FORUM

An Examination of Criticisms of Automatic Radar Plotting Systems and their Advantages in Relation to Manual and Semi-auto Systems

Captain F. J. Wylie, O.B.E., R.N. (retd.)

CRITICISM of the automatic (computerized) plotting systems has so far concentrated on the supposed danger of inadvertent hiding, through immaculate presentation, of the effects of radar, gyro and applied own speed errors, which could lead to false assumptions on the situation being made. However, although not stated in the criticism, the errors in question affect all methods of plotting, so that if the charge is valid it is a challenge to the usefulness of radar plotting as an aid to avoiding collision at sea.

The suggestion made is that the efficiency and assurance which the automatic presentation is thought to imply will deceive the observer and lead him to neglect the possibility of error; it also carries the implication that there would be difficulty in teaching otherwise efficient and cautious mariners to be conscious of the possible presence and magnitude of such effects. Whether in fact experienced seamen would have more complete confidence in intelligence presented to them on a plate, so to say, than in the result of their own careful and intense labour is certainly debatable but, as it is hoped to show, the automatic presentation excels so immeasurably that of any other system that the question is rhetorical. One factor which is incontrovertible is that they will have very much more time to study the intelligence offered by the automatic systems and to draw conclusions from it than they have when they are tied up in its production.

A great deal of what the critics say is based on scientific facts and practical generalities and, when general statements founded on these premises are made by otherwise reputable and informed authorities, they may carry much weight, far more, when one descends from the general to the particular, than they deserve.

References have been made to errors inherent in the radar and gyro systems and in the figure provided for own ship's speed either by log or estimation. The magnitudes of these depend on circumstances including the state of the sea, the size of the ship, &c. but, however this may be, they will affect plotting by any method and be hidden in whatever method of presentation is employed. Incidentally, they will also affect the intelligence derived from true motion radar, which some regard as a substitute for plotting. The slower and (for the observer) more cumbersome plotting methods may be affected more seriously than those in which the radar data is up-dated every scan.

So much value is rightly attached to the practice of plotting, in whatever form, as a means of extracting useful information from simple radar data, that one should examine closely the criticism which appears to discredit it. One

https://doi.org/10.1017/S0373463300025212 Published online by Cambridge University Press

should be clear about the legitimate area of application of the criticism and of the magnitude of the stated errors, in relation to the accuracy needed in the intelligence ultimately offered to the Master of the ship.

The area of concern is the use of radar to avoid collision in poor visibility; the poorer the visibility the more dependence has to be placed on the radar, and the more accurate the intelligence needs to be. Very poor visibility is seldom accompanied by heavy seas; hence rolling and pitching of the ship is unlikely to be substantial in the circumstances which demand high accuracy. The larger the ship, the less will it be affected. The steadiness of the ship contributes to a reduction of radar bearing error.

In merchant vessels, where the master gyro is normally placed at or near bridge level, bearing errors are similarly caused by excessive movement of the ship. In this case additional causes of bearing error are rapid acceleration or deceleration and rapid turns. Such movements are not characteristic of medium or large tonnage merchant ships. Here again it seems that, in the circumstances in which high accuracy is needed, errors of significance are unlikely to be met with, while the factors which might give rise to larger errors are not of a kind which mariners would find any difficulty in recognizing, and so in being on their guard.

Mention has also been made of errors caused by the application of incorrect figures for own ship's speed, whether by submerged log or by estimation. Data direct from the radar is relative to own ship, stabilized in azimuth by the gyro; relative intelligence such as C.P.A. distance and time will not, therefore, be affected by own speed errors. Deviation of target course will vary as the sine of the angle between it and own ship's course, so it will be zero when the courses are opposite or parallel and maximum when they are at right angles. It is interesting that the error will be small in the difficult head-on encounter. The size of the error also varies with the reciprocal of target speed.

The radar intelligence derived from radar data, time and own ship's course and speed falls into two distinct categories, for which different degrees of accuracy are needed. 'Relative' intelligence conveys degree of risk of collision and is expressed as target bearing and distance at the moment of its predicted closest approach (C.P.A.) and the time which will elapse before that point is reached; fundamental to this is, of course, the predicted relative track of the target, involving its course and speed relative to own ship. 'True' intelligence comprises the estimated true course and speed of the target ship and its aspect as well as the predicted future positions of both ships, obtained by forward plotting.

