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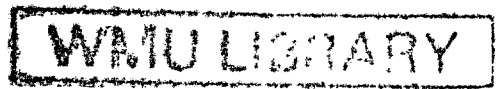
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WORLD MARITIME UNIVERSITY
Malmö, Sweden

ARPA TRAINING IN VIETNAM;
IMPLEMENTATION AND CERTIFICATION

by

Tran Dac Suu

Vietnam

A dissertation submitted to the World
Maritime University in partial fulfilment of
the requirements for the award of the

Degree of Master of Science

in

Maritime Education and Training (Nautical)

Year of Graduation

1991

I certify that all material in this dissertation which is not my own work has been identified and that no material is included for which a degree has been previously conferred upon me.

The contents of this dissertation reflect my personal views and are not necessarily endorsed by the University.

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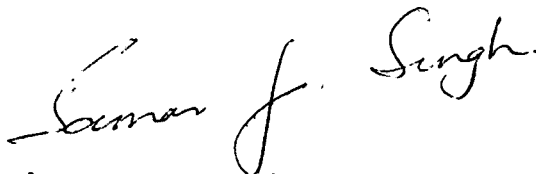
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PREFACE

This paper deals with a proposal for the further improvement for ARPA Training Course at Vietnamese Maritime University (VMU).

The lack of training of the master and officers in ARPA operation is very often one of the significant factors pointed out during investigations of certain accidents.

To compensate for the lack of training due to the lack of facilities and equipment up to 1992 at VMU.

The ARPA course will offer a suitable and adequate means for the acquisition of new knowledge and skills which will contribute to improve safety standards and efficiency on the job.

Keeping the above in view, I consider the " ARPA training course in Vietnam, Implementation and Certifications " to be an appropriate subject for my paper in VMU.

By writing this thesis I had the opportunity to understand the working of ARPA. I obtained guidance from good books and articles written by expert on the subject.

This paper also indicates that new course compliance with STCW 78 will be developed.

The content of this paper have been divided into four chapters. Chapter 1 briefly describes why the development of ARPA course is urgent and necessary to Vietnamese Merchant Fleet. Chapter 2 deals with ARPA training that is urgent requirement for navigational safety on world scale and with requirements for ARPA equipment and ARPA training course.

Chapter 3 outlines the objectives and structure of ARPA training course including participants, equipment requirements, exercises and syllabus.

Chapter 4 gives conclusions and recommendations.

In addition there are four appendixes. The first appendix deals with theory of ARPA. Accuracy of ARPA has been described in the second appendix . Next appendix describes the ARPA functions and the last one deals with minimum requirement for ARPA simulation equipment in education and training.

I consider the training of course instructors of vital importance. The instructor's team must have specialized ARPA training course and is often the updating of their knowledge by participation in forums like the " International Radar and Navigational Maritime Lecturer Association. The conferences provide an opportunity to develop contacts which may achieve closely co-operation with other academies and colleges running similar courses.

It is necessary that the course instructors to keep abreast of latest practices and developments on board ships can not be stressed enough. There is no better way to get this than by making regular short voyage on ship fitted with appropriate equipment.

I also believe that this paper may provide valuable information and guidelines for the instructors in charge of the Nautical Department at VMU. I will feel satisfied that my efforts were worthwhile.

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ARPA TRAINING COURSE
IN VIETNAM,
IMPLEMENTATION AND
CERTIFICATION.

CHAPTER 1

INTRODUCTION

1.1 ARPA AND SAFETY OF NAVIGATION

Safety at sea has been a constant problem to mariners since the earliest ship sailed. Collisions between ships and between ships and other objects have always been a worrying subject in maritime history and continue to occur with alarming frequency.

Sea going vessels have increased more and more in number, speed and size therefore making navigation become more complex so that traffic flows lead to congestion in certain areas around the world. Increasingly more and more vessels are carrying noxious (or dangerous) goods that have the potential to pollute the marine environment.

Through the statistical analysis of marine casualties their distribution has shown that safety of navigation can be increased if the effectiveness of collision avoidance and navigation practices on board ships are improved.

When radar was first used for merchant fleets, many people thought that a practical solution to the collision avoidance problem had been found. But even when radar is used more extensively the overall collision rate still remains too high. There are several reasons for this, and that is because watchkeeping deck officers are not properly trained on shore-based radar before going on board ships or they have little practice in switching on, tuning and target identification, and also in radar plotting. In addition, for the the safety of navigation radar has many limitations.

1.1.1 THE LIMITATIONS IN USING RADAR FOR THE SAFETY OF NAVIGATION

The radar provides the range and bearing of targets around the own ship. But it is necessary for a navigator to know the closest point of approach and direction and speed of movement of the target to analyse the threat presented by the target to his own ship and to make a proper assessment regarding evasive action. This can only be done if the target is tracked by plotting its position at regular intervals. Before ARPA the plotting was done in two ways:

- on radar plotting sheets or maneuvering board,
- on reflection plotter.

The above two methods are manual and suffer various impediments. The biggest one is that any alteration of course and speed by the own ship or target ship makes the plot useless. Any change in range scale in use creates discontinuity and necessitates the re-plot of the targets. Furthermore a navigator can become fully occupied in plotting alone, and is only able to plot and monitor two or three targets at a time without confusion.

Analysis of many collisions in the LLOYD'S List Law Report, Vol 1 (1963) and Vol 2 (1981). indicate that the problem is limited capability of human beings in correctly operating and using the information available on the PPI with adequate speed and accuracy. Furthermore the radar picture is a current value presentation only and the measurements normally are relative to a moving reference (own ship), the human interpretation of the situation is dependent on considerable skill, based upon experience and concentration.

In recent times ships have been increasing in number and size associated with high traffic density. It is difficult to interpret radar data and to plot on a plotting diagram. However even after a plotting system improved this situation the ships continued to collide and in many cases the collision cause could actually (partly) be traced to the wrong use of such equipment.

There can be no doubt that a watch officer is unable to derive the amount of information necessary to handle a complex situation from the conventional appreciation of the radar data. In low traffic density with the aid of a reflection plotter or other appraisal aids there may be sufficient time available for an experienced officer to conduct a formal plot, to analyse the data and implement an avoiding action. When the density of traffic and the complexity of the situation increases, no longer has adequate capacity to analyse the received information from raw radar data and to select the optimum action in the avoiding maneuver.

1.1.2 THE DEVELOPMENT OF ARPA

Manual plotting is time consuming and difficult in congested traffic conditions. Bearings and distances of displayed targets must be compared with previous bearings and distances. But this data is lost after one scan because the target echoes have moved to another position on the display. In addition the watch officer can track no more than two or three targets at a time. For the solution of these problems ARPA was designed to facilitate plotting routines, using the computer. The technique of digitizing analogue radar signals made it possible to process radar data by data processors for the simultaneous and automatic

plotting and tracking of multiple targets.

Before the appearance of ARPA many aids and plotting devices were produced and used at sea such as:

- The Digiplot, produced in 1968 by the Iotron Corporation (USA) can well be called the first ARPA. It was a computer - based radar plotting device with automatic echo selection. Especially the " trial maneuvering " facility whereby it predicts target ships and land vectors during the next 30 minutes, i.e by a scale of 30:1

- IBM Collision Avoidance System - In this system all targets (with the exception of land masses) were automatically acquired and a maximum of 21 targets, selected by priority, could be tracked. But only 6 vectors of the six most threatening targets were continuously displayed on the screen.

- Anti Decca TM - AC Collision Radar has a true motion presentation which also shows whether the bearing of other ships is changing. There the advantages of relative and true motion presentation are combined.

- Collision Avoidance Systems (CAS) produced by Sperry, Marconi Companies. CAS was designed using the interscan technique by which lines are produced on relative motion off-center head up stabilized display showing the " Potential Area of Danger - PAD " with its PPC (Point of Possible Collision). The true motion lines extend from the echo's target to the PPC and therefore are not vectors. First PADs had an elliptical shape, later they were replaced by hexagonals.

- During the late seventies first small-screen color radars (with rasterscan) were manufactured in Japan. Rasterscan display radar enhances display characteristics of echoes. Japanese radar colors differed with red, yellow and green colors for strong, medium and weak echoes. In Britain and Holland radar colors were used to show consistency between different targets, because most of them did not look like real picture. For purpose of navigational safety raster scan ARPA needs to satisfy the IMO standard for a 16 inches model or over. Colour radar is misused if the colour represents the strength of the echoes which may easily give false interpretation and this depends on what the observer expects.

- The first ARPA equipment (about 1980) varied considerably concerning both available information and operating procedures. However they were based on IMO resolution A422. Mean while by (1990) ARPA sets have de-facto become much more similar to each other. This is due to rasterscan techniques.

- In modern radar - ARPA techniques, digital processing of the radar data is applied. The first step is the conversion of the radar video into digital range, bearing, and intensity values. The quantised picture is stored in a huge matrix of about 512 range and 2048 bearing increments including the echo intensity as the 3rd parameter.

- Modern radar sets have many features in common relating to:

- + signal processing (delay video display by raster scan technique; suppression of clutter;
- + scope of system (combination of several

- transceivers and displays by interswitching,
slave monitors;
 - + display (rectangular with circular radar picture; size of screen; multi-level radar intensities; status display and target data display on screen; cursor with range and bearing display; separate information zones on the screen;
 - + new features (centre display / centered TM; synthetic trail; system self tests for monitoring a fault finding; video mapping);
 - + operating switches (+ / - buttons).
- Differences among the ARPA equipment are more detailed and related to :
- + signal processing (number of sweeps for correlation; M-out-of-N criteria; clutter processing);
 - + scope of the systems (interfacing; additional devices, e.g. printer; combination with automatic track control);
 - + information display (number of pixels; resolution; refreshing frequency; monochrom / colour; day / night intensity option; number of tracked targets; display of danger, e.g PADs, PPCs);
 - + new features (number of video maps and their elements; target identification on the screen; simulated targets for exercise and testing).
- Today there is an increasing trend to integrated navigation and ship handling system in which Radar- ARPA are connected to other navigation equipment, steering

systems and control systems by appropriate interfacing. An important application is the automatic radar - controlled track-keeping. For example the system ATLANTACOS (KAE) contains two (or more) radar sets, Doppler-log, echo sounder, and an "ARCAP", i.e an "Adaptive Radar Controlled Auto Pilot". The system can be interfaced e.g to the multi-sensor navigation set MNS 2000 (RACAL-DECCA) for position determination and rout planning on the open sea. The ARCAP may be used in three operational modes:

- course control,
- radar-controlled sailing,
- control via navigation system.

1.1.3 ARPA FOR SAFETY OF NAVIGATION

ARPA was designed and modified from time to time to reduce the incidence of ship casualties. ARPA has become a welcome piece of equipment for deck officers on watch. It has the following advantages:

- Automatic plotting frees the watch officer from the tedious and time consuming task of plotting and tracking ships around his own ship.
- Human errors in manual plotting (on a radar plotting sheet or on a reflection plotter) are eliminated.
- ARPA provides full, continuous, accurate and quick information concerning closest point of approach (CPA), time to CPA (TCPA), speed and course of multiple targets and does so quicker than is possible manually in an encounter situation.
- The information is provided in true or relative vector

form and digital displays that can be easily understood by the deck officer often proper training.

- The operator can put in selected limits of CPA and TCPA, on which alarms will be given to warn about imminent dangerous or developing close quarters situation.

- Trial maneuver facility can help the officer on watch in choosing optimum safe avoiding action in close quarter situations. ARPA can be used to calculate and show the effects of an avoiding maneuver in advance (next 30 -60 minutes). The officer can use trial course, trial speed and time between the start of the simulation and the actual course and or/speed alteration, which must be supplied to the computer.

- The process of tracking all targets is continuous even after a change in course and / or speed of own ship and / or of targets and after a change in the range scale in use.

It is clear that ARPA is a powerful tool in the hand of the officer on watch who can make the maximum use of it for safety of navigation. But we must always remember that ARPA itself does not make any decisions regarding maneuvers or avoiding action to be taken by the own ship in a close quarter situation.

1.2 ARPA AND THE VIETNAMESE MERCHANT FLEET

1.2.1 THE VIETNAMESE MARITIME EDUCATION AND TRAINING

There are two different education and training schemes which lead to certificates of competency in Vietnam

regarding Nautical Education and Training. The two schemes are the following:

*** VIETNAMESE MARITIME UNIVERSITY (VWU)**

- entrance examination (after 12 years of basic education)
- 5 years in the university including 10 months sea time (ship board training),
- the diploma covering all theoretical studies up to university's level,
- 4th Mate Certificate,
- sea time after graduating from university 18 months followed by 3rd Mate examinations
- sea time after 3rd mate exam 18 months followed by 2nd Mate examinations,
- sea time after 2nd mate exam 18 months followed by 1st Mate examinations,
- sea time after 1st mate exam 24 months followed by VMU for 6 months and Master's examinations.

*** MARITIME SCHOOL**

- entrance examination (after 8 or 12 years of basic education),
- 3 years including 10 months sea time (ship board training)
- certificate of able bodied seaman.
- possibility to sit for 3rd mate certificate.

The State examinations are administrated at the State Qualification Examination Board in conjunction with the VMU. The State examinations are conducted for 3rd Mate Certificate of Competency and subsequently for 2nd Mate,

1st mate and Master certificates. The program of Nautical education and training in VMU until now, has no ARPA training course, even most of deck officers don't have examination and certificate of competency in Radar Observation and plotting.

1.2.2 VIETNAMESE MERCHANT FLEET

There are two kinds of shipping companies in Vietnam . Firstly the four governmental shipping companies are VOSSCO - Vietnam Ocean Shipping Company, VIETCOSHIP - Vietnam Coastal Shipping Company, VITRANCHART - Vietnam Transport and Chartering, VITACO -Vietnam Tanker Company with total about 90 ships. Secondly there are 10 private shipping companies. In addition about 20 ships with Vietnamese crews are sailing under foreign flags. According to the list of shipowners 1990-1991 published by Lloyd's Register of shipping, Vietnam national fleet consists of 142 ships with tonnage of 401,984 GRT, including 80 general cargo ship and 11 tankers.

The average growth rate of the fleet over period 1976-1989 is 11 % (see Table 1.1 and figure 1.1).

TABLE 1.1: Vietnam national fleet, 1976-1989.

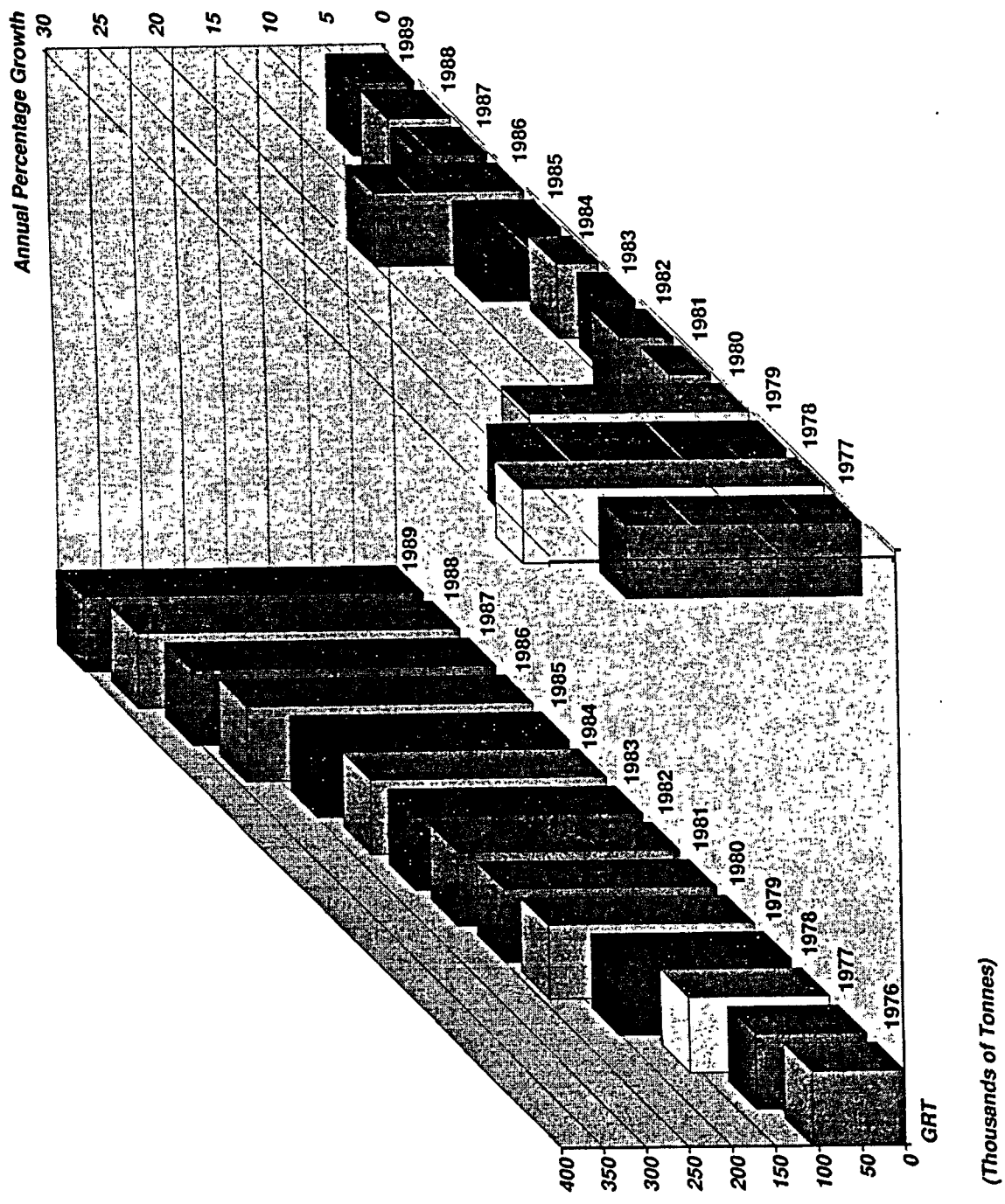
Year	1976	1977	1978	1979	1980	1981	1982
Tonnage (GRT)	107	129	163	202	241	250	262
Growth (% Pa)	-	20.5	26.4	23.9	19.3	3.7	4.8
Year	1983	1984	1985	1986	1987	1988	1989
Tonnage (% Pa)	269	279	299	339	360	381	402
Growth (% Pa)	2.7	3.7	7.2	13.4	6.2	5.6	5.5

Sources: Statistical Yearbook, 1982-United Nations,
 Statistical Tables 1983-1986 Lloyd's Register
 List of shipowners 1990-1991-Lloyd's Register

The above table 1.1 and fig 1.1 show that the Vietnam shipping fleet required an annual increase continuously. As a result of this, the demand for the number of masters and deck officers is also increasing. Therefore in order to satisfy navigational safety requirements, it is imperative that they have the necessary training and competence.

