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THE WORLD MARITIME UNIVERSITY

MALMO, SWEDEN

" CRITERIA DETERMINATION FOR IMPLEMENTATION AND OPERATION OF A MARITIME SENSOR-BASED SURVEILLANCE SYSTEM IN PERU "

BY

ROLANDO CHIAPPO BONICELLI

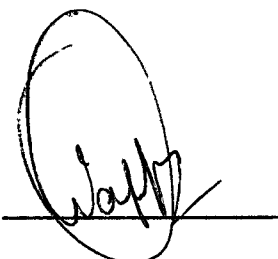
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THE WORLD MARITIME UNIVERSITY

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DR. FRANK L. WISWALL JR

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INTRODUCTION

Maritime surveillance constitutes one of the most important functions in which not only the maritime administration has to be present but also a number of high level national organisms.

In this regard, it could be said that, the control of Peruvian Jurisdictional Waters is very close connected with the national economy and safety because, most of the activities carried out at sea are of national interest, i.e, preservation of natural resources, living or not, looking after lifes and vessels in distress and awareness of those perils coming from the sea against national safety.

Nowadays, the current maritime surveillance system used by the Peruvian Maritime administration is based on conventional means, which depend on the availability of patrol boats and sometimes aircraft when an emergency so requires.

The aforesaid brings as a consequence, high operational costs and makes the system inflexible and unreliable. Furthermore, the system employs conventional VHF and HF radio communication links, which in certain events are telephone lines, which means that it is not possible to transmit information directly from radar PPIS' or displays to coastguard centre.

However, in spite of a well organized surveillance system which the Peruvian coastguard has, it is very difficult and complex to give full coverage of the whole maritime

territory at all times.

The employment of a sensor-based surveillance system represents a very good alternative to control the entire maritime territory, which will allow the total control of Peruvian jurisdictional waters.

The sensor-based system will give new characteristics for control purposes, i.e, communications will be faster, safer and more reliable, and a number of functions will be improved with computer assistance.

First of all, the objective of the present investigation is to diagnose the current situation of the Peruvian maritime surveillance system in connection with the requirements of the maritime administration in Peru.

Furthermore, to evaluate one alternative of solution which is the employment of a sensor-based maritime surveillance system in relation to the effectiveness and economic criteria, in order to judge the elements which allow the responsible organism to decide when participating in the acquisition and operation project of a sensors-based maritime surveillance system.

On the other hand, it is important to emphasize that, the contents of their investigation is to give a first approach about a sophisticated system.

The final investigation report points out the following:

- a) Through the first chapter, global problems of Peruvian maritime surveillance are described. The most significant aspect and the interrelation of problems are included.

b) In the second chapter, the development of theoretical bases, on which the present investigation was established as well as the most relevant definitions used throughout the investigation process are described.

c) The methodology procedures used through the investigation are detailed in the third chapter.

d) Through the fourth chapter, the development of each of two ends of the present investigation is detailed.

The aforesaid is attained through four objectives and nine goals, which are contained in the investigation.

Taking into account the aforesaid objectives and goals, the judgment elements for acquisition and operation of a maritime surveillance system project based on sensors are decided.

e) In the paragraph five, the main final conclusions of the investigation are specified.

f) In paragraph six, recommendations resulting from main conclusions are stated.

g) In paragraph seven, recommendations for the futures investigations based on the main conclusions and obstacles found in the present investigation are stated.

h) In paragraph eight, the bibliography references and sources which were consulted are listed.

i) Into ANNEX A the whole investigation plan is

described.

The limitation concerning the requirements of the current maritime surveillance system has been contrasted with a sophisticated sensor-based system which would entirely satisfy the requirements of giving full coverage to Peruvian maritime extension and make the system safer, flexible, faster and more reliable.

The economic characteristics of the alternative, force organisms to make a national effort which they will benefit from, by getting together requirements and economic resources in only one project. However, taking into account a number of factors it could, to a certain extent be self-financed in parts.

The collateral effects will be of immaterial value.

CHAPTER I

GLOBAL PROBLEMS

1.1 In every country, the maritime surveillance system must comply, first of all, with the basic function of covering its national maritime territory entirely in order to control the major areas in which maritime activities are carried out.

On the other hand, one of the most important aspects to consider is the strategic function in exerting sovereignty and national safety in order to protect and manage the maritime interest.

Many years ago, at the beginning of the past century, when human beings started to develop the shipping industry and consequently the seaborne trade, the maritime traffic has gradually increased to a large extent by bringing, as a consequence, many

problems which the coastal states have had to face.

Most of the problems which have arisen from the increasing maritime traffic through the different routes, have taken place since many international organizations issued regulations related to prevention of detriment, conservation and management of natural resources, whether living or not, prevention and control of marine pollution, and the safety of life at sea on behalf of the international community. So, coastal states have had to implement their national legislations in order to confront these regulations

Most countries which have adhered to the various international organizations and ratified their several conventions have not only developed or improved their own maritime administrations by implementing its national legislations in order to enforce the provisions of such international conventions on behalf of the international community, but also on behalf of their own people.

The Peruvian Maritime Administration, which is the responsible organization in charge of carrying out several tasks within the maritime field in order to protect the national interests at sea in their territorial waters and the Exclusive Economic Zone, must face one of its major tasks within the scope of their functions, which is the control of their national sea waters dealing with: safety of life at sea, maritime police, marine pollution, search and rescue, among others.

Therefore, the Peruvian Maritime Administration, through the Coast Guard Organization, has an important role within the strategy of the national

economy, improving surveillance of their jurisdictional sea waters.

The Peruvian maritime territory has a litoral, of approximately 1200 nautical miles in length and 200 nautical miles in breadth, giving nearly a whole area of 240,000 square nautical miles (830,000 Km²).

Many activities, such as fishing in shallow waters nearby the coastal line as well as in deep waters between 100 and 200 NM far away from land, oil exploitation on the continental shelf, and so on, are carried out in the aforesaid areas whereon, the Maritime Administration has to exert control and surveillance in order to prevent the infringement of national and international regulations and agreements, and illegal activities.

The increase in shipping and fishing industries, and other various activities which are performed in the sea areas belonging to the Peruvian state, has brought as a consequence the necessity to improve the control of the Peruvian territorial waters and its adjacent Exclusive Economic Zone which is important not only to protect the vested interest, but also to conform with international regulations and agreements.

The high costs of a high-technology surveillance system is one of the major problems which the Peruvian Maritime Administration has faced and therefore, the lack of an economical and operational criterion is a barrier in order to decide the acquisition and put into operation a sophisticated surveillance system.

However, nowadays in spite of the present turbulent situation, it could be feasible to get some financing not only from international development agencies or

credit from suppliers, but also the project could be self financed in part on a long term basis.

For this purpose we must consider that the costs must be balanced against the benefits achieved by the system. The benefits may, in some cases, be calculated from incomes in the form of fines for illegal fishing, offenses against maritime law and so on. On the other hand, it is not possible to put a price on the benefits because many of them are of immaterial value.

Therefore it demands, due to the importance of the project for the Peruvian Maritime Administration and consequently for the Peruvian nation, the attention from organisms in charge of protecting the Peruvian maritime interests to adopt such a highly sophisticate system to ensure the national interest at sea.

Nowadays, the electronic field has, within communication and computing sciences, developed itself in such a way that, systems have been created for the purpose of performing surveillance functions, especially upon the areas where both, the distances and speed of communications are the main factors.

The surveillance system by electronical means, is a high-technology system which gives, whatever the operational requirements may be, a total control, not only on nearby areas to the coastal line, but also on the Exclusive Economic Zone up to 200 NM and more.

The aforesaid depends of course, on how sophisticated the system is, on the quantity of equipment, communication systems and data processing centers used in the system. The more sophisticated the system is, the more efficient the surveillance coverage range will be.

In the surveillance field, many types of equipment

with different characteristics can be utilized.

Obviously, each piece of equipment could be operated independently of each other; however, the best performance is obtained when, all pieces or most of them work as a whole system, thus attaining a very well organized data source, communications network and a data processing center.

Actually, in a maritime surveillance system, it is feasible to use airborne, ship and shore-based sensors, which have been especially designed for this purpose.

Employing a sensor-based maritime surveillance system, it is possible to cover most of the areas within jurisdictional waters in which the major maritime activities are carried out.

Furthermore, communication of any kind of data and information extracted from radar PPI's can be transmitted by using microwave links or telephone lines added to special electronics devices.

On the other hand, information and imageries can be transmitted from airborne sensors to land stations via microwave. The information can be recorded and displayed in command centers for being used as good evidence on what is going on at sea.

Actually, many ports and harbor areas are facing great problems caused by the growing volume of shipping traffic and the continuous evolution of marine transport technology, tankers and other type of vessels with dangerous cargoes which require careful management.

Technological advances have been made in this field, getting information from radar PPI'S, the

data can be sent through any communication link to command centers where data is displayed and processed.

The aforesaid work as the entire system, therefore, have been implemented in advanced traffic control systems to ensure smooth, safe and efficient traffic flows.

Considering both, land-based radar stations and shipborne and airborne sensors as components of a surveillance system, a number of alternatives to build up such a system could be considered.

One of those alternatives could be: increasing the number of patrol vessels, and providing specially designed equipment for carrying out the surveillance functions. This alternative could be developed in arrangement with exploration aircraft.

On the other hand, the increase in air surveillance capability makes a joint effort with the patrol vessels available which gives another alternative. As a results this would have a great advantage giving a larger range of coverage.

As regards the implementation of land-based radar stations interacting with both, surface and air surveillance units, they could be consider as a third alternative where the three maritime surveillance components would be used in the system.

All the above mentioned possibilities to implement a maritime surveillance system have, to a certain extent, their advantages and disadvantages from an operational and economic point of view.

However, the last alternative could represent the best solution for the surveillance requirements of the Peruvian Maritime Administration, because it would cover the larger interest areas and would not be subject solely to one element of operation.

Maritime surveillance constitutes one of the most important aspects within the scope of the Peruvian Maritime Administration because it includes the major functions for which they are responsible. Actually, such maritime surveillance is carried out through both the Coast Guard Patrol Fleet and the Naval Air Force.

The former, is not only used for such a task, but also other tasks that the Maritime Administration has to fulfill within the context of their functions. The latter has no the specialized sensors on board aircraft for such a task.

Taking into consideration several aspects in which the Peruvian surveillance is involved and the extent of the Peruvian maritime territory, the maritime surveillance to be set out in Peru has to fulfill certain objectives as regards to national and commercial interests:

- (i) Protection of territorial waters
- (ii) Protection of the EEZ
- (iii) Prevention of illegal activities
- (iv) Prevention of illegal transport
- (v) Co-ordination of rescue operations
- (vi) Prevention of environmental damages
- (vii) Navigation assistance
- (viii) Traffic separation
- (ix) Harbors traffic control
- (x) Planning of piloting

The system must provide the capability to exert not only an effectiveness control upon merchant vessels

allowed to sail into the Peruvian waters, but also take control upon them during their stay within Peruvian jurisdiction.

It must be capable of controlling that the foreign fishing vessels which are performing fishing duties within jurisdictional waters have the duly authorized licence for such an activity. Also the system must be able to detect the following:

- (a) All types of vessels in territorial waters without permission from national authorities
- (b) National and foreign fishing vessels carrying illegal activities into prohibited zones
- (c) National and foreign vessels carrying out not only smuggling activities, but also those which can affect national safety

The system must also be able to cover large areas in order to detect people and/or vessels in distress as well as oil spills and noxious substances in the marine environment.

The system must also include traffic surveillance centers and traffic control centers in order to:

- (a) track and identify vessels and other sea targets within the surveillance areas.
- (b) expose and analyse risks and threats.
- (c) co-ordinate and control warding-off operations and remedial actions.
- (d) inform co-operating authorities and organizations.

Traffic management must be able to

- (a) detect, track and identify vessels traffic.
- (b) analyse collision risks and traffic conflicts.
- (c) supply navigation assistance and traffic separation.
- (d) inform co-operating authorities and organizations.

In order to fulfill the above mentioned requirements, a number of alternatives, previously named, may be considered, namely

- (i) Air surveillance, implementing the already existent proposed aircraft with specially designed sensors for such a task, and performance of conjoin operations with surface surveillance units.
- (ii) Surface surveillance, increasing in number the current coast guard patrol fleet.
- (iii) Acquisition of land-based radars which could be set out along the Peruvian coast.
- (iv) Establishment of a system employing both, air and surface units, and land-based radar stations making a joint effort as a whole system interfaced to a processing data center, regional centers and command control center.

All the above named alternatives have high costs, however, taking into account the maritime surveillance requirements, as before mentioned, and obviously, the area to be covered, the three first alternatives would

have certain limitations in order to efficiently perform a surveillance task.

The last alternative has not the same limitations; However, we must take into account that the short-term costs will be higher due to a mayor factor to be considered when implementing a maritime surveillance system which is not only the technical performance of the system, but also the costs of it.

Those costs are the acquisition and installation costs but also the costs for operation and maintenance of the system during its life time.

The employment of a maritime surveillance system utilizing sensors along the Peruvian coast is going to represent an alternative which will permit the use of high-technology, and consequently the Peruvian Maritime Administration will be able to act as soon as required without a waste of time and useless human and economic efforts, giving quicker, more reliable and safer information upon almost all jurisdictional waters.

The control of Peruvian maritime territory is a very important function which the maritime administration has to perform, therefore, the Peruvian surveillance system has to be implemented in such a way enough to cover the entire maritime territory, and account with the proper means to take control and enforce the national and international regulations.

Actually, the maritime territory is controlled by an organized system employing for this purpose patrol boats and conventional communication equipment, ie, no

electronic sensors or computerized system for controlling maritime areas, recording and storing information, automatic tracking or image transmission etc. This brings as a consequence high operational costs of the system, lack of permanent control in maritime areas of interest, and sometimes useless of human and economic efforts.

However, the Peruvian Maritime Administration has not yet developed a proper system to satisfactorily perform such functions in order to give surveillance coverage of the most congested areas where maritime activities are developed, and to enforce such regulations and to prevent illegal activities.

In this sense, it is necessary to establish criterion which allow, to the Peruvian maritime organization to take a decision as regards to acquisition and operation of a sensors-based maritime surveillance system to satisfy the surveillance requirements within the entire maritime territory.

CHAPTER II

CONCEPTUAL FRAME

In the present chapter the author will carry out the development of theoretical bases on which the present investigation is established as well as, the most concerned definitions used throughout the investigation plan and the process itself.

