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Finding Distance – The Haecke Rangefinder

Peter Ifland

KEY WORDS

1. History. 2. Sea. 3. Instruments.

This article is the second in a series dealing with the hand-held instruments and techniques navigators have used to find distance.

Warships frequently steam in tight formation in order to concentrate defensive gunfire. It is the Conning Officer's responsibility to keep his ship on station at an assigned range and bearing from the guide ship, usually the flagship of the Senior Officer Present Afloat. This can be an easy task when the fleet is steaming along peacefully, but it becomes a particularly challenging responsibility when the formation is changing course frequently under battle conditions. In such difficult situations, the Conning Officer needs all the help he can get.

In the days before radar, and even now when radar and laser are blacked-out, the Conning Officer had to rely on optical instruments to determine range and bearing. Bearing always has been easy – a pelorus mounted on the wings of the bridge gives bearing quickly and accurately. Measuring range is more difficult. Many ingenious instruments relying on prisms or the doubly reflecting principles of the sextant have been produced to simplify the task of finding distance (Ifland, 2002).

Most optical range finders depend on knowing height – the height of the masthead or the stack above the waterline. These values are known for all the ships in the fleet, even for enemy warships. For coastal navigation, the height of the lighthouse at the harbour entrance or that of a promontory is given on the chart. The rangefinder can be adjusted so that the height is one value of a right triangle and distance is the other. The optics of the system are then adjusted so as to bring the image of the masthead down to coincidence with the waterline.

The Haecke rangefinder is one of the simpler executions of the concept. It was produced by the H. Haecke Company of Neukölln, a southern suburb of Berlin (see Figure 1). The imperial crown and the letter 'M' stamped on the index arm suggest that the instrument was produced for Emperor Wilhelm II's 'Kaiserlich Marine', probably in the first or second decade of the twentieth century. The unique feature of the Haecke rangefinder is that is can be readily set to measure distance to any one of several classes of warships in the German fleet of that era (see Figure 2).

The abbreviations for the three classes of ships correspond to terms used up to the

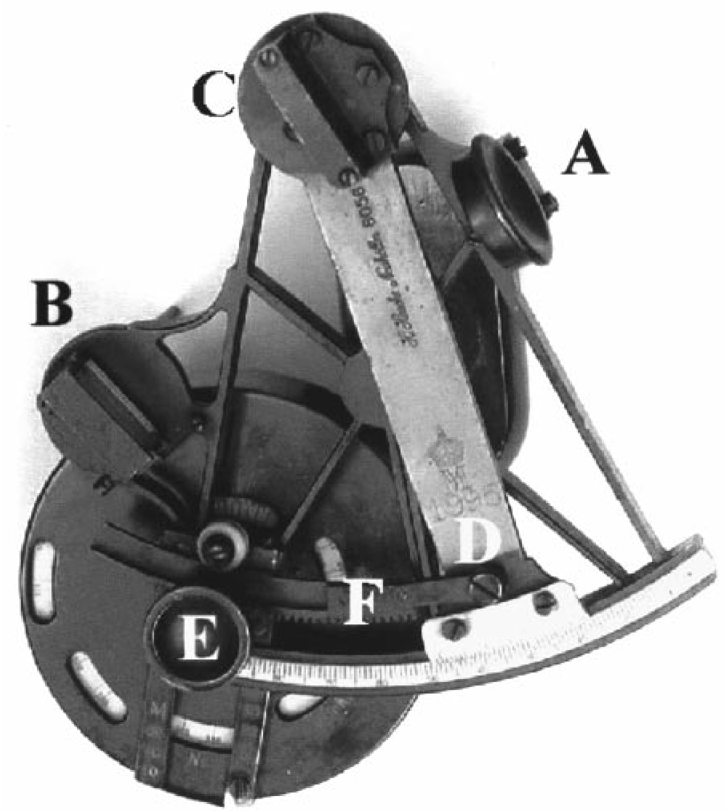

Figure 1. The Haecke Rangefinder. The optics are that of an octant: A is the eyepiece; B is the 'horizon glass' through which the waterline of the ship is viewed; C is the 'index mirror' that reflects the top of the object (the masthead or funnel) into the horizon mirror. The index mirror is rotated by the index arm D using the gear and ratchet E and F. With the ratchet F in place, the scale can be read from −5 to only 31 degrees. With the ratchet F removed, the scale reads up to 100 degrees.