Vietnam National Fleet - Growth Profile (1976-1989)

FIGURE 1.1 :



increasing, and especially the requirement for necessary courses for their competency and to satisfy requirements for navigational safety of the present and future fleet.

1.2.3 NEED FOR DEVELOPING THE ARPA COURSE

As required by the International Conference for the Safety of Life at Sea, 1974 and its subsequent amendments (SOLAS) ARPA have been installed on 5 tankers and 8 bulk carriers. By the year 2000 there are plans to add 30 new ships (including tankers, bulk carriers, crude oil, container, passenger ships etc.) to the Vietnamese shipping fleet. These ships would surely need to be fitted with approved ARPA in accordance with the SOLAS Convention (as Amended up to 1983).

The International Convention on Standards of Training, Certificates and Watchkeeping for Seafarers, 1978, and International Maritime Organization Assembly Resolution A482 (X11) require that masters and deck officers be trained in the use of ARPA.

Though the navigating officers in the Vietnamese shipping fleet receive training in Radar Observation and Plotting, they are not examined and also separate certificates of competency are not issued to them. Most of them have not received any formal training in the operational use of ARPA, and have even never seen an ARPA before (except some masters and officers who graduated in foreign countries).

The tankers, bulk carriers and cargo ships mainly ply on the routes such as Haiphong (Saigon) - Hongkong, Singapore, Japan and West European ports, where the

traffic density can be substantially high. Proper use of ARPA is imperative for safe navigation of these ships on above routes.

There are about 100 masters and over 1000 deck officers, that are working on board Vietnamese ships. In addition about 50 navigating officers are sailing on foreign ships as employees. The number of masters and deck officers is growing with time. But, there is only one Maritime Education and Training Institution - VMU. The Ministry of Transport and Communication has planned for the acquisition and installation of a simulator with ARPA at VMU. Therefore with the restricted number of navigating officers who can be trained at VMU, it may be a long time before all officers are trained on the use of ARPA. This is a problem that need to be satisfied in the ARPA training plans in the future.

CHAPTER 2

INTERNATIONAL REQUIREMENTS
FOR ARPA EQUIPMENT AND FOR
ARPA EDUCATION AND TRAINING

2 INTERNATIONAL REQUIREMENTS FOR ARPA EQUIPMENT
AND FOR ARPA EDUCATION AND TRAINING .

2.1 ARPA training is urgently required for safe
navigation on an international scale.

- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW 78) requires that all masters and ship's officers in charge of a navigational watch shall make most effective use of all navigational equipment at their disposal. Especially they are required to demonstrate their knowledge of the fundamentals of radar and ability in the operation and use of radar, and in the interpretation and analysis of information obtained from radar equipment.
- Resolution 20 to the STCW 78 Convention has recognized that the masters and deck officers should be properly trained in the use of collision avoidance aids and should be fully aware of capabilities and limitations of such equipment.
- In addition to the above the Appendix to Resolution A482(XII) requires that the masters and all deck officers on ships carrying ARPA should be trained in the fundamentals and operation of ARPA equipment and the interpretation and analysis of information obtained from the equipment.
- In American a law court has denied limitation of liability to a ship owner for failure to properly train his crews in the use of ARPA. The court,

finding out that the master did not know how to use the ARPA, stated " the shipowners have ability and responsibility to ensure that the master is sufficiently trained on the ships equipment, particularly those required by law. It undermines the law that required the equipment if shipowners do not train their masters in its operation."

(Collision in fog between the Seapride II and an electric power transmission line tower on the Delaware River, United State of American)

- In the United Kingdom the Department of Transport stipulated that on or after 1st September, 1985 masters and all deck officers of ships equipped with an ARPA shall be qualified in the operational use of ARPA. This means that they have to be trained in the use and the operation of ARPA.

- The 4th International Radar and Navigation Simulator Lecturers' Conference (IRNSLC) in Mariehamn ,May-1986, distributed a questionnaire about ARPA to about 100 Nautical Colleges which have radar simulators. The received result are :
 - 60% of them agreed that ARPA training was required for all watchkeeping officers,
 - 70% of them agreed that ARPA training was required for all watchkeeping officers on ships with ARPA.

- At the same Conference 85% from above colleges have consented to compliance with the recommended IMO training in the operational use of ARPA.

- The development of ARPA has been a great jump

forward in radar technology (see paragraph 1.1.2). The synthesis of digital data processing technology and radar technology has opened the gate to an exciting new area with a promise of many applications.

- For the purpose of navigational safety Automatic Radar Plotting Aids appeared 20 years ago. The role of the ARPA is thus seen to be the elimination of a tedious, time-consuming task. However ARPA does not replace the decision of the watch officers. ARPA can not make decisions in conducting one's own ship at sea such as changing course and speed, collision avoidance, ship maneuvering. ARPA is only a machine.

All countries are concerned about maritime safety for seafarers, ships and cargo. This concern has focused on many areas contributing to navigational safety. Among them instrumentation training, seafarer qualifications and regulations are emphasized. This circumstance results from an increasing potential for catastrophic consequences to man and the environment if an accident should occur. Maritime casualties have steadily increased in numbers, cost and impact on the environment. Investigations of maritime accidents have generally supported two major reasons:

First, the majority of accidents (collisions, ramming and grounding) have occurred in restricted water areas.

Second human error is a major contributory factor in more than 80% of the accidents. Mishandling and lack of knowledge of radar and ARPA are main reasons leading to

collisions between ships or ship and other targets. From the Lloyd's List Law Report, vol.1 (1963) and vol.2(1981) we know that human errors stem from very poor decisions which are the most often result of one or more of the following three problems : inexperience, stress and poor attitude. All above problems can be corrected in training field such as nautical colleges or on board.

The students of nautical colleges and deck officers had educated and trained some years ago, that does not ensure that they will be able to operate the modern ships. Because developments in automation and computer technology with increasing use of them in ship equipment have become the biggest problem for watch officers. One of them is how to use and operate ARPA to ensure safety of navigation. ARPA equipment is not easy in its operation. It is not "a clever equipment" that can correct all mistakes. On the panel of the modern ARPA system there are many switches, with much information displayed and many warning signals. There is also a danger of decreased attention owing to a too strong feeling of security. It is very dangerous if the watch officer lacks knowledge of ARPA. This knowledge of technology and operational practice needs to be present before a deck officer goes on board a ship fitted with ARPA. It requires formal course work, much practice and careful thought to master the modern ARPA display. Therefore the effect of ARPA use needs to be adequately researched.

2.2 International requirements for ARPA equipment.

Modern technology has made it possible for ARPA to present to an observer an analysis of the area surrounding his own ship. With computers developing at an ever increasing pace it was only a matter of time before the mariner was provided with a tool to assist him in resolving the continuing problem of tracking targets and analysing their movements.

In the past many aids to radar plotting have appeared to assist this task (section 1.1.2), this did satisfy safety standards. But systems which conform to the IMO performance standards for ARPA may be used on board.

The IMO Performance Standard for an ARPA requires that ARPA should reduce the workload of the watch officer and provide continuous, accurate and rapid situation evaluation. Therefore the ARPA display needs to satisfy all requirements in accordance with performance standards for navigation radar equipment.

The IMO - SOLAS (1974) Convention as amended up to 1983 sets out a schedule whereby various sizes of vessels are required to be fitted with an approved ARPA over a period of 4 years which ended on 1st September 1988. As a result all tankers of 10.000 gross tons and upwards and all ships other than tankers of 15.000 gross tons and upwards should be fitted with an approved ARPA. In the particular case of vessels constructed on or after the 1st September 1984, all vessels of 10.000 gross tons and upwards should be fitted with an approved ARPA (i.e one complying with the IMO Performance Standard).

Though all manufacturers incorporate minimum performance standards as laid down by the IMO, many of them provide additional features or adopt different methods of providing the information required by the performance standards. The performance standard is given in appendix C.

2.2.1 Acquisition

Target acquisition may be operated by manual or automatic mode but its acquisition should have a performance not inferior to that which could be obtained by the use of the radar display.

An ARPA with automatic acquisition must have a capability of at least 20 targets, with manual acquisition only a capability of at least 10 targets to be acquired and tracked.

Manual acquisition: According to the traffic situation the watch officer selects those targets which he wishes to be tracked. By means of a " JOYSTICK " or a " ROLLER BALL " (on Krupp - Atlas ARPA system) a marker is positioned on the echo and the " TARGET ACQUIRE " key is pressed. That initializes the tracking.

Automatic acquisition: Each target echo entering a " GUARD ZONE " is automatically acquired. In order to avoid too many and not interesting targets (e.g coast line) the " GUARD ZONE " can be limited by EXCLUSION AREAS/SECTORS. Some ARPAs give an acoustical warning with each automatically acquired echo.

It is possible to use the set in automatic and manual acquisition. After about 10 antenna revolutions the

computer would normally have acquired and commenced to track the target. IMO requires a trend indication latest after 1 minute, and full accuracy after 3 minutes.

Deleting a target: As soon as a target shall no longer be tracked (e.g a target is astern of own ship) it can be deleted. It has to be without delay, if the number of tracked targets is close to the total tracking capacity, otherwise a newly acquired target will bring about the " TARGET OVERFLOW " warning.

2.2.2 Vector presentation

The presentation of other ship's motion on the radar screen by means of vectors is very easily perceptible. ARPA offers relative or absolute (true) vectors presentation at operator's choice. The direction of a true vector indicates the other ship's true course, the direction of a relative vector indicate the other ship's motion relative to own ship. The vector length indicates the other ship's true / relative speed. Depending on the selected " VECTOR TIME " the point of the vector indicates the future position of the other ship (e.g six minutes later). Vectors help to :

- indicate future (dead reckoned) position of target for any desired time,
- detect possible points of collision and the time until collision by using absolute vectors,
- estimate CPA by using relative vectors.

Note:

- * Relative vectors have the following advantages :
 - + dangerous targets are clearly detected (relative vector is pointing to the own ship)
 - + CPA distance is easily estimated by extended relative vector.

* Absolute (true) vectors have some following advantages:

- + the total situation (other ships, buoys etc.) is presented in a easily perceptible presentation,
- + targets' motion are easily detected,
- + course change and speed change of other ships are easily detected,
- + risk of collision can be detected by changing the vector time.

In general, these formats are best for monitoring and later, to assist decision making for collision avoidance navigation.

2.2.3 Past tracks (or history)

The past positions are displayed from computer memory. They show how the situation has developed and therefore are useful in determining if the target has maneuvered in the recent past. IMO requires the storage of four positions for the past eight minutes. Past tracks can be valuable for the following reasons:

- they indicate, if the past target motion and the vector (for future) show the same direction, i.e. the target has maintained course,
- they allow a check of the correct automatic tracking,
- if the observer has to concentrate on one target, or has to leave his place for a few minutes, then he can obtain a quick information about the targets' motion / maneuvers during his absence.
- they indicate the degree of damping during poor tracking condition.

2.2.4 Potential point of collision (PPC)

PPCs are displayed on the radar screen and allow for a very fast survey with respect to actual or potential risks of collision:

- actual risk of collision exists, if the PPCs are directly on the own ship's heading line,
- potential risk of collision exists, if the own ship's course is altered in such way that the heading line meets PPCs which were well off the heading line before. Collisions are avoided by keeping the heading line always well clear of all presented PPCs. PPCs are only displayed for tracked targets! PPCs move relative to the own ship on the screen with maneuvers of the target. Depending on the speeds of own and other ships, 0, 1 or 2 PPC's for a given target.

2.2.5 Predicted areas of danger (PAD)

A PAD is a hexagonal area (in reality an ellipse), determined by the set CPA distance, which must not be entered by the own ship. The computer automatically calculates form and size of PAD, in PAD mode it is presented on the screen of radar.

Like PPC the PAD allows the navigator to determine a manoeuvre to avoid a close quarters situation, or a collision:

- a PAD on the heading line indicates actual risk of a close quarters situation, i.e. shorter CPA distance than determined,
- a PAD away from the heading line indicates a potential danger area, becoming an actual danger area if the own ship alters course in such way that the heading line crosses the PAD.

The PAD has the following advantages:

- + simple and fast assessment of danger situation
(PAD on the heading line ?),
- + decision on appropriate manoeuvre,

and several disadvantages:

- the rest of radar picture can be obscured by the PADS,
- it may create a false feeling of safety if PADS are rounded like islands,
- PADS are only related to the own ship, dangers between other ships are not indicated (naturally also not for targets which are not tracked).
- PADS are only correct for the instance of time for which they are computed future decision can not be based on current PAD display e.g time to return to course.

2.2.6 Trial manoeuvre.

In order to assess a manoeuvre considered to be appropriate in the given situation, it can be simulated by the computer. The presentation on the radar screen is a " view into future ", i.e. the calculated results of the envisaged manoeuvre.

The operator enters " TRIAL COURSE " or / and " TRIAL SPEED " together with a " TIME DELAY "; the results are immediately presented on the screen in rapid motion but not real time :

- in TRUE VECTOR mode the true own ship vector changes,
- in RELATIVE mode the relative vector of all tracked targets change,
- the CPA digital display shows the new CPA distance,
- PADS (PPCs) change their form and positions on the screen.

Some ARPA equipment have additional functions:

- dynamic maneuvering characteristics,
- simulation values of course and speed are permanently variable during the simulation, allowing fast and simple determination of optimal values,
- simplified maneuvering characteristics (e.g. for different loading condition / draught).

2.2.7 Automatic alarms and warnings

There are many types of alarms and warnings that are used in ARPA equipment :

- audio alarm
- visual alarm
- visual warning by symbols (e.g. flashing) on the radar screen or a separate display. IMO requires that all audio alarms in ARPA systems be capable of being silenced.

1. Operational warnings.

Warnings to alert the operator if special traffic situations or changes in the behavior of tracked vessels require special attention:

- target enters guard zone,
- a tracked target will come closer or approaches faster than the set values of CPA and TCPA,
- the computer lost an acquired echo,
- tracked target has changed course and / or speed,
- more than 40 targets to be tracked.

Only ARPA " DECCA " can give alarm for own ship moving relative to a set reference point.

2. Equipment warnings.

Warnings to alert the observer if any malfunction from radar, the ARPA, or sensor occurs.

3. Operator error warnings.

Warnings to indicate wrong operation by the operator, i.e. false, non-plausible input or non-compliance with operation instructions.

2.2.8 Navigation line and reference echoes.

- The automatic tracking capacity of the computer can be used to determine the own ship's exact course and speed over ground.
- To support navigation in restricted waters, video maps may be superimposed to the radar picture. Video maps contain lines, dots, and marks to display the fare way, rough coast lines (particularly if the coast line does not have radar conspicuous targets) shallow areas, anchorage positions etc... The scope of video map is from few " Navlines " up to a huge number of elements (e.g 12,000). The video maps may be stored in a " route library " from which the individual rout may be activated.
Operating the video maps requires the following step:
 - * Route planing and map generation using sea chart and radar.
 - * Selection of the route.
 - * Display and adjusting the route on the radar via reference targets.
- For application with the "PARALLEL INDEXING METHOD " such lines can also be used.
- ARPAs can offer up to 20 or more (depending on the manufacturers that made ARPA sets) of such navigation lines, which can be set in any position, direction and

2.3 REQUIREMENTS OF SIMULATOR FOR ARPA TRAINING.

In coming years the number consist of ARPA equipment in use on board ships will increase heavily. One important reason for that is requirement of the proposed IMO rules concerning implementation of ARPA systems. Other reasons are the integration of radar and ARPA functions, the decreasing cost of ARPA installations and the general acceptance of ARPA systems in navigation . The STCW (1978), Attachment 2 , Resolution 18 shows the vital importance of adequate radar training with regard to the safety of life and property at sea and the protection of the environment and to recommend, or that radar simulator training be give to all masters and deck officers.