2.1 THEORETICAL BASES

As is well known, the oceans cover around 70% of the earth amounting to roughly 99% of all the water on the earth. On the other hand, the ocean is inhabited by living organisms which can be translated as one of the most important and basic resources for human life. In this respect, we can point out how important the marine environment is and how many efforts have to be devoted to preserve it.

On the other hand, maritime activities, during the

last century, have largely increased bringing as a consequence a number of problems which have to be confronted not only from a national, but also from International point of view.

In this regard, international organizations, specially dedicated to maritime affairs, have convoked a number of international conventions issuing regulations regarding to different maritime fields which have been accepted by most states.

In this sense, the maritime states have had, through maritime administrations, to implement their own legislations in order to enforce such regulations.

However, national legislations have not only been created for the solely purpose to enforce such International regulations, but also states face a number of internal problems which arose out of illegal maritime activities against their national economy and safety.

Taking into consideration a national Maritime legislations involves a large number of responsibilities and functions, For the present case, the author is going to consider one of the responsibilities which is to look after national maritime interests, and one of the functions which is to exert maritime surveillance within jurisdictional waters.

Pollution of the marine environment is one of the most important aspects we have to consider. It is clear that human activities produce any type of wastes, especially activities carried out at sea, for instance, hundreds of vessel crossing through the ocean pollute the marine environment with all types of substances, mainly those vessels carrying oil and derived products; In spite of several conventions providing a great number of rules to avoid these kind of actions, tankers whilst they are sailing, at the same time are performing

activities against regulations, such as:

- Discharging oil and mixtures in " prohibited zones " which are, in areas less than 50 miles from the nearest land in where discharging is forbidden at a certain rate.
- Cleaning of cargo tanks under way and discharging into to the sea.
- Discharge of ballast tanks into the sea
- Discharge from machinery spaces bilges at non-allowed rates of discharging etc.

The aforesaid actions are performed simultaneously in different areas of a state.

Safety of life at sea, search and rescue operations and control of vessel traffic, are other responsibilities which states, as SOLAS Convention contracting parties, have considered into their legislations. Therefore they have to implement, to a certain extent, co-ordinating systems and provide facilities in order to detect, within large sea areas, people and/or vessels in distress and take decisions at opportune time; events of this sort may occur at any time and place at sea.

On the other hand, great extensions of sea areas have to be covered to control maritime traffic in order to avoid unlawful actions within a states is maritime domain.

As regards activities dealing with national economy and safety, a number of areas spread within the maritime territory must be controlled and managed in order to avoid actions and activities against national regulations, fishing, oil extraction from continental shelf, mining from subsoil, smuggling etc.

Maritime surveillance is a function by which a state keeps close control on certain areas of national interest to avoid unlawful actions. In this regard, to reach full control upon the whole maritime territory it mostly depends on how many means are used and how complex the surveillance system is.

Maritime surveillance can be effected essentially by surface surveillance units, air surveillance craft and land-based sensors.

The surveillance surface units are mostly specialized vessels built under certain design requirements and speed.

They always carry on board special equipment to detect any target at sea and also, some of them carry special sensors for discovering and tracing oil discharges.

Regarding search and rescue operations, surveillance equipment can also be used, thus enabling large areas to be recognized speedily however, if taking into account the large maritime extension a great number of limiting factors exist to cover all areas involved. Some of those factors are for instance, the available number of units to give full coverage to the whole maritime territory and how well-equipped they are, availability of operation expenses to keep patrol vessels operating full-time throughout the year, the speed of patrol vessels, the size and facilities on board which involve operation effectiveness and time at sea as for, how far they can operate and crew welfare.

Air surveillance is a very effective control means for large areas in a relatively small time reducing thus cost factors and increasing effectiveness.

Systems have been especially designed for air surveillance being those high performance tactical display systems designed for harsh environments carried on board helicopters, aircraft, naval aircraft etc. They are fully

autonomous and comprises all hardware and software necessary to accept, process and display information. Raw and/or extracted radar pictures, electronics maps synthetic symbols and alpha-numeric data can be simultaneously displayed.

The configuration of a basic system consist of two main units, the computer and display unit, and the operator panel, however, the variety of optional features available makes it possible to extend the capacity of the system to include other sensors such as sonar, sonarbuoys as well as weapon control systems and various data links. Systems are basically designed to accept, process and display radar information, but other sensors can be connected as well. Most of the functions are realized in software and, when ever required, supported by hardware to give state of the art performance. Time critical functions are usually realized in hardware.

We have also to consider other airborne sensors specially designed for surveillance tasks which will increase the capability of the system as far as protection of national interest at sea is concern.

The equipment carried on board craft includes the Side Looking Airborne Radar (SLAR), Infra-Red and Ultra-Violet scanner (IR/UV), Forward Looking Airborne Radar (FLAR), all of which have supporting equipment for real-time processing and display, Quick-Look documentation unit and air-to ground image transfer via microwave link, Automatic positioning of select targets on the operator's TV display and Automatic annotation device with date, time position on all sensors and camera imagery.

The Side Looking Airborne Radar (SLAR), which is an airborne sensor used for most surveillance systems in developed countries, has specially been designed for maritime surveillance with a number of applications:

- Surveillance of sea traffic
- Oil spill detection
- Search and rescue operations
- Fishery protection

One of the SLAR main characteristics is to operate in all-weather conditions covering large areas and detecting small targets.

Other capabilities:

- SLAR is capable of surveying around 15,000 square kilometers per hour for life boats and oil spill detection.
- It has the capability of surveying about 30,000 square kilometers per hour for small fishing vessel detection.
- It is able to inspect about 60,000 sq k/h for cargo ships.

Comparing SLAR with similar sensors, such as conventional Forward Looking Airborne Radar, it is possible to say the latter can not detect oil spills and very small targets at all and for bigger ones it has around half the capacity of the SLAR.

The SLAR range coverage is about 80 NM each side effective; The attached equipment uses a standard TV display which gives true real-time presentation of bright and flicker-free imagery.

The infra Red and Ultra Violet (IR/UV) scanner system is another specialized sensor, mainly used for maritime

administrations. The specific applications are:

- Inspections of suspected oil discharges
- surveys of accident sites and,
- monitoring of pollution in ship wakes

This system uses both, the IR and the UV scanners are operated into two different channels; the first one can be operated during the day and night.

IR is able to detect and give relevant information on the spreading of oil and also indicates the relative oil thickness within the oil slick.

Obtaining information from the IR system, clean-up operations can be planned and addressed by the respective authorities reaching maximum results.

Regarding the UV channel, it can be used only during the daylight mapping the whole area covered with oil irrespective of thickness. Attached equipment to the IR/UV system offers real-time presentation on TV monitor. It is well proven that, maritime surveillance systems employing airborne sensors are operated to low cost and are truly operational.

(Airborne sensors characteristics see ANNEX II)

Land-based radar stations is the third main component of a maritime surveillance system. It is based on a number of land-based radars performing continuous coastal surveillance of vessel traffic, in particular of small vessels in a cluttered environment. It can be pointed out that land-based stations can be not only used along the coastal line as control of vessel traffic but also in controlling and managing harbors and crowded roadsteads.

A coastal surveillance system consists of the following main components:

- Radar stations including towers and complete infrastructures
- Radar data transmission
- Control center

Each fixed radar station consists of the following equipment:

- Radar antenna
- Radar cabin containing:

Radar transmitter/receiver

Extractor*

Service - PPI*

Remote control system

VHF - direction finder*

VHF - radio

Modems*

Mux and radio link

- Emergency power supply

It must be pointed out that the radar stations are designed for unmanned operations and they can be remotely controlled from the main radar center.

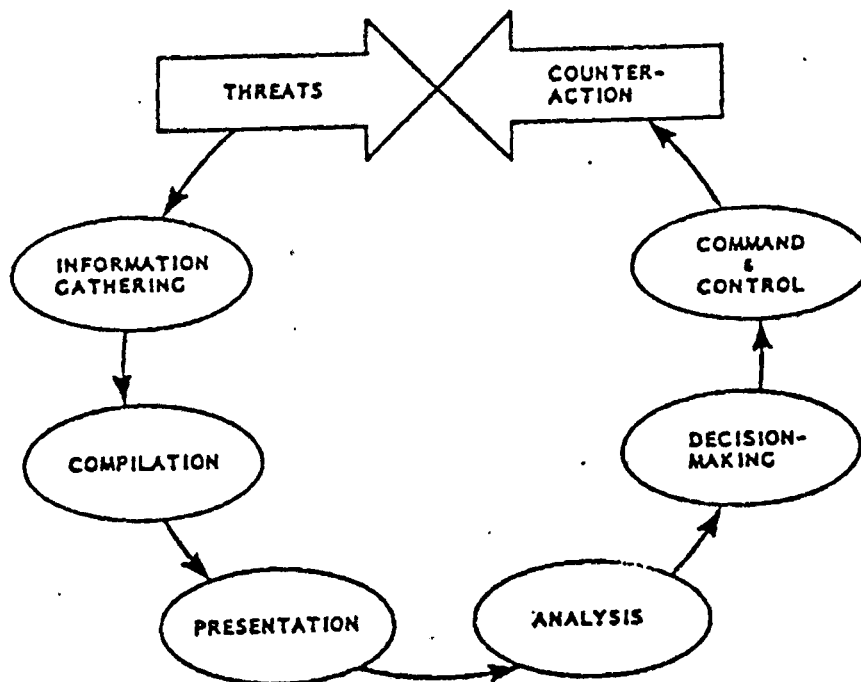
The operation concept is such that the fixed radar station scans the correspondent area set up out to maximum range which is limited by the radar horizon. In each station the radar information is processed in a plot extractor which will automatically detect targets then for

each target a report message is produced. This defines the range and azimuth to the target. The message is then transmitted via modem over the telephone channel to the main radar center where the positions of the targets will be indicated with symbols on PPI's. The target positions are updated by each antenna revolution.

SURVEILLANCE SYSTEM MAIN TASKS

The main tasks and consequently the main operational functions of the Coast Guard Headquarters system are

- Information gathering
- Filtering of information (Compilation)
- Presentation
- Analysis
- Decision making
- Command and control

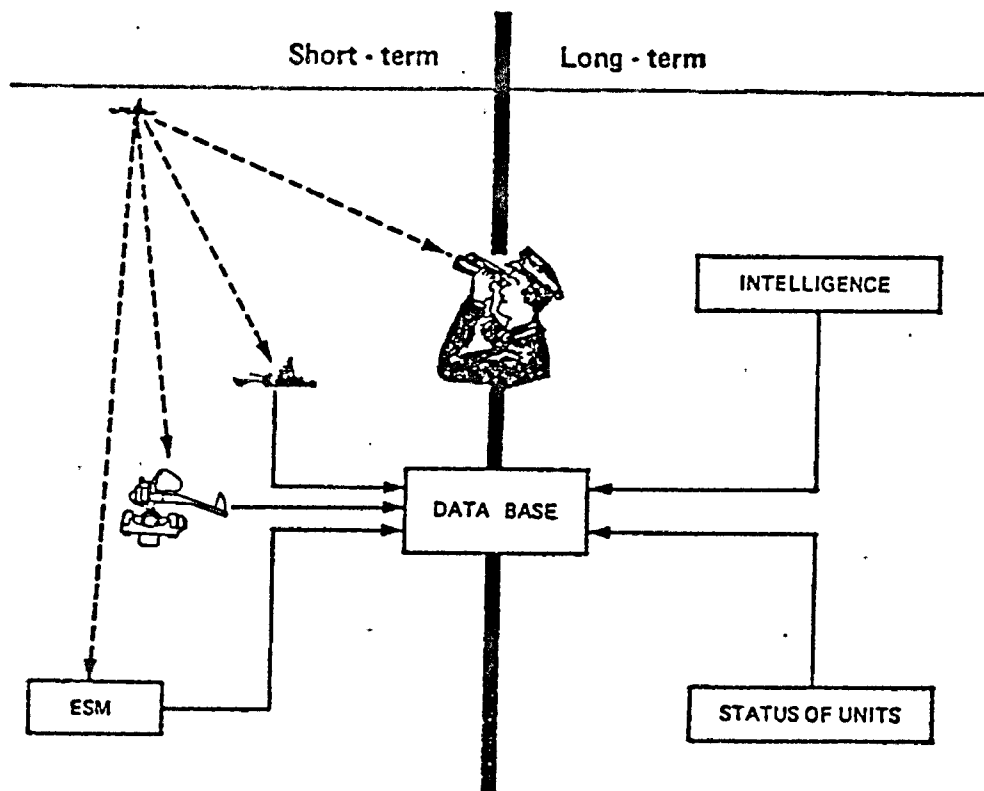


OPERATIONAL FUNCTIONS

As regards to the main radar center where the surveillance is performed the following operational functions are provided:

Information gathering

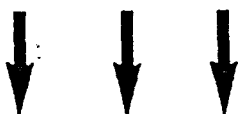
The initial activity of the system is to collect information from all sources available such as, data report from ships (targets tracks, status of proper forces, weather etc.); radar data transfer, and data reports from other systems etc.



Filtering of information

Information gathering normally results in great amounts of unstructured data, therefore these figures must be processed such as to be useful for presentation and decision making.

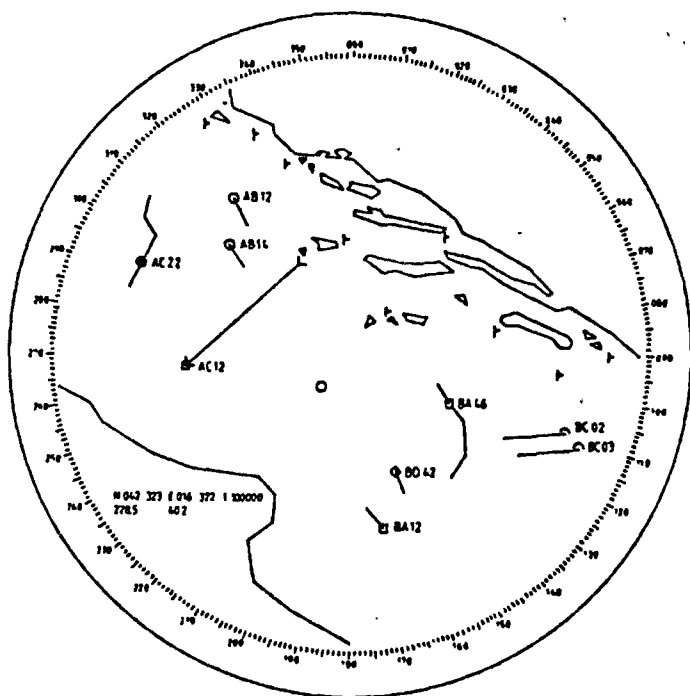
RECEPTION OF THE TARGET DATA



- TARGET NUMBERING
- TARGET CORRELATION
- DATA BASE UPDATING
- TARGET MANAGEMENT
- TARGET CLASSIFICATION
- TARGET IDENTIFICATION



PRESENTATION



Presentation

Presentation of processed data available in the data base can be made on:

- Color/Monochromatic PPI display
- Large screen display
- Text terminal
- Plotter and printers

The following can be presented on PPI displays:

- Plots and raw video from radars
- Targets tracks sent from ships or other sources presented as symbols with targets number and speed vector.
- Additional information, such as maps and sea charts including fixed points and reference grid nets, coastal lines, territorial lines, waterways, economic zones and search areas.

