

graphical presentation, either on the PPI itself or on a separate cathode ray tube.

Graphical presentation on the PPI has the great attraction of permitting the observer to concentrate on one instrument and avoiding any problem of identification between the echo and the tracks referring to it. However, it is quite essential that the method of displaying the tracks on the PPI should not cause any significant obscuration of echoes.

One further and highly important factor is that of the permissible delay in providing any particular piece of intelligence when the need for it arises. Supposing that the observer was using a conventional PPI and was dependent upon the echo trails for giving him either true or relative information; apart from the normal imperfections of this source, a change from relative to true presentation or vice versa involves a delay of several minutes for the new trail to build up. This kind of hiatus would be quite unacceptable in connection with the ultimate need; only a very few seconds delay would be tolerable. Also, the normal radar picture on the PPI must continue to show the latest position of all echoes to within a few seconds.

The requirements for this kind of presentation, which would leave the navigator with little to do but concentrate intelligently on the information displayed so coherently, may be summarized as follows:

(i) To show, on the PPI, on demand and with minimal delay, the tracks of all vessels simultaneously, whose echoes are on the screen;

(ii) The tracks to be relative or true at choice and to extend over a maximum period to be determined, up to the latest positions of the echoes;

(iii) The execution of this choice must not cause any displacement in the positions of echoes on the screen;

(iv) The tracks to show time intervals, from which speeds may be assessed; an indication of own ship's speed in a similar manner would be a great convenience;

(v) There must be no significant obscuration of echoes by the tracks;

(vi) Means should be provided for showing the effect upon the relative tracks of an intended alteration of course and/or speed.

This arrangement will suggest that neither computers nor any form of automatic plot, operating on a limited number of pre-selected echoes, will meet the ultimate requirement, however graphic the presentation of intelligence may be. This is thought to be true, whatever kind of ship is in mind, but it is quite certainly so in the very large number with one officer on the bridge.

Some Suggestions on the Rules for Preventing Collision at Sea

from J. F. Kemp

IN recent years the Regulations for Preventing Collisions at Sea have been the subject of considerable interest to mathematicians. It has been demonstrated that the

Rules as they stand are not entirely satisfactory, and this confirms a certain uneasiness which most navigators have in this respect. One of the imperfections in the Rules is that they are not universal: they do not apply in fog, when vessels are not in sight of one another, they do not apply to certain classes of vessel, they are affected by limitations of weather and sea-room, and so on. It does not seem unreasonable that a set of Rules could be devised, based on the mathematical work lately carried out, which would be more rational than the present Rules. Discussion of this problem in a general way has seemed inconclusive, and so I have taken the bull by the horns, and suggested amendments which might be made to the present Rules as a basis for perhaps more fruitful discussion. In arriving at these amendments, I have had the following points in mind:

1. *Practicability.* Since any changes in the Regulations for Preventing Collision at Sea have to be agreed internationally, it is important that changes should be of such a character that this agreement is at least a possibility. It might be desirable mathematically to have a clean sweep and construct a completely new set of Rules, but such a measure would not be feasible politically. Alterations and additions have therefore been kept to a minimum, and radical changes in format have been avoided.

2. *Acceptability.* It is not much use constructing a mathematically perfect set of Rules if they are not to be obeyed. A law which is not obeyed and which cannot be enforced is not only bad in itself, but brings the law in general into disrepute. This aspect is one which does not appear to enter much into discussion, perhaps because it is difficult to represent by a mathematical symbol, but it is nevertheless very important.

On the high seas the enforcement of a rule is extremely difficult, and if it is to be obeyed it must be evident to the user that it is a reasonable rule, and that it is likely to be effective. It should not require a delay or deviation which is incommensurate with the danger of the situation which it seeks to resolve (no use routing ships north about to avoid dangers in the Dover Strait). Furthermore, the rule must be simple so that it is easily comprehended and easily applied with little risk of misunderstanding, and hence mistaken action. In this respect the work of Calvert and his associates is significant. The most important advantage of the Calvert diagram is its simplicity of action so that a rule based on its use does not need to be complicated.