Appendix II requires that training facilities should include the use of simulators or other effective means capable of demonstrating the capabilities, limitations and possible errors of ARPA. That means the ARPA simulator should provide a capability such that a trainee undergoes a real time exercise where the displayed radar information is the choice of the trainee or the instructor. This also means that ARPA simulator training should be given to all masters and deck officers.

2.3.1 WHAT IS AN ARPA SIMULATOR.

1. An ARPA Simulator is equipment that is capable of producing raw radar signals. The radar video needs to be controllable, defined for example as targets with courses and speeds. The next step to realize a total traffic situation is to give the operator of the ARPA system a possibility to control a maneuverable ship model. ARPA simulators are realized using modern digital computer techniques.

2. There are three different types of ARPA simulator used in nautical colleges worldwide:

* Case 1 simulator may be characterized as a multipurpose, multiuser, partly integrated and partly separated simulator. The block diagram is shown in Figure 2.1. This is a 4 own ships simulator where the instrumentation for each own ship is placed on a separate cubicle or " navigation bridge ". The case 1 simulator is rather expensive and space consuming and requires extensive installation. The need for highly skilled instructors is necessary to exploit the possibilities of this simulator. The case 1 simulator needs a sophisticated and dedicated instructor station .

* Case 2 simulator as shown in Figure 2.2 may be characterized as a single purpose, single user and integrated ARPA simulator. This case requires less investment than a type 1 simulator. This is a 1 own ship simulator with necessary instrumentation. Case 2 simulator needs simple instructor station with alphanumeric display and keyboard and a simple instructor control unit.

* Case 3 simulator may be characterised as single purpose, single user and separated ARPA simulator. Block diagram is shown in Figure 2.3. This simulator is comparatively inexpensive and will require little space. The simulator may be interfaced to existing ARPA units both ashore or on board ships. This case is low cost and needs simple instructor station with alphanumeric display and keyboard and simple instructor control unit.

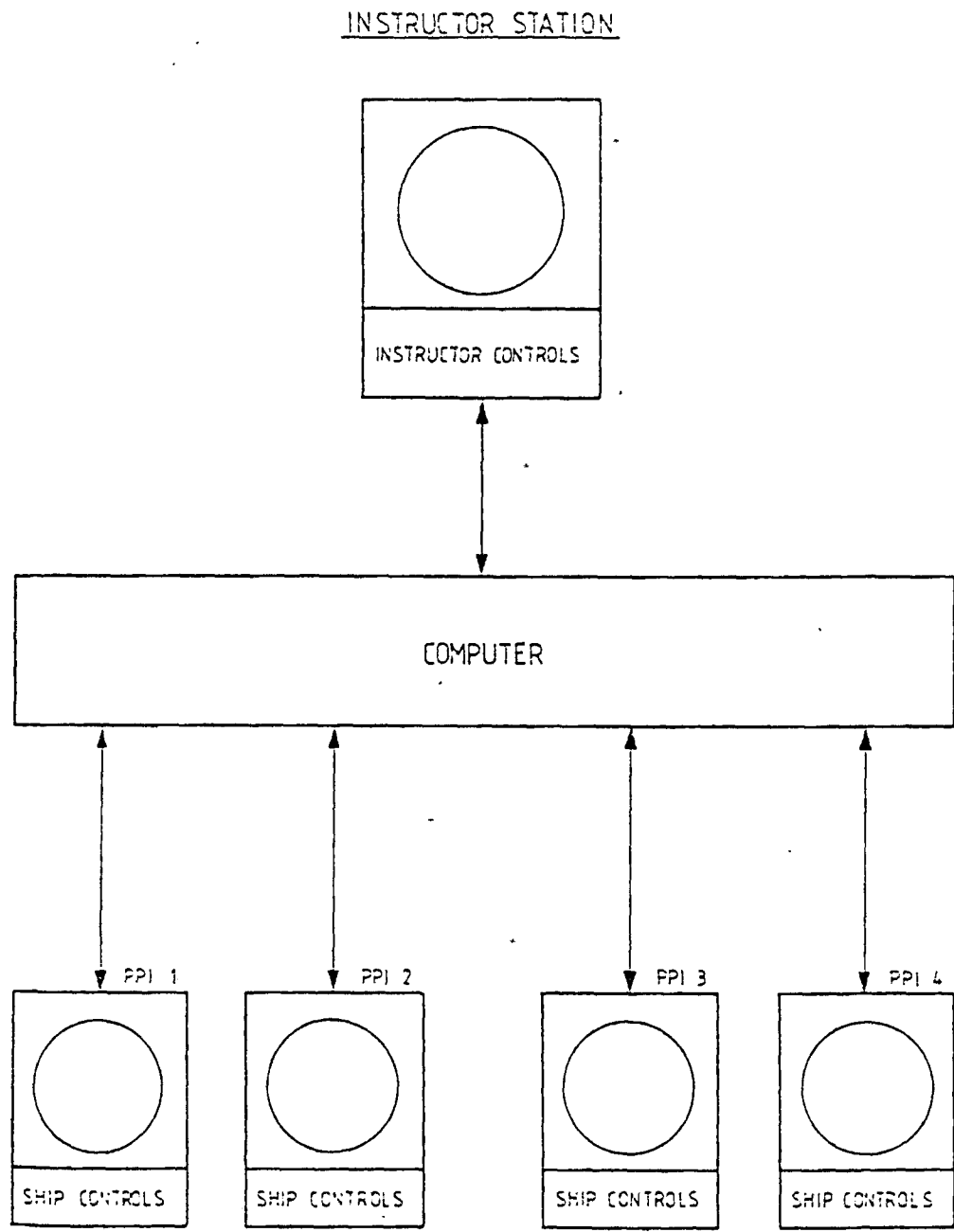


FIGURE 2.1 : THE BLOCK DIAGRAM OF A FOUR OWN SHIP SIMULATOR (CASE 1).

INSTRUCTOR FACILITIES

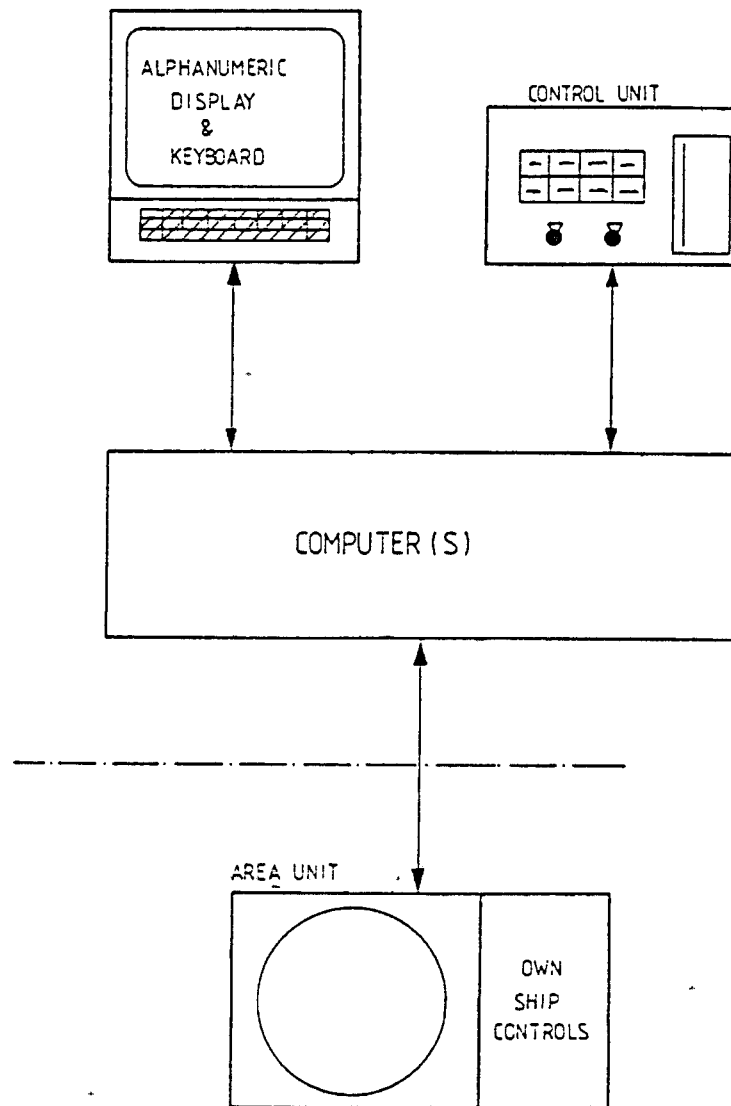


FIGURE 2.2 : THE BLOCK DIAGRAM FOR SINGLE USE ARPA SIMULATOR (CASE 2).

INSTRUCTOR FACILITIES

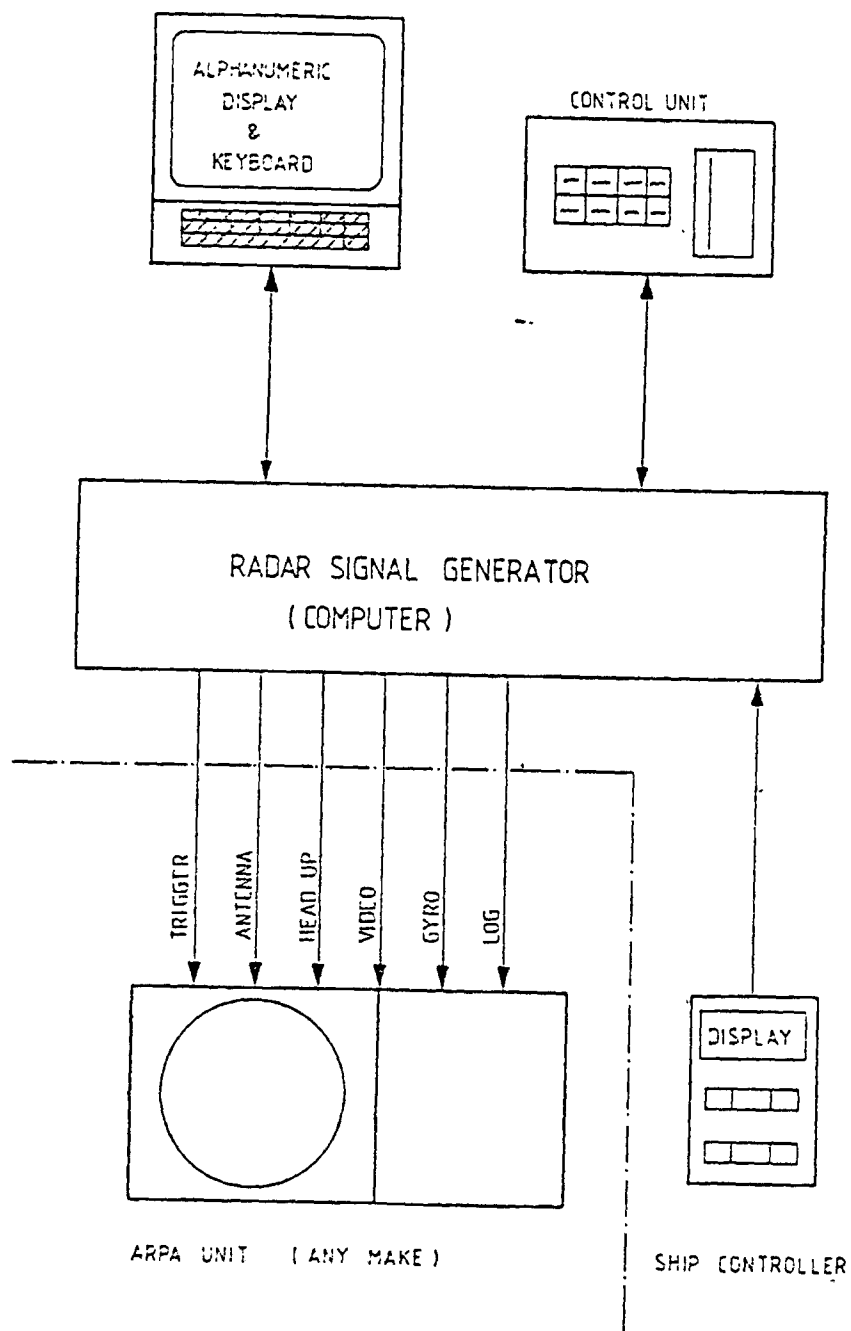


FIGURE 2.3 : THE BLOCK DIAGRAM FOR SINGLE USER ARPA SIGNAL SIMULATOR (CASE 3).

2.3.2 ARPA TRAINING - THE NEED FOR SIMULATION.

The highest standards of navigational control must be maintained to ensure maximum economy and safety. The aforementioned errors (section 2.1.9) can be addressed by a proper simulator. In this case that is the ARPA simulator. It must be seen as decision making training. Simulators are used to replicate the real-life situation but they are not able to perfectly represent the real world. They are capable of very accurately measuring and recording the result of a simulated exercise.

An ARPA simulator plays an increasingly important role in the educational process of the nautical student, also in the training of deck officers and there is no other method which can be compared with it. Compared to other training methods ARPA simulators have many advantages such as:

- An ARPA exercises can create dangerous navigational situation with the own ship, target ships and other targets. Sometimes training beyond limits of ship safety is possible.
- The exercises, environment in simulators can be repeated.
- A wide variety of location and environmental condition can be used for training.
- Theoretical concepts can be applied to demonstratè their practical ability.
- It saves time in learning and cost of fuel is zero.
- On a simulator human performance under stress may be assessed.
- On a simulator interactions between the watch officer and ARPA equipment can be studied.

Training by radar simulation has been implemented since

the fifties in Britain. At first it was a very simple plotting procedure not dynamic enough and not comparable with observations and actions on the real ship. The coastline generator was then added and exercises became more realistic. Now a days nautical students and deck officers in many countries are trained on an ARPA simulator, on which they learn the art of collision avoidance at sea, embracing all aspects such as collision avoidance, navigation in narrow channels, traffic separation areas. In addition they also learn how to carry out Search and Rescue operations. In recent times many nautical colleges and academies in the world are carrying out research in design development, economics, human behavior under different conditions and circumstances, analysis and causes of accidents (e.g collision or stranding etc.). Capt.S.J.Singh of HongKong Polytechnic proposed the following directions of development in navigational simulation :

- To develop standardization in radar navigation,
- To conduct research studies at RNS centers to define human factors contributing to casualties; and
- to define the direction of development in simulator design.

2.3.3 TRAINING REQUIREMENTS WITH AN ARPA SIMULATOR

Effective ARPA training course need to satisfy following points:

- equipment requirement
- exercise design
- evaluation and analysis.

2.3.3.1 EQUIPMENT REQUIREMENT

Through statistical data at (IRNSLC), Tasmania, Feb/1988 number of own ships ARPA simulator 60 Nautical Colleges the world over were:

- 8 own ship cubicles occupied 10 % ,
- 4 own ship cubicles occupied 42 % ,
- 3 own ship cubicles occupied 27 % ,
- 2 own ship cubicles occupied 17 % ,
- 1 own ship cubicles occupied 5 % .

Most ARPA simulators (69 %) had three or four own ships.

At an other IRNSLC, St.Malo, May / 1990 it was the intention; minimum standards of ARPA simulation equipment for education and training were drafted. The minimum simulator configuration consists of :

- one Instructor station,
- two Ship stations,
- one Debriefing room.

In addition there is one subspace that shall be allocated to each Ship station, and at least one subspace to the Instructor station and Debriefing room. Detail of equipment requirement may be found in appendix D.

2.3.3.2. REQUIREMENT FOR ARPA SIMULATOR EXERCISES

Simulator exercises must be designed based on:

- analysis of past casualties and other sources of ideas,
- mistakes and misunderstandings which are repeatedly observed in the behaviors of trainees,
- the experience of practicing mariners who find a certain situation particularly difficult to deal with.
- the requirement to reinforce statutory requirement such as COLREGS.

At the 4th International Radar and Navigation Simulator Lectures' Conference, held at Mariehamh, May 1986 A.G.Bole has shown that effective ARPA simulator exercises can be described in following terms:

- an effective exercise plays most important role in ARPA training course,
- all aspects of an exercise appear by design and are under the conscious control of the instructor,
- exercises designed to run in a parallel mode should have a predictable result and are intended primarily for training on the basis of comparative discussion,
- exercises run in an interactive mode have an indeterminate result and are therefore more appropriate for independent decision making and interpretive discussion,
- the exercise needs as little explanation as possible from trainers,
- for students and deck officers alike integrity of exercise is essential,
- target vessels should play as little part in the final encounter as possible,
- during debriefing, instructor play a major role in guiding discussion, but minimum role in active discussion,
- the ultimate objective with any exercise is that it should be both effective and successful.

2.3.3.3 EVALUATION

Evaluation method for participants of ARPA training course are different in training centers all over the world.