Regarding decision making, a surveillance system offer a situation picture of high quality and a set of operational functions so as to study and analyse the current situation from which the decision maker makes the decisions. To realize the decisions made command and control functions are available in the system; the functions are not only used to distribute orders but also to get feed back and supervise consequences and results.

The radar center consists of the following equipment:

- Operators' working positions containing PPI's, as

much as needed, depending on system configuration.
Displays and control units for VHF direction
finders

Radar remote control panels

Telephone panels

VHF-radio panels

- Common equipment containing

Modems

Amplifier/processor units for VHF-DF

Telephone equipment

(System and equipment characteristics ANNEX 3)

In this process two very important factors intervene, the first one is how many radars station and regional centers have to be laid down along the coast and the second one the radar coverage and communication links. The number of radars needed for the surveillance of a defined coast length depends on several main parameters:

- Radar range.
- Detection depth and position of radar with respect to the water line.

The range is defined by the main equipment characteristics, such as antenna gain and power, and with respect to the radar horizon, by the target height and the antenna height.

The antenna height can be calculated for a given target height and range from the following equation:

$$R(\text{km}) = 4.12 (\sqrt{ht} + \sqrt{ha}) \quad (\text{ht and ha in meters})$$

The aforesaid also depend on the free space radar range, because this is increased to a certain extent. This causes an increase of the tower height and consequently tower cost, therefore the break-even point for minimizing total costs is directly dependent on antenna height.

(See diagram 1).

On the other hand, an additional point of view which influences the number of radars needed is the detection depth for a gap-free detection of vessels, which will depend on where the radars can be placed, i.e., in the middle of the detection zone (in the water), or at the waterline. It is true that for a maximum detection depth, the optimal placement of the radar is in the water in the middle of the detection zone.

The two cases have been investigated by the following equations:

a) Radar in the middle of the detection zone

$$\text{the } N = \frac{L}{A} = \frac{L}{2\sqrt{R^2 - (D/2)^2}}$$

b) Radar at the waterline

$$\text{then } N = \frac{L}{A} = \frac{L}{2\sqrt{R^2 - D^2}}$$

Where :

L = length of the coast area to be subjected to surveillance

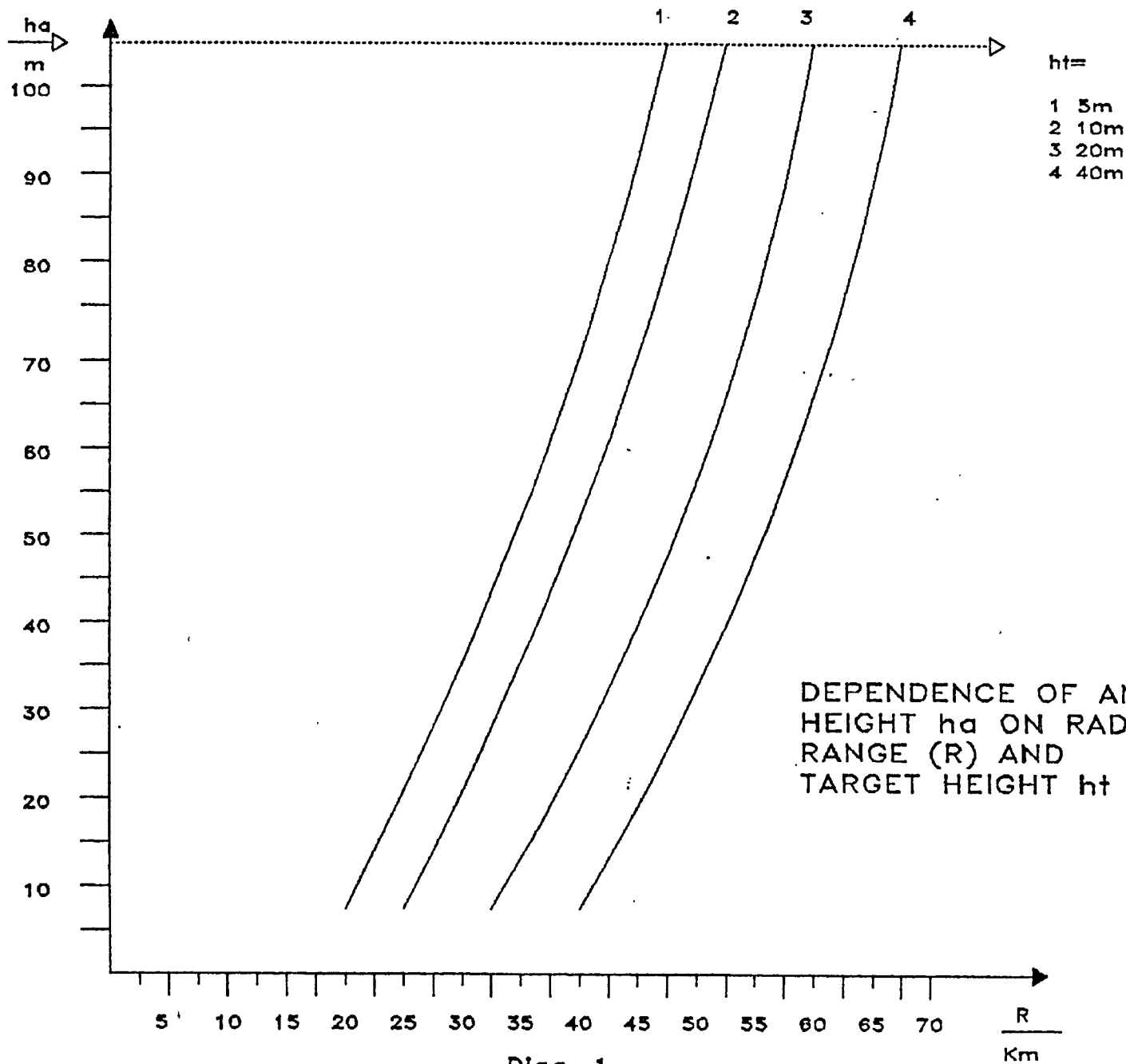
A = distance of radar

R = range of radar

D = detection depth

The number of regional centers are normally given by the coast length and number of laid down radar stations. It is desirable that at least two regional center be set out in addition to the main radar center, which usually operate, in the Head Quarter. Communications links must be available where radar stations are placed in order to receive/transmit data information from other sources to regional and main centers. The communications can be received/transmitted by normal telephone lines, VHF radio and microwave links which can be connected to a modem to transfer information directly from system to system.

System duration is of long life, naturally depending on the operation and maintenance given.



DEPENDENCE OF ANTENNA HEIGHT h_a ON RADAR RANGE (R) AND TARGET HEIGHT h_t

Diag. 1

CHAPTER III

INVESTIGATION METHODOLOGY

3.1 Specific Method.

Through the investigation development it has been used the DEDUCTIVE - INDUCTIVE method in the following way:

- a) In order to identify the problem, the author has employed the deductive method
- b) During the unfolding of the investigation, the inductive method was used
- c) In order to process the information, the contained analysis method has been employed
- d) For presentation of results, the investigation has

been managed by objectives.

3.1.1 Procedures

- a) For the problem identification, the author has used the deductive method, it means that the procedure stated from general enunciations (global problems), in order to structure particular enunciations.
- b) During the development of the investigation the author has used the inductive method, i.g, I have started from particular observations then, they have transmitted to general enunciations
- c) In the presentation of results, for each objective, global appreciations were given based in particular observations.

3.2 Universe and sample

The universe during the development of the present theme, was conformed by sensors-based surveillance system used in a number of countries around the world, and as the sample was considered the Peruvian maritime system from the Maritime Administration point of view

3.3 Techniques to get information

Collection of information from primary and secondary sources, and from interviews

3.4 Record techniques

For recording information, index and localization of documents were used

3.5 Processing information technique

The information has been processed classifying it by chapters

3.6 Analysis technique

For the present investigation, the logic reasoning has been employed

CHAPTER IV

PRESENTATION, ANALYSIS AND DATA INTERPRETATION

In the present chapter the author will carried out the investigation analysis, which makes it possible to diagnose the current situation of the Peruvian maritime surveillance system in connection with the requirements of the Maritime Administration in Peru.

The author will also evaluate the employment of a maritime surveillance system using both, shipborne and airborne sensors, land-based radar stations as well as a data processing center, in order to know the operational effectiveness and investment appraisal of such a project.

The results of the above mentioned analysis will allow to the Peruvian Maritime Administration to be aware of the operational feasibility and, cost of acquisition and operation of a highly sophisticated maritime surveillance system.

4.1 Diagnose the current status of the Peruvian Maritime Administration as regards to the national requirements in order to determine the satisfaction level of such requirements against the actual using system.

Every surveillance system which belongs to an organization must meet its requirements providing means that it needs to fulfill their functions.

In this sense, the Peruvian Maritime Administration must satisfy the surveillance requirements which are requested by the higher-level organism responsible to prescribing laws regarding the taking care of Peruvian interests at sea.

Such requirements which also involve the enforcement of international regulations and agreements within the Peruvian jurisdictional waters and those legal devices engaged in the safety and national economy, have most of them been embodied in the National Maritime Legislation and other legal documents issued by the organisms dealing with maritime affairs.

At this stage, the author will concentrate on analyzing the several aspects which allow him to find the necessary information in order to identify the national requirements with respect to maritime interests. Later on the author will confront such requirements against the actual maritime system in order to determine the present satisfaction level of it.

4.1.1 Identify the national requirements in respect of protection of Peruvian maritime interests, in order to know the maritime surveillance needs to be satisfied by the Maritime

Administration.

The Peruvian Maritime Administration is addressed by the General Directorate of Coast Guard and Captancies through the Peruvian Coast Guard corps which was created by law in 1969, as a component of the Peruvian Navy.

The law creating the Peruvian Coast Guard established the mission for this corps giving the Naval Ministry the task to organize and implement it.

That mission in accordance with Peruvian maritime law is:

" To exert naval jurisdiction of control, safety and protection upon the maritime, fluvial and lacustrine activities, as well as upon the natural resources existing in Peruvian waters in order to comply and carry out the enforcement of national maritime law and the international agreements signed by the Peruvian Government."

The Peruvian Maritime Administration due to the environmental nature and diversified elements within the maritime scope, in which it has developed itself, has assigned a number of functions to be fulfilled; However, most of these functions are not only engaged in national organizations, but also have a number of international undertakings with organizations whose several conventions the Peruvian Government has accepted and/or

ratified.

According to the national legislation where the international accepted or ratified Conventions have been embodied, the pointed out responsibilities involve as many maritime activities as the sea areas in which they develop themselves; therefore, the General Directorate of Captancies and Coast Guard thus count on great variety of requirements which force them to have a diversity of means and tools in order to meet them.

When analysing each function in a maritime administration it was found that more than one national and/or international organism involved exists, and in most cases, there is a law, regulation or scheme prescribing normative rules which lead to particular requirements to be performed under one specific function.

In the present case, we are interested in selecting only such functions which allow to assign the maritime surveillance necessities in order to afterwards meet the global surveillance requirements to be satisfied by the General Directorate of Captancies and Coast Guard.

4.1.1.1 Analyze the maritime administration requirements directly connected with management and control of such activities carried through the jurisdictional sea waters in order to identify the surveillance functions to be performed.

The General Directorate of Captancies and Coast Guard as a maritime authority exerts control, surveillance, safety, protection and enforcement of laws upon the maritime activities, as well as beaches and natural resources, which develop in the sea compass upon the whole maritime territory; therefore, a number of functions dealing with the context of assignments have been set up to comply with the large range of responsibilities.

However, all of those do not deal with one of the most important functions, which is the control of activities carried out within the Territorial sea, Exclusive Economical Zone and sea-port areas.

Thereupon, the Peruvian surveillance requirements are given by a number of National Organisms and International Organizations whose regulations are embodied into the maritime legislation; On the other hand, the standards and procedures to follow are prescribed by law through decrees, resolutions and/or other official documents.

In this sense, after analysing the maritime legislation, it has been found that the most important sources of requirements dealing with maritime surveillance are the following:

National Organisms

- (i) Ministry of Defense
- (ii) Ministry of Transport and Communications
- (iii) Ministry of Fisheries
- (iv) Ministry of Economy
- (iv) Ministry of Energy and Mining

INTERNATIONAL ORGANIZATIONS

- (i) United Nations
- (ii) International Maritime Organization

Before selecting the functions of a maritime administration connected with surveillance tasks, the author has to state the aforesaid organism requirements in this respect.

In this sense after carrying out the aforesaid analysis reviewing plans, decrees, legislations, documents and related regulations, the following requirements has been decided :

National Organisms

- (i)
 - a.- Protection of territorial waters
 - b.- Protection of the EEZ
 - c.- Protection of frontiers and beaches
 - d.- Prevention of illegal transport
 - e.- Prevention of illegal activities

- (ii)
 - a.- Navigation assistance
 - b.- Traffic separation
 - c.- Harbor traffic control

- d.- Planning of piloting

- (iii) a.- Protection of prohibit fishing areas
b.- Control of allowed fishing areas
c.- Control of national and foreign fishing vessels

- (iv) a.- Protection of economically strategic maritime areas
b.- Control of such fundamental maritime activities intended against the national economy

- (v) a.- Protection and control of areas and activities dedicated to mining and oil extraction from the continental shelf and subsoil

International Organizations

- (i) a.- Enforcement of such regulations related to the Law of the Sea as regards protection of living and not living resources, and those activities of international conditions carried out within jurisdictional waters.

- (ii) a.- Enforcement of such regulations related to the SOLAS Convention regarding safety of life at sea.
b.- Enforcement of such regulations related to the MARPOL Convention in respect of protection of the marine environment.