The accuracy required of 'Relative' intelligence is high since small errors in the data at medium and long range may cause considerable errors in predicting the C.P.A. This intelligence is based only upon changes of target bearing and range with time, in which the errors, in the circumstances already described, should be within acceptable limits, particularly with the automatic systems in which the data is up-dated every scan (3 secs).

Since the true movement and aspect of the target are the main features of 'True' intelligence and since these are required mainly in connection with decisions on evasive action, the accuracy needed is not so high. The total of the instantaneous values of the radar, gyro and own speed errors is unlikely to be great enough seriously to affect choice of action, particularly if the plotting system includes a trial manœuvre facility.

In short, when the generalized criticisms of the fully automatic radar plotting systems are put into the perspective of practical use, they are found to be restricted to ground which is shared by all plotting systems and to refer to errors which on the whole are manageable. Conditions which are conducive to larger errors are easily recognizable and should be an integral part of any scheme of teaching on the subject of plotting. All this is borne out by the already considerable amount of experience that has been gained in the operation at sea of fully automatic systems.

Automatic versus manual. In a paper dealing with adverse criticism of automatic systems, and showing it to be based upon factors which can equally affect even the simplest form of plotting, it seems appropriate to draw attention to some of the deficiencies of the older forms from which the fully automatic plotter can release the safety seeking sailor.

The principal deficiencies of the manual transferred plot, the simplest perhaps, lie within the observer/PPI combination; they are poor accuracy, slow delivery, low maximum capacity and fatigue. The PPI is a poor discriminator of small changes of bearing and this leads to the first three of the deficiencies mentioned and, in considerable degree, to the fourth. The observer can only deal with one problem at a time concerning one echo at a time. So, if there is more than one target to study, the delay in providing the required intelligence accumulates in proportion. The delays can, of course, be cut by using other forms of manual or semi-automatic plot; with the reflection plotter the observer does not have to read off the range and bearing, but the need to use a grease pencil reduces accuracy and it has other disadvantages.

Everyone concerned with radar plotting knows that every system has a limited capacity, in terms of the number of targets which can be dealt with and of the quantity and quality of intelligence which can be provided for each. In a situation of increasing congestion every system has a point of saturation and expiry and, with human operation, this will be well within imaginable circumstances. The cause of the expiry makes obvious that it will occur at a point when the need for intelligence is most urgent. At some earlier point of time the quantity and quality of intelligence will begin to fall off.

Each Master will have his own ideas of what he requires from the plot but, for the sake of argument, in a multi-ship situation he may have to divide targets into three categories—fully plotworthy, worth watching and negligible; for the first group he will need C.P.A. distance and time, true course and speed and aspect; for the second, occasional check on C.P.A. and, for the third, nothing but a note to see that they remain negligible. All these items, including the correctness of categorization, will need to be checked at short intervals, as will the status of new arrivals on the screen. All this represents a great deal of high pressure work, rapid study and decision. The regular checking of the important items is a cycle which will be repeating every three or four minutes perhaps; this implies that intelligence will be three or four minutes out-of-date before it is up-dated. If time has to be taken to plan an evasive manœuvre, out-of-dateness will increase and a similar dead time occurs when own ship alters course or speed, as the plot must be restarted when she is steady again.

How can this unsatisfactory situation be eased by the use of a fully automatic system? To begin with, a device such as Digiplot will process over 200 of the nearest targets, ranking them in priority and displaying the closest, most dangerous 40, on the bright screen. This is without human intervention. If 'Relative' intelligence is required the plot will show an appropriate relative vector leading

https://doi.org/10.1017/S0373463300025212 Published online by Cambridge University Press

ahead from each target, a line whose direction is that of the relative track and whose length shows the distance along that track the target will proceed in the time interval set on the control. The control can be set so that the end of the vector of a particular target is at the C.P.A. and the time to C.P.A. can then be read off (0–69 minutes).