3. *Assignment of Responsibility.* Responsibility for taking action to avoid collision should be assigned initially to one party (except in the special head-on case). This is an important principle of the present Regulations, but even so, the second party is still required to take action (under Rule 21) when the encounter develops beyond a certain limit. Many people consider this limit to be too late. It is considered that under the amended Rules responsibility should continue to be assigned initially to one party, but that the other party should be allowed (although not in general required) to manoeuvre at an earlier time. The assignment of responsibility to one vessel was deliberate policy when the regulations for preventing collision were first drafted. This was in order to avoid a situation in which every vessel would be responsible for avoiding collision, and there would be a tendency for each party to an encounter to delay manoeuvre in the hope that the other party would take the necessary action. Dual responsibility appears to be undesirable in practice, although perfectly feasible mathematically. It is considered that it would lead to uncertainty and delay in manoeuvre, and

that an irresponsible fringe might abuse such a system by making no alteration at all, depending solely on the action of the other party to avoid collision.

4. *Rotation of Sightline.* A set of rules based on the Calvert diagram must derive from convention as to the rotation of the sightline. The preference of the existing Regulations, implied in Rules 18, 19 and 22, is for an anti-clockwise rotation. The suggested amendments to the Rules make an anti-clockwise rotation a requirement instead of a strong recommendation. Account is taken of the fact that a vessel is generally in a position to alter course or if necessary to reduce speed or stop, but frequently it is not possible for a vessel to increase speed. The amendments have been framed so that in no case is a vessel required to increase speed, although in certain cases it is permissible to do so.

5. *Communication.* It is considered that communication between the parties to every encounter will not be practicable within the foreseeable future, and the amendments have therefore been framed so that under normal circumstances reverse manoeuvres, i.e. those requiring a clockwise rotation of the sightline are unnecessary. Exceptional circumstances requiring departure from the Rules would be covered as now by Rule 27.

6. *Restrictions.* All rules imply certain restrictions: a feature of the present Rules is that, except in the head-on case, a wide choice of action is allowed to the vessel which has to give way. The standing-on vessel, however, has its course and speed severely restricted by Rule 21. The changes suggested are in effect to allow the present standing-on vessel considerably more freedom of action, in return for the acceptance of a moderate degree of additional restriction by the giving-way vessel. The end effect of this adjustment would seem to be that overall the freedom of action between the parties to an encounter would be increased.

7. *Form of the Rules.* The present Rules do not, except again in the head-on case, require specific action to be taken in an encounter between two ships. They lay down obligations, e.g. when two power-driven vessels are crossing so as to involve risk of collision the vessel which has the other on her own starboard side shall keep out of the way. They lay down restrictions, e.g. every vessel which is required by these Rules to keep out of the way of another vessel shall avoid crossing ahead of the other vessel. And they lay down permissive actions, e.g. whenever a power-driven vessel, which under these Rules is to keep her course and speed, is in sight of another vessel and is in doubt as to whether sufficient action is being taken by the other vessel to avert collision, she *may* indicate such doubt by giving at least five short and rapid blasts on the whistle.

The suggested amendments take a similar form to the existing Rules, the changes being very few:

Rules 17–20. No change required.

Rule 21. Where, by any of these Rules, one of two vessels is to keep out of the way, the other shall keep her course and speed, or take such action as will contribute to the avoidance of collision, in accordance with Rule 22.

Rule 22. A vessel which takes action to avoid collision with a vessel on her own starboard side shall avoid crossing ahead of that vessel. A vessel which takes action to avoid collision with a vessel on her own port side shall avoid crossing astern of that vessel.

Rule 23. Every power-driven vessel which is directed by these Rules to keep out of the way of another vessel on her own starboard side, shall on approaching her, if necessary, slacken her speed or stop or reverse.

Rules 24–27 and 28a. No change required.

Rule 28b. Whenever a power-driven vessel, which under these Rules is keeping her course and speed, is in sight of another vessel, and is in doubt whether sufficient action is being taken by the other vessel to avoid collision, she may indicate such doubt by giving at least five short and rapid blasts on the whistle. The giving of such a signal shall not relieve a vessel of her obligations under Rules 27 and 29, or any other Rule, or of her duty to indicate any action taken under these Rules by giving the proper sound signals laid down in this Rule.