Taking into consideration the large amount of requirements requested by organizations dealing with Peruvian maritime interests, The author is going to select solely those functions directly engaged in surveillance in order to afterwards, obtain global maritime surveillance requirements.

- Exert maritime control within the Peruvian maritime domain to the full extent of up to 200 NM and also littoral, beaches and ports.
- Exert maritime traffic control within jurisdictional waters.
- Exert maritime control upon illegal activities carried out within jurisdictional waters, littoral and sea port areas.
- Exert control upon fishing activities within fishing areas.
- Keep awake on safety of life at sea.
- Detect and control oil spills and noxious substances into the sea.

4.1.1.2 Analyze each maritime function taking into account the set out requirements in order to determine global surveillance needs

For obtaining global maritime surveillance requirements, those functions directly involved with the control of sea areas in which surveillance has to be exercised must first of all be analyzed.

The Peruvian maritime domain has, a littoral of nearly 1200 NM in length and 200 NM in breath giving it a closed area of 240,000 square nautical miles meaning that, every activity herein has to be controlled and managed in order to obtain full benefits as regards the national safety and economy at sea.

As regards the maritime police, they has to be commanded by the Coast Guard corps through the aforesaid areas taking into consideration maritime traffic of vessels transporting cargoes from/to jurisdictional waters, traffic of vessels between national ports in addition to vessels crossing within the extent of the Peruvian jurisdiction enjoying the right of innocent passage.

The aforesaid means that, the Maritime Administration must take control, track and identify, all types of vessels and other sea targets within Peruvian jurisdictional waters which include the high seas, territorials waters, littoral and beaches in order to avoid activities threatening National interests.

Furthermore, the control of such activities related to extraction of biological resources, living or not has to be exercised, which means, fishing activities, extraction of oil from the continental shelf and other different than oil from the sea bed.

In relation to the functions of a Maritime Administration coming from the Ministry of Transport, the maritime administration as a maritime authority must provide navigation assistance and traffic separation not only upon national and International maritime routes within Peruvian waters, but also within roadsteads and port areas.

Regarding functions related to international organizations the author has mainly, pointed out such conventions directly engage in surveillance activities leading the maritime administration to only take into consideration, safety of life at sea and marine pollution, which involve a large number of responsibilities and actions to be taken into account for the entire Peruvian maritime extension.

Such responsibilities means, that the Maritime Administration shall oversee every activity developed into areas where merchant, fishing and/or any kind of vessels are sailing or performing any type of duty. On the other hand, traffic of oil tankers along the Peruvian coast, International routes and loading and unloading port areas have to be considered in order to protect the marine environment from accidental and/or intentional oil discharges and noxious substances.

The author will continue carrying out the analysis of such maritime areas in which the Maritime Administration has to perform their functions and responsibilities in order to consolidate global surveillance requirements considering functions to be performed, activities to be carried out within jurisdictional waters and areas in which they are developed. For this purpose, The author will set up the different areas in which the various activities take place within the Peruvian maritime jurisdiction. First of all the author is going to describe the entire Peruvian maritime extent, including main ports, littoral, beaches and high sea areas.

The Peruvian maritime territory, for administrative reasons, is divided in three main zones along the line coast each one approximately 400 NM in length and 200 NM in breadth, the later of which contains the EEZ.

The north zone contains a sea area from the border of Ecuador to Salaverry port, the central zone is located between Salaverry port and San Juan port in the mid-south of the littoral and finally, the southern zone is placed from San Juan port to the Chilean frontier. (Fig 1-1)

The aforementioned areas include within its extent, calling ports of international traffic, oil tanker routes, loading and discharging oil ports, refineries, areas in which nationals and foreign fishing vessels are allowed to exercise fishing duties, prohibited areas for fishing activities during close season in certain periods of time throughout the year, prohibited areas

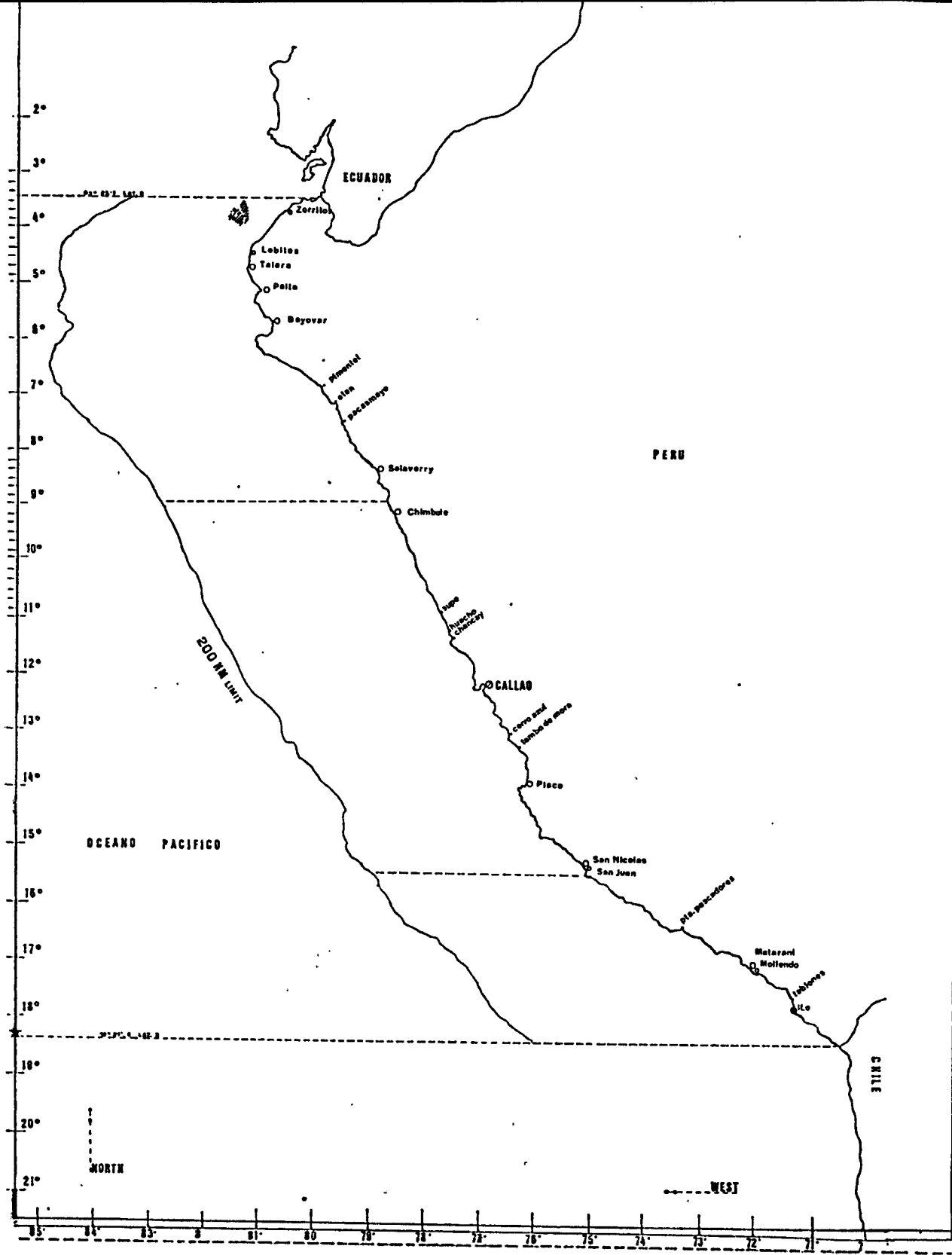


Fig. 1-1

for national and foreign fishing vessels during the whole year, forbidden traffic routes, accessible beaches for smugglers and other threatening national safety.

NORTH ZONE

The north area, as before mentioned, include areas and ports in which different activities are developed, therefore, a surveillance function has to be performed:

Fishing activities are carry out in the whole extent of the north zone, however, specific areas must be pointed out.

In the northernmost point, next to the Ecuadorian border three very important areas in which the Maritime Administration has to use intensive control; have to be considered.

A very productive fishing area, in which depredation and catching of more than permissible maximum yield take place, is located from, the northern limit 100 NM south the along line coast up to around 40 NM towards the west; On the other hand a very rich fishing area, well known as "Banco del Peru" (MANCORA), is also located next to the Ecuadorian frontier southward, approximately 60 NM in front of Punta Malpelo.

Other productive areas in which national and foreign fishing vessels develop illegal fishing are located near the line coast in front of Paita, Pimentel, Eten and Pacasmayo Ports and, "Lobos de afuera" and "Lobos de adentro" islands. Looking at the high sea areas, the author could point out that there exists a great area within the EEZ limits, from 100 S up to the northern

border line and 80 NM from the coast up to 200 NM in breadth, in which prohibit foreign fishing vessels are carrying out fishing duties.

The author can also mention a weak zone for smuggler activities; from Punta Capones to Paita Port, the same illegal activities are taking place in port areas.

Regarding areas in which oil pollution may take place, "Lobitos" port, can be mentioned, it an are close to the coastline where oil extraction from the continental shelf takes place; Talara port, where the main Peruvian refinery is located; Bayovar port, which is an oil pipe line terminal coming from the mountain area and, Pimentel and Salaverry which are discharging ports. (The whole area is shown in FIG 1-2)

CENTRAL ZONE

The central zone as the former, involves a number of main ports, fishing areas, proper areas for smugglers, traffic routes, loading and discharging oil ports etc, where which the involved activities take place. Fishing areas are located mainly close to the coastline in the following places:

Port of Chimbote *

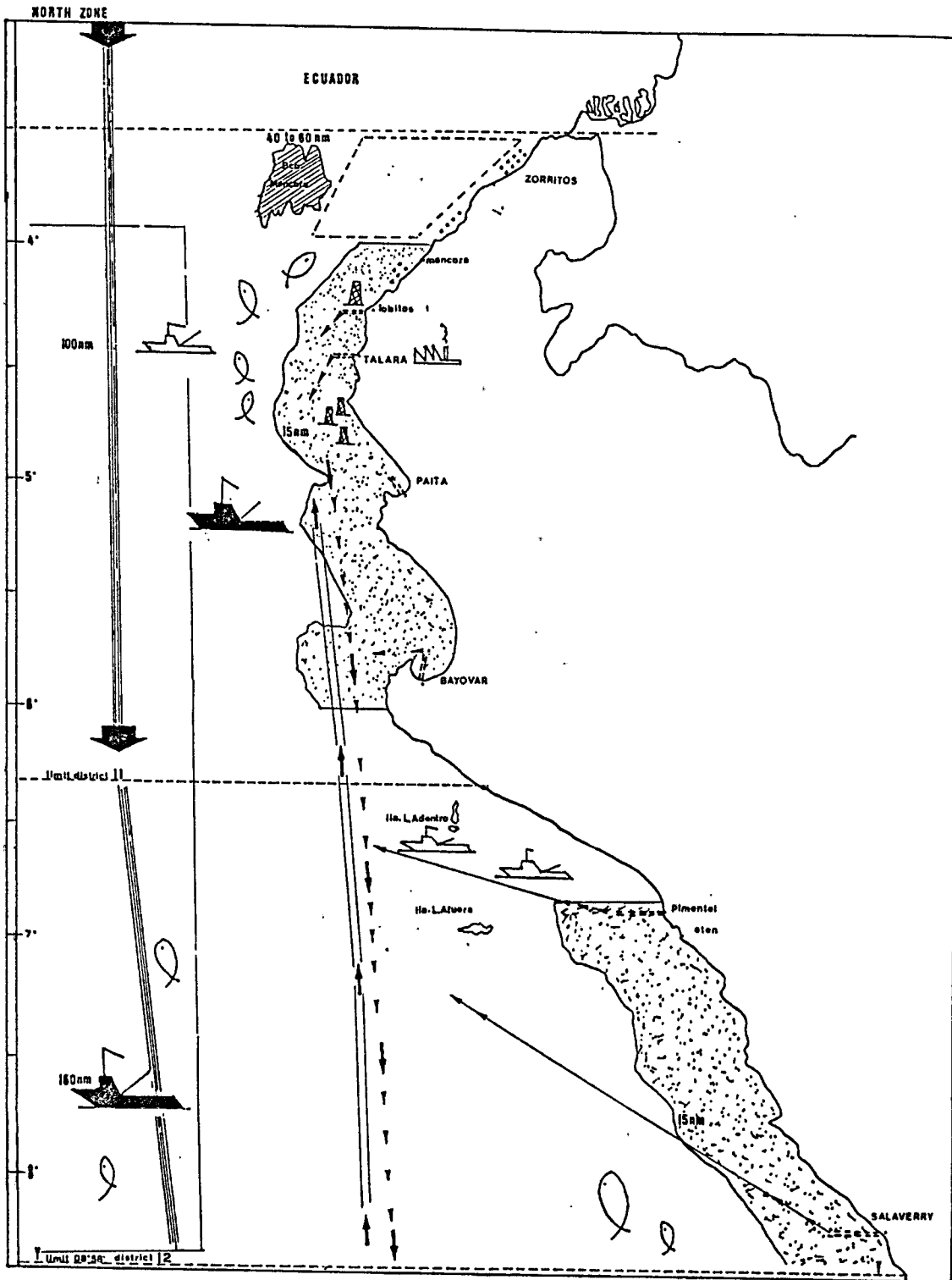
Port of Supe

Port of Cerro Azul

Port of Tambo de Mora

Pisco port

* Main industrial fishing port



- | | |
|--|---|
|  FOREING FISHING VESSELS AREA |  SEASONAL FISHING ZONE |
|  NATIONAL FISSING AREA |  TANKERS TRAFFIC |
|  INTERNATIONAL ROUTE |  REFINERY |
|  SPECIAL FISHING ZONE |  OIL TERMINAL |

Fig.1-2

We can state the aforesaid places embrace a large strip of 60 NM in breadth from Salaverry port to the south limit of the mentioned zone.

In respect of oil tanker traffic routes and loading and discharging ports, the author would like to mention the most probable areas in which the marine environment is polluted.