end of World War I. The correct translation of the abbreviation Na. is not clear. *Nachen* translated as 'small boat' (Anonymous, 1966) does not seem to fit with a masthead height almost that of a light cruiser and a funnel height even one metre taller. Neither the Boats and Ships chapter of the *Illustrated Technical Dictionary in Six Languages* (Anonymous, 1966) nor *Jane's Fighting Ships of World War I* (Anonymous, 1990) gives any other ship type beginning with the letters Na. One possibility is that the abbreviation relates to one specific ship, the *Nautilus*, a 1910 mine layer whose masthead and funnel heights fit the specifications given for Na (Broelmann, 2001).

To find out if you are on your assigned station, decide whether you are going to observe the masthead or the funnel of the guide ship, rotate the drum G until the window for the appropriate class of ship clicks into place, adjust the index system to align the sight, and read the distance in metres off the scale. It is as simple to use as that.

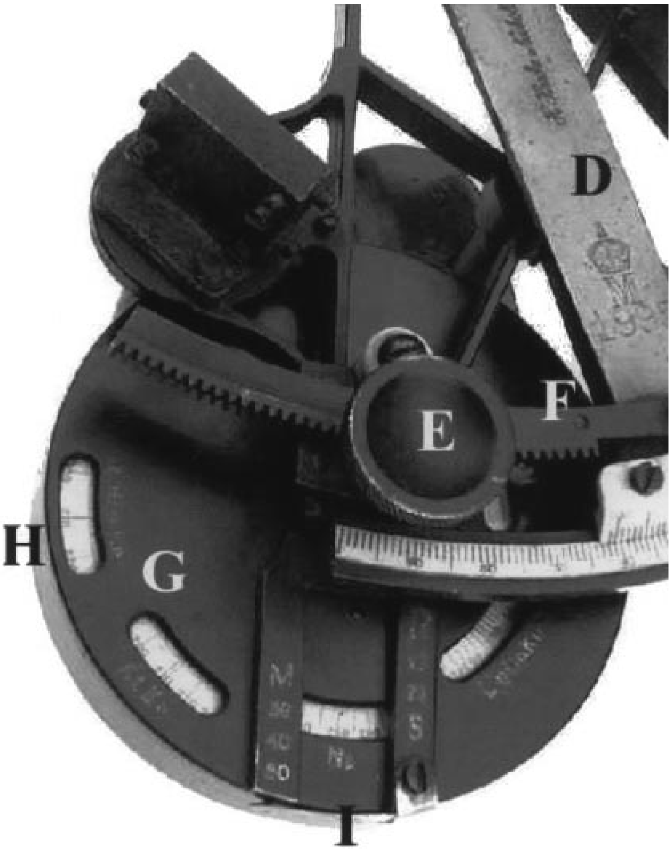

Figure 2. The distance scales of the Haecke rangefinder. G is a rotatable drum $3\frac{1}{2}$ inches in diameter, 5/8 inches deep. The knob E rotates a disc inside the drum as the index system is adjusted to align the sight. The disc is printed with six concentric scales of distance in metres. The three outermost scales relate to the masthead height of three different classes of ships while the three innermost scales relate to the funnel height of the three classes of ships. See Table 1. The drum G can be rotated to align one of the six windows H over the appropriate scale depending on which class of ship is being observed and whether the masthead or the funnel is being used. The M and S scales at I give masthead height and funnel height in metres for the three classes of ships. The scales at I also could be used to measure distance to any other object whose height happens to be the same as that of the masthead or funnel of a ship. A detent at I assures precise alignment of the index mark in the window with the scale. See Table 1 for translation of the abbreviations marked on the scales.