- Some require a written test.
- Most evaluate the participants on a continuous basis i.e the trainees are monitored throughout the process for their ability to operate, to use the ARPA correctly and to understand the limitation and capabilities of ARPA.
- In UK and Germany no formal examination are held.
- Only Norway and Sweden use simulator examinations. At 5th (IRNSLC), Tasmania, Feb/1988 Mr.Bo Hogbom (Sweden) shown how after completing ARPA training they use two different examination exercises were used as follows:
 - * One student only in the own ship cubicle: he has to demonstrate his ability to operate the ARPA in a proper way, to get target information, to use maneuver simulation to plan avoiding action etc. At any moment the instructor may ask a question on the use of the main functions or on target manoeuvres
 - * Two students in the own ship cubicle. An exercise with navigation and dense traffic with about 40 targets navigating more or less correctly in the Traffic Separation System. This exercise takes about 90 minutes and ends with a general assessment of the knowledge and behavior of the two students in a more difficult situation.
- 27 out of 58 Nautical Colleges in the world preferred a continuous assessment to an examination. But it is very difficult to identify what is the difference between continuous assessment and an examination.

2.4 SOME EXPERIENCES IN ARPA EDUCATION AND TRAINING

At present more than 100 ARPA simulators are distributed around the world. IRNSLC is a meeting place of maritime lecturers world wide who use radar / ARPA navigation simulators for teaching, training, assessment and research. Many papers on ARPA training were presented at IRNSLC, Tasmania, Feb/1988. These are important to VMU and other colleges, preparing ARPA training. Some of the important remarks are following:

1. Manual plotting may be done on an ARPA.
2. ARPA training should not be part of general radar simulator course.
3. Only students with radar training should be allowed on the ARPA course.
4. Prior to the ARPA course students have had 4 hours of ARPA theory and demonstration, 4 hours training in setting up and maintaining display and more than 4 hours of individual use of ARPA on board ships (better doing it on training ship).
5. Radar and ARPA should not be treated as separate topic. The items as plotting, bridge team training, passage planing, Nav.aids, R/T communication should be taught separately. But Nav-lines must be included in the ARPA course.
6. An ARPA course should be 30-35 hours.

7. A minimum of two ARPAs should be provided.
8. VHF. R/T procedures should be followed during ARPA courses and close watch should be kept on the use of good English.
9. Students should not alternate between cubicles because they become confused with the controls.
10. For the students it is a good policy to have . difference manufacturers for ARPA, although it causes difficulties for the instructor.
11. Evaluation of ARPA courses by final assessment or final written test or final observation of practical exercise.
12. A radar simulator course plus an ARPA course should be required for all officers in fishing vessels.
13. A agreed international programme to teach radar plotting and ARPA techniques should be devised and taught at all nautical schools.

3 THE IMPLEMENTATION OF A ARPA TRAINING COURSE IN VIETNAM.

The Ministry of Transport and Communication has planned for acquiring a ARPA simulator to be installed at the Vietnam Maritime University, Haiphong. This plan is to be carried out in to following way:

STEP 1: until Dec/1991

- The Ministry creates the legal framework for Radar, ARPA training and certification to all masters and deck officers on board ships fitted or requiring to be fitted with ARPA equipment.
- selecting ARPA instructor team. They have to learn English, computer and theory of ARPA,
- choosing type of ARPA simulator.

STEP 2: until Jun/1992

- Sending ARPA teams to study and train on ARPA simulators at ARPA manufacturer,
- acquiring ARPA simulators,
- assembling ARPA simulator and preparing teaching and training aids,
- completing textbook "ARPA manual"
- ARPA instructor team will train itself and design ARPA exercises for ARPA training course under leading ARPA training expert,
- prepare ARPA handout for deck officers.

STEP 3: from July/1992.

- opening first ARPA training course for masters and deck officers.
- teaching ARPA to 4th year nautical students at VMU,
- developing more ARPA training programs to encompass bridge team procedures, passage planning, navigation aids, radar maps etc. VHF and R/T communications.

STEP 4. From Jan / 1993

- running separate ARPA course for:
 - * deep sea and harbour pilots.
 - * masters and chief officers,
 - * deck officers,
 - * nautical students at VMU,
 - * maritime superintendents.
- preparing a plan to fit in with ship handling simulator by 1995.

3.1 THE SELECTED ARPA SIMULATOR EQUIPMENT

The radar-ARPA simulator is basic equipment. It shall comply with the specifications approved by the Rector of VMU and the Directorate General in the Ministry of Transport and Communication. The ARPA simulator JRC (Japan) was selected by them. One of the important reasons is that it is convenient and economical for maintaining and repairing ARPA simulator in the future. IMO does not require knowledge of more than one ARPA but for the participant it is a good policy to have different manufacturers for ARPAs. Although it creates,

difficulties for the instructors, paying more money and problem of maintenance and repair.

The simulator will be required with four "own ships" cubicles, each having a radar and ARPA. The scheme of radar/ARPA simulator is illustrated at figure 3.1.

A greater number of "own ship" cubicles, will increase the number of participants per course and also the opportunities for interactions between "own ships".

The plotter is necessary to record maneuvers of "own ship" for subsequent discussion and also for analysis in the future. The printer will supply the parameters selected by instructor. These parameters consist of radar and ARPA information, display mode, course and speed from all "own ship" and "target ship".

3.1.1 EQUIPMENT IN SIMULATION ROOM

Each "own ship" cubicle must have the following parts:

DISPLAY PART:

- * ARPA,
- * Radar,
- * Gyro Compass Repeater,
- * Rudder Angle Indicator,
- * Speed Log Indicator,
- * Echo Sounder Indicator,
- * Rate of Turn Indicator,
- * Ship's Time Display,
- * Engine Control Telegraph,
- * Main Engine RPM Indicator,
- * Wind Speed and Direction Indicator
(Anemometer).

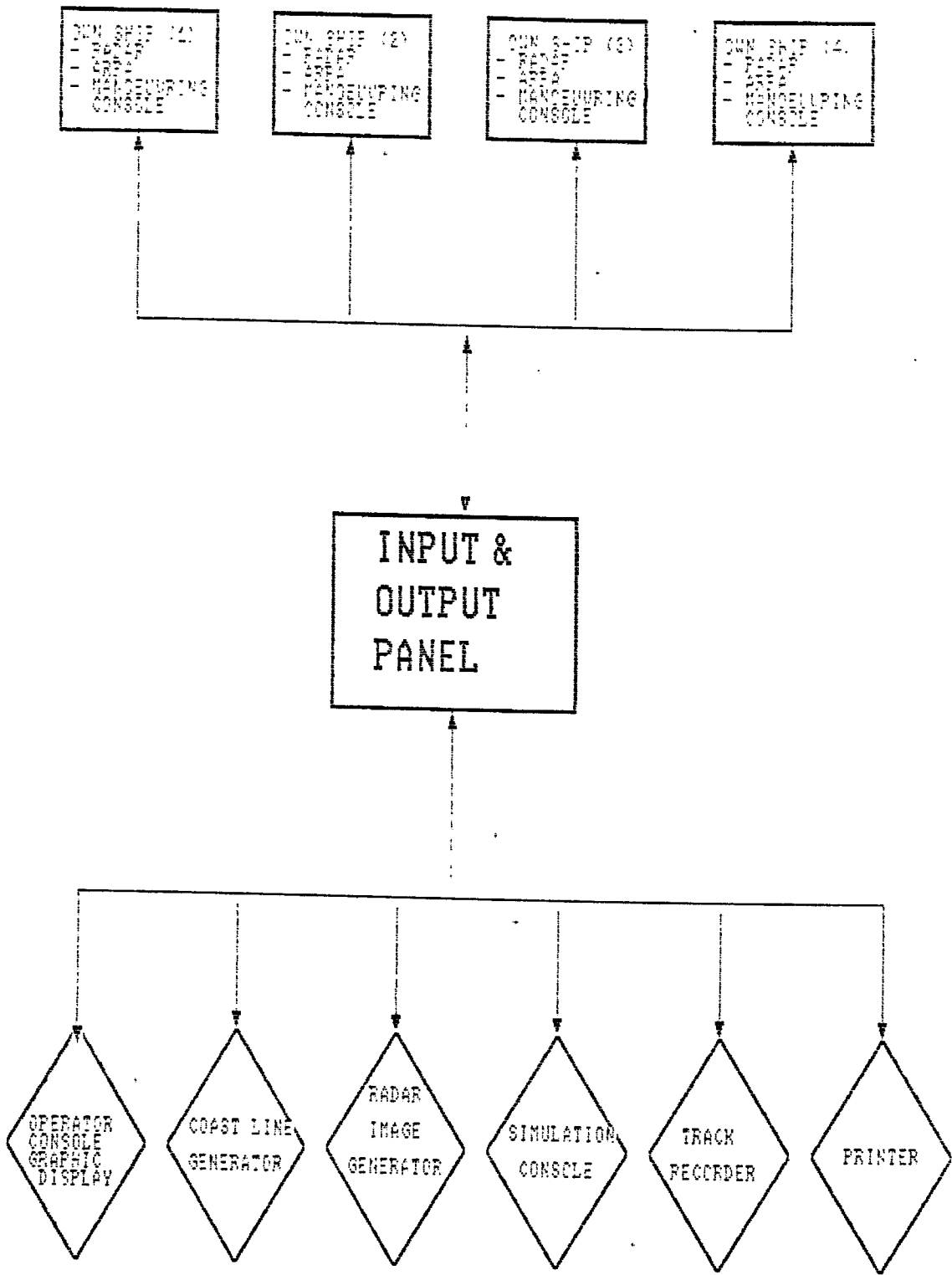


FIGURE 3.1 THE BLOCK DIAGRAM FOR RADAR/ARPA SIMULATOR WITH 4 OWN SHIPS WILL BE AT VMU.

EQUIPMENT:

- & Telephone with multiple lines that can be used for communication between "own ship" and Instructor and for simulating intra-ship communication,
- & V.H.F Radio Telephone for simulating inter-ship and ship-shore communications,
- & Facility for Sounding Fog Signals,
- & Reflection Plotter,
- & Steering System with Auto-pilot,
- & Chart table,
- & Sea Chart and Navigational Publications,
- & Log books for Bridge and Radar, Movement book,
- & Plotting tools such as parallel ruler, pencils, erasers, dividers, compass,
- & Own ship maneuvering characteristics as indicated in the sea trials,
- & Tables of basis parameter of ship and engine, speed in knots against RPM,
- & Sample examples of manual plotting methods for quick reference including true and relative motion,
- & Table of passing distances against course alterations and time.

3.1.2 EQUIPMENT IN CLASS ROOM

The classroom need to be equipped with an overhead projector and black-board for teaching the theoretical part of the syllabus. The teaching equipment plays an

important role in helping the Instructor implement exactly his teaching plan for the theoretical part of the syllabus

3.1.3 TEXTBOOKS

There are a lot of books written on ARPA but no specific textbooks are recommended for trainee use. Most of them are written by English authors. This makes it difficult for many Vietnamese participants to understand deeply an ARPA. Therefore it is necessary to prepare an ARPA textbook. The author can recommend some excellent books and a lot of articles written by experts on the ARPA subject such as the book " Automatic Radar Plotting Aids Manual" from Bole A.G & Jones K.D (1983), " Radar and ARPA manual " from Bole A.G & Dineley W.O (1990) or the articles of the International Radar and Navigation Simulator Lecture Conferences. Then the experienced Instructor will have to prepare " Automatic Radar Plotting Aids " handout for the participants.

3.1.4 VIDEO TAPES / FILMS

Video tapes or films showing particulars of different types of ARPA from various manufacturers should be obtained for viewing. This will satisfy partially the need to demonstrate functions of different types of ARPA.

3.2 THE ARPA INSTRUCTORS

The ARPA training team would consists of four ARPA instructors and one technician.

The training of the course instructor is of vital importance, because the success of the participant and

student would depend to a great extent on the competence of the instructor. The most important requirement for the ARPA instructors is that are well qualified, well trained, dedicated and a highly motivated faculty. In an ARPA Model Course IMO requires, that the instructor should hold a certificate as master and have a minimum of two years' watch-keeping experience with radar. He has to be familiar with the operation of the ARPA equipment, which will be used in the training course. When four "own ships" are in use, the instructor will need assistance during exercises.

The necessity for the ARPA course instructors to keep abreast of latest practices and development on board ship cannot be stressed enough. It is a must for them to make regularly short voyages on ships fitted with appropriate equipment.

The ARPA instructors need to be trained on the simulator manufactured by JRC (Japan) for 3-4 weeks. They need to be trained in operation and use of the hardware, software and capabilities of the equipment. This is necessary because when the instructors master the above ARPA training equipment, they will be able to design effective exercises. The more often an exercise is run, the wider is the range of solutions which the instructors will have observed and on which they can draw when searching for optimum maneuvers. They will have experienced the overall scenario before using ARPA to train participants. In future they should carefully watch the exercise to see that it is developing as planned and monitor it closely to ensure that the objectives are achieved.

The effect of ARPA training will improve when the

instructors discuss all aspects of simulator training with practitioners from all over the world through the IRNSLC. If it is possible this team needs to visit and observe simulator instructors in other colleges.

The maintenance of simulator and peripheral equipment is very important for a successful ARPA course. Therefore the technician should be trained by the ARPA simulator manufacturer (JRC) in maintenance, fault finding and repairs. During implementation of ARPA course it will be necessary to have available a technician having adequate knowledges in electronics and specific training on computers and simulators.

In addition instructors need to keep detailed information regarding participants and their performance during ARPA training course, that will be necessary for statistical analysis. This data consists of :

- name, age, rank,
- data of Radar certificate,
- sea time,
- types of ships worked on,
- level of experience on ARPA.

and the records of the performance :

- + common, abnormal or novel manoeuvres,
- + normal or abnormal mistakes,
- + types of exercises that the participant finds particularly difficult.

The VMU has a group of radar observation and plotting instructor with good experience. Most of them studied, graduated and trained in the Soviet Union, Poland and some other countries. There is confidence that, they will be to able to prepare the syllabus, to conduct the course and to

evaluate participants. The instructors need continuous contact with shipboard practices, because the practices are an essential source for them in designing and altering the ARPA course to reflect current trends. Therefore regular periodic voyages on board for the ARPA course instructors will be necessary and will prove to be useful.

3.3 PARTICIPANTS

The participants for the ARPA training course will be masters, first mates, other navigating officers and nautical students of VMU. All participants must have been trained in radar observation and plotting course, before joining the ARPA course. This requirement also applies to nautical students. In future all participants must hold a radar observer, plotting certificate prior to the ARPA training course.

If the above requirement is satisfied every Vietnamese officer as well as foreign participants will join this course.

The ARPA training courses will be of 34 hours (44 hours for nautical students at VMU) duration and will be conducted frequently as per the requirement of Shipping Companies and other participants. In addition, depending on the requirements of shipping companies and participants, VMU can conduct additional special courses such as:

- Additional Radar training course,
- Shorter ARPA training course (18 hours, but no certificate).

The ARPA training course will divide the participants

in to some different levels (application from Jan/1993)

- + Deep sea and harbour pilot,
- + Masters and first mates,
- + Other navigational officers,
- + Marine superintendents
- + Nautical students of VMU.

3.4 THE ARPA TRAINING PROGRAM

Duration: 6 days (1 week)

Number of participants : 8 persons

(2 persons / 1 cubicle)

This arm of the course is to enable masters, deck officers, nautical students and other participants to understand the basic principles of the operation of Automatic Radar Plotting Aids, including their capabilities, limitation and possible errors.

The teaching method will consist of a series of lecture and practical demonstrations on the use of ARPA operational controls, and traffic encounters to illustrate the capabilities and limitations of the equipment. However, all of them emphasize that exercises on the simulator impart the most benefit to the participants. Due to different levels of participants and studying time, a suggested schedule for the ARPA training course is divided into two types as follows:

- for masters and deck officers,
- for nautical students of VMU.