Firstly Chimbote Port, the main fishing port and steel producer, therefore a great consumer of oil products and, exporter of fishing and steel products; Secondly, Callao Port, the major port in Peru, between which two oil refineries are located one of them, "La Pampilla", 12 NM north and the second one "Conchan", 15 NM south; finally, Pisco and San Juan ports with activities in the same regard. (Fig.1-3)

SOUTHERN ZONE

The same activities, as mentioned before, take place in this zone, taking into consideration that the fishing areas are very close to the coast. In respect of calling ports by national and international vessels the following ports are important:

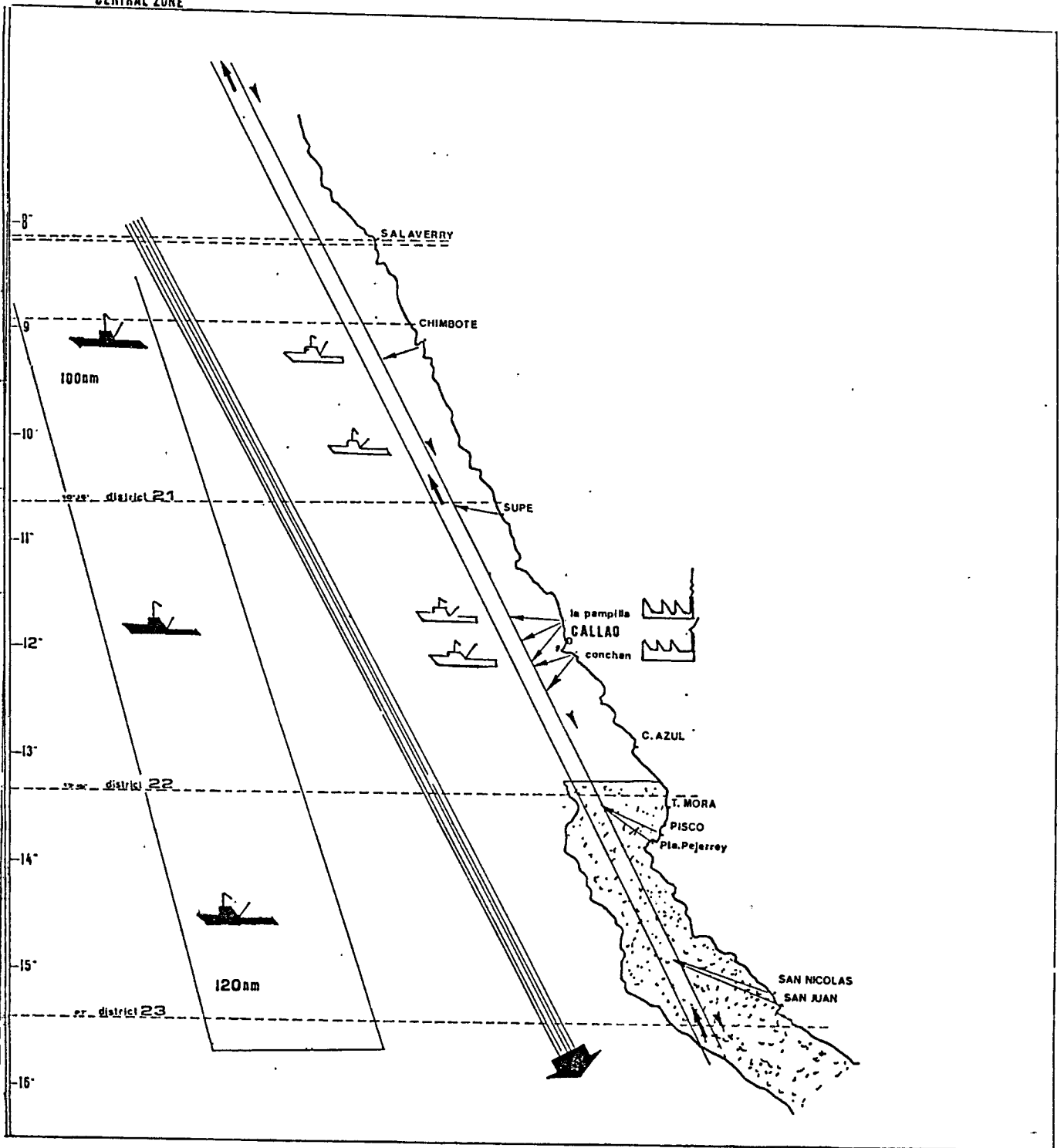
Port of Mollendo

Port of Matarani

Port of Ilo

Regarding smuggling activities, most of

CENTRAL ZONE









- | | |
|---|---|
|  FOREIGN FISHING VESSELS AREA |  SEASONAL FISHING ZONE |
|  NATIONAL FISHING AREA |  TANKERS TRAFFIC |
|  INTERNATIONAL ROUTE |  REFINERY |

Fig. 1-3

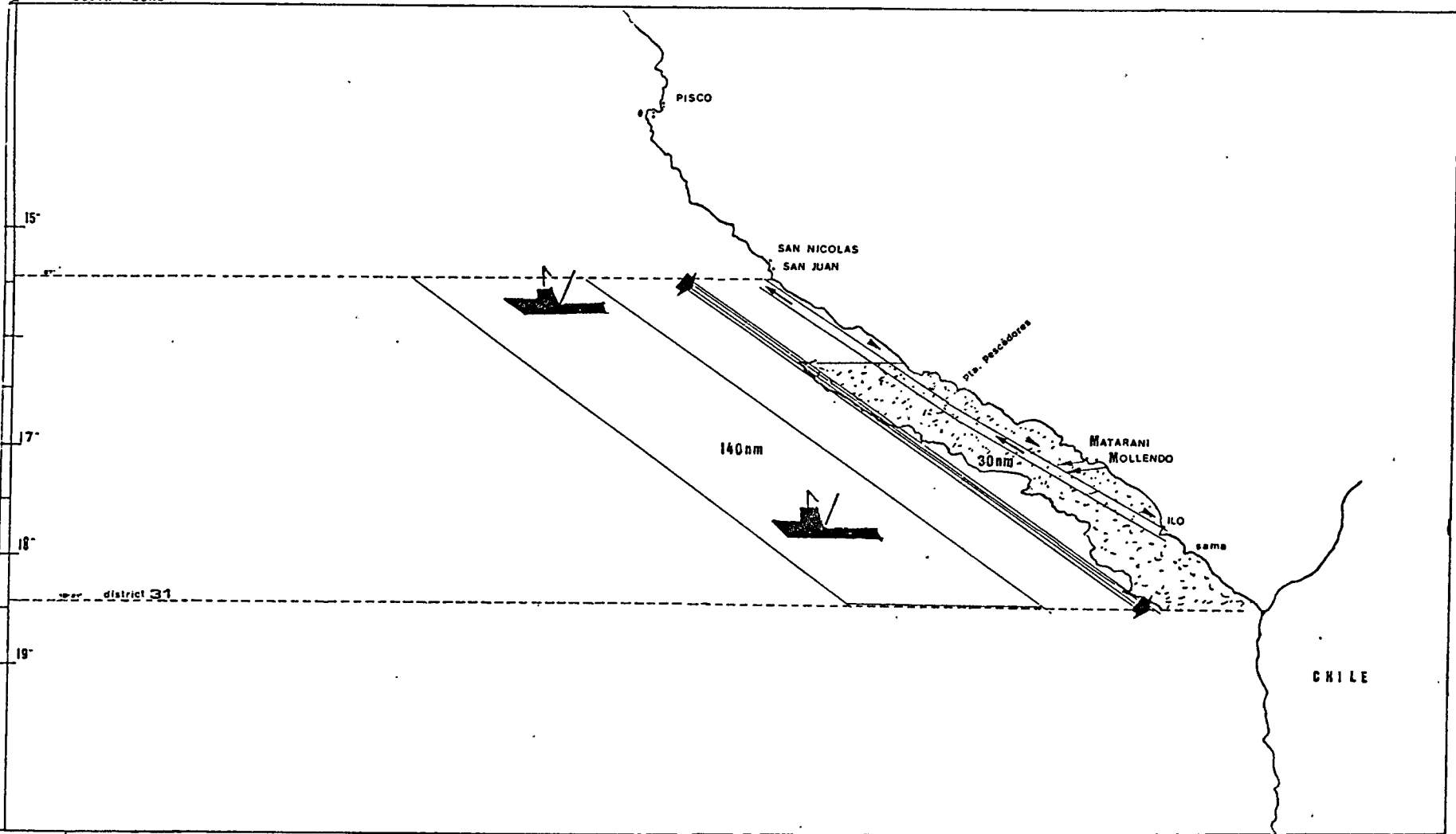
those take place in the southmost point of the south zone, between the port of Ilo all the way down along the littoral to the Chilean frontier. The areas in which different maritime activities develop are shown in Fig.1-4.

Traffic routes into the whole Peruvian Maritime area, those are shown in Fig.1-5

From an analysis based on information available it can be observed that the surveillance requirements requested by the different national organisms and international organizations are grouped by activities in different zones and areas into the whole Peruvian maritime territory; however, it can be divided into categories according to different factors.

- (i) At any time it was found that, it is desirable to control and manage the various activities to the full extent, therefore the areas have to be covered at any time by different means capable of giving surveillance coverage to the entire maritime territory.
- (ii) Taking into account the proximity to the coastal line we can classify the maritime surveillance in:
 - a) Surveillance within port areas, roadssteads and littoral
 - b) Surveillance near to the coast in a range of 20 to 40 NM away from land
 - c) Surveillance upon maritime areas away

SOUTH ZONE



 FOREIGN FISHING VESSELS AREA
 INTERNATIONAL ROUTE

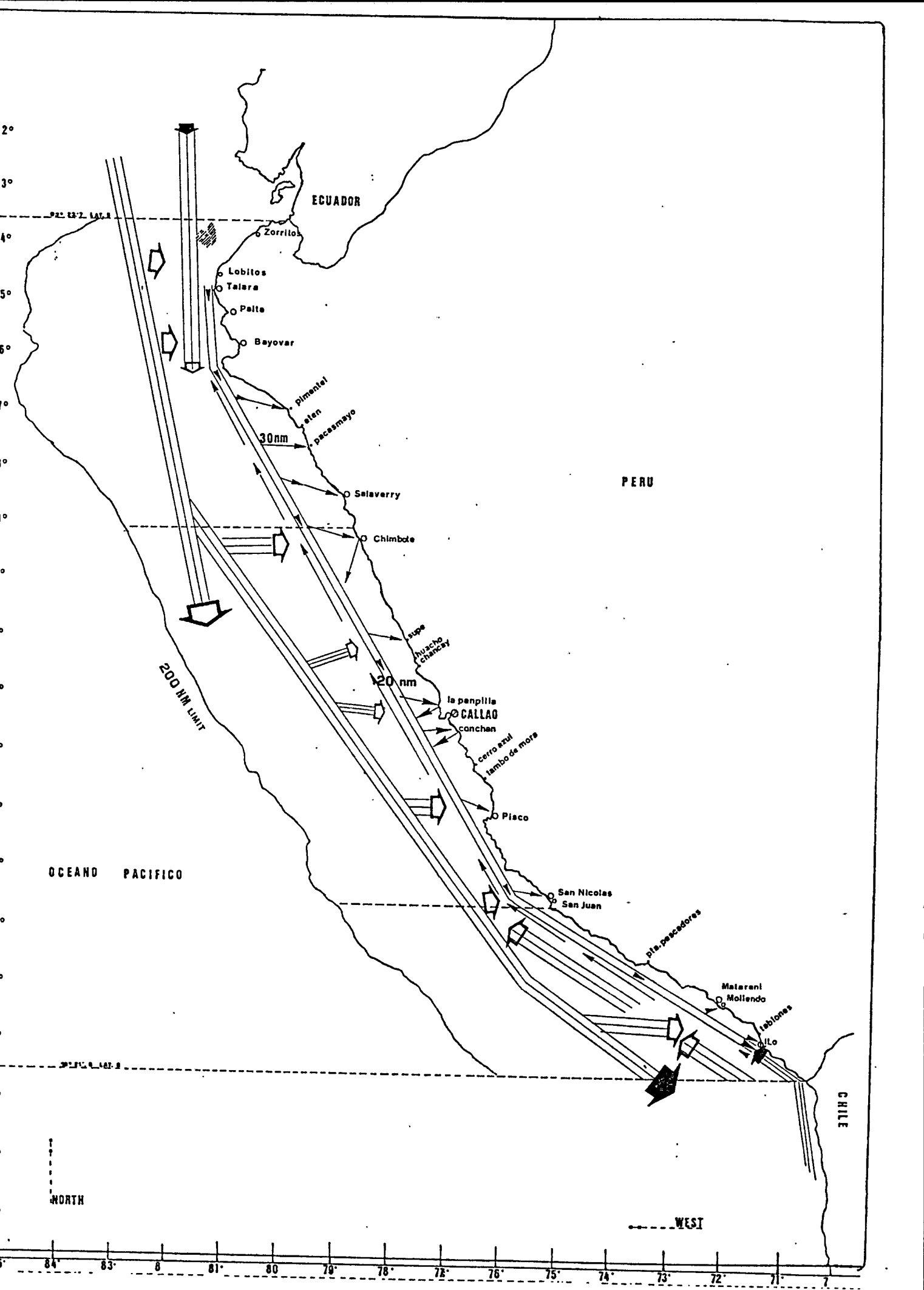


FIG. 1-5

from land, and high seas as far as 200
NM

(iii) Considering activities differ from each other, it can be noticed that it is necessary to use different means to detect, identify, track and control vessels, and take remedial measures at any time wherever something happens.

(iv) According to the type of surveillance, it can be classified in:

-Physical, which means, Patrol boats, craft and people acting in the area in question

- Non-physical, which means, equipment to be used to perform surveillance functions, communications network and equipment to be used as data processors.

4.1.1.3 Pre-conclusion

During the unfolding of the present objective the author has determined the global surveillance requirements which must be satisfied by the Peruvian Maritime Administration. The requirements are given by, the coverage of each area, independent of each activity to be controlled, it is supervision and control of:

- The north and south frontiers
- Regulations for safety at sea
- Fishing and hunting areas

Detection, identification and tracking of any kind of vessels in coastal areas, traffics routes and high seas.

Provide :

- Search and rescue service round the clock.
- Environmental protection measures against pollution by oil, chemical, or other harmful substances.

Due to operation methods, there must be a Command control center in order to centralize and record information.

Communication links must be available between a place where an event occurs and the command control center.

Furthermore, stations acting as detector centers, which could be surface units, aircraft and/or land-based sensors have to be made available.

Therefore, The Peruvian Maritime Administration must be provided with any type of means and specialized equipment in order to take coverage of the three main zones which means, ports, close to coastal areas as well as in the high seas, taking control of the various activities, being able thus to disclose potential infringements within port areas, territorial waters and Exclusive Economic Zone.