Rules 28c, 29 and 32. No change required.

At this stage it would seem reasonable to leave Rule 16 and the annex on the use of radar as they stand. The situation at short range would thus remain unchanged, but the amended Rules would bring the action which may be taken at long range from radar information into line with that which would be taken in clear weather under similar circumstances. This would mean that the section in the preliminary to the Steering and Sailing Rules of the 1960 Regulations, to the effect that they should be used only when vessels are in sight of one another, would be redundant.

The examples illustrated (Figs. 1–4) show the manoeuvres which might be made in the course of four typical encounters under the existing Rules, and under the proposed Rules.

From consideration of these four cases it is clear that for vessels meeting head-on the prescribed action is identical under both the present rules and the suggested amendments. For crossing vessels or for a vessel overtaking another vessel from the port quarter of the overtaken vessel, the action required by a vessel obliged to give way is that which is already implied by the present Rules, but the other vessel is given options other than maintaining course and speed.

A vessel which is overtaking another from the starboard quarter of the overtaken vessel provides the only case in which the action taken by the vessel obliged to give way is radically different from that implied by the present Rules. Even if difficulty is experienced during the transition period, it would not seem potentially dangerous in this particular case. What may feel unnatural to the established mariner is that a giving-way vessel should cross ahead of the vessel she is keeping clear of, but, in fact, there is in general no reason why a fast ship should not use her speed in this way to keep clear of a slower ship. Where danger lies is when each of two vessels attempts to cross ahead of the other, or when each of two vessels attempts to pass astern of the other.

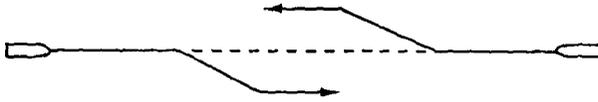
In conclusion I should perhaps reaffirm that the amended Rules I have suggested are not intended to be cut and dried, but are presented as a basis on which further discussion can be built. They are presented not from the point of view of the mathematician or of the lawyer, but from the point of view of the seaman.

CASE I (Fig. 1). *End-on or nearly end-on meeting.* No change in procedure under amended Rules, save that similar action should be taken in fog.

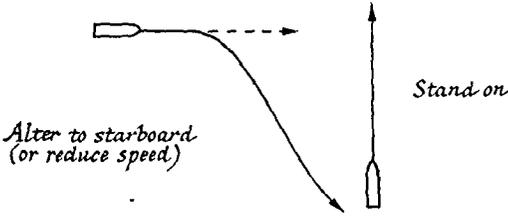
CASE II (Figs. 2a, 2b). *Crossing vessels.* Under the present Rules (2a) only part of the potential manoeuvring space may be used. Not applicable in fog. Under the proposed Rules (2b) all potential manoeuvring space may be used, which may be important in restricted waters or high traffic density. Not applicable in fog.

CASE III (Figs. 3a, 3b). *Overtaking from port quarter.* Present Rules (as in 3a). Proposed Rules (as in 3b).

CASE IV (Figs. 4a, 4b). *Overtaking from starboard quarter.* Present Rules (as in 4a). Proposed Rules (as in 4b).