Table 1. Abbreviations and translations

Scale Abbreviations	**M** – *Masttop* – Masthead (metres)	**S** – *Schernstein* – Funnel (metres)
L.u.Gr.Kr. *Linienschiff -und Gross Kreuzer** Battleships and Heavy Cruisers	50	22
Kl.Kr. *Kleine Kreuzer*** Light Cruiser	40	18
Na. *Nachen* Small ship/boat	36	19

**Linienschiff Kreuzer* also was applied earlier to Dreadnoughts.
Linien Kreuzer was also applied to earlier Battle Cruisers.
***Kleine Geschülzte Kreuzer* was the official classification of 'Small Protected Cruisers'.
Abbreviations used on the rangefinder are in **Bold**.
Possible German for the abbreviations are in *Italic*.

REFERENCES

Anonymous (1966). *Illustrated Technical Dictionary in Six Languages*, Permanent International Association of Navigation Congresses, Brussels.

Anonymous (1990). *Jane's Fighting Ships of World War I*. Studio Editions, London. A reprint of the 1919 edition.

Broelmann, J. (2001). Personal communication. Deutsches Museum.

Ifland, P. (2002). Finding Distance: The Fiske Rangefinders. This *Journal*, Vol. 55, No. 1, p. 145.

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Definition of a High Speed Craft

A. T. C. Millns

KEY WORDS

1. Colregs. 2. Sea. 3. Safety.

1. Following my earlier article 'Fast Craft and the COLREGS' (Millns, 1998), I was pleased to see the article by R. D. Pike 'Collision Regulations and Fast Craft' (Pike, 2001). However, I cannot find any research to substantiate the recommendations in this article. Reductions in speed within two miles may, in my view, cause more confusion.

2. In my earlier article, I described my concern – following a visit to HMS *Dryad* – about the ability of various types of vessel (i.e. a frigate, a container ship or a VLCC) to conform to the current COLREGS. You may recall that I had the opportunity to witness some tests in the bridge simulator at HMS *Dryad*, known as 'Amethyst'. Amethyst can be changed from representing a frigate to a container ship, then to a VLCC and back to a frigate, and in each case the representation is very realistic. A simulation was set up in deep water with a HSC or hovercraft crossing

from starboard to port; thus the 'Amethyst' was always the give-way vessel. The Amethyst's OOW picked up the stand-on vessel six points on the starboard bow at seven miles; about the limit of a flashing light. Wind force four was used since above that strength the HSC started to become obscured by spray, and its aspect became unclear. The OOW appraised the situation and went 'Hard a Starboard' with the engine set at full speed. Basically, the manoeuvre required a ninety-degree turn to be successful because of the speed differential of the vessels involved in the encounter. The results were as follows:

(a) As a frigate, Amethyst manoeuvred with adequate sea room.
(b) As a container ship (37636 gt), Amethyst manoeuvred well at 25 kts provided that the OOW or Master have very strong nerves. The HSC disappeared below the flare of the bow before emerging the other side! Any slight hiccup such as a line squall, another vessel manoeuvring to enter the separation lane, fishing boats, RFA refuelling etc., could well result in the HSC being sunk. With a combined closing speed of 50 kts plus 25 kts (75 kts) there are only 5·6 minutes prior to disaster.
(c) Continuing as a container ship, speed was reduced to 12 kts so as not to arrive ahead of schedule. At this speed, Amethyst was unable to respond adequately to the COLREGS; that is 'to keep out of the way of a HS crossing vessel'.
(d) As a fully laden VLCC (254000 gt), Amethyst's response was very sluggish and again was unable to respond in time to give way under the COLREGS.

3. Despite the COLREGS, it is the practice of HSC to keep out of the way of other vessels, but a QC, when questioned about this at a meeting of the Marine Traffic and Navigation Group (MT&N, 2000), advised that this was in fact illegal. Thus the good sense of the mariner in using a practical solution to a potential problem may well have the law turned against him should an accident occur. I therefore recommend that pressure be continued on IMO to legalise this common practice, otherwise it will encourage uncertainty, court cases etc. It seems unbelievable that a major international agency does not choose to carry out some very simple trials on a simulator to research and establish the problems that appear to exist and so develop solutions.