3.4.1 SCHEDULE FOR THE COURSE TO MASTERS AND DECK OFFICERS

The suggested plan for the ARPA training course is based on IMD MODEL COURSE 1.08 and experiences of ARPA training of many Nautical Colleges all over the world (through IRNSLC) to be conducted at the Vietnam Maritime University is shown on the table 3.1 and the time plan of this course is shown as following:

SUBJECT AREAS	HOURS	
	LECTURE	SIMULATOR
1. Introduction	1.0	
2. Revision of plotting techniques	1.5	
3. Review of plotting techniques		
- relative motion		1.5
- reflection motion		1.5
- true motion		1.5
4. Basic theory of ARPA	1.5	
5. IMD performance standards for ARPA	0.5	
6. Setting up and maintaining displays		1.0
7. Acquisitions of targets	0.25	0.5
8. Tracking capabilities and limitations	0.25	1.0

9. Processing delays	0.5	1.0
10. Display of target data and error in displayed data	1.5	1.0
11. System operation tests	0.5	1.0
12. Obtaining information from ARPA, including: - risk of over reliance on ARPA - application of COLREG-72 - errors in interpretation	1.0	7.5
13. Trial maneuver		1.5
14. Traffic separation scheme		1.5
15. Exercise in area of high traffic density		1.5
16. Principal types of ARPA		1.0
17. Test - theory - simulator		3.0
18. Debriefing	0.5	
	8.5	25.5
SUBTOTALS	8.5	25.5
		34.0
TOTAL		34.0

TABLE 3.1: WEEKLY SCHEDULE FOR ARPA TRAINING COURSE

PERIOD DAY	MORNING SESSION 07.00 TO 12.30	AFTERNOON SESSION 13.30 TO 17.00
MONDAY	1. INTRODUCTION (L) 2. REVISION OF PLOTTING TECHNIQUES (L) 3. REVIEW OF PLOTTING TECHNIQUES (S)	3. REVIEW OF PLOTTING TECHNIQUES (S)
TUESDAY	4. BASIC THEORY OF ARPA (L) 5. IMD PERFORMANCE STANDARDS FOR ARPA (L) 6. SETTING UP AND MAINTAINING DISPLAYS (S)	7. ACQUISITION OF TARGET (L,S) 8. TRACKING CAPABILITY AND LIMITATION (L,S) 9. PROCESSING DELAYS (L,S)
WENESDAY	10. DISPLAY OF TARGET DATA AND ERROR IN DISPLAYED DATA (L,S) 11. SYSTEM OPERATIONAL TESTS (L,S)	12. OBTAINING INFORMATION FROM ARPA (L,S)
THURSDAY	12. OBTAINING INFORMATION FROM ARPA (S)	12. OBTAINING INFORMATION FROM ARPA (S)
FRIDAY	13. TRIAL MANDEUVRE (S) 14. TRAFFIC SEPARATION SCHEME (S)	15. EXERCISE IN AREA OF HIGH TRAFFIC DENSITY (S) 16. PRINCIPAL TYPES OF ARPA (S)
SATURDAY	17. TEST (S)	18. DEBRIEFING

3.4.2 BRIEF DETAILS OF LEARNING OBJECTIVES

.1 INTRODUCTION

- objectives of the ARPA training course,
- schedule for the course,
- introduction by instructors,
- documentation.

.2 REVISION OF PLOTTING TECHNIQUES

- technical features and characteristics of relative and true motion plotting,
- determination of range, bearing, true course, speed, closest point of approach (CPA), time to CPA of target using relative (both north up and head up) and true motion display observation,
- advantages and disadvantages for each type of plotting techniques.

.3 REVIEW OF PLOTTING TECHNIQUES

- familiarization with simulator:
 - + explanation of equipment,
 - + layout of "own ship" cubicle,
 - + radar controls.
- exercises on plotter.
 - + observation of target,
 - + construction of the relative motion triangle and identifies the sides and angles,

- + determination of their CPA, TCPA, true course and speed on plotting sheet and reflection plotter.,
- exercises on relative plots:
 - + observation of targets,
 - + observation of their CPA, TCPA, true course, speed on relative motion presentation,
 - + observe changes in CPA and TCPA resulting from alteration of course and speed of "own" or target ship,
 - + observe a relative plot to determine the alteration of course or speed needed to achieve a required CPA,
- exercises on true plots with:
 - + observation of targets,
 - + determination of their CPA, TCPA, true course and speed on true motion presentation,
 - + determines changes in CPA and TCPA resulting from alteration of course and speed of "own" or target ship,
 - + detecting alteration of course or speed of a target and determines the alteration from a plot.

.4 BASIC THEORY OF ARPA

- digital radar processing,
- principle and types of ARPA,
- ARPA features:

- + vectors,
- + graphic,
- + alphanumeric data,
- + potential points of collision (PFC),
- + predicted areas of dangers (PAD),
- + sector of danger (SOD),
- + sector of preference (SOP),
- + trial maneuvers static and dynamic,
- + operational warnings,
- + navigation lines,
- + speed and course measurement.

- error and limitation:

- + sensor errors,
- + ARPA error,
- + error of interpretation.

- manual and automatic acquisition of targets and their respective limitations.

The instructors can refer to some books such as " Radar and ARPA manual ." from Bole A.G & Dineley W.D., or " Automatic Radar Plotting Aids Manual " from Bole A.G & Jones K.D or see appendix A.

.5 IMO PERFORMANCE STANDARDS FOR ARPA

- the requirement for acquisition and tracking of targets,
- the requirement for the operational warnings,
- the requirement for the data in alphanumeric form,
- the standard accuracy for ARPA on basic of sensor error by IMO performance standards,

- the performance standards for gyro, log inputs
- the performance standards for range and bearing accuracy and discrimination of radar.

(see section 2.2 and appendix B)

.6 SETTING UP AND MAINTAINING DISPLAYS

- familiarisation with ARPA controls and their function,
- selection of mode and presentation,
- proper use of gain, anti-sea clutter and differentiation control for optimum display of data,
- selection of ARPA plotting controls, manual / automatic acquisition, vector / graphic display of data,
- selection of time scale of vectors / graphics,
- performance checks of radar, compass and log input sensors and ARPA.

.7 ACQUISITIONS OF TARGETS

- explains how ARPA acquires a target,
- procedure to acquire targets,
- describes the criteria for manual and automatic acquisition of targets,
- the number of acquired targets is limited depending on which kind of ARPA equipment,
- explains what are guard zones and alarm,
- explains what are target overflow and alarm.

.8 TRACKING CAPABILITIES AND LIMITATIONS

- IMO performance standards for tracking,

- describes the criteria for the selection of targets by automatic acquisition,
- explains what are the factors leading to the correct choice of target for manual acquisition,
- what are a "lost" targets and target fading effects of them,
- describes the reasons leading to "target swop" and its effects on displayed data,
- explanation of criteria for automatic cancellation of target tracking.

.9 PROCESSING DELAYS

- explains delay in the display of correct target data on acquisition, re-acquisition and when the target ship is maneuvering,
- knowledge of full accuracy of derived information is attained only three minutes after acquisition or manoeuvre of the target.

.10 DISPLAY OF TARGET DATA AND ERROR IN DISPLAYED DATA

- uses display and defines bearing, range in true and relative mode,
- defines course, speed, CPA, TCPA and vectors on each mode,
- explains how past position of tracked targets are displayed,
- knowledge of the result of trial maneuverers approximate depending on the model of "own ship" maneuvering characteristics,
 - + explains that errors in bearing are caused by backlash, ship motion, asymmetrical antenna

- beam and azimuth quantification,
- + also that errors in range are caused by rolling of "own ship" and range quantification
- + knowledge of errors caused by input errors from compass and log,
- + describes the effects of heading and speed errors on derived information.

.11 SYSTEM OPERATION TEST

- describes methods of testing for malfunction of ARPA equipment including functional self-testing,
- explains the need to check performance, including trial maneuver by manual plotting,
- knowledge of action taken after malfunction occurs

.12 OBTAINING INFORMATION FROM ARPA DISPLAY

- demonstration of ability to obtain information in both relative and true motion displays, including:
 - * identification of critical echoes,
 - * determination of target's relative direction and speed,
 - * determination of target's CPA and TCPA,
 - * definition of true course and speed of target,
 - * description of course, speed and aspects of targets, detecting course and speed changes of targets and limitation of such information,
 - * demonstration of effects of changes in own ship's course or speed or both,
 - * operation of the trial maneuver.

- risks of over-reliance on ARPA.

- * the trainer has to understand that ARPA does not relieve him of responsibility for keeping lookout,
- * need to comply at all time with the basic principle in keeping a navigational watch,
- * unreliable target data due to maneuver of target and / or own ship,
- * need to know that small passing distances indicate possibly dangerous situation and not safe passage,
- * need to understand that only failure of sensors will be indicated by alarm. Any inaccurate input from sensors will not be indicated.

- Errors of interpretation:

- * need to show that inaccuracy in interpretation may lead to a dangerous misunderstanding of the present situation,
- * misinterpretation concerning vectors,
- * need to understand that misinterpretation may occur due to ground or sea stabilized motion,
- * need to explain that the PAD and PPC apply only to "own ship" and targets and can't indicate mutual threats between targets,
- * errors of interpretation due to varying display symbol of different ARPAs.

- Application of COLREG 1972.

- * analysis of potential collision situations from displayed information, determination,

execution and subsequent monitoring of action to avoid close quarters situations in accordance with International Regulations for Preventing Collisions at Sea.

- * to practice manual plotting and comparing results with ARPA is very important, and advantageous,
- * before using ARPA the need for early use of radar in clear weather at night and when there are indications that visibility may deteriorate,
- * the need for comparison of features displayed by radar with charted features,
- * the need for comparison of the effects of differences between range scales,
- * that various types of ships give different maneuvering characteristics,
- * what is safe speed and why, when using it.

.13 TRIAL MANEUVER

- static and dynamic maneuver,
- own ship manoeuvring characteristics,
- detecting changes in course or speed or both of target ships,
- effects of change in course or speed or both of own ship,
- hazards of small changes such as speed or course in relation to rate and accuracy of detection.

.14 TRAFFIC SEPARATION SCHEME

- exercises of application of COLREGS in area of traffic separation schemes.

.15 EXERCISE IN AREA OF HIGH TRAFFIC DENSITY

- exercise of application of COLREGs in area of high traffic density.

.16 PRINCIPAL TYPES OF DIFFERENT ARPAs

- introduction to PAD and PPC theory,
- principal ARPA systems and their particular features using video films, technical literature, brochures, posters.

.17 TEST

- each participant is required to undergo examination exercises on the ARPA simulator. The exercise takes about 90 minutes and it will be applied by the test method of Sweden (see paragraph 2.3.3.3) During this exercise the instructor may ask question on operating ARPA, getting target information, planning avoiding action etc.

.18 DEBRIEFING

- Debriefing of the participants at the end of the exercises forms an important part of the ARPA courses and also in assessment of proficiency of the participants. Some of the participants will be experienced masters, will also be able to provide valuable inputs in preparing the guidelines.
- Documentation,
- Course evaluation,
- Suggestion from participants.

3.4.3 THE SCHEDULE OF ARPA COURSE FOR NAUTICAL STUDENTS

This course will be presented in the second semester of the fourth class year. The ARPA course for nautical students will occupy 44 hours, that divides in to 2 class hours per week and 2 ARPA simulation per week. The students use textbook " Automation Radar Plotting Aids Manual " for this ARPA education and training course. A suggested schedule for the ARPA training course to be conducted at the VMU is shown as follows:

1st week:

1. Course overview.
2. Proposed Minimum Requirement for Training.
3. Introduction to ARPA simulation.

2nd week:

1. IMO PERFORMANCE STANDARDS.
2. Principle of ARPA.
3. ARPA exercise 1.

3rd week:

1. The principal types of ARPA and their display characteristics.
2. ARPA video instruction.
3. Short test 1.
4. ARPA exercise 2.

4th week:

1. ARPA features..
2. Predicted Areas of Dangers (PAD).
3. ARPA exercise 3.

5th week:

1. Tests, warnings, alarms.
2. The collision regulations-relevance of ARPA.
3. ARPA exercise 4.

6th week:

1. Error and limitation of ARPA.
3. Short test 2.
4. ARPA exercise 5.

7th week:

1. Trial maneuver.
2. History past positions.
3. ARPA exercise 6.

8th week:

1. Manual and automatic acquisition of targets and their respective limitation.
2. Processing delay.
3. Short test 3.
4. ARPA exercise 7.

9th week:

1. Tracking capabilities and limitation.
2. Analysis of data collected.
3. ARPA exercise 8.

10th week:

1. Factors affecting system's performance.
2. Analysis of useful observations.
3. ARPA exercise 9.

11st week:

1. Revision of ARPA theory.
2. Short test 4.
3. ARPA exercise 10.
4. Class discussions.

12nd week:

1. ARPA exercise test
2. Debriefing ARPA course.

Before ARPA exercise test for certificate each nautical student at VMU has to pass 4 short test during studying ARPA course. Any one fails in each short test (less than 50 %) needs to exam again. The contents of the short test are as following:

Short test 1: IMD requires performance standards for ARPA system and ARPA training.

Short test 2: Theory of ARPA.

Short test 3: Accuracy and limitation of ARPA.

Short test 4: Application of ARPA for avoiding collision.

In addition he needs to implement 10 ARPA exercises (see section 2.3.3.2 and 3.5.1).

3.5 EXERCISES

A software library of different ship-models and various exercises should be available for practice. These exercises will be designed and prepared by the instructor's team of VMU.

3.5.1 THE OBJECTIVES OF ARPA EXERCISES

The objective of an exercise should take into consideration the need and experience of the participants. The exercise will demonstrate the use of ARPA controls to obtain vital information from ARPA display and also demonstrate various ARPA functions and the limitations and errors of ARPA more effectively than by mere lectures. Regardless the degree of complexity, the objective of an exercise should be written in clear, specific and well-defined terms. The objective of the exercises will illuminate the following:

* SETTING UP PROCEDURE:

- correct setting up of radar controls especially anti sea clutter and FTC controls and effects of improper use of these controls,

* ACQUISITION:

- change in the size of the tracking window,
- acquisition of target, targets close to each other, targets at the same bearing, targets within an area of sea or rain clutter,
- acquisition time,
- use of guard zones, exclusion areas.

* TRACKING:

- target lost including the period of time until a warning is given,
- target swap,
- processor overload,
- accuracy of information regarding CPA, TCPA, target ship's true and relative course and speed,
- effects of sensor malfunctions including incorrect speed and course input,
- effect of changes of own ship's course and speed,
- effect of changes of target ship's course and speed;
- differences between trial manoeuvre information and actual ship manoeuvre executed,
- advantages and disadvantages of true and relative vectors and of past positions,
- applicability of ARPA in different sea areas for collision avoidance in two-ship and multi-ship encounters,
- processing delays especially when there are too many targets on the same bearing.

* APPLICATION OF THE INTERNATIONAL REGULATIONS FOR PREVENTING COLLISIONS AT SEA

- Analysis of potential collision situations from displayed information, determination, execution and subsequent monitoring of action to avoid close quarters situations in accordance with International Regulations for Preventing Collision at Sea.

3.5.2 DESIGNING EXERCISES

The objective is first identified for designing an exercise. When designing an exercise, the instructors need to consider carefully the following factors:

1. the exercise area,
2. the number and types of own ships,
3. the number and types of target vessels under the instructor's control,
4. the number and types of pre-programmed target vessels and their respective tracks,
5. the number and the types of fixed targets,
6. the starting position, course and speed of each own vessel,
7. the starting position, course and speed of each target vessels,
8. the position of each fixed target,
9. environmental conditions such as direction and rate of current, wind direction and speed, state of sea, condition of visibility, etc.
10. radar effects such as sea clutter, rain clutter, radar noise and mutual interference,
11. radar characteristics e.g. aerial height and shadow sectors,
12. type of encounter eg head on, overtaking, etc.
13. the zone where the encounter is to take place,
14. the approximate time of encounter,
15. faults or failures that are to be introduced,
16. the times at which the faults or failures are to be introduced,
17. the type of navigation aids to be incorporated in the exercise,

18. VHF, R/T or W/T messages, if any,
19. exercise mode i.e parallel or interactive,
20. duration and scale of plot,
21. vessels and targets to be included in the plot
22. center and scale of plot
23. the portions of the exercise that are to be recorded for replay.

(Cap.S.M.Ahmed and Cap.I.A.Karin at the IRNSLC.5 held at Tasmania, February 1988)

The ARPA simulator at VMU shall have the following mathematical ship models for exercises:

- 250,000 DWT VLCC loaded and in ballast,
- 90,000 DWT tanker tanker,
- 45,000 DWT bulkcarrier,
- 40,000 DWT container vessel,
- 16,000 DWT general cargo ship.

The simulator shall have the following sea area for exercises:

- Dover straits,
- Singapore straits,
- Straits of Gibraltar,
- Approaches to Kobe,
- Approaches to Hongkong,
- Approaches to Vungtau (Saigon)

CHAPTER 4

CONCLUSIONS

AND

RECOMMENDATIONS

4.1 CONCLUSION.

- .1 Many Governmental and Private Shipping Companies of Vietnam own and operate a fleet of ships will be equipped with ARPA systems. But, most of masters and deck officers have not received any formal training in the operational use of ARPA. Many of them may never have seen ARPA equipment.
- .2 STCW 78 and IMO Resolution A482 (XII) require that all masters and navigating officers be trained in the use of ARPA.
- .3 It is very urgent and necessary to conduct on operational use of ARPA for masters and navigating officers working in Vietnamese ships, and for nautical student at VMU.
- .4 The IMO Model Course 1.08, in a slightly adapted form, is a good basic for the needed training as mentioned above.

4.2 RECOMMENDATIONS.

- .1 Simulator with ARPA planned to be acquired should have four own ships. It should be possible to interface various modern navigational equipment and visual projection system with the simulator. The simulator is manufactured by JRC company, Japan.
- .2 Instructors must have specialised ARPA training on simulator by the manufacturer " JRC ".
- .3 Funds must be made available so that instructors attend and participate in " The International Radar and Navigation Simulator Lecturers " conferences.
- .4 During ARPA training course there should be available a competent technician with capacity to maintain, correct and carry out minor repairs. He should be trained by the simulator manufacturer in maintenance and repairs of equipment.
- ✓ .5 All records of participants and feedback from them needs to be maintained for future analysis. It is important to improve the quality of ARPA training course with time.

✕ .6 There is great need to develop other courses in the future on the base of ARPA simulator course such as passage planning, navigational aids and VHF. R/T communications.

✕ .7 With time a package of course need to be developed in different levels:

- deep sea pilots,
- masters and chief officers,
- other navigating officers,
- nautical students at VMU,
- marine superintendents.