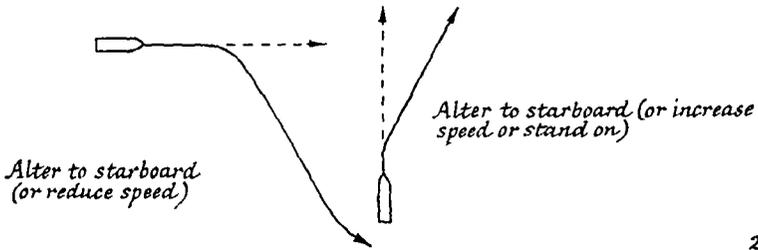


1



*Alter to starboard
(or reduce speed)*

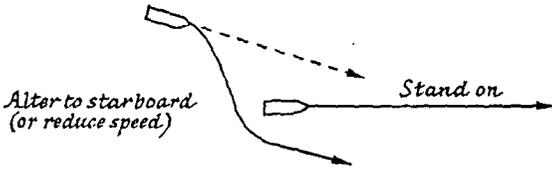
2a



*Alter to starboard
(or reduce speed)*

*Alter to starboard (or increase
speed or stand on)*

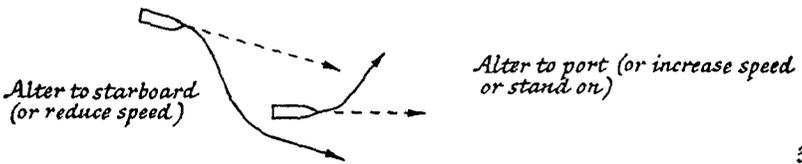
2b



*Alter to starboard
(or reduce speed)*

Stand on

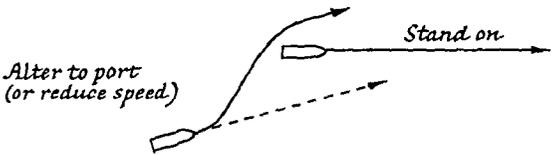
3a



*Alter to starboard
(or reduce speed)*

*Alter to port (or increase speed
or stand on)*

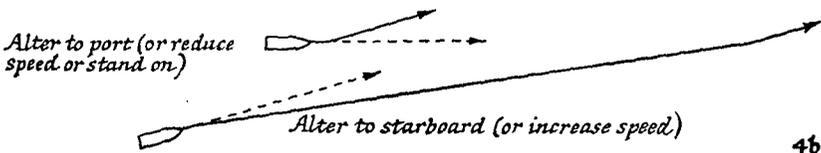
3b



*Alter to port
(or reduce speed)*

Stand on

4a



*Alter to port (or reduce
speed or stand on)*

Alter to starboard (or increase speed)

4b

FIGS. 1-4. Changes proposed in the present Rules

Most navigators have at some time or another felt dis-satisfaction with some aspects of the Regulations for Preventing Collisions at Sea. It might be a general feeling that the Rules are not always definite enough in assigning responsibility for manœuvre, or it might be more specific, as for instance, that it would be a dangerous practice if Rule 21 were always followed to the letter. This dis-satisfaction is a good thing, because it has meant that the rules have evolved over the years to meet the changing situation in which they are operated. In the latest Rules, agreed in 1960 but not yet in force, amendments have been made to take account of the fact that for instance most sailing vessels are not nowadays square rigged. It is in this context of a living and evolving set of Rules that I have made my suggestions. Looking to the future when maritime traffic will be heavier and faster, and when the disparity in performance between individual vessels will be greater, it would seem very desirable to have a set of Rules which could be used equally well in thick or clear weather conditions and by all types of craft. It might be that we cannot afford quite such a leisurely rate of change in the future as we have enjoyed in the past. [Some discussion on these proposals follows. Further contributions and a reply from Captain Kemp will be published in the next number. *Ed.*]

Captain F. J. Wylie writes:

This is an admirable, even though it may be an unsuccessful, attempt to make the Rules more simple and rational by infusing into them the basic precept of the mathematical approach, the rotation of the bearing or sightline in an anti-clockwise direction. The extent to which it may be practicable to mate this excellent and rational precept with the irrationalities of the maritime scene, of human judgment and behaviour and of the elements, remains to be seen. Meanwhile this proposal should start a useful and lively discussion.

To take up for a moment Captain Kemp's criticism of the weakness of the present Rules, I think that to say they are not entirely satisfactory will be found to be high praise when any other system is put under the same microscope! I understand that his comment, that they do not apply to certain classes of vessel and are affected by weather and sea room, is intended to refer mainly to vessels hampered by tows and other handicaps which might not be immediately evident. I do not think his proposals do anything to improve on present conditions in these respects.

The basic element of change in Captain Kemp's proposals is to give limited freedom of action to the stand-on ship in Rule 21, which relates, of course, to Rules 19 and 24. As a direct consequence of the loosening of Rule 21, there is a tightening of Rule 22 to ensure anti-clockwise rotation of the bearing or sightline. In defining Rule 22 he omits for some reason the emphasis on early and positive action which was added to the Rule in 1960.