However, to do this, one must first identify a HSC. Originally, I suggested the IMO formula be used (IMO, 1995), but this may not be suitable for all lengths of craft. In retrospect, I recommend that it would, for the purpose of COLREGS, be better to define a HSC dependent on its hull design. The COLREGS were defined at a time when displacement hulls were the norm, but evolution has developed many other hull forms, such as: wing-in-ground effect vessels, hovercraft and HSCs. These vessels are able to attain higher speeds because of their reduced drag/displacement and, since these are the craft causing the problem, I suggest that hull types that are designed to reduce drag/displacement should be used to define a High Speed Craft as follows:

> 'A High Speed Craft shall be deemed to be a craft whose hull/s is designed to plane on the surface of the water or close to it. This designation will always apply to such craft whatever their speed'.

This definition would cover all methods of propulsion and vessels of all sizes, be they pleasure vessels on a lake or large commercial vessels at sea. Each can cause danger in its own environment. Furthermore, since they are able to adjust their speed so quickly, I feel that it is impractical for HSCs that reduce to below a given speed to become normal vessels; this would simply lead to further confrontation in the courts. I am certain that a positive way forward, based on hull design, must prevail. Once an HSC, always an HSC!

REFERENCES

IMO. (1995). *Resolution on High Speed Craft, MSC 36 (63)*. International Maritime Organisation, London.

Millns, A. T. C. (1998). Fast craft and the COLREGS. This *Journal*, Vol. **51**, 437.

MT&N. (2000). Maritime Traffic and Navigation Group meeting, 8 March 2000.

Pike, R. D. (2001). Collision regulations and fast craft. This *Journal*, Vol. **54**, 477.

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Finding the Wind

L. M. Dougherty

KEY WORDS

1. History. 2. Dead Reckoning. 3. Air Navigation.

Ayliffe, in his article 'The Development of Airborne Dead Reckoning, Part I: Before 1940' uses the sub-title 'Finding the Wind' (Ayliffe, 2001). However, within the article, he does not discuss the only direct method for doing so in the air that I recall being in print in the pre-1940 period. An Admiralty publication with the somewhat pretentious title 'Air Navigation' was a collection of instructions for solving the several variations of the relative velocity triangle likely to be of use to the Swordfish and Walrus observers of the time, and it included the wind finding method outlined below. Despite its content being no more than typical sixth-form work of the day, it was dignified with an OU (Official Use only) designation, which required some level of physical security. Here is my recollection of it.

Choose a convenient and conspicuous fixed object or, if over the sea, drop a smoke candle for this purpose. Estimate the wind speed and direction. Flying at operational height on a heading approximately 90° to the wind direction, fire a smoke cartridge when over the object and start the stopwatch (Point A on Figure 1). This is time zero t_0. Observe the smoke cloud drifting downwind and, after a suitable time interval, turn 180° into wind, and then turn to fly the transit of the cloud and the object. Note the heading, the air speed, a, the time, t_1 of passage over the object (Point B), and t_2, the time through the smoke cloud (Point C). Then

$$(a+w)(t_2-t_1) = wt_2, \tag{1}$$

where: w is the wind speed, and the reciprocal of the transit heading is the wind direction. It follows that the wind speed, w, is given by:

$$w = a(t_2/t_1-1), \tag{2}$$

a trivial calculation even when balancing a plotting board in a Swordfish.

This was a training exercise for naval pilots and observers in the late 1930s and in

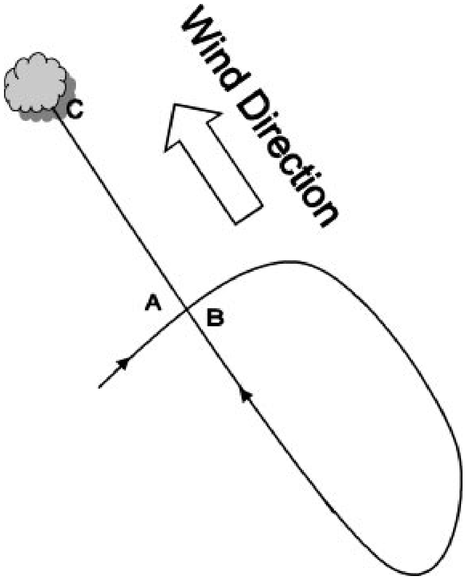

Figure 1. Track flown for wind finding. (A – t_0, B – t_1, C – t_2).

the 40s. As operations were mounted from ships or naval air stations, all of which had adequate wind information, the method was not required in operational practice, and I do not recall it being so used. Perhaps one of my contemporaries, having a better memory than I, or having taken part in unconventional activities, can clarify this.