4.1.2 To effect a comparative analysis between the national maritime surveillance requirement and the equipping feasibility in order to determine the current satisfaction level of such requirement.

Surveillance is a function of a Maritime Administration, at the same time, it is an activity which must satisfy the requirements of giving full coverage to the whole national maritime territory to permit detection, tracking and identification of vessels and other sea targets within the surveillance area, disclosure of potential infringements into jurisdictional waters and exposure and analysis risks and threats. On the other hand as far as ports and traffic management are concerned, analysis of collision risks and supplying navigation assistance are other requirements in which surveillance as a system must be present.

All the above mentioned requirements must be interfaced in such a way that, quick and reliable information is transferred to data processing centers in order to give a chance to the Administration Officers to take decisions at the correct time. This means, the Maritime Administration must be provided with specialized equipment in order to detect any type of sea targets to be able to control and manage different situations anywhere at sea; a communications network in order to transfer information; data processing centers, in order to record and process information, and qualified personnel to act as soon as the situation need it.

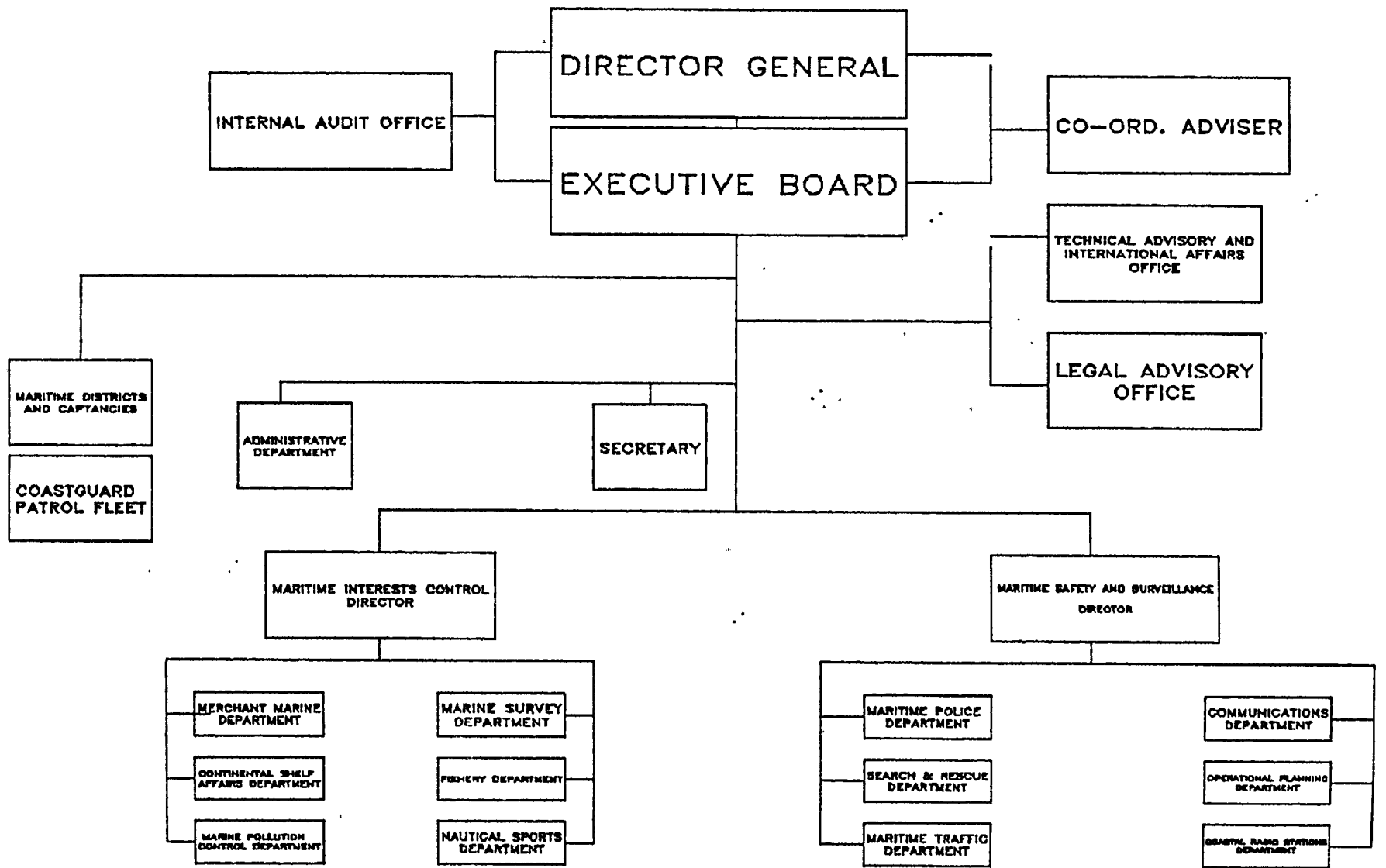
In this sense, the surveillance system must answer to the specific needs of each stated requirement in such a way that it ensures the control and management of different types of activities at sea, safety of life and/or vessels, and preservation of the sea environment.

4.1.2.1 Comparison of the surveillance requirement according to the current equipment the Maritime Administration has, in order to determine the present satisfaction level of such requirements.

The General Directorate of Captancies and Coastguard is divided in a number of operative departments as far as internal structure is concerned; On the hand side, regarding external branches it is divided into Maritime Districts and Captancies spread along the Peruvian littoral; the former is under direct control of The general Director of Captancies and Coastguard, the latter, under the responsibility of district commanders.

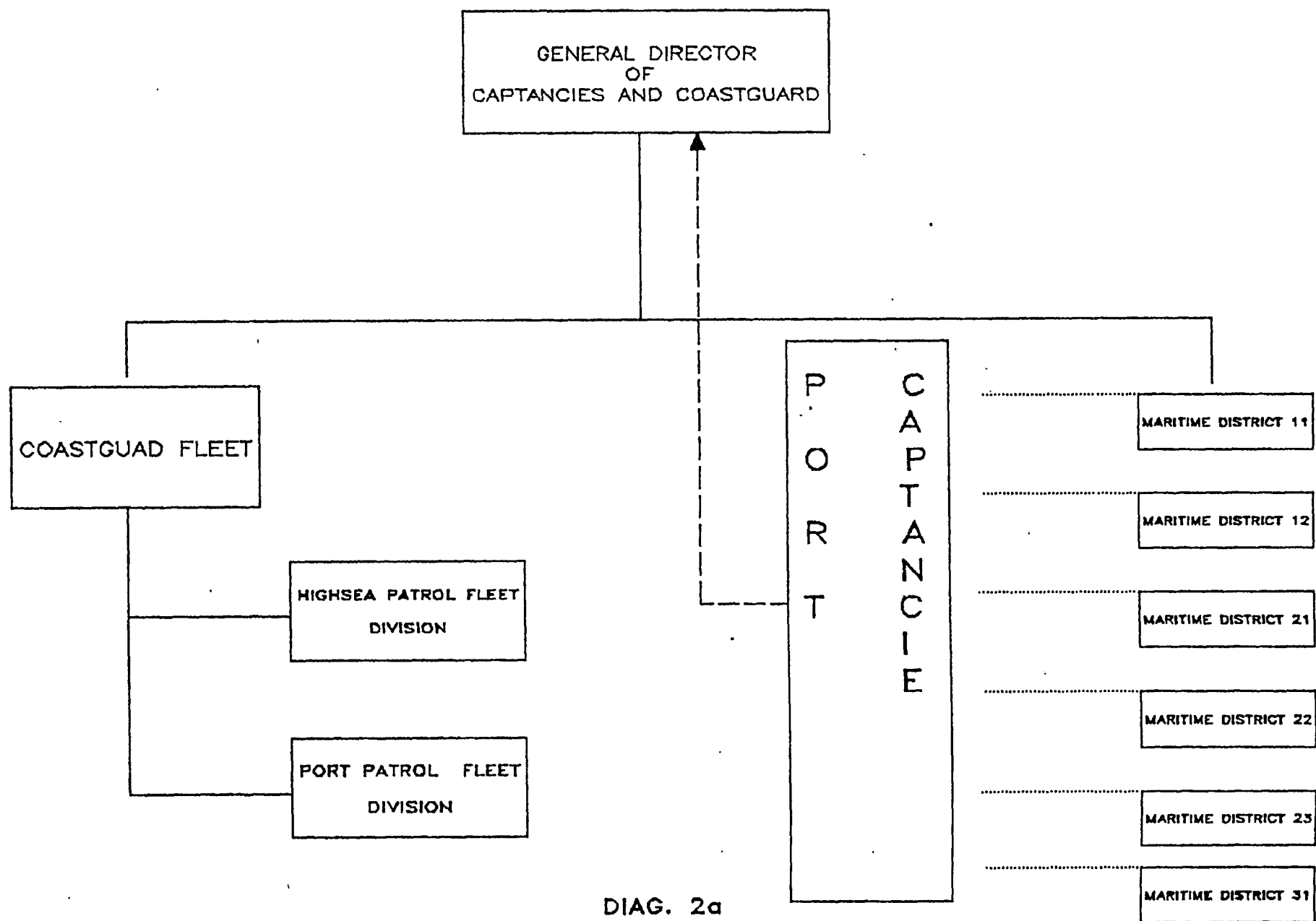
Furthermore, there is an external branch playing the most important role in maritime surveillance, namely, the Coastguard Patrol Fleet, which is an autonomous organism in direct line with the General Director, however it is under the command of Patrol fleet Commander (diag.2)

MARITIME ADMINISTRATION ORGANIZATION CHART



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Diag. 2



DIAG. 2a

The Maritime Administration structure as far as surveillance is concerned is based on four main divisions which are responsible for taking full control and management of the already established activities carried out at sea.

- Maritime Districts
- Captancies of Ports
- Coastguard Patrol Fleet
- Headquarter Operations Department

MARITIME DISTRICTS

The territorial structure of the Peruvian Maritime Organization, regarding the maritime territory, has six districts, which constitute the organizational link between the General Directorate of Captancies and Coastguard and the Port Captancies. The purpose of the districts is to centralize support functions and decentralize operational control in the maritime districts according to the policies of the Head.

Taking into account the duty of centralizing support functions in their jurisdiction, the Maritime District must determine and use the available means in the area to control and manage every incident.

Before establishing the current level of satisfaction, as regards surveillance in the districts, the author is going to determine the geographical location in order to have

knowledge of district jurisdiction, afterward the author will decide about the facilities which have to be controlled and the management of activities within each district's jurisdiction.

- Maritime District 11, Headquarters in Talara Port, stretches from the Ecuadorian border down to 6o 21' S
- Maritime District 12, Headquarters in Salaverry Port, includes a sea area from 6o 21'S to 8o 58' S.
- Maritime District 21, Headquarters in the port of Chimbote, is limited by parallels 8o 58' S and 10o 36'S.
- Maritime District 22, Headquarters in the port of Callao, a district in which also the Maritime Administration Headquarters is placed, is located between 10o 36'S and 13o 18'S.
- Maritime District 23, Headquarters located in the Port of Pisco, stretches from 13o 18'S to 15o 27' S
- Maritime District 31, the southmost district on the Peruvian littoral, with its head office placed in the Port of Mollendo, stretches from 15o 27' S to the Peruvian and Chilean frontiers at 18o 21'S.

Surveillance areas of interest for each district has in specific terms been, pointed out in objective 4.1.1

It has to be mentioned that jurisdictional limits include as far as 200 NM in

breadth.

PORT CAPTANCIES

This is another one organism involved in control and management of activities carried out at sea. It is the organism that is the most directly engaged in enforcement of regulations in the maritime field. Among its many functions it has to perform one important task which is exert control in near coastal sea areas and beaches.

The Port Captancies are organisms under control of the General Director of Captancies and Coastguard through the Maritime District Commander under whom they are subordinated.

The coast patrol vessel fleet headquarters, is based in Callao Port. According to an established plan and available patrol vessels, they are assigned to different zones under command and control of the respective Maritime Districts Commanders in order to effect surveillance missions within their jurisdictions.

The patrol vessels' surveillance mission is in fact based on recognizing specified areas of interest, looking for actions against national and/or international regulations, taking preventive actions and sending data information through maritime districts to Coastguard Operation Department enabling them to take corrective measures; In this sense, patrol vessels as well as Maritime district headquarters are sufficiently equipped as

regards the satisfaction of communication links.

On the other hand, activities carried out within ports and roadstead areas are under the responsibility of Port Masters who for surveillance purposes have port patrol boats permanently designed to perform actions in order to control specific areas and manage certain events.

The four above mentioned organisms act, as a whole system, co-ordinating actions and taking measures in case any event occurs.

Actually, the Maritime Districts, as the main responsible authority in each operative area, is the main link between the responsibility area and the Coastguard Headquarter Operation Department which acts as a co-ordinating center. In this regard, the surveillance resources are mainly the patrol vessel fleet and any other available means within the area in question when something occurs and possibly naval air craft which are assigned to fulfill specific tasks.

It can be stated that, surveillance task is divided by areas and activities; the first one, in respect of beaches and nearby coastal areas, the high seas, and port and roadstead areas; the second one regarding the detection of any illegal function at sea, people and/or vessel in distress and oil spills into the marine environment.

Taking into consideration the above mentioned, as regards areas, the principal means to exert surveillance within the high seas areas

are constituted by the coastal patrol fleet and naval air force craft.

Looking at littoral and beaches where obviously many illegal activities occur, there are not enough available means to control certain areas, mainly those which are separated from urban zones along the littoral and specially in zones close to frontiers.

In order to carry out the comparative analysis between the surveillance requirements before deciding on the current means which the Maritime Administration could use, we have to take into consideration the fundamental aspects of surveillance regarding sensors, equipment and tasks they can perform, which were mentioned in chapter II. The coverage of the whole maritime territory depends on the ability in controlling each area and keeping a constant information flow coming from permanent sources.

Thus, by processing, evaluating and making decisions at opportune times, permanent surveillance and full territory control will be obtained. It is necessary to have certain electronic sensors, processors, communication links and other means especially designed for this purpose.

Today, the Peruvian maritime surveillance consists of the four main elements before described, with the Patrol Coastguard fleet to support the principal course of action; Patrols boats are provided with all the necessary navigational aids and equipped with VHF and HF radio frequencies.

They are designed for a certain period of time to different areas for operational purposes under direct command of Maritime District Commanders, and some of those, when required, are designed to special missions around the littoral and the high seas.