In pursuing his plan he has had to drop the opening words of Rule 22 and substitute 'a vessel which takes action to avoid collision'. This expression is difficult to interpret precisely and it would seem to refer not only to encounters which begin with a steady bearing but also to any attempt to increase a passing distance. This would entail deviations which would be intolerable and may not be intended but, as has been pointed out before, the difficulty, not to say impossibility, which any precise directive always encounters is that of defining the limits within which the rule has to be operated.

One great virtue of the present Rules 19 and 24 is that the problem of deciding whether action is necessary is the responsibility of one ship only and action is restricted to the same ship. No two people will make exactly the same estimate of the degree of risk in a particular encounter. For example, if in the diagram for Case III, Proposed Rules, of Captain Kemp's article, the overtaking ship has decided that all is well but the overtaken ship takes the opposite view, the latter will impale himself on the other's bows. This is not an absurdity! What bi-lateral Rule based on estimate of risk can prevent it happening? If the Rule is not based on risk it cannot make sense in the maritime context.

Precisely the same considerations apply to the crossing situation. Hundreds of safe passings ahead occur every day. If what is at present the give-way ship decides that he can safely pass ahead but the other alters course to starboard and increases speed because he finds the situation dangerous, the latter action cannot surely be regarded as making things safer even if it is more rational.

For these reasons, confining the Rules to allocation of responsibility and restricting the action under Rules 19, 21 and 24 to one of the two ships is a vital consideration, particularly when time is short, e.g. sighting in poor visibility but, though an obvious, simple and rational arrangement, it is inclined to be forgotten by the apostles of change. It works well in the two ship encounter, but has even greater advantages in the multi-lateral situation.

If anything is required, it is a reduction of uncertainty. One absolute certainty in the present Regulations is contained in Rule 21 and its unequivocal nature is not really invalidated by the last-minute escape clause which it contains. However, it is utterly destroyed in Captain Kemp's amendment. He puts very clearly in his para. 3 the objections to dual responsibility for taking action but his Rules do not follow this out.

Finally, there is the question of applying the Steering Rules in fog. The importance of showing that the present (bi-lateral) Rules can only be effective when ships can see one another was dealt with at length in an article in Volume 3 of this *Journal* and in Chapter 10 of *The Use of Radar at Sea*. I think that the reasons given must apply to any system of Rules which depend upon the mutual cooperation of two parties. Whatever changes Captain Kemp has suggested, he leaves the Rules unequivocally bi-lateral, which, I think, involves the necessity to be assured of the cooperation of 'the other ship' before any reasonable assumption of safe action can be made. I do not think any judge will blame a ship for making the assumption if there is direct vision, because then all uncertainties and the presence of factors which might dictate behaviour, e.g. a fishing fleet, may be eliminated. To apply bi-lateral Rules in fog must surely imply every ship's ability to detect 'the other ship' (however many there may be) other than by sight and to obtain instant confirmation that its behaviour at any moment is in accordance with those Rules. Obviously, this implies complete reliance on electronics and is, in any case, ahead of our time.

Apart from this aspect of the matter, the suggestion that both Rule 16(b) and Rules 17 to 24 can be in force at the same time in fog is not, I think, a proposition which would lead to greater certainty or confidence on the part of mariners. It introduces what I believe to be the most dangerous kind of system, one in which the nature of the action required changes at a time which cannot be precisely defined. A change between the state of seeing and that of not seeing presents, in my view, no particular difficulty, but a change based on proximity with the possibility of concurrent operation of two systems cannot be regarded with equanimity.

S. A. Azad writes:

Captain Kemp's note seeks international agreement on the use of a code of action which Calvert held to be entirely consistent with the existing regulations. I think Kemp is right in the belief that it requires international agreement and wrong in seeking such an agreement, because the code is potentially dangerous.

Clearly the 'nearest approach' distance can be increased if the two ships cooperate, but I suggest that such cooperation should only be permitted if the required manœuvres stand up to the following tests:

1. They should be practicable for all ships to which they apply.
2. They should in themselves be safe so that the danger is not increased by the failure of one ship to take the required action.
3. They should not increase the speed of approach.
4. They should remain safe up to the last minute or so before a collision.

I do not think the proposals stand up to these tests. Let us consider three situations which must occur very frequently.