APPENDIX A

THEORY OF ARPA

APPENDIX A.

THEORY OF AUTOMATIC RADAR PLOTTING AIDS

This appendix deals with the following:

1. Principles of ARPA.
2. Data quantisation in ARPA.
3. Reduction of clutter.
4. Automatic tracking.
5. Errors and limitation of ARPA.

A.1 Principle of ARPA.

Basically ARPA equipment should give the operator relevant information concerning the surrounding traffic situation in such a manner that the risk of collisions and stranding is decreased. ARPA equipment is capable of, based on raw radar signal, extracting and processing video signals to yield position, course and speed estimates for desired target, and to reject video noise. This equipment needs a fast digital computer to perform these functions in real time.

The technical possibility of digitizing analogue radar signals has made it possible to process radar data for simultaneous and automatic plotting and tracking of multiple target. The plotting and tracking are done by Automatic Radar Plotting Aids (ARPA).

The whole process of target detection, tracking, calculation of parameters and display of information is know as automatic radar plotting.

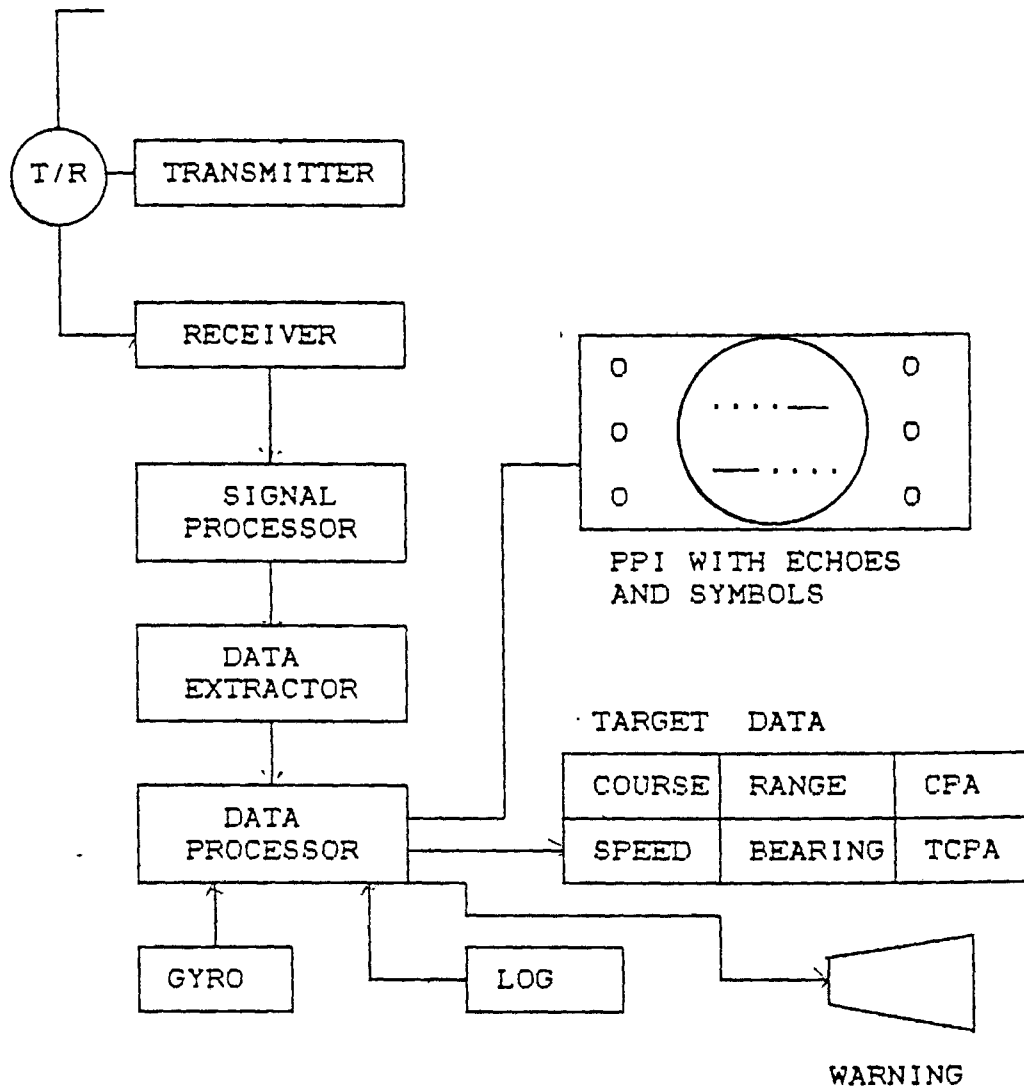


FIGURE A.1 ARPA BLOCK DIAGRAM

Tracking is the process of observing the sequential changes in the position of target to establish its motion.

ARPA provides continuous, accurate and fast information concerning closest point of approach (CPA), time to CPA (TCPA), speed and course of more targets and quicker than is possible manually in an encounter situation (fig A.1).

ARPA equipment will provide true or relative vector graphic and alphanumeric displays that can be easily understood to operator. Alarms based on operator selected limits of CPA and TCPA warn the watching officer about threatening or developing close quarter situation.

Trial manoeuvre facility assists deck officer in choosing safe avoiding actions in close quarter situations.

Tracking continues even after change in course or speed of own ship and / or of targets and after change in range scale in use.

A.2 DATA QUANTISATION IN ARPA.

Echoes of targets are received and displayed on radar PPI in polar co-ordinates, i.e. azimuth and range. For the computer to process the target data, it is necessary to convert the azimuth and range information into digital signals. The quantisation is the process that converts target data into digital form.

Quantisation in data is carried out on the I.F. signal from the amplifier before displaying on PPI. The quantized picture (including quantisation in range,

bearing and intensity) is stored in a huge matrix of typically 512 range and 2048 bearing increments including the echo intensity as the 3rd parameter. Table A.1 shows the principle involved and some typical parameters and characteristics.

TABLE A.1 QUANTISATION OF THE RADAR VIDEO.

QUANTISATION	PRINCIPLE	PARAMETERS (example)	RESOLUTION
RANGE	SWITCH REGISTER; SYNCHRONISED TIMING	512 CELLS FOR 3 N.M	11 m
BEARING	PULSE COUNTING OR SHAFT ENCODER	2048 PULSES □ FOR 360	□ 0.18
INTENSITY	ANALOG/DIGITAL CONVERSION (threshold)	1 bit to 3 bits	2 levels to 8 levels

Quantisation is achieved by dividing the area around own ship into revolution cells. The size of cells is determined by the pulse duration and the horizontal beam width. The processor will calculate the centroid of the cells which are covered and assigns the co-ordinates of centroid to the target.

QUANTISATION IN RANGE:

The register receives not only pulses from echo signal of target but also pulses from an oscillator clock synchronised with the transmission of radar pulses. The echo signals are stored in the appropriate cell depending on range of target. The oscillator clock pulses enable the cells to be "clocked" or numbered. The number of the cell is shown by a binary number that is used by the computer for processing. For example at table A.1 the radar to be on 3 miles range, and visualise a time base to be divided in to 512 cells or bins. This will mean each successive cell represents an increase in range of:

$$\begin{aligned} & 3 * 1852(\text{m}) \\ & = \frac{\text{-----}}{512} = 11 \text{ m} \end{aligned}$$

Remember that an echo pulse from a target at 3 miles will take :

$$\begin{aligned} & 3 * 1852 * 2 \\ & = \frac{\text{-----}}{300} = 37.04 \mu \text{ sec.} \end{aligned}$$

and there are 512 cells to be clocked in 37.04 u sec. Therefore an oscillator will then provide a pulse every

$$\begin{aligned} & 37.04 \text{ u sec} \\ & = \frac{\text{-----}}{512} = 0.072 \mu \text{ sec.} \end{aligned}$$

for each successive cell.

In the above example the range discrimination is 11 meters. The oscillator providing the clock pulses at 0.072 μ sec must have a frequency of:

$$\begin{aligned} & 6 \\ & = 10 \mu \text{ sec} / 0.072 \mu \text{ sec} = 13.9 \text{ MHz.} \end{aligned}$$

Clearly, although this is suitable for purpose of

illustration, its steps are much too coarse to be of practical use. Reference to echo B in figure A.2 shows that a target at a range of almost 65 meters will have a stored range of 60 meters. It follows that if the target is moving with respect to the observing vessel range will appear to change in steps. Range quantizing error is of particular significance in automatic tracking (see section A.4 of appendix A).

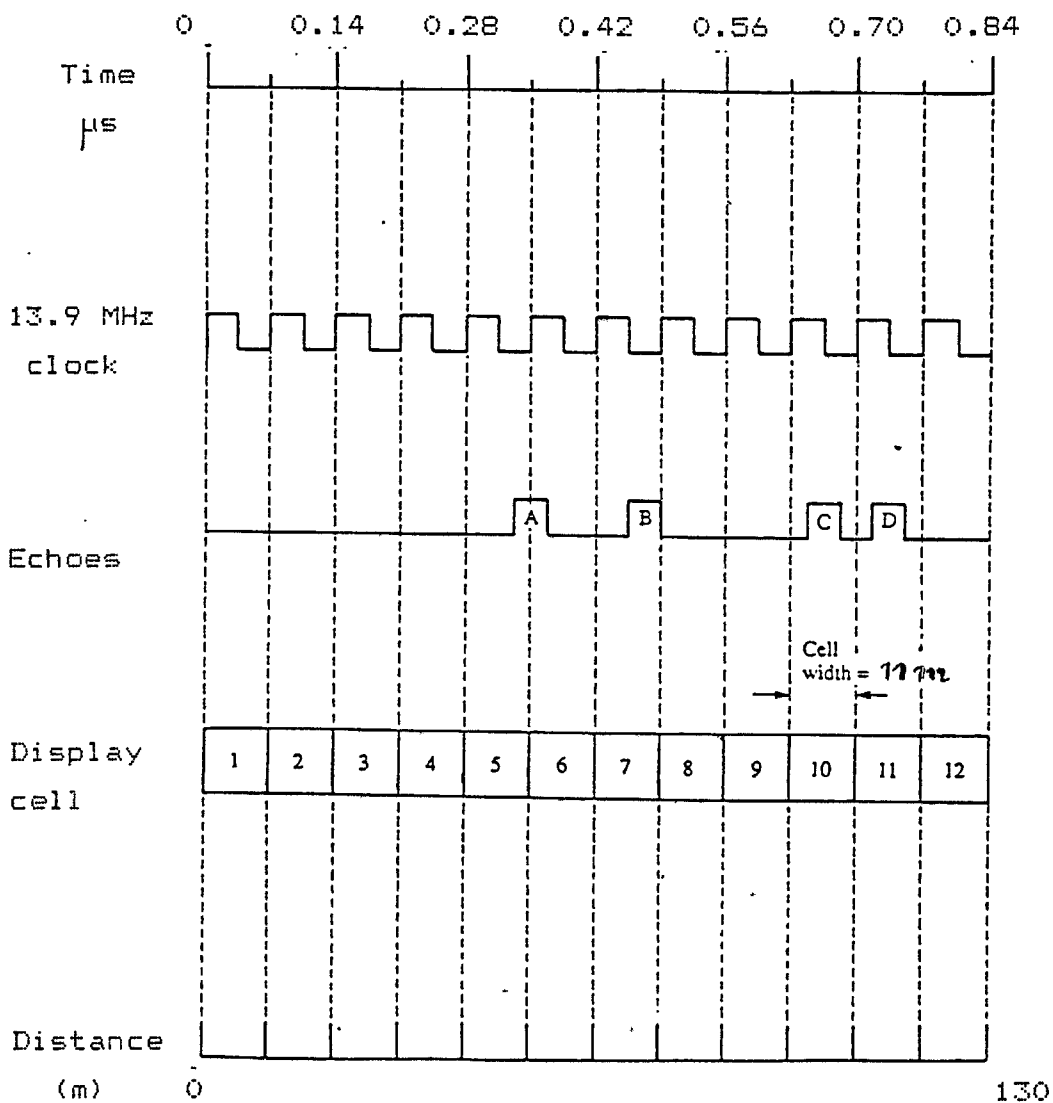


FIGURE A.2 QUANTISATION IN RANGE.

QUANTISATION IN AZIMUTH:

* Pulse count techniques: In the radar system the antenna rotates at the uniform rate. For example the antenna rotates 20 RPM and the PRF is 1000 Hz. We can calculate the antenna rotates 120 degrees per one second . Due to corresponding to 120 degrees angular movement for 1000 pulses or 0.12 degrees angular movement for every pulse. Value 0.12 degrees also shows the bearing discrimination.

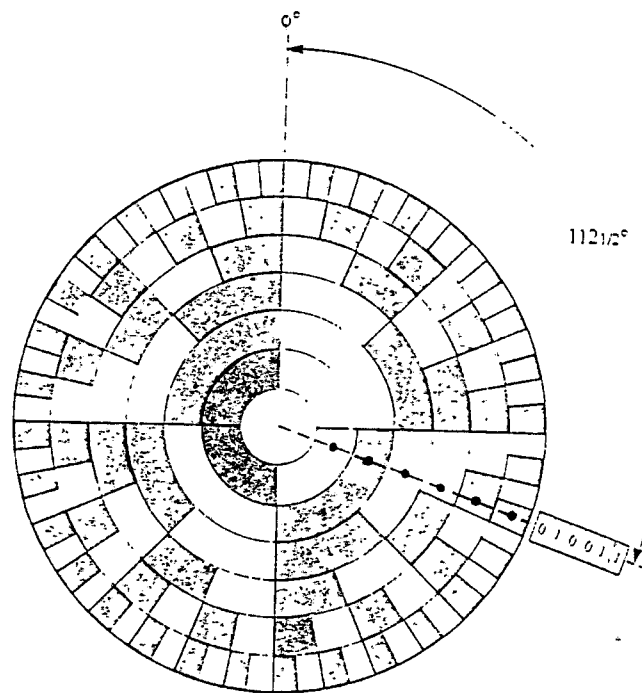
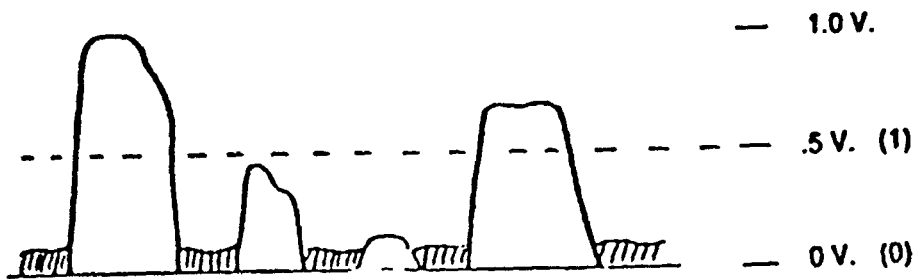


FIGURE A.3 SHAFT ENCODER

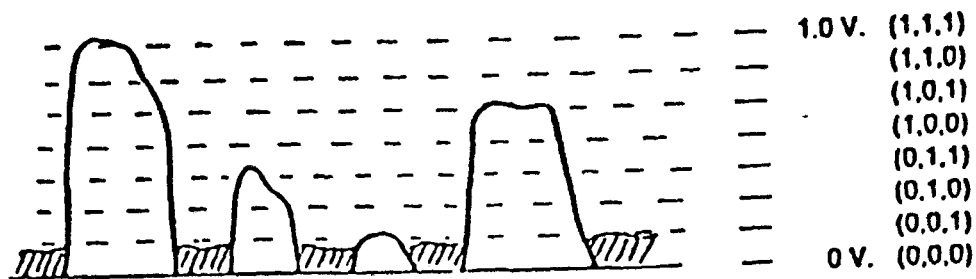
* Shaft encoder techniques: This is a disk which has a number of concentric rings. Each outer ring is divided into twice the number of " segments " in the inner ring. The number is represented by a power of 2. The number of rings depends on the desired discrimination of bearings.

Figure A.3 shows an encoder having only 5 rings, i.e a
 2^6
 six-bit-encoder. It has 64 (2^6) segments in the outer
 rings and thus the digital angle will increase in steps of
 $360 / 64$, i.e 5.625 (one half compass point).
 At the example at table A.1 a shaft encoder is divided
 into 2048 windows (using 11 rings) which provides
 discrimination of:

$$360 / 2048 = 0.18$$



**SINGLE-LEVEL QUANTIZATION
(1 BIT)**



**EIGHT-LEVEL QUANTIZATION
(3 BITS)**

FIGURE A.4 THRESHOLD LIMITS FOR REDUCTION IN CLUTTER

QUANTISATION IN INTENSITY :

Clutter can also be reduced by comparing the processed video output with predefined threshold limits for echo strengths. The threshold is set at a level below that most of clutter echoes will lie and therefore rejected. The operator must always remember that any target below the threshold will also be rejected and not appear on the PPI (see figure A.4). The table A.1 provides :

+ 1 threshold level, the video signals will be stored as (1) strong (target existing) and (0) as weak (target not existing). This needs to require 1 bit of computer memory for every cell to be stored.

+ 8 threshold level, the video signals will be stored in 3 bits for every cell as following:

000	=	0	means no target.
001	=	1	means very weak target.
010	=	2	means weak target.
011	=	3	means less than normal target.
100	=	4	means normal target.
101	=	5	more than normal target.
110	=	6	means strong target.
111	=	7	means Very strong target.