REFERENCE

Ayliffe, A. (2001). The development of airborne dead-reckoning, Part I: Before 1940 – Finding the Wind. This *Journal*, Vol. **54** (2), p 463.

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Specifications for Reflectors and Radar Target Enhancers to Aid Detection of Small Marine Radar Targets

Tim Bartlett

KEY WORDS

1. Radar. 2. Sea. 3. Safety.

John Briggs, in his paper 'Specifications for Reflectors and Radar Target Enhancers to Aid Detection of Small Marine Radar Targets',[1] refers to an article in *Practical Boat Owner* (PBO) 1999.[2]

The article in question was, in fact, the final article of a series. As one of the team involved in the research for the PBO article, the owner of the boat used for the sea trials, and as the journalist who wrote the article itself, I take issue with the way our results were quoted in Briggs' paper and with his precis of the conclusion we reached. Briggs writes: *When a good-quality 2·5 m^2 reflector was hoisted up the mast, RCS never fell below 10 m^2* … . The results tabulated in the PBO article, however, show that the RCS of the boat and reflector combination invariably fell below 5 m^2, regardless of which particular reflector was in use.

Briggs writes: *Some yachtsmen are sceptical of radar reflectors, holding that there are no real improvements in detectability* … and then adds *recent controlled trials of a radar reflector on a 7 metre yacht seem to refute this*. The conclusion to the PBO article however, actually says 'Several reflectors actually made matters worse, probably because their interference effects knocked the peaks out of the boat's own response. These included two of the reflectors. Most made little difference either way. Two reflectors did achieve a worthwhile improvement; the down side of both is their size.'

The original data from the sea trials shows that the mean RCS of the boat without a radar reflector was 37·2 m^2. Five of the reflectors tested actually reduced the mean RCS. Three achieved marginal improvements (to 38·29 m^2, 40·98 m^2, and 41·62 m^2). It should be noted however, that the best of these three was a placebo, consisting of a plastic refuse sack filled with screwed-up kitchen foil. The best performer achieved a mean RCS of only 69·51 m^2.

To a reader unaware of these facts, Briggs' paper may seem a convincing argument in favour of large radar reflectors. Unfortunately, incomplete arguments usually do seem convincing: it is only when one looks at the more complete picture that doubt sets in.

There are a number of significant omissions and unjustified assumptions in the paper:

1. … *this serious safety problem* … Is it a serious safety problem? In ten years, the Marine Accident Investigation Branch (MAIB) investigated collisions in which 17 recreational craft were struck by ships.[3] Eleven of the recreational craft were on moorings or at anchor. In only two incidents did the MAIB inspector comment on the use of radar, and in no case was the presence or absence of a radar reflector commented on as a main or contributory cause of the incident.

2. *RCS is a measure of the retro-reflecting quality of the target*. RCS is indeed a measure of the retro-reflecting quality of the target, but it is compared with the retro-reflective qualities of a sphere of known cross-sectional area. Many non-specialists do not appreciate that this means that a RCS of 10 m^2 (equivalent to a sphere more than 3·5 m in diameter) can be achieved by a flat metal plate of 285 cm^2 – rather less than half a sheet of A4 – when subjected to a typical X-band marine radar.

3. *10 m^2 octahedral has effective size 0·25/2·5*. The point that an octahedral has significant nulls has been made in too many references to name them individually, and is indisputably true. This, however, seems a barely adequate reason to rename something that most users know as a '10 m^2 reflector'. This becomes particularly significant when viewed in conjunction with Table 4 of Briggs' paper, in which he proposes radar reflectors up to 100 m^2. To anyone accustomed to conventional terminology, the proposal appears to be for radar reflectors up to ten times larger than the present IMO recommendation. Using Briggs' own terminology, however, it seems he is suggesting reflectors up to forty times that size!