1. A and B are two sailing vessels, both running free. It is proposed that A must cross ahead of B (Fig. 1).
2. Using the same diagram, let B represent a power-driven trawler or a power-driven vessel engaged in surveying &c. A sailing or power-driven vessel A must not pass astern of B.
3. Both A and B are power-driven vessels and a close-quarter situation has developed and there is a risk but not a certainty of collision. It is proposed that if B cannot increase speed she must alter course to port (Fig. 2).

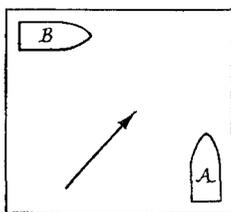


FIG. 1.

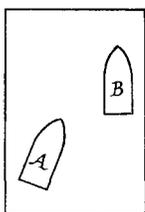


FIG. 2.

In the first two cases the proposals fail the first two tests: it is probably impossible for A to cross ahead without the cooperation of B, and B might fail to cooperate. In the third case the proposals fail the last two tests.

But while Kemp's proposals fail to pass these tests, I share his conviction that there would be fewer

collisions if both ships cooperate, and I hope it is not the last we shall hear of that idea. I can see no good reason for making cooperative action conditional upon an anticlockwise rotation of the line of sight. After all, even a clockwise rotation is preferable to no rotation at all.

Lt. Commander P. C. H. Clissold writes:

Anyone suggesting alterations is placed in a dilemma. If, as the author says, the proposals are too sweeping, the measure would not be feasible politically. If, on the other hand, they are not sufficiently general, the criticism is that such small improvements are not worth all the trouble necessary to get them accepted. Nevertheless, avoidance of collision is so important that no pains should be spared to perfect the Rules.

The proposals are very attractive. Any change which will remove the difference between the actions taken by ships when not in sight of one another and when in sight of one another is to be welcomed. An additional reason for permitting the stand-on ship to take avoiding action earlier is that very fast craft—hovercraft and hydrofoils—now coming into use, will *have* to do so since ships which are much larger and much slower will be unable to avoid them. Some detailed comment follows:

The proposal of assigning responsibility to one party (excepting the end-on case) as at present, but allowing the stand-on ship more freedom of action, seem excellent and desirable.

Rule 22 (Crossing ships, illustrated in Case II). There is a difficulty here. At present the stand-on vessel (ship B, heading north), if in fog, may reason like this: 'Ship A has either observed me, in which case he will presumably alter course to pass under my stern; or he has not observed me, in which case he will presumably keep his course and speed. It would be foolish of me to stand on into a close-quarter situation. I must not alter course to port in case he alters to starboard; if I alter course to starboard it will merely prolong the crossing. I shall therefore reduce speed drastically until I see what course ship A is pursuing.'

Ship B might be held to be breaking the proposed new Rule 22, yet her action would be, I think, entirely seamanlike. She would be committed to an alteration of course to starboard by the new rule: perhaps this would be acceptable.

Perhaps a sentence such as: 'Alterations of course to port are to be avoided' might be added.

Rule 23, I think, should be left unchanged.

Case III and IV Present Rule. Overtaking ships are merely told to keep clear and are not directed to alter course in any particular direction.

Latitude by Maximum Altitude

from J. W. Crosbie

LATITUDE by meridian altitude is one of the commonest position lines used in the Merchant Navy today, and the traditional method of obtaining it is to observe the Sun until it reaches maximum altitude, at which point it is said to *dip*. With the advent of power-driven vessels, however, this method became liable to an error of 5 minutes of arc,¹ and as faster surface craft are developed it is reasonable to assume that the error could be even greater. This is because the rate of change of altitude of a body is related to the observer's speed over the Earth so that the body will *dip* either before or after meridian passage depending on whether the observer is moving towards or away from the geographical position of the Sun.

Modern textbooks on navigation recommend that meridian altitudes be observed at the calculated time of meridian passage,^{1,2} which normally presents no problem to the Merchant Naval officer as it is customary for him to find his 'Longitude by Chronometer' before noon. The old method of observing the maximum altitude is, however, still widely used and may be defended on the grounds that its error is limited by the ship's north-south speed, whereas with