This is considered that to provide 8 threshold levels the computer will need 3 times the memory required for one threshold.

Table A.1 shows that when using a matrix of 512 times 2048 (= 1,000,000) elements it is obvious that the resolution due to quantisation is not worse than conventional discrimination of range and bearing. If 8 threshold levels of intensity are used, the synthesized picture is a close reproduction of analogue raw radar picture in term of range and bearing discrimination.

All quantized radar data are used as input for a computer that processes signals for :

- reducing clutter,
- automatically tracking and calculating true course and speed, relative course and speed, CPA, TCPA, PPC, PADS, SOD and SDP.
- creating other ARPA functions such as automatic and manual acquisition including target detection on crossing guard zone, specifying exclusion areas to avoid acquiring echoes of unwanted targets, specifying priorities for automatic acquisition and cancellation of target.

A.3 REDUCTION IN CLUTTER

Technically the most effective cleaning of the picture from clutter are:

- threshold (see above section),
- correlation (comparison of sweeps)

It is clearly that targets may be lost by misadjusting threshold values when the buttons "GAIN", "TUNE", "STC", are not set properly. However, the correlation criteria (M out of N) may strictly prevent the detection and display of targets.

Correlation implies that the radar returns on different sweeps (scans) are checked to find common returns. A target is only acknowledged and displayed if the returns occur on at least " M out of N " sweeps. That means 3 out of 4 or 3 out of 3 sweeps. Figure A.5 show a simple example of " 2 out of 2 " sweeps.

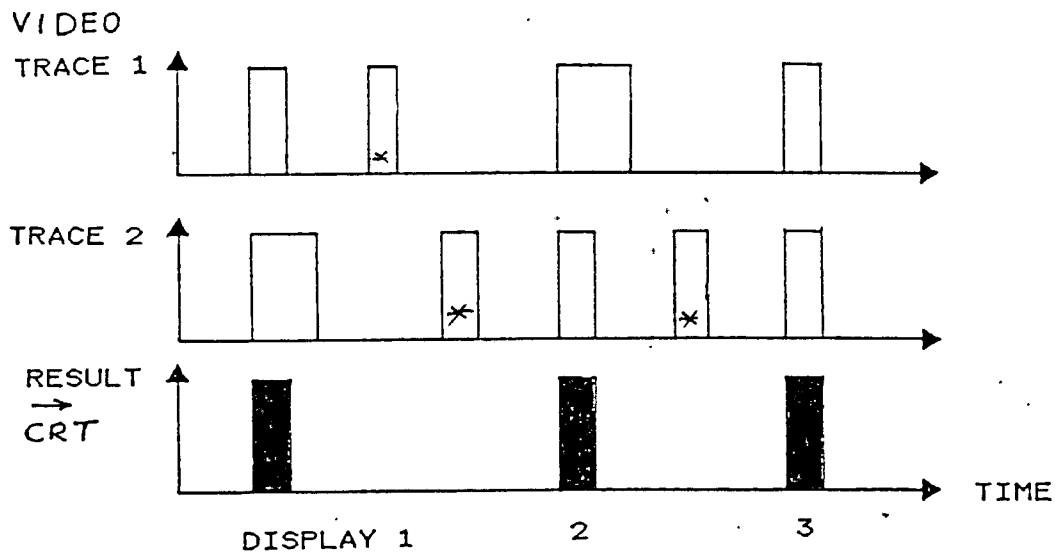


FIGURE A.5 CORRELATION USING THE "2 OUT OF 2".

* Interference

The two types of correlation and their benefits are demonstrated at table A.2. Technically, the correlation is implemented by logical gates (AND / OR)

TABLE A.2 TYPES OF CORRELATION.

CORRELATION TYPE	SWEEP INVOLVED	TIME INTERVAL	LIMIT OF
SWEEP-TO-SWEEP	NEIGHBOURS, SAME SCAN	e.g 1 μ s	NOISE, INTERFERENCE
SCAN-TO-SCAN	SAME BEARING, NEXT SCAN	2 - 3 SEC	SEA CLUTTER

Basically, correlation is an appropriate procedure to remove clutter. But, it implies a reduction of information even a potential target loss. When a gyro compass is not stabilised, the echoes will be received from unstable bearings and therefore they may be falsely eliminated by correlation.

In addition after having first track (see below section A.4), the position of target at next scan is calculated and is surrounded by an area known as the "correlation area or tracking window". This area is large enough so that the target lies within that area and small enough to minimize the possibility of two echoes falling within it. The size of the tracking window depends on the following factors:

- tracking time,
- CPA range,
- number of targets within it,
- actual size of target,
- number of succeeding lost target samples.

A.4 AUTOMATIC TRACKING.

The process of tracking can be visualised if successive plot of a moving target are superimposed. The radar data are originally measured in polar co-ordinates (azimuth and range). The necessary coordinate transformation is performed by digital scan converter (DSC). It has to be done for every cell of radar matrix (typically, a total of 1,000,000 matrix elements). If assuming that the transformation time for each increment is 500 μ sec, therefore the conversion of total picture takes 0.5 sec that can easily be performed within the time for one rotation of the antenna (from 2 to 3 sec). But,

the transformed picture needs to be smoothed.

Safe and up-to-date tracking means providing an accurate and smoothed track without jumping vectors and without missing potential manoeuvres of targets. The main problems that need to be solved for safe automatic tracking are as follows:

- proper selection of the tracking window,
- target extraction (by the MDON principle),
- filtering (using the $\alpha - \beta$ filter),
- track-in file/target association
(including traces),
- rate aiding (to minimise target loss).

However, the progress in computer development allows for faster calculations and faster tracking. First ARPA needed almost 1 minute (that is the required IMO A422 limit) to show the first trend vector after the acquisition of a target. The ARPAs of today have no problem to solve these above procedures in reasonable time. That depends on how many targets are acquired and what the processor is doing.

1. The signal processor detects the presence of target and also reduces clutter. The data extractor may be observed as a "window" moving over the matrix of digitised signals of radar echoes. The "window" covers a predetermined number of cells in the matrix. The target is acquired if it fills (m out of n) consecutive cells of the "window". After calculating the centroid of all the cells covered by the target, the data extractor assigns this value to the target. Every target is individually identified and its speed and other parameters calculated.

2. After establishing first track, an estimate of position and speed of a target can be received from two consecutive target returns. The velocity is the ratio of change in position of target to time, such change being measured by radar scan time.

The position of the target is predicted for the next scan on the basis of current position and speed. While predicting the next position of the target, estimated errors in position and speed would be taken into account. The predicting area for next position of target must be sufficiently large so that the target will lie inside that area. However the area must also be small enough to reduce the possibility of two targets coming into it. The search area must be extended, considering the target's capability to manoeuvre. The extended search area is called as "maneuvering window".

3. After establishing the first target track, the estimate of target's position and velocity will be improved on the use of next echoes. This process is called as track filtering logic or $\alpha - \beta$ filter (see figure A.6). The $\alpha - \beta$ filters evaluate the errors between measured and predicted positions and use their errors to smooth the track prediction. Each successive measured and predicted position will reduce the predicted error for next position. If a target has just been acquired the fast filter will come into operation. When the track of a target is in steady state, the slow filter is used. The α and β filter in ARPA needs about 10 to 30 rotation of antenna. During this period, the displayed data is not accurate and therefore can not be used.

The figure A.6 shows that $\alpha - \beta$ filters at start of tracking with values of α and β that guarantee a fast response. Noise reduction is not good. With successive

scans α and β are decreased to value $\alpha = 0.52$ and $\beta = 0.14$. At the above example in figure A.7 the steady state values of α and β are required after 6 scans. The α and β are functions of the number of scan (N) and obey:

$$\alpha = \frac{2(2N-1)}{N(N+1)}$$

$$\beta = \frac{6}{N(N+1)}$$

and

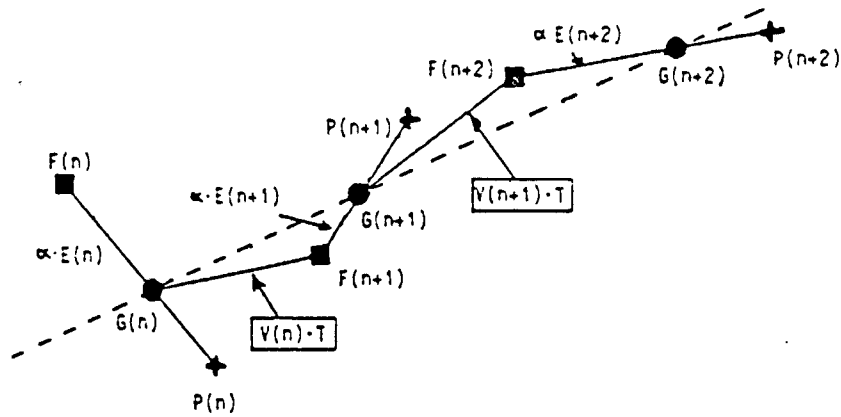
$$G(n) = F(n) + \alpha * E(n)$$

$$V(n) = V(n-1) + \beta/T * E(n)$$

$$F(n+1) = G(n) + V(n)*T$$

For the α - β filter the following parameters in respect of every track will be stored in the data processor:

- track identification code,
- predicted position,
- best estimated position,
- filtered speed,
- time from last update,
- number of radar scan elapsed from initialisation,
- gain (α and β) of tracking filter,
- quality measure of track,
- track status



There $P(n)$ is observed position,
 $F(n)$ is forecast position,
 $G(n)$ is estimated position,
 $V(n)$ is velocity,
 $E(n)$ is (plot-error) = $P(n) - F(n)$

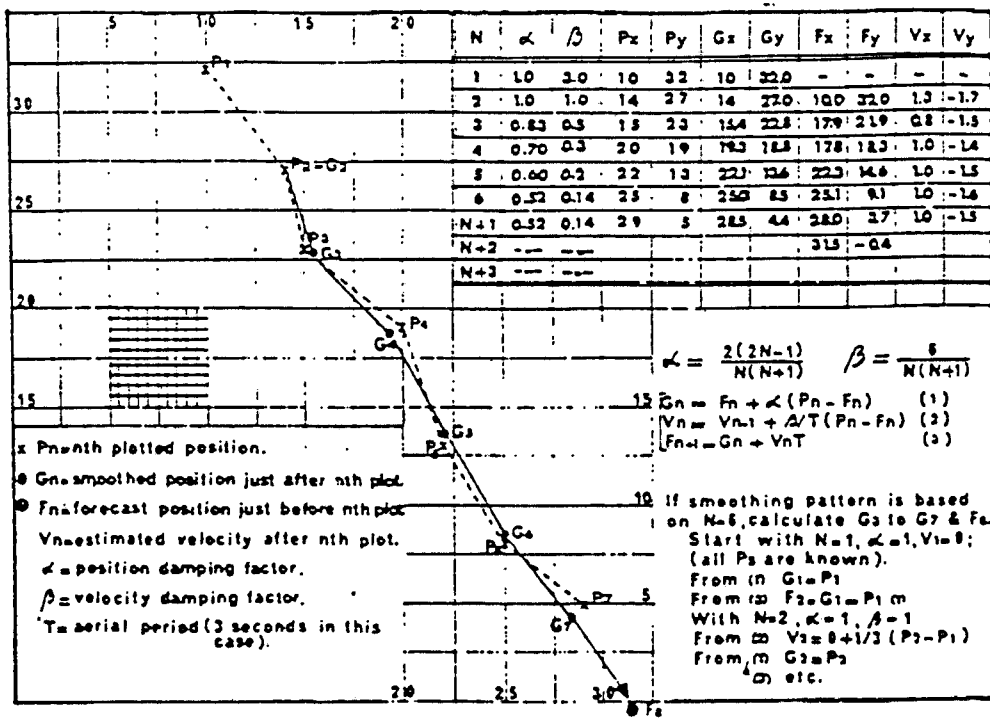


FIGURE A.6 SMOOTHING PROCEDURE ($\alpha - \beta$ FILTER).

A.5 ERRORS AND LIMITATIONS OF ARPA.

The operator can not control all the errors in ARPA equipment. But, it is very vital to have knowledge of the causes of each type of errors. In particular, errors that can affect the accuracy of displayed data. They are classified in two groups:

- errors in displayed data (including sensor errors and processing errors),
- errors in interpretation.

The trainees have to understand that true vector PPCs and PADs are affected by the gyro compass and log errors. While the relative vectors are not affected by them but are affected by radar errors.

1. SENSOR ERROR

Following sensor errors are appropriate to equipment complying with IMO Performance Standards for shipborne navigation equipment.

Note: σ means " standard deviation ".

A. RADAR.

Target glint: (for 200m length target)

Along length of target $\sigma = 30$ meters
(normal distribution)

Across beam of target $\sigma = 1$ meter
(normal distribution)

Roll-pinch bearing: The bearing error will peak in each of the four quadrants around own ship for the targets on

relative bearings of 045 , 135 , 225 , 315 and will be
zero at relative bearings of 0 , 90 , 180 , 270 . This
error has a sinusoidal variation at twice the roll
frequency.

For a 10 roll the mean error is 0.22 with a 0.22
peak sine wave superimposed.

Beam shape: Assumed normal distribution giving bearing
error with $\sigma = 0.05$.

Pulse shape: Assumed normal distribution giving range
error with $\sigma = 20$ meters.

Antenna backlash: Assumed rectangular distribution giving
bearing error ± 0.5 maximum.

Quantisation:

Bearing - rectangular distribution ± 0.01 maximum.

Range - rectangular distribution ± 0.01 N.M maximum

Bearing encoder assumed to be running from a remote
synchro giving bearing errors with a normal distribution

$\sigma = 0.03$.

B. GYRO COMPASS.

Calibration error 0.5 .

Normal distribution about this with $\sigma = 0.12$.

C. LOG.

Calibration error 0.5 knots.

Normal distribution about this with $\sigma = 0.2$ knots.

D. OTHER ERRORS OF SENSOR.

* Bearing errors due to unstable platform of antenna.

$$e(\text{in radians}) = -0.5 * B * \sin \theta * \cos \theta$$

where B = an angle of heel in radians,

θ = relative bearing of target from own ship.

* Bearing errors due to roll of own ship.

$$e(\text{in degrees}) = \frac{180 * H \sin B * \cos \theta}{\pi R}$$

where H = antenna height above roll axis of ship (in meters)

R = range of target (in meters).

This error will vary sinusoidally with time and has a period equal to the roll period.

* Bearing error due to azimuth quantisation errors.

The antenna position must be converted to digital form before it can be used by the computer. Most civil marine system designed for large ship use a 12 bit-shaft encoders. The error will be :

$$= 360 * 0.5 / 40.96 = 0.045$$

The same error will arise if the computer truncates the input azimuth information to 12 bits.

* Bearing error due to the gyro compass repeater.

Transmitter for gyro compasses consist of two kind : step type and synchronous. Most of them are step by step, with

o

a step size of 1/6, the bearing error is very much smaller

o

0.17 .

* Range error due to rolling of own ship.

$$e(\text{in meters}) = L * \sin B * \sin \theta$$

where L = height of antenna roll axis of ship.

B = angle of roll.

θ = relative bearing of target.

2. ERRORS IN PROCESSING DATA.

The operators need to remember that every ARPA system has four following problems:

- tracking in clutter,
- target loss,
- target swop,
- delay in target data.

A.Target swop.

When two targets are close to each other, their echoes come within the same window or two tracking windows overlap so that the processor can not distinguish between the two. Due to target swop a dangerous target may loss

its vectors and be assigned vectors of a non-dangerous target (see figure A.7). It is always good to remember that own ship may be involved in a situation where your own ship is subject to "target swop" on the ARPA of other ship.

B. Target loss.

- Target may be lost due to large changes of bearing in a too short period of time, especially at close range. This is also caused by fast maneuvers of own ship or target (figure A.8.a) or by too large change in the gyro error over a short period of time due to drift or adjustment of gyro heading while targets are being tracked.

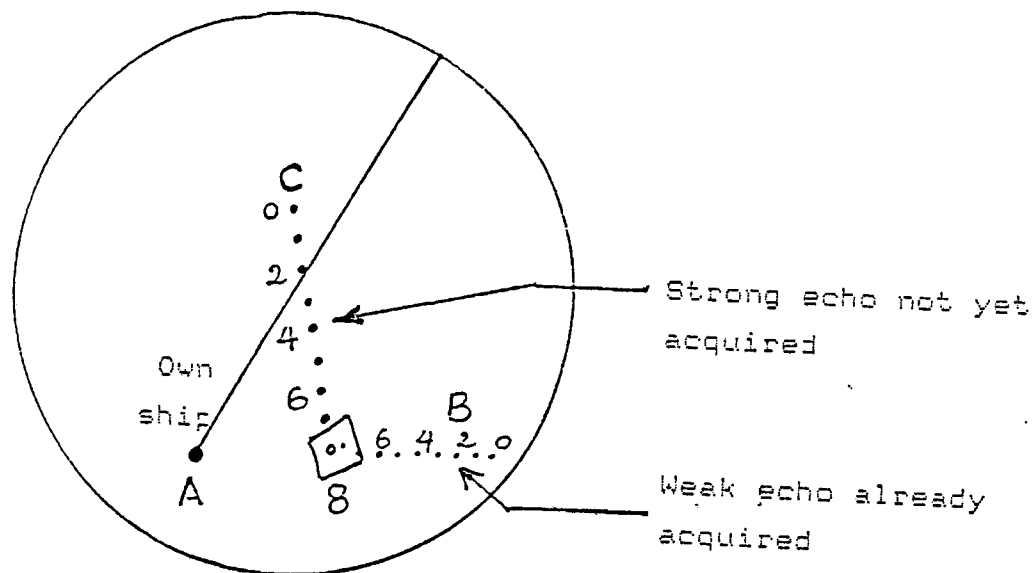


FIGURE A.7 TARGET SWOP

- Where only the target maneuvers the displayed vector will seek to follow the change and to stabilize on the new track. In case of a fast maneuver of target, the vector may be separated from echoes because of the time consuming filtering process depends on degree of damping..