4. *Lens reflectors use different principles but their bulk is similar*. The dimensions of lens reflectors are certainly similar to those of comparable reflectors using arrays of

trihedral. It should be noted, however, that one of the most popular models (nominally 10 m^2 using conventional terminology) weighs over 8 kg, and its manufacturers insist that it must be fitted at the top of a yacht's mast.

5. *the better designs … have … narrow nulls which are usually tolerably shallow. Tolerably* needs qualification, particularly as the polar diagrams of several radar reflectors in my possession show nulls 25–30 dB down from their peak performance; i.e. a reflector whose peak RCS is 10 m^2 can show nulls of less than 0·1 m^2.

6. *Non-metallic vessels always have rather poor RCS. Rather poor* also needs qualification. The mean RCS of a Sonata (a popular class of 7 m sailing yacht) was measured by the Defence Evaluation and Research Agency for the article in Practical Boat Owner, and was found to be 37·20 m^2. Given that a 7 m yacht is one of the smallest seagoing vessels, it seems that Briggs regards 0·1 m^2 as *tolerable* in a radar reflector but as *rather poor* in a yacht.

7. *Combination of reflectors*. Briggs suggests that when two or more reflectors are used in combination, *average RCS is raised*. This is not the case in practice, as was shown by the PBO/DERA tests in 1999, in which five of the reflectors actually reduced the mean RCS.[2]

8. *Necessary detection range*. Briggs argues that IMO requires marine radar to give a clear indication of a standard reflector at 3·5 nm. From this, he deduces that the target RCS should be sufficient to ensure detection at 3·5 nm. To suggest that there is a certain symmetry to this argument is an understatement: it's completely circular!

9. *The intent of the requirement would be nullified if manufacturers or users started to ignore targets below 100 m^2 RCS*. On this, we can agree. I believe, however, that it is a pious hope. Overworked watchkeepers are already tempted to neglect Rules 5 and 6, and to place undue reliance on radar alone. The effect of Briggs' proposal, I suggest, would be to breed a culture in which any small craft without a radar reflector many times larger than those currently available would be dismissed as 'asking for it'.

REFERENCES

[1] Briggs, J. N. (2002). This *Journal* **55**, 23–38.
[2] Practical Boat Owner. (1999). Number 391, July 1998.
[3] Marine Accident Investigation Branch Summary of Investigations No. 1/91 et seq.

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Reply to Tim Bartlett's Comments

John Briggs

I am sorry Tim Bartlett takes amiss parts of my paper commenting on his very worthwhile *Practical Boat Owner* reflector trials (PBO 391, July 1999). Although my paper was mainly addressed to the problem of small ships within SOLAS, his concerns may be shared by other yachtsmen, so the Editor has kindly given me space to reply in detail. All the following refers to the 9 GHz or X band, and sections of my paper are referenced thus (§ 1.2.).

Rather than a précis of the conclusions on the trials results in the PBO article, I drew my own inferences direct from its polar diagrams. 'Good quality 2·5 m^2 reflector' meant, say, Reflector H, (Firdell Blipper 300), and by *RCS never fell below*

10 m^2 is to be inferred from my context *over any arc exceeding 10°*, which scrutiny of the diagrams will confirm.

Table 3 in the PBO article shows the bare boat exceeded 10 m^2 RCS (buff tint) for 40% of 360° (aggregating 144°) and with reflectors, only the anomalous Mobri S4 first run was worse. The screwed up tinfoil (PBO Mark I) was the same and, worryingly, the widely used octohedral only marginally exceeded the bare boat. But Table 3 showed all the other reflectors gave improved angular cover at the 10 m^2 level; the Cyclops 2 for 290°, the Firdell 300 and Cyclops 3 each close to the full 360°.

Yes, reflectors may knock the peaks out of the boat's own response. Dropping odd narrow 1000 m^2 spikes down to say 100 m^2 is unimportant; what matters is secure all-round RCS not less than 10 m^2 for reliable detection in moderate clutter (my Table 3). This was achieved with several of the reflectors but not the bare yacht. Yes, reflectors are bulky. Physics unfortunately dictates they must be to do any good. This is why my paper included discussion of target enhancers.