Nowadays, the Peruvian Maritime Administration has a very well organized maritime surveillance system to cover great part of the maritime territory taking control of most of the activities carry out at sea.

However due to the dimension of the maritime territory, it is very hard to control the illegal activities occurring near coastal areas as well as to disclose potential infringements against the marine environment which in fact requires constant control and specialized equipment.

Furthermore, the current system features and territory dimensions do not allow for taking control over the whole territory at any moment because there are not enough surveillance surface units available and information transmitted by VHF and HF radio frequencies is not trustworthy.

Actually the maritime surveillance is obviously limited by the patrol units, in number and performance. In fact they are not capable of covering the entire area as required due to speed and radar coverage which are translated in to much effort and high operational costs. On the other hand, there is no available computerized system to help in processing and recording

information as well as taking decisions.

Finally, the surveillance systems use solely surface units and occasionally air units without equipment specifically designed for those tasks. Therefore they can not efficiently fulfill the referred Maritime functions in addition to the scarce available means of the Maritime District Headquarters and Port Captancies as well as Operations Department Headquarter who acts as a coordinating center.

4.1.2.2 PRECONCLUSION

The development of the present objective leads to the current satisfaction level of requirements for the Peruvian Maritime surveillance which is not the best due to a number of limitations. Surveillance Systems must satisfy requirements such as, by giving full coverage to main areas at any moment; detection, identification and tracking of targets; disclosing potential infringements against the marine environment and activities carried out against national safety; data transmission and evaluation as well as recording and storage information.

In spite of the fact that the Peruvian Maritime system is very well organized, there is a lack of certain specialized equipment resulting in weakness in controlling activities

carried out within the whole maritime territory.

4.1.3 PARTIAL CONCLUSION

Taking into consideration the development of the present END (4.1), The author has determined the following partial conclusions:

- Maritime Surveillance, which must be satisfied at all times by the Peruvian Maritime Administration, should be represented by surface units, aircraft, airborne sensors, land-based radar stations, different modes of communications links, data processing centers and command control centers, all of which together as a system must permit permanent surveys around the whole maritime territory giving specially emphasis on those areas in which unlawful activities can occur, e.g. fishing areas, vessels traffic routes, coastal zones, boundaries, beaches, ports, roadsteads and the high seas. Furthermore it must be capable of covering as many zones as possible at the same time, be able to operate 24 hours round the clock, be able to detect, track, identify and display targets and finally it must be able to transmit/receive, process, evaluate, record and storage information.
- The communication links must be in such a way that imageries and other type of signs can be transmitted from both airborne and shipborne sensors, and land-based radar stations to data processing centers, such as it is, command and control center.

- Given such requirements, the current satisfaction level of maritime surveillance due to the equipment the Maritime Administration have, there are limitations, limitations to give full coverage to the maritime territory, gather information, transmission of data and lack of specialized equipment for such tasks. Therefore, the system does not meet the requirement of being reliable and flexible.
- It is necessary to look for another alternative to meet the maritime surveillance requirement in addition to those giving speed and less operational costs to the system.

4.2 It is necessary to evaluate the alternative to employ a sensors-based maritime system to satisfy the Peruvian Maritime surveillance requirements, taking into account effectiveness and economical aspects in order to give judgment elements for the acquisition and operation of a maritime surveillance system.

In the modern world, technological improvements have been demonstrated in the maritime field by developed countries where, surveillance systems have been implemented in their coasts, controlling great sea areas. Those systems are being used by a number of countries facilitating their maritime administrations to cover maritime territories to a full extent, infringement disclosures against national regulations within maritime interest areas, decision making regarding oil spills, and better performance in carrying out search and rescue operations.

All this is because they use a surveillance system based on sensors and processors which work

efficiently and therefore data can be transmitted faster than conventional systems in addition to imageries, giving decisions makers a complete view on what is going on over the whole maritime territory.

However, to evaluate in a real sense how surveillance requirement can be satisfied by employing a determined system, it is necessary to consider the various requirement aspects which are covered by the system, as well as how the maritime administration is affected and/or benefited.

4.2.1 It is necessary to analyze the effectiveness of employing a sensor-based maritime surveillance system to solve the Peruvian maritime surveillance requirements.

As can be seen in chapter II, a maritime surveillance system can be considered as a set of airborne, shipborne and land-based equipment perfectly interfaced by different communication link systems. In addition to equipment to perform complementing functions. The main purpose of the sensor based Maritime surveillance system is to give full coverage to maritime areas in order to control every activity, thus permitting the responsible organism to take decisions and corrective measures in appropriate time. Furthermore, the control of those activities must at all time and in all place keep, track and records every event. On the other hand, one difference between maritime surveillance exerted by a sensor-based system and maritime surveillance

exerted by conventional means is that the former includes fixed stations working 24 hours and sophisticated communication means to transmit all types of information giving special configuration to the system.

In order to analyse the alternative, The author is going to set up the system characteristics, independent of equipment features, which could be used by the Peruvian Maritime Administration.

First of all, the basic system configuration depends on the number of sub-systems forming it. The sub-systems, irrespective of their builders, are normally operational centers, each one interfaced, performing functions intimately related., and of course independent of the environment in which they are acting.

Sub-systems can be named as follows:

- Main operational centers or command centers
- Subsidiary centers or regional centers
- Fixed or mobile land-based radar stations
- Aircraft carrying specialized surveillance sensors on board
- Surface surveillance units
- Communication equipment: radio links, radio stations and wire network.

Command centers, in a normal situation act as main operation centers, which must be located in the Organization Headquarter; On the other hand, a number of regional centers are placed between command centers and data sources; Both, command and regional centers can be laid out for different numbers of operator

and commanders to suit individual requirements.

Information emanating from the entire area covered by the system is transmitted from various sensors and data sources to the regional centers.

At the regional centers, the information is filtered before further transmission to the command center.

In order to ensure operations control in an efficient manner, all centers must be equipped with computer systems for signal processing, data storage console handling and overall system administration; those operational functions must be handled by computers in each center, supplied by a specific control console and mainly determined by the system software.

(Characteristics are shown in annex III)

Air surveillance must be a totally integrated system built up from several sensors and sub systems in a modular concept. Data from the sensors have to be processed to enhance features relevant to the maritime application, and to obtain a suitable image format for presentation. After processing, imagery from all sensors can be recorded, documented and displayed in a real time to the operator on a TV screen. All imagery in the aircraft can be relayed to ships and land-based centers using a microwave image link. The ship and shore equipment must be provided with the same presentation and documentation facilities as the aircraft; The airborne sensor system is fully autonomous and comprises all hardware and software necessary to accept, process and display information. Raw and

extracted radar pictures, electronics maps, synthetic symbols and alpha-numeric data can be simultaneously displayed.

The basic system consists of two main units, the computer and display unit, and the operator's panel. A number of sensors can be added to the basic system configuration to increase their capabilities which have been pointed-out in chapter II. (see annex IV)

One of the most important sensors for the gathering of information in a maritime surveillance system is obviously the radar stations, either fixed or mobile. Radar stations, mainly used as a source of short term data, have been designed to operate in heavy clutter environments; They must be placed in strategic areas along the coast in a number which directly depends on coastal length. However, transmission of radar video requires costly wide-band communication links, installation of automatic plot and target extractor at the radar station which will reduce the amount of required communication capacity to a level enabling transmission on normal telephone lines or voice radio channels.

This device operates as a normal extractor but can be furnished with software for automatic initiation of target tracking.

Features of radar stations have been pointed out in chapter II.

Regarding communication links, in order to accomplish the requirement of the control and command centers systems, the communication must be flexible and reliable, which is guaranteed

by the use of standardized protocols and interfaces, and network structure which is easily configurable given the communication situation today. Since the system consists of seaborne and land-based, sub systems as well as both wire connections and radio connections can be used. The transmission network consist of the transmission of signals between radar sites and command centers. It may consist of radio links connecting both sites, airborne sensors and the command centers. Furthermore, the net can transmit video, radar plots, target information, control and speech signals as well as camera imageries from aircraft.

The following two types of channels may be used:

- Telephone channels for all narrow-band transmission
- Video channels for the broad-band raw radar information

The telephone channels used for data transmission must be equipped with necessary modems. On the other hand, high level data link control must be used in every point-to-point communication, which is an error detection performed by a special control device and cyclic redundancy check and error correction is performed by re-transmission. All line communications must be point-to-point connections using high level data link protocol.

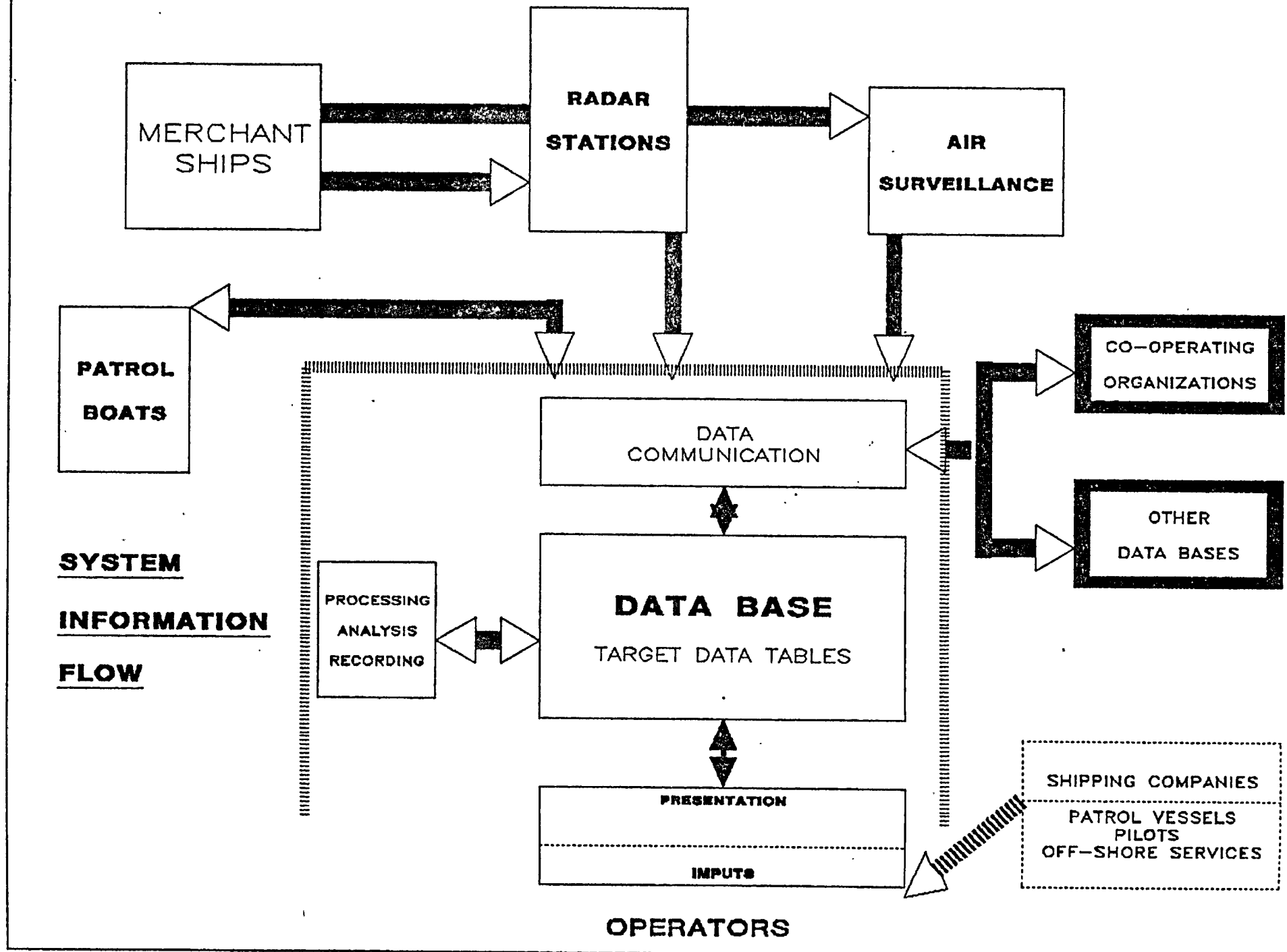
Considered line connections are connections between the command center and radar sites, and command center and other centers, the figures on the next pages propose a structure of a line communication net and a system information flow.

The radio communication network can be divided into two parts, radio networks using VHF and long distance point-to-point radio connection by using HF radio.

VHF communication is used for tactical data communications between ships operating together and the system command centers; the coverage of VHF net is limited by a circle with an approximately radius of 40 Km. To extend radio coverage, radio stations may be installed at the radar sites. On the other hand, HF communication can be used in long distance communications to connect ships, command centers and other centers; The range of a HF radio point-to-point connection is approximately 100 Km using the ground wave. In the same way for VHF, in order to extend the HF coverage, radio stations must be installed at the radar sites. Furthermore, radio equipment installed at the radar sites may be remotely controlled from the command center via radio links connecting the radar sites to the command center.

4.2.1.1 It is necessary to design a proper maritime surveillance system according to Peruvian coastal geographical conditions in order to evaluate its effectiveness and operation.

In the maritime surveillance field there are a number of alternatives to build up a proper system which can be used to control the entire maritime territory providing the appropriate means. However, every alternative presents di-



fferent characteristics, according to geographical conditions and requirements of the country.

First of all, the alternative of employing a surveillance system will be used, considering for such a case a number of sub-systems and sensors already mentioned, which will satisfy the Maritime Administration requirements, which have already been analyzed. In brief, the system must cover to a full extent the Peruvian maritime territory and provide communications links between data sources and the Coastguard command center enabling thus different types of transmissions.

It is clear that, before deciding about the number of radar stations to be laid down along the Peruvian coast, a search into coastal geographical characteristics to figure out the best places where they can be constructed has to be made.

As aforesaid, two places where radar antennas can be placed exist; the first one is on the water line or ashore, which means to search for geographical places where they can be laid down; the second option is to place radar towers in the middle of the detection zone, which means towers have to be built up as high as possible to get the maximum range. As we have seen

in chapter II, the range of radars depends, among other factors, mostly on the antenna height, i.e., the higher the antenna is, the more range and the lower the costs will be; Therefore, the best performance and the cost break-even point could be reached looking for the highest ridges nearest to the Peruvian coastal line.

The proposal for a Peruvian Maritime Surveillance System is to include equipment for a fixed Coastguard radar system which enables surveillance of the sea traffic and other activities around its maritime territory.

