to be of significant benefit is at longer ranges, where the returns are starting to become erratic.

To test this, we mounted both antennas on 2.3m windsurf masts and lashed them to the A-frame of a RIB. We then headed out for open water to the east of the Isle of Wight, pursued by Trinity Star, a Nelson 42 owned by Alan Watson of Trinity Nautical Training and equipped with a Raymarine HD radar with a 48in, 4kW open array scanner. Once at No Man's Land fort, when the echoes from other vessels became fewer and farther between, we first tested how easy it was to track the RIB without an RTE by noting down how far away the RIB had reached when the radar's MARPA system lost lock.

With no RTE active, the RIB reached four miles before we lost lock. We then switched on the Sea-Me, which extended this range to 5.5 miles. Carrying out the same test with the Echomax allowed the RIB to continue to a range of 6.7 miles before we lost lock, a significant improvement and very close to our approximate radar horizon of 6.5 miles.

We then tested the units for performance at different angles of heel by deliberately tilting each mast in increments of 10°



The Raymarine HD radar shows echoes as red, yello or green according to their strength

Calculating Radar Cross Section (RCS)

■ To calculate the RCS of a vessel, you model it as a sphere that would have the same radar signature as the vessel. A good yacht radar reflector might have a stated RCS of 2m2, which is equivalent to a sphere of 1.6m diameter. The Sea-Me's stated RCS at 0° heel is 42.57m2, equivalent to a 7.4m diameter sphere, while the equivalent sphere for the Echomax's 111.36m2 RCS measures 11.9m.

The choice of a sphere is due to its even response both across the frequency spectrum and also physically – with no sharp angles it reflects the radar pulses in a consistent manner.

For detection by radar, the crucial parameter is how the surfaces of the object to be detected are positioned with respect to the incoming pulses, which is why a passive radar reflector aims to present as many flat surfaces at as many angles as possible. A slab-sided container ship will have a huge RCS when side-on to the radar, but a stealth vessel of the same size with surfaces angled to reflect incident radar pulses away from the receiver will either not appear at all or have a tiny radar signature that could be from a much smaller vessel. Imagine a cone pointing directly towards the radar scanner – it could be physically enormous, but because all the surfaces are angled to reflect the incident pulses away from the receiver would have no radar signature at all. Using the sphere model in the cases of the container ship and the stealth ship, the sphere used to model the RCS of the container ship would be enormous, as the slab sides of the ship form a near-perfect reflector. For the stealth vessel, the sphere is much smaller and hence its curvature is increased, resulting in a smaller area at an appropriate angle to reflect the radar signal back to the receiver. In the case of the container ship the sphere would be bigger than the vessel, while the stealth ship's sphere would be smaller, but the useful reflective area of the sphere cannot exceed the size of the vessel. It's impossible to make the object look larger than it really is – all you can do is make it a better or worse reflector.

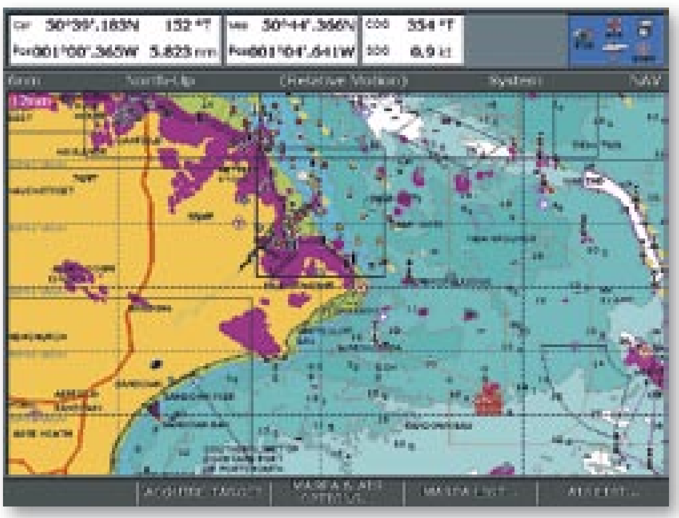
at a range of four miles. One of the advantages of Raymarine's HD radar is it allows you to assess the strength of an echo on the screen by its colour: red for strong, yellow for medium and green for a weak return. The Sea-Me continued to return a strong echo at 10° heel, with a medium return at 20°. The signal was detectable but weak at 30°, and by 40° we had lost contact.

The Echomax lived up to its specification sheet, returning strong echoes at angles up to 20°. At 30° it showed a medium return, while at 40° the signal was weak. However, we reached 60° heel before we lost lock altogether.

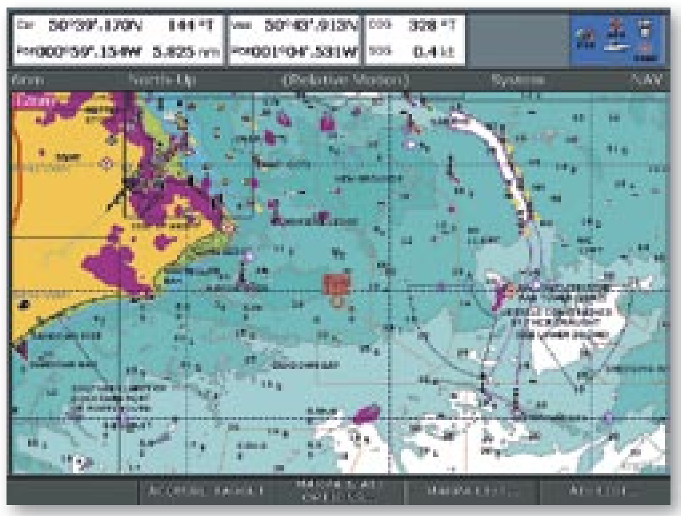
Test results

	Echomax	Sea-Me
Heel	**Range @6.7nm**	**Range @5.5nm**
0°	Strong	Strong
10°	Strong	Strong
20°	Strong	Medium
30°	Medium	Weak
40°	Weak	–

Alan Watson's Nelson 42 and 48in, 4kW Raymarine HD radar provided the perfect platform for our test



The Echomax showed strong returns right up to the theoretical radar range for our test vessels



The return from the Sea-Me was of variable strength at distances exceeding five miles

PBO'S VERDICT

■ The specification sheets and our test results leave little doubt that Echomax have moved the active radar reflector market one step further. The Active-X showed improved performance over the Sea-Me on both our range and heel tests, and the reduced current consumption is also compelling, allowing sailors to leave the unit switched on in open water for a meagre 15mA, barely higher than the self-discharge rate of a typical lead-acid battery. Provided they can continue their aggressive pricing compared with Sea-Me's product, there seems little doubt that we now have a new market leader.

However, past tests carried out with commercial vessels have shown that an X-band RTE is not a complete solution to being seen at sea. Ships tend to use S-band radar for preference, as it is more tolerant to sea clutter, and neither of these products have any response at S-band. For now, even if you fit an RTE you should also fit a passive reflector, which although optimised for X-band will have some response to S-band radar.

But the story has by no means finished. Sea-Me are awaiting the completion of the international standard that will allow them to launch their S-band Sea-Me, expected later this year, and I can't imagine that Echomax will be far behind with a competing product. And all the while, Class B AIS has a growing following of those who wish to be seen at sea. This could be a fascinating area of the marine market to watch over the coming months.

WITH THANKS TO: Alan Watson of Trinity Nautical Training for his expert advice and use of his boat and radar, Peter Crump of PC Marine for his time, advice and the use of his RIB and Alex Bell for his advice and active participation in the test