Miscellaneous Radar Reflective Materials

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The preceding two articles in this series discuss passive and active radar reflectors, devices that are purpose-designed for use on small vessels to improve their radar signature. This article focuses on several miscellaneous devices and materials that have radar properties the sailor should be aware of: aluminum foil, radar-reflective cloths and sails, and light-reflective tapes.

Aluminum foil

One could glue a sheet of kitchen aluminum foil to a flat board. In theory, this would give a radar cross section (RCS) equal to that of a sheet of conducting metal. In practice, this does not work too well because it is nearly impossible to get the foil perfectly flat. Theory says that even slight ripples or bumps in the foil reduce RCS significantly (surface ripple of 2 mm at X-band reduces the RCS 50%), and my measurements bear this out. The foil must be almost perfectly flat and perfectly smooth to be useful.

I recently evaluated an "emergency" radar reflector comprised of crumpled balls of kitchen aluminum foil in a plastic garbage bag (see reference 7). Measured radar cross section (RCS), ***on average***, was pretty close to the theoretical RCS of a metallic sphere the same size as the bag of aluminum balls. Although the average RCS was similar to that of a sphere, the response was very erratic. That is, the RCS would become zero (and the target would be invisible to radar) with small changes in orientation. I used two 50-foot rolls of aluminum foil and got 110 crumpled balls and a trash bag of foil one foot in diameter. The radar cross section of a one-foot diameter sphere is 0.073 square meters (m^2), which is not a very strong reflector. For comparison, a person provides about 1 m^2 and a good radar reflector for sailboats in poor weather should be about 10 m^2. The small RCS of any bag of balls one could make with the amount of aluminum foil likely to be on board is too small to be of much use, and the erratic response just makes things worse.

Instead of balls of foil, one could use strips of foil, the length corresponding to half the radar wavelength. That is, chaff. Chaff consists of numerous strips of foil, half a radar wavelength in length. X-band wavelength is 3.2 cm (1.3 inches); S-band wavelength is 9.8 cm (3.9 inches). Radar theory says that one would need over 500 X-band foil strips to give the same 0.07 m^2 RCS I got from the bag of aluminum balls. One would need over 64,000 strips to give 10 m^2. The large number of strips required to provide useful RCS makes this approach impractical. In addition, deployment of chaff assumes that the numerous strips are distributed widely in an open cloud. Filling a bag or jug with foil strips does not provide a cloud, and a jug of foil strips would react very much like the bag of aluminum foil balls. There is little if any benefit from having resonant strips if they are tightly packed together.

I don't doubt that people have filled plastic jugs with foil strips and detected them with radar. One must remember, however, that radar will detect almost anything if it is close enough to the radar scanner. Being able to detect a target with very small RCS at a hundred yards should not be interpreted to mean that the same target can be detected in bad weather at several miles.

Metallic fabric and carbon fiber sails

Metallic fabric reflects radar as long as it is electrically conducting. I have worked with two examples. The first is the ingenious patented fabric used in the Radar Flag. My measurements show that the radar-reflective fabric used in the Radar Flag is very flexible and about as reflective as conducting metal. It is almost ideal. The second is carbon fiber sails. The carbon threads in the sail conduct electricity and the resulting sail reflects radar. The pattern of carbon fibers determines the RCS so some sails will give a strong effect and others a weaker effect.

Maximum RCS is obtained from a target when the surface is flat and perfectly smooth. Smooth and simply curved, as with a cylinder or sphere, is next best. Convoluted and erratic surfaces do not give predictable, or large, radar cross sections. Draping a metallic cloth over a person, hanging it from a pole, or sewing it into clothing, suggested applications of the Radar Flag, do not give very good RCS even if the cloth itself is a strong reflector ***when perfectly smooth***. A collapsible Davis Echomaster octahedral would be a much better emergency radar reflector than a draped cloth.

Carbon fiber sails introduce two concerns. The first is reflection. Carbon fiber sails reflect radar and may be good targets. The RCS depends on the pattern of carbon fibers, which varies from sail to sail, and the sail shape. On the one hand, the surface of the properly trimmed sail will be a gentle curve so the RCS will be smaller than if the sail were perfectly flat. In addition, the surface is probably not ideally smooth and there will be additional losses due to surface roughness. On the other hand, the sail is comparatively huge and it might provide significant RCS. The second concern is shadowing. Carbon fiber sails will block, either completely or partially, radar waves. Consequently, a radar reflector may be entirely ineffective if a carbon fiber sail is between the radar reflector and the radar scanner on another boat. Most sails are made of a synthetic such as Dacron, which is transparent to radar. Dacron sails are not detected by radar and do not affect performance of radar reflectors. Even when thoroughly soaked with water, especially salt water, the effect is minimal. The average sailor does not need to be concerned about sails, but a sailor of a high performance sailboat at least should be aware of the possible effect of carbon fiber sails on radar.

Stick-on patches and tapes

Several light-reflective adhesive patches and tapes are sold in chandleries and hardware stores. These patches are often applied to PFDs and liferafts as light reflectors. Although the manufacturers of these patches make no claim about radar reflectivity, some people have suggested that they do reflect radar. This is not necessarily true, as reported in Practical Sailor (reference 8). In the Practical Sailor tests, plain metallic adhesive tape from a hardware store worked quite well as a radar reflector, patches from ACR worked somewhat, and SOLAS tape was virtually invisible to X-band radar. In the case of SOLAS tape, there is a definite pattern of small hexagons on the tape. These hexagons are small compared to the radar wavelength (3.2 cm) and hence are virtually invisible. The ACR tape also has a pattern, but it is much less pronounced that the pattern on the SOLAS tape. The best radar reflectivity came from the smooth non-patterned hardware tape. One should be aware that just because a patch reflects light does not mean that it also reflects radar.

References

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