- Where both own ship and target maneuver at the same time, unreliable indication of any target data will be provided until either the own ship or the target ceases to maneuver.

- When the target is not found in the tracking window that is enlarged to a predetermined size, the processor will usually be stimulated into a "lost target" conclusion.

- It is very important to remember to note the position of the target when the lost target alarm is given because after the alarm has been acknowledged, the target is dropped from memory and is not retrievable.

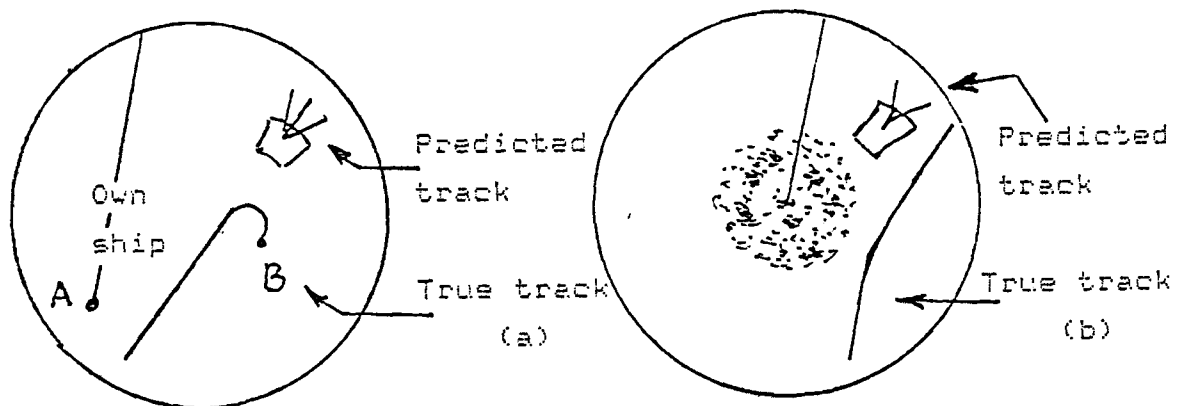


FIGURE A.8 TYPICAL TARGET LOSS

- a. Target loss due to maneuvering.
- b. Target loss due to clutter.

C. Tracking in clutter.

- Target are detected only if their echoes are above the specified threshold values and acquired if they successfully pass through the " m out of n " test (section A.3).
- When the automatic acquisition mode is used, echoes may not be of sufficient strength and not crossing the threshold value, are not detected (see figure A.8.b).
- It is good to remember that after crossing into the guard zone the alarm must be reset manually.

D. Delay in target data.

- The target's course and velocity are calculated by the data processor on base of quantised information in respect of target's range and azimuth. Due to errors in measuring and quantising range and bearing, the track would not be straight line (look like a jagged line - see section A.4 and fig. A.6).
- The filtering introduces delay in the displayed data when own ship or the target maneuvers. During this period the displayed CPA and TCPA will be in errors and can not be relied upon. It may take up to three minutes before data with the accuracy required by IMO performance standards is once again displayed.

- It needs to be remembered that due to track smoothing algorithms, small alterations of courses by target ships may not be detected immediately. In addition any course alteration by own ship should be substantial to be quickly detected by other ships.

3. ERRORS IN INTERPRETATION

Errors in interpretation occur misunderstanding, inexperience and casual observation. These errors are likely to be made in the observation and interpretation of:

- display presentation modes true or relative motion,
- vector presentation mode: true and relative vector,
- predicted areas of danger (PAD),
- failure to detect when using manual acquisition,
- failure to detect when using automatic acquisition and the presented data.

* Errors in selected mode for display presentation.

Due to the observer either from lack of concentration or through lack of knowledge, confusing relative and true vectors, the most common mistakes that will arise are:

- Measuring CPA using the true vector instead of the relative.
- The operator should select the mode for his comfort. For collision avoidance relative motion display is usually optimum as this display is not susceptible to input errors in own course and speed.
- "North up" true motion display is optimum to compare radar picture with charted data.

* Errors in PPCs and PADs

When attempting to interpolate or extrapolate data from displayed PPCs and PADs, mistakes may arise. Typical errors occur, because of of the following failures in understanding:

- The line jointing the target to the collision point is not a time related vector and does not indicate speed.
- The collision point does not indicate of miss distance.
- Changes in collision point positions do not indicate change in target true course and speed.
- The area of change does not change symmetrically with change in miss distance.
- The collision point is not necessarily at the center of the danger area. It is well to remember that the areas of danger on the display are referenced a own ship. They do not always give warning of mutual threat between two targets.

* Failure to detect when using automatic acquisition.

- The ARPA may also drop or cancel a fading target.
- When fading targets may subsequently be re-acquired and present a course and speed which may indicate that the target has maneuvered. when, in fact the track is new and has not yet established its long term accuracy.

* Error in presented data.

- It is important to remember that ARPA in current use must comply the Performance Standard of IMO. While

acquiring ARPA experience care should be taken to check the data using manual plotting if necessary. It is necessary to compare alpha numeric data with the graphical presentation.

*** Failure to detect when using automatic acquisition system.**

- The ARPA may also drop or cancel a fading target.
- When fading targets may subsequently be re-acquired and present a course and speed which may indicate that the target has maneuvered when, in fact the track is new and has not yet established its long term accuracy.

x

APPENDIX B

ACCURACY OF ARPA

APPENDIX B .

ACCURACY OF AUTOMATIC RADAR PLOTTING AIDS.

Errors present in the data displayed on the ARPA screen or by the alphanumeric read-out will effect decision making. Therefore the observer has to know of the level of accuracy of all received information from ARPA. It is not a simple matter to specify the accuracy because it depends on, among other thing, the geometry of the plotting triangle.

1. THE TEST SCENARIOS.

For this reason IMO has specified accuracy values (95% probability) for four different scenarios for information to be provided within one minute and within three minutes after steady state tracking.

In the scenarios, the target's motion is specified in terms of its relative course and speed and the accuracy values are given for sailing condition including rolling of up to plus or minus ten degrees.

For each of the following scenarios, predictions are made at the target position defined after previously tracking for the appropriate time of one or three minutes:

TEST SCENARIO 1

Own ship course	000 degree
Own ship speed	10 knots
Target range	8 n.miles
Bearing of target	000 degree
Relative course of target	180 degree
Relative speed of target	20 knots

TEST SCENARIO 2

Own ship course	000 degree
Own ship speed	10 knots
Target range	1 n.miles
Bearing of target	000 degree
Relative course of target	90 degree
Relative speed of target	10 knots

TEST SCENARIO 3

Own ship course	000 degree
Own ship speed	5 knots
Target range	8 n.miles
Bearing of target	045 degree
Relative course of target	225 degree
Relative speed of target	20 knots

TEST SCENARIO 4

Own ship course	000 degree
Own ship speed	25 knots
Target range	8 n.miles
Bearing of target	000 degree
Relative course of target	45 degree
Relative speed of target	20 knots

2. THE ACCURACY OF DISPLAYED DATA.

The accuracy of displayed data required by IMO Performance Standard is that it should be that of a manual plotting under condition of 10 degrees of roll.

The ARPA should present within 1 minute of steady state tracking, the relative motion trend of a target with accuracy values not less than those shown in table B.1.

TABLE B.1 ARPA ACCURACY VALUE (95% probability)
REQUIRED AFTER ONE MINUTES.

Scenario \ Data	Relative course (degrees)	Relative speed (knots)	CPA (n.m)
1	11	2.8	1.6
2	7	0.6	1.6
3	14	2.2	1.8
4	15	1.5	2.0

The ARPA should present within three minutes of steady state tracking the motion of a target with an value not less than those shown in the table B.2.

TABLE B.2 : ARPA ACCURACY VALUE (95% probability)
 REQUIRED AFTER THREE MINUTES.

Scenario	Relative (degrees)	Relative (knots)	CPA (n.m)	TCPA (min)	True course (deg.)	True speed (kt)
1	3.0	0.8	0.5	1.0	7.4	1.2
2	2.3	0.3			2.8	0.8
3	4.4	0.9	0.7	1.0	3.3	1.0
4	4.6	0.8	0.7	1.0	2.6	1.2

When the tracked target or own ship has completed a maneuver the equipment should present in a period of not more than one minute an indication of the target's motion trend, and display within three minutes the target's predicted motion in accordance with above tables.

Table B.1 and B.2 give 95% probability values, that means the results must be within the tolerance values on 19 out of occasions.

It is necessary to appreciate that the results from a computer are not perfect. The errors of the above tables do not include or errors from the input of incorrect data.

Data obtained from the radar, log and compass will to subject to random variation which contribute to the uncertainly of results as predicted by the computer.

Therefore in any case the tables included in the specification should be taken as a guide as to what can be expected, especially with regard to CPA.

To appreciate that there is a delay after a maneuver by own ship or target before accurate information is provided again.

APPENDIX C

LIST OF ARPA FUNCTIONS

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LIST OF ARPA FUNCTIONS.

1. Target acquisition:
 - manual acquisition (*)
 - automatic acquisition
 - acquisition zones with variable range
(Guard Zone)
 - exclusion zones/lines/sectors (*)
 - warnings (*)

2. Presentation of ship's motion:
 - vectors with variable vector length (time) or
fixed time scale (*)
 - past track for minimum 8 minutes (*)
 - relative and true motion presentation with
relative and true vector. (*)

3. Automatic warnings
 - automatic target acquisition in a guard zone
" GUARD ZONE ALARM " (*)
 - closer approach than preset CPA
" DANGEROUS TARGET ALARM " (*)
 - echo of acquired target lost
" TARGET LOST ALARM " (*)
 - sensor malfunction
 - system failure e.g " TARGET OVERFLOW ALARM "
 - detection of target maneuver e.g
" TRACK CHANGE ALARM "
 - " ANCHOR WATCH ALARM "

- 4. Maneuver simulation (trial maneuver) (*)
 - alteration of course
 - alteration of speed
 - allowing for maneuvering characteristics

- 5. Alphanumerical display of target data.
 - bearing and range of target (*)
 - course and speed of target (*)
 - CPA and TCPA (*)

- 6. Additional graphic symbols on the screen
 - predicted areas of danger (PAD)
 - potential points of collision (PPC)
 - navigation lines
 - electronic bearing line (EBL)
 - warning by symbols on the screen (flashing)

In the list of ARPA functions the marked symbols (*) indicate requirements by IMO (ARPA Performance Standard A.422).

APPENDIX D

MINIMUM STANDARDS OF ARPA
SIMULATION EQUIPMENT FOR
EDUCATION AND TRAINING

APPENDIX D:

MINIMUM STANDARDS OF ARPA SIMULATION EQUIPMENT
FOR EDUCATION AND TRAINING.

< They were drafted at IRNSLC, ST.Malo, May / 1990 >

The minimum simulator configuration shall be one Instructor station, Two Ship stations and one Debriefing room. The simulator space shall be divided into subspaces conforming to the "separation requirements". One subspace shall be allocated to each Ship station, and at least one subspace to the Instructor Station and Debriefing Room. Subspaces assigned to Ship stations shall be provided with facilities to vary ambient lighting to simulate a darkened ships bridge as well as to provide sufficient illumination for maintenance work.

The subspace shall:

- * Constitute discrete physical enclosures with ready means of access to the briefing room.
- * Be acoustically isolated to prevent conversation being transmitted between the subspaces.
- * Be environmentally conditioned to preserve temperatures in the range 15-22 degrees Celsius when the subspaces are occupied by the maximum number of occupants for at least three hours.
- * Be provided with furniture and fittings commensurate with the purpose of the subspace.

1. SHIP STATION FACILITIES.

- & Radar Displays: The number and type of Radar / ARPA displays shall be " subject to specifications".
- & Electronic Radio Navigation Aids: Not less than two systems "subject to specifications". Where satellite based systems are simulated a fully functional facsimile may be provided.
- & Environmental Indicators: Nature, number and type "subject to specifications". Typical range includes depth sounder, Exercise Time indicator, relative wind direction and relative wind speed indicators. The depth indicator shall be provided in all cases.
- & Control System: Controls for the regulation of RPM in steps averaging less than 15 % of the range extending from the full astern to the full ahead condition, and for the regulation of helm in steps not greater than 1 degree of helm with a range extending from not less than 35 degrees port to 35 degrees starboard. Controls shall also be provided for the maintenance of a set course.
- & Communication Facilities: A communication system between the stations shall be provided. This may simulate voice, text or graphic media, and provide representative facilities for data input and routing of communication.
- & Chartwork Facilities: Books, publications and chartwork instruments, commensurate with the " base coastline " and " subject to specifications " are to be provided.

2. INSTRUCTOR STATION.

A. Exercise preparation facilities.

The Instructor station shall provide facilities for the assignment of the following characteristics individually to each Ship station.

- Instructor defined selective masking of radar video to own ships.
- Yaw characteristics.
- Environmental characteristics consistent with indicators provided.
- Manoeuvring model.
- Tidal direction and speed.
- Shadow sectors.
- Detection range.
- One of three levels of radar noise and sea clutter.
- Position in terms of latitude and longitude to a resolution of better than 0.003 minutes.
- Course to a resolution of better than 0.5 degrees.
- Speed to a resolution of better than 0.1 knots.
- Shiplength in metres to a resolution of better than 8 metres.

The Instructors station shall provide facilities for the assignment of the following characteristics individually to each of not less than 40 movable targets.

- Position in terms of latitude and longitude to a resolution of better than 0.003 minutes.

- Course to a resolution of better than 0.5 degrees.
- Speed to a resolution of better than 0.1 knots.
- Shiplength to a resolution of better than 8 metres.
- Manoeuvring characteristics at least as a function of turn rate and acceleration.
- Detection range.
- All forty targets pre-programmable with not less than 10 waypoints per target.

The Instructors stations shall provide facilities for the assignment of the following characteristics individually to each of not less than 200 fixed targets.

- Detection range.
- Position in term of latitude and longitude to a resolution of better than 0.003 minutes.
- Length to a resolution of better than 8 metres.

B. Exercise storage facilities.

The Instructor station shall provide facilities for the non volatile storage of exercise, coastline, and shipmodel data.

C. Exercise execution facilities.

The Instructor station shall provide facilities for:

- Starting, freezing, resetting and stopping of exercise time.
- Selection and activation of exercise monitoring and exercise debriefing facilities.

D. Exercise debriefing facilities.

For the purposes of debriefing the Instructor Station shall provide facilities for:

- Static display of all or selected Ship station and target positions with reference to a definable geographical area at specified intervals not exceeding 1 minute for a period of not less than 120 minutes.
- Dynamic display of a concluded exercise on the facilities specified under exercise monitoring, at a selectable time factor with a range not less than 1-5.
- Relay of selected communications.

E. Exercise monitoring facilities.

The simulator system shall provide, in respect of each Ship station, for the display of:

- Radar data, unaffected by the Ship station's selection of radar display function.
- The overall scenario to allow rapid interpretation of navigational and collision risk with reference to a selected Ship station.
- Real time information on the displayed values of environmental and feedback indicators on the selected Ship station or stations.
- All parameters specified during exercise preparation.
- Additionally, the simulator shall provide facilities for alteration of relevant exercise preparation parameters and for the activation and deactivation of failures and defined offsets.

3. SYSTEM FACILITIES.

The Simulator system shall provide:

- Facilities for assigning to each individual Ship station, one of not less than three ship manoeuvring models of which one shall be the " base model ".
- Facilities for the generation of radar noise to be superimposed on the radar video received by Ship stations.
- Facilities for the simulation of radar transponders, "subject to specifications".
- Facilities for the allocation of tidal models in terms of drift speed, direction and height to affect either Ship stations or Ship stations and targets according to instructor selection.
- Modelling of charted depth values for the "base coastline" so that the difference of simulated and charted values at any position within this coastline is not greater than 10 % when compared to a chart at a scale of 1 : 150000 or some larger scale, enclosing such position.
- Range fall off and shadowing characteristics with respect to radar video.
- Facilities for implementing an instructor definable connectivity matrix between stations in respect of the communication system.

- Facilities for selected Ship station instrument inputs to the Ship station shall be subject to offsets selected at the Instructors station.

- * Radar stabilisation inputs. e.g. direction and heading.
- * Electronic Radio Navigation inputs.
- * Feedback indicator inputs where appropriate.
- * Environmental indicator inputs where appropriate

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