

⁴ Hollingdale, S. H. (1961). The mathematics of collision avoidance in two dimensions. *This Journal*, 14, 243.

⁵ Kemp, J. F. (1965). Some suggestions on the rules for preventing collision at sea. *This Journal*, 18, 233.

‘The Sector Rule and the Collision Problem’

Captain García-Frías has made the following comments on the discussion of his recent paper (this *Journal*, 18, 141) contributed by E. S. Calvert and S. H. Hollingdale.

CAPTAIN García-Frías observes that while Calvert and Hollingdale recognize that this paper combines his earlier suggestion for a sector rule with a set of manoeuvring rules, they have failed to recognize the fundamental distinction between the structural and operational aspects of an encounter; his proposed manoeuvring rules deal with the operational aspect. These rules differ from the manoeuvres they have themselves proposed in that they depend only on the bearing of the target as seen on the radar at a distance of 2 miles; they derive from his sector rule and do not require a quantitative estimate of the miss distance. His rules are only the same as their manoeuvres for the case of a steady bearing since their manoeuvres also require the sign of the miss distance.

They also fail to recognize the extent to which his sector rule can take the place of ‘aspect’ and ‘the seaman’s eye’, in a visual encounter, when shaping a prudent approach by radar only. It is certainly true that his manoeuvring rules and their system of manoeuvres require the same basic information from the radar; they are the essential elements for any solution, but with his proposed rules the information provided by the radar is applied directly and without the analytical procedure which their manoeuvres require.

The acceptance of the 2-mile range is not a matter of cooperation between the vessels involved, it is the distance judged to be necessary for prudential action to prevent the distance closing to one mile. To propose minimum and maximum speeds for vessels with and without radar is the only way to meet the problem where radarless vessels are concerned and the principle is already acceptable for hovercraft &c. A certain degree of cooperation between vessels is in any case inherent in the Steering and Sailing Rules. To clear up any confusion between the 2-mile and 2.5-mile limits it may be repeated that Rule 16(c) prescribes two miles as the distance within which both the vessels concerned should take proper action to check the approach. The 2.5-mile range is only mentioned in Rule (a) and relates to only one of the vessels concerned.

The proposed Rule 16(c) does not, as they suppose, require a vessel to alter speed or make a larger turn than 60° port or 120° starboard when the target is two miles distant; changes in speed are optional and large changes in course are only prescribed ‘if necessary’, the sector rule being kept as a last resort. They are also wrong in supposing that initial course and speed can only be resumed when it is clear that the danger is over; the vessel will in fact return to her former course