On the other hand, it is also intended to include the necessary airborne sensors, equipment and services to build up the coastguard center. As regards to the former situation, the author is going to consider one Coastguard center which must be located in the Coast Guard Headquarters, which means, in Callao Port; Therefore, information from a number of regional centers, fixed and unmanned radar stations as well as airborne and shipborne sensors shall be transmitted to the Coastguard command center where the surveillance task must be performed. In this sense, the following operational functions have to be provided in the Coastguard center:

- Target detection and plotting
- Identification and direction finding

- Radio and telephone communications
- Remote control of radars

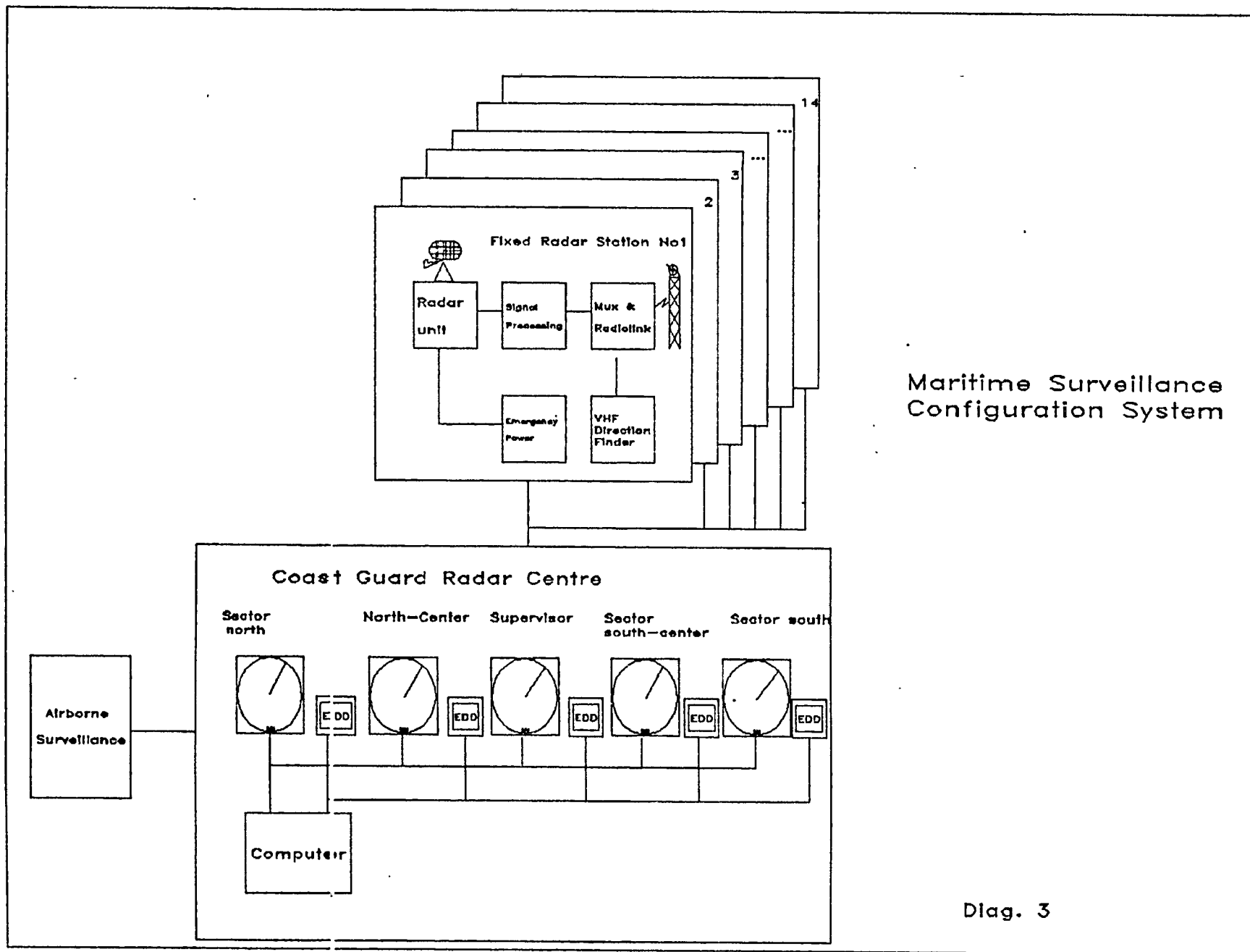
At the same time, a number of computer assisted functions shall be performed:

- Automatic tracking
- Recording and replaying of tracks
- Target data collection and display
- Airborne surveillance system camera equipment included. (an overview of the proposed system is shown in Diag.3).

Regarding target detection and plotting, fixed radar stations must be established along the Peruvian coast in a necessary number to cover the whole maritime littoral. It is obvious that they will scan the coast out to a maximum range, which is limited by the radar horizon.

In each station, the radar information will be processed in a plot extractor which will automatically detect targets, then for each target a report message is produced; This defines the range and azimuth of the target. The message will then be transmitted via modem over a telephone channel to the Coastguard command center where the positions of targets will be indicated with symbols on PPI's.

After analyzing Peruvian geographical



Maritime Surveillance Configuration System

Diag. 3

conditions and documentation related to this subject, a number of high ridges exist where fixed radar stations can be placed. A selection of radar sites is presented in the following table, considering however that other places could be selected throughout additional research in case of implementation of the system.

According to coastal length to give full coverage along the coastal line, 14 fixed radar stations would be necessary, considering both antenna height and radar range.

The table below is intended to show the possible radar sites and ridge height where they may be located.

TABLE 1

<u>RADAR SITES</u>	<u>AREA/ZONE</u>	<u>M. DISTRICT</u>	<u>HEIGHT (mt)</u>
La Garita	North	11	235
Tunal	North	11	480
Silla de Paita	North	11	385
Illescas	North	11	500
Chiclayo	North	12	1334
Chicama	Center	12	343
Trujillo	Center	12	1123
Santa	Center	21	1144
Ancon	Center	22	1464
Pisco	Center	23	2636
Chala	South	23	1267
Ocona	South	31	680
Mollendo	South	31	1073
Caleta Sama	South	31	1133

The table below is intended to show the radar coverage considering both, antenna and target height.

$$R(Km) = 4.12 (\sqrt{H_t} + \sqrt{H_a})$$

TABLE 2

Ht (mt)		5	10	15	20
		Km	Km	Km	Km
Radar sites	Ha				
La Garita	235	72.37	76.19	79.12	81.58
Tunal	480	99.48	103.29	106.22	108.69
Silla de Paita	385	90.05	93.87	96.80	99.27
Illescas	500	101.34	105.15	108.08	110.55
Chiclayo	1334	159.69	163.51	166.44	168.90
Chicama	343	85.52	89.33	92.26	94.73
Trujillo	1123	147.28	151.09	154.02	156.49
Santa	1144	148.56	152.38	155.31	157.78
Ancon	1464	166.85	170.67	173.60	176.07
Fisco	2636	220.74	224.56	227.47	229.65
Chala	1267	155.86	159.68	162.61	165.08
Ocona	680	116.65	120.47	123.39	125.86
Mollendo	1073	144.17	147.99	150.91	153.38
Caleta Sama	1133	147.89	151.71	154.64	157.10

Source: (Table 1)

Charts from "Instituto Geografico del Peru"
Report from "FFV Telub AB"

Due to the large area which has to be supervised, it must be divided into four smaller sub areas; north, north center, south center and south, located in places where radio communications facilities exist. Those places could be Paita, Iquitos, Mollendo, Callao Where naval radio communications centers are well established.

On the other hand, to coordinate the work and assist in certain situations there is a need for a supervisor must have access to one PPI. Therefore the Coastguard center must have five positions for operators. On each PPI it will be possible to have information from several radar stations simultaneously displayed. This will improve the possibilities of target detection thanks to the overlapping coverage zones of the proposed fixed radar stations.

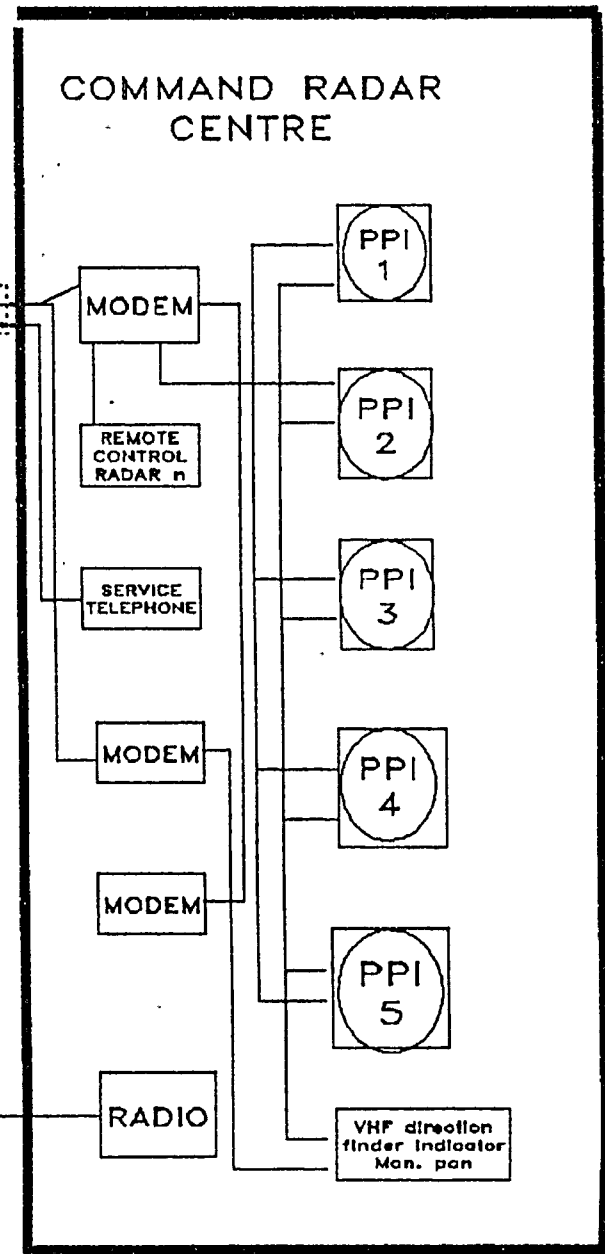
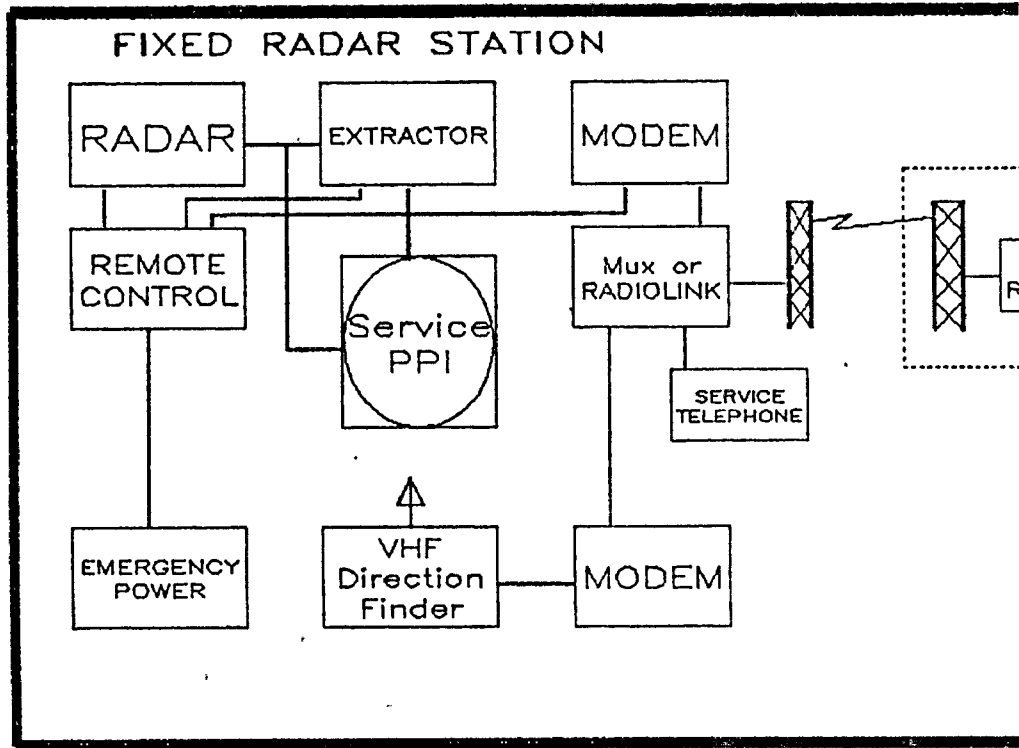
VHF Direction Finder (DF) must be used as an aid when identifying radar echoes in order to get the same coverage for a radar and associate DF, it is proposed to place one DF at each radar station. DF can be remotely controlled by the operators from the Coast Guard center.

Communications links can be made by different systems as before mentioned in point 4.2.1

(See equipment configuration **Diag.4**)

The coast radar center, as aforesaid, must be provided with a number of equipment in order to perform several computer assisted functions. Detection and tracking of targets shall be done in the Coastguard center when radar information from the fixed radar station is displayed on the respective PPI's. Then the plotting and tracking of targets will be done automatically.

Each target will be identified on Coast Guard center PPI with a track number then, all data concerning this track will be displayed on separate electronic data



MARITIME SURVEILLANCE SYSTEM
EQUIPMENT CONFIGURATION

Diag. 4

10
64

display (EDD). Each row in this display corresponds to a certain track, which shows the data stored in the computer memory concerning that track. The data could either be calculated values from the computer such as speed, positions or, data which have been fed into the computer by the operator, such as name of vessel, country, type, destination, etc.

Regarding the airborne surveillance system, it must be included in the whole maritime surveillance system in order to cover areas which are not within radar range. A number of sensors which were described in chapter two must be provided to existing craft to increase their surveillance capabilities and operational functions.

The coverage of SLAR is up to 80 NM on each side of the aircraft when using a slotted waveguided antenna.

Together with the fixed radar covering a distance of 40 to 60 NM, the total coverage will be 200 NM.

The proposal for a Peruvian maritime surveillance system is shown in Fig. 1-6, 1-7, 1-8.

4.2.1.2. It is necessary to determine the employment effectiveness of a maritime sensors-based surveillance system to solve the Peruvian maritime surveillance requirement in order to meet judgment elements which make it possible to take a decisions on such alternative.

Surveillance systems as we have seen are conformed by a number of sensors and data transmission systems which are able to detect targets anywhere at sea even in