This control is the future position control and, more than any other perhaps, it demonstrates the grip on understanding the situation which the observer with a fully automatic plotter is able to maintain. Merely by moving it step by step, in quick succession or more slowly, the expected development of the whole situation is unfolded minute by minute; the critical points in a multi-ship encounter may be detected well in advance, approximate passing distances observed, the best place to cross a line of traffic determined or the undesirability of doing so made apparent. All this without losing the permanent up-to-dateness of the plotted picture and all expressed in terms with which the trained observer is completely familiar.

If 'True' intelligence is required, the plot will show vectors indicating the true course of each target; in this case the length of the line will represent the distance run at the true speed in the time interval set on the control. The approximate aspect can be gauged from the bearing and true course shown on the display.

If a more accurate estimate than can be made from the display is required, of bearing, distance, course, speed, or C.P.A. distance and time, of any target on the screen, that target may be 'marked' electronically and the item needed read in a window on the console. As far as continuity is concerned, there is no break whatever in the delivery of intelligence. Changes of scale, which are independent of the parent radar, orientation or mode, do not interrupt it. Even when own ship is changing course and/or speed, the computer continues its work and the course of a threatening target can be watched during the change.

Concerning up-to-dateness, target positions are up-dated every scan (3 secs) and the ranking of echoes for display is revised every 15 seconds. A change of course by a target will appear in about 15 seconds. It is hardly necessary to add that all targets are dealt with simultaneously or within a scan.

The fully automatic system, therefore, provides the Master with a continuous supply of intelligence in the form in which he needs it and with a minimum of delay. He can switch from Head-up to North-up, from true to relative motion and from scale to scale, and receive intelligence instantly from the new viewpoint; he can study the effect on the situation of a projected alteration of course or speed, or several alternatives, within a few seconds. It can readily be seen that with such equipment time will be available to spend in studying up-to-date intelligence, rather than in the laborious production of much less timely and comprehensive information.

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Some further Comments on the Regulations for Preventing Collisions at Sea, 1972

Captain F. N. Hopkins

HAVING read with great interest the comments of Captain F. J. Wylie in the July 1973 issue of the *Journal*, and moreover found himself in complete sympathy with the views expressed, the present writer, who shares Captain Wylie's disappointment and apprehension with respect to the construction of the 1972 Rules, offers some further comments as follows.

The 1910 Articles, which as Captain Wylie says employed a minimum of verbiage, were written in impeccable English, were free from ambiguity and possessed such a rhythm that they were easy to learn by heart and remember. Whether the ability to repeat them by heart was commendable is perhaps open to question, but the fact remains that Masters and officers of British merchant ships who were required to have that ability were never any the worse for it. It is realized that in those pre-radar days ships were generally much slower than they are today and the whole tempo of life was more relaxed, but even so one feels that there were fewer cases involving disregard of the Rules than there have been in more recent times. The comparative simplicity of the Rules and the fact that they were better understood may well have had much to do with that.

The 1948 Rules lacked the rhythm of the previous Articles so that learning by heart dropped out of fashion, whilst the 1960 Rules were even more prolix. Such is progress! However, in both those sets of Rules the standard of English employed was beyond serious criticism.

Regretfully, the same cannot be said of the 1972 Rules. In addition to the faults to which Captain Wylie has drawn attention there are numerous weaknesses, some of which are shown below.

In Rule 3(i) and elsewhere a newly coined word 'underway' has replaced the former expression 'under way'. 'Underway' is a noun form like railway, seaway, or carriageway and conjures up a vision of some kind of subway, underpass or underground passage. Surely it would be better to say that 'a vessel is under way (adverbial) when she is not at anchor, or made fast to the shore, or aground' rather than 'The word "underway" means, &c.'.

In Rule 7(a) the word 'if' in the first sentence should be 'whether', although 'If' is correctly used in the second sentence. The same fault is repeated in Rule 7(d).

Looking at Rule 10(g) one is tempted to ask how a vessel can anchor in something so abstract as a scheme. Presumably the intention is to recommend that a vessel shall so far as is practicable avoid anchoring in an area in which a traffic scheme is in operation.

https://doi.org/10.1017/S0373463300025212 Published online by Cambridge University Press