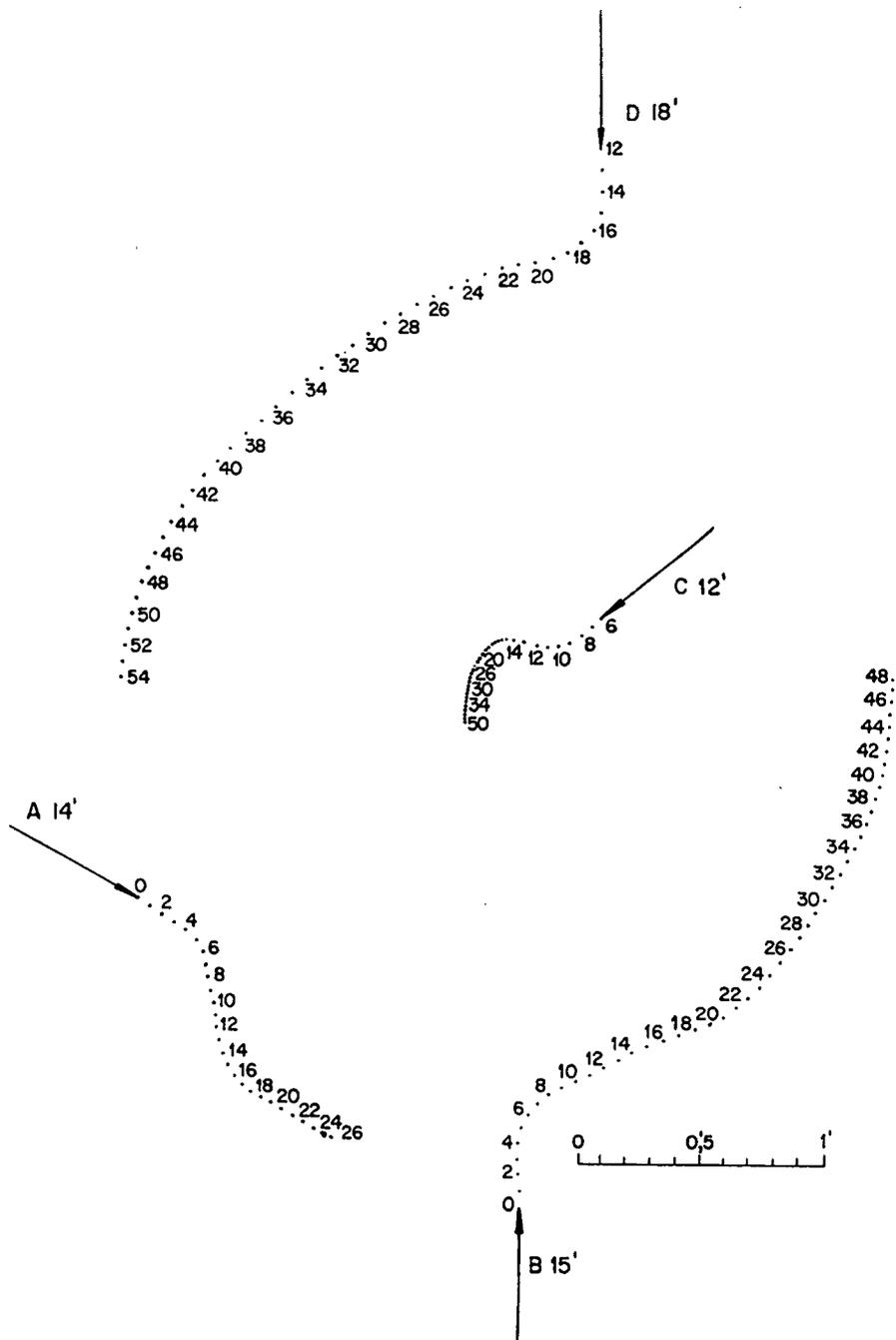


FIG. 1.

as the manoeuvre develops and also to her original speed, if she had chosen to alter speed at all.

Dealing with the multi-vessel situation, they ask how several vessels can 'arrive at the critical manoeuvring range at about the same time'. In fact, any vessel will take action when she comes within 2 miles of any other of the group. Any 'inner' vessel is free to maintain any speed not exceeding 6 knots and to steer any course, subject to the provisions of Rule 16(e). Captain García-Frías offers another diagram and explanation to clarify the multi-vessel situation.

When vessels A and B are at position 6 (about 2 minutes after they have begun the operation) C enters the group, arriving within 2 miles of B. A continues her operation with respect to B as before, since her pivot-vessel has not changed. B, however, now has C for pivot-vessel. When A, B and C have reached position 12 (about 4 minutes after the operation began) D enters the group on arriving within 2 miles of C. C now becomes an 'inner' vessel as she is within the polygon ABC and reduces speed to 6 knots under Rule 16(e); she also steers towards the centre of the polygon waiting for the group to disperse. As C is now pivot-vessel for B, and within 2 miles, B rotates on the contour with respect to C. In the same way, D rotates on the contour with respect to A who will resume her original course at position 19. B is back on course at 44 and D at 54. Meanwhile, C ceases to be an 'inner' vessel as soon as the range of either A or B begins to increase and she is then only concerned with D, under Rule 16(c). As to the sea room required for the manoeuvre, the radius of the contour is about 1 mile and the vessels will have resumed their courses after an interval which varies between 6 minutes for A and 14 for B.

The comment by Calvert and Hollingdale poses five questions, to which Captain García-Frías makes the following replies:

(1) Whether or not the system will be accepted and practised by seamen is hardly a matter which can be settled at this stage.

(2) That the establishment of traffic lanes might be a good way of solving the collision problem is beside the point; as long as there is the possibility of such encounters there is a need for anti-collision rules. Furthermore, the proposed rules do provide for an early resumption of course and speed.

(3) No doubt, given time enough and sea room, ships could get themselves out of danger, but the proposed operating range of 2 miles is a good deal less than is often considered necessary and with the proposed rules it is shown to be sufficient. In this connection, the basic distinction between the organic and operational aspects of the situation is not something one can overlook.

(4) The proposed rules do tell the mariner what manoeuvres he can safely make, and they are not self-cancelling. It may also be doubted whether their 'neutral diagram' does actually resolve the marginally negative encounter. This is why the distinction between the organic and operational aspects is so important.

(5) It would be rash to reduce the minimum range for collision avoidance, or to fix minimum or maximum speeds, if the rules did not also embody the sector rule as a guarantee of the safety of the manoeuvre.

Finally, as to the suggestion that a multi-place simulator experiment should now be organized, Captain García-Frías points out that this is exactly what has been done with the simulator equipment at the Naval War College, Madrid. The equipment provides for eight ship echoes and is the type used by the Royal Navy for tactical exercises.