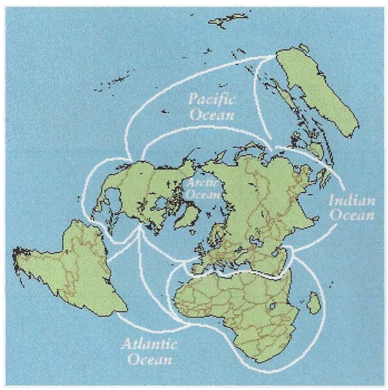
RADAR AND COLLISION - Handbook for Mariners

L. OUDET, Capitaine de Fregate, French

Compares visual versus radar encounter in time consumed stating "...in clear weather 5 min are needed to recognize a risk of collision and the necessary evasive action to be carried out, whereas using radar at least 20 min are required to do this and determine the maneuver is effective"

"ESCAPE Time" RION article, by CAPT F. J.WYLIE RN. - ship collision expert states: " ..realize that there are only 5 to 15 min of ESCAPE TIME with 8 min for the average ship collision."

Quote: One of the major sources of ship collision disasters:
A vessel is following, in fog, on one of the main shipping routes on which 99 percent of the encounters between ships, and 99 per cent of the accidents, occurs. *From time to time an echo is seen on the radar screen, on a bearing close to the heading. It is apparent that this represents a vessel on a near reciprocal course:* ***it will be an end-on meeting,*** *and our vessel, without bothering to see whether there is any change in bearing, alters course away from the initial bearing. One vessel alters to port "in order to keep clear," while in the majority of cases is on the reciprocal, the other vessel argues the same, turning to port, so a collision is averted.*



However, if one ship misreads the Direction of Relative Motion (DRM), and turns starboard, he not only increases collision risk but provides a wider broadside target

A major reason for the Andrea Doria/Stockholm 40 knot closing speed from 5 nm detection was the Captain's decision to make up time by going fast against the normal traffic (in then unmarked lanes) that increased the odds (4 to 1), because of statistics, it's essentially like getting off of a major highway by going down the on-ramp.

Not only traffic, ships speed and lack of maneuverability have increased exponentially since WW-II, but real time computing radar plotters that provided ALL echo Situational Awareness at a glance stopped production.

A 1984 USCG IMO Final ARPA Reg eliminated UNATTENDED as a manual "FAKE Collision Avoidance System" with "sounds alike in performance" since its stated purpose is that ARPAs SHOULD "improve the "STANDARD of collision avoidance at sea by (watering down a US government mandate for a slight cost saving to shipowners, as often happens Law enforcers save $ for them):

1.Reducing work load of observers by enabling them to automatically obtain information so that they can perform AS WELL with multiple targets as they can by MANUALLY plotting a SINGLE target (as in WW II ; and

2. Provide continuous, accurate and rapid situation evaluation. Appendix B US Marad, WAS in effect from 1971 to 82 (until shipowners and NAVY contractors allowed manual) The DIGIPLOT provides unattended monitoring of ALL echoes AT A GLANCE with automatic audio and visual alarm signals alerting the watch officer of ANY echo as a possible threat.

DigiPLOT was developed for $3M as an embedded mini-UNIVAC MAC 16 computer Collision Avoidance System for the US Maritime administration as an UNATTENDED backup to watch officers and is still the ONLY fully AUTOMATIC ALL ECHO Real Time Radar Analyzer needed for an anti-collision that is 10 times more accurate 12 deg in one minute than the DRM spec 3.5 in 3 minutes, DigiPLOT is STILL the ONLY UNATTENDED IMO ARPA with DRM of 1 deg to confirm "Side of Passing" & all True & Relative vectors to 2 deg accuracy.