The PBO article concluded that reflectors sometimes reduced mean RCS. This is puzzling: (a) PBO Table 3 indicates the reverse; (b) theory dictates that when more scatterers, even screwed-up tinfoil, are introduced, mean RCS (but not necessarily RCS on a given bearing) must rise (see my Figure 2); (c) PBO indeed reported three reflectors improved the boat's mean RCS by several square metres. If PBO really have found a reflector that reduces RCS, tell the military, who are always looking for new stealth techniques! Seriously, such anomalies point up the uncertainties associated with all limited trials under sea conditions, e.g. Mobri S4 first run, and reinforce my recommended action (§ 12) that many more … trials should be conducted.

Turning to Bartlett's numbered points:

1. *Magnitude of safety problem* (§ *1.2.*). IMO must consider poor detectability of small SOLAS ships to be a serious safety problem for them to require carriage of reflectors. How far non-SOLAS vessels are jeopardised is for debate. Many owners have voted with their wallets, voluntarily buying reflectors despite the drawbacks of bulk and weight aloft – availability of a wider range of sizes would widen voluntary carriers' choice; the large number of makes trialled by PBO indicates industry finds a market, and one hears off-the-record grumbles from officers of the watch (OOW). A dispassionate formal cost-benefit analysis would clear the air. Any volunteers?

2. *Disc reflectors* (§ *2.1.*). Agreed, a 285 cm^2 flat disc (191 mm diameter) does have 10 m^2 RCS at 9 GHz. BUT only through 9·6° azimuth and elevation angles. Dozens of metal shield-discs would be needed to give a Viking longboat all-round RCS.

3. *Octahedral sizing*. Yes, I recommend larger reflectors in line with my Table 2, based on CIRM calculations. My reason for writing the paper was to point out that the present *10 m*^{2} reflector is a boy on a man's errand when clutter is significant, especially when so-called 10 m^2 octohedrals can exhibit as little as 2·5 m^2 over significant angles (§ 2.2.). It is misleading to categorise devices by their best-possible performance in limited arcs. It is grossly unfair to the better proprietary devices, which have uniform RCS but without high peaks. Instead of the 2·5 m^2 nulls of a *10 m*^{2} octohedral, I would rather trust my life to a device of steady 5 m^2, better still of steady 10 m^2.

4. *Lens reflectors* (§ *2.3.*). I agree with Bartlett's comments. A reflector exhibiting a steady 10 m^2 would still be called 1/10 in my terminology (meaning actual m^2 at 3/9 GHz).

5. *Tolerably shallow* (§ *2.3.*). Means the angular widths of any deep nulls are less

than the yaw and heel (§ 8.1.) of the vessel likely to carry the reflector in its worst clutter. RCS nulls right down to zero through 1° are insignificant on a yacht yawing 10°.

6. *Non-metallic vessels* (§ *2.4.*). *Rather poor* is relative to an all-metal vessel of the same size and shape. I was at pains (§ 5·3.) to argue that detectability is governed by minimum RCS sustained through angles linked to yaw and heel, rather than the average. The bare boat polar diagram includes arcs exceeding 10° through which RCS is well under 10 m^2, despite averaging 37·2 m^2.

7. *Reflector combinations*. See 4th paragraph above.

8. *Necessary detection range* (§ *3.2.*). On test, IMO require radars to detect a reflector at 3·5 nm, this being the range giving the OOW time to assess the target vessel, decide and execute a manoeuvre and retain safe clearance. Today's faster shipping makes some hanker for more, but this would necessitate significantly higher target RCS than proposed in my Table 3. Can serving Masters give their views?

9. *Ignoring small targets* (§ *7.2.*). The laws of physics dictate that a low-RCS vessel in heavy clutter amid shipping is undetectable to the best OOW in the world and in Bartlett's phrase 'asking for it' already. Should we deter cyclists from wearing reflective clothing because those in black are hard to see at night? Surely we must assume professional and amateur seafarers usually act in a seamanlike manner and do their best to avoid collision, as required by law. Maybe adequate reflectors would help them see and be seen.