I

THE INITIAL DISAPPOINTMENT

I. *Collision, the bane of modern navigation*

RADAR has been in common use as an instrument of navigation for more than ten years. During that time the majority of ships have been equipped with it: and yet it has failed to fulfil the hopes it inspired. Radar can be of great service in determining position in fog, but so far has it fallen short of providing the mariner with a certain method of avoiding collisions that it has even been accused of causing them. The consequent uneasiness, common to most seamen, is aggravated by the fact that collision is now the gravest and most frequent of navigational hazards. This is entirely a matter of speed, and has no intrinsic connection with radar. In the days of sail, collisions at sea were as rare as collisions on land between horse-drawn vehicles; they are now, with power-driven vessels, as common as automobile collisions.

The lesson of the tremendous efforts that have been necessary to check at last the increase of accidents on the road is that we cannot expect to find some magical formula which will immediately eliminate all collisions at sea, whether in fog or in clear weather; and yet when radar first appeared there were high hopes that collisions in fog would soon be a thing of the past.

It was an illusion, fostered at first by the small number of vessels which were so equipped. The fortunate few were able to detect ships which were without radar and concluded that they were emancipated from all the customary rules. They pressed on through fog without even announcing their presence by any sound signal: a precaution, they maintained, against causing unnecessary alarm to the other ship. At this stage, they had no difficulty in avoiding a collision; but it was not long before the number of sets in use had so increased that encounters between radar-fitted ships became frequent. It was then that it became apparent that radar was no guarantee of safety in such encounters, and that it could sometimes even contribute to disaster.

An attempt was made by specialists to classify these collisions according to some sort of system. In 1954 Mr Thorolf Wikborg, a

Norwegian underwriter, came to the conclusion that collisions occurred most frequently between vessels initially on reciprocal courses. Both before and after that date there was no lack of evidence, from collisions between ordinary merchant ships, to support his view; but in 1956 the collision between the *Andrea Doria* and the *Stockholm* shocked the world by proving that the best-equipped ships were not immune from the common danger.

Everyone asked how it was that such simple encounters could have such disastrous results, and there was unlimited speculation about some hidden fault, inherent in radar, or some grave negligence in its use. There was, however, no such mystery. Mr Wikborg had already, in 1954, explained precisely how the catastrophes occurred.

2. *The source of disaster*

A vessel is following, in fog, one of the main shipping routes, on which 99 per cent of the encounters between ships, and 99 per cent of the accidents, occur. From time to time an echo is seen on the radar screen, on a bearing close to the heading. It is apparent that this represents a vessel on a reciprocal course; it will be an end-on meeting, and our vessel, without bothering to see whether there is any change of bearing, alters course away from the initial bearing.

Fig. r illustrates what happens: vessel A, on the course *A* I, believes B to be on the course *Bz;* A alters to port, until she is on the course *A3,* 'in order to keep clear'. In the majority of cases, Bis in fact on course *Bz,* the reciprocal of A's; B argues exactly as A argued, turns to port on to B4, and an accident is avoided.

Quite inconsiderable variations, however, from the circumstances that generally prevail may set the scene for a catastrophic ending. It can happen that B is on the course *Br* ; he argues as A does, concludes that A is on *Az,* and alters to starboard, 'in order to keep clear'. Not only is there now a risk of collision but, since *A3* and *B3* are at a broader angle to one another than Ar and Br, each vessel now presents the other with a larger target.

Even when A and B are not simply acting on preconceived ideas, a similar result can follow. They detect one another at a range of some ten miles, sometimes more, on a bearing close to their own headings. They keep each other under observation for some minutes and determine that the bearing remains steady, or shows little variation. There is still no anxiety on either side; they are still at a range of some six or eight miles and think that they have the situation well in hand. Unconsciously, both are treating the problem as though it were an ordinary visual encounter, and conclude that a few degrees alteration of course will remove any possibility of danger. Even so, they disregard the rules for clear weather, under which both vessels should take concerted action; each alters to port

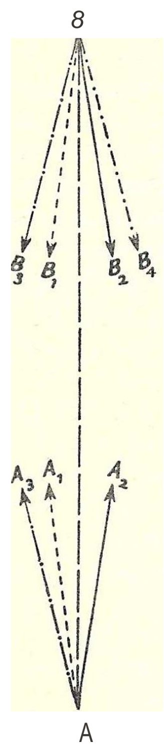


Fig. 1

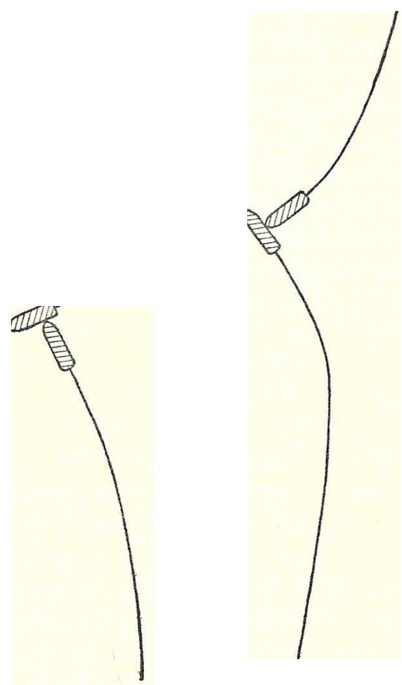


Fig. 2

or starboard, whichever happens to seem best at the moment, in the belief that the other vessel will understand what he is doing, and yet at the same time they both fail to help the other to understand by carrying out a positive and decided manreuvre. The natural result is that there is an even chance that each ship's manreuvre will cancel out the other's.

So long as there is a considerable distance between the two vessels, there is still a possibility that the danger may be avoided.

But both parties have got off to a bad start, and it is not often that the first check to their plans opens their eyes. They persist in the initial manceuvre, with an increased alteration of course, even when the range has closed. Moreover, it often happens that each vessel becomes aware of the proximity of the other only at close range, and each then manceuvres at 3 miles as though the range were 8 miles. The bold alterations of course which they then make to compensate for lack of sea-room are again contradictory but there is now no way of avoiding their consequences.

Fig. 2, based on the findings of Courts of Inquiry, shows the result. Had both vessels maintained their original courses they would have crossed at close range; they might, indeed, have collided end-on, in which case they would have caused one another considerably less damage. But by turning towards one another, they have done their best to aggravate the consequences. Even if one vessel has the prudence to stop, she will present her beam to the other's bows, she will be badly damaged and may even be cut in two.

Marad UNATTENDED CAS Relative Motion Analyzer's ARPA Spec test results to USSR for Type Approval-was rejected

Table 1 ACQUISITION TRACKING ERRORS (acquisition occurs earlier, so all red errors are meaningless vs degraded MARAD's "end on" accuracy)

1 Minute After Acquisition

Data Scenario	Relative Course deg DigiPLOT	IMO	Relative Speed kts DigiPLOT	IMO	CPA nm DigiPLOT	IMO	Av
1	5.3	11	1.8	2.8	0.8	1.6	
2	4.4	7	0.3	0.6			
3	18.0	14	1.7	2.2	2.5	1.8	
4	19.8	15	1.3	1.5	2.7	2.0	
Av Scenario	11.9	12	1.3	1.8	2.0	1.8	
Av Ratio	1.0		1.4		0.9		1.1

3 Minutes After Acquisition

Data Scenario	Relative Course deg DigiPLOT	IMO	Relative Speed kts DigiPLOT	IMO	CPA nm DigiPLOT	IMO	TCPA MIN DigiPLOT	IMO	TRUE COURSE deg DigiPLOT	IMO	TRUE SPEED kts DigiPLOT	IMO	Av
1	1.1	3.0	0.8	0.8	0.0	0.5	0.9	1.0	1.9	7.4	1.2	1.2	
2	3.2	2.3	0.1	0.3					0.6	2.8	0.0	0.8	
3	0.1	4.4	0.7	0.9	0.1	0.7	0.8	1.0	1.8	3.3	0.9	1.0	
4	0.4	4.6	0.6	0.8	0.2	0.7	0.7	1.0	3.4	2.6	0.0	1.2	
Av Scenario	1.2	3.6	0.1	0.7	0.1	0.6	0.8	1.0	1.9	4.0	0.5	1.1	
Av Ratio	3.0		7.0		6.3		1.3		2.1		2.0		5.0

Table 2 TRACKING ERRORS AFTER TARGET MANEUVERS (90 DEG AT 5 DEG/SEC AT 6 MINUTES)

1 Minute After Target Turn Completion

Data Scenario	Relative Course deg DigiPLOT	IMO	Relative Speed kts DigiPLOT	IMO	CPA nm DigiPLO	IMO	Av
1	0.1	11	0.9	2.8	0.4	1.6	
2	0.2	7	0.2	0.6			
3	0.9	14	3.0	2.2	0.1	1.6	
4	1.6	15	0.9	1.5	0.1	2.0	
Av Scenario	0.7	12	1.2	1.8	0.2	1.7	
Av Ratio	16.8		1.4		8.7		16.8

3 Minutes After Target Turn Completion

Data Scenario	Relative Course deg DigiPLOT	IMO	Relative Speed kts DigiPLOT	IMO	CPA nm DigiPLOT	IMO	TCPA MIN DigiPLOT	IMO	TRUE COURSE deg DigiPLOT	IMO	TRUE SPEED kts DigiPLOT	IMO	Av
1	1.4	3.0	0.8	0.8	0.1	0.5	0.2	1.0	1.6	7.4	1.2	1.2	
2	0.1	2.3	0.0	0.3					0.4	2.8	0.5	0.8	
3	0.6	4.4	0.9	0.9	0.1	0.7	0.0	1.0	1.4	3.3	1.3	1.0	
4	1.4	4.6	1.3	0.8	0.1	0.7	0.0	1.0	4.5	2.6	0.1	1.2	
Av Scenario	0.9	3.6	0.8	0.7	0.1	0.6	0.1	1.0	2.0	4.0	0.8	1.1	
Av Ratio	4.1		0.9		6.3		15.0		2.0		1.4		5.4

Table 3 TRACKING ERRORS AFTER OWN SHIP MANEUVERS (90 DEG AT 5 DEG/SEC AT 6 MINUTES)

1 Minute After OWN SHIP Turn Completion

Data Scenario	Relative Course deg DigiPLOT	IMO	Relative Speed kts DigiPLOT	IMO	CPA nm DigiPLO	IMO	Av
1	1.1	11	0.2	2.8	0.1	1.6	
2	2.0	7	1.1	0.6			
3	0.5	14	0.6	2.2	0.1	1.8	
4	1.1	15	0.7	1.5	0.1	2.0	
Av Scenario	1.2	12	0.7	1.8	0.1	1.8	
Av Ratio	10.0		2.7		18.0		10.0

3 Minutes After OWN SHIP Turn Completion

Data Scenario	Relative Course deg DigiPLOT	IMO	Relative Speed kts DigiPLOT	IMO	CPA nm DigiPLO	IMO	TCPA MIN DigiPL(	IMO	TRUE COURSE deg DigiPLC	IMO	TRUE SPEED kts DigiPLO	IMO	Av
1	0.5	3.0	9.0	0.8	0.1	0.5	0.1	1.0	3.5	7.4	1.2	1.2	
2	1.8	2.3	0.0	0.3					0.4	2.8	0.2	0.8	
3	1.1	4.4	0.7	0.9	0.1	0.7	0.1	1.0	1.0	2.6	0.2	1.0	
4	0.2	4.6	0.3	0.8	0.1	0.7	0.1	1.0	2.1	2.6	0.5	1.2	
Av Scenario	0.9	3.6	2.5	0.7	0.1	0.6	0.1	1.0	1.8	3.9	0.5	1.1	
Av Ratio	4.0		0.3		6.3		10.0		2.2		2.0		6.0

Overall Average Performance Advantage-IMO ARPA Spec/DigiPLOT RATIO at 1 and 3 minutes **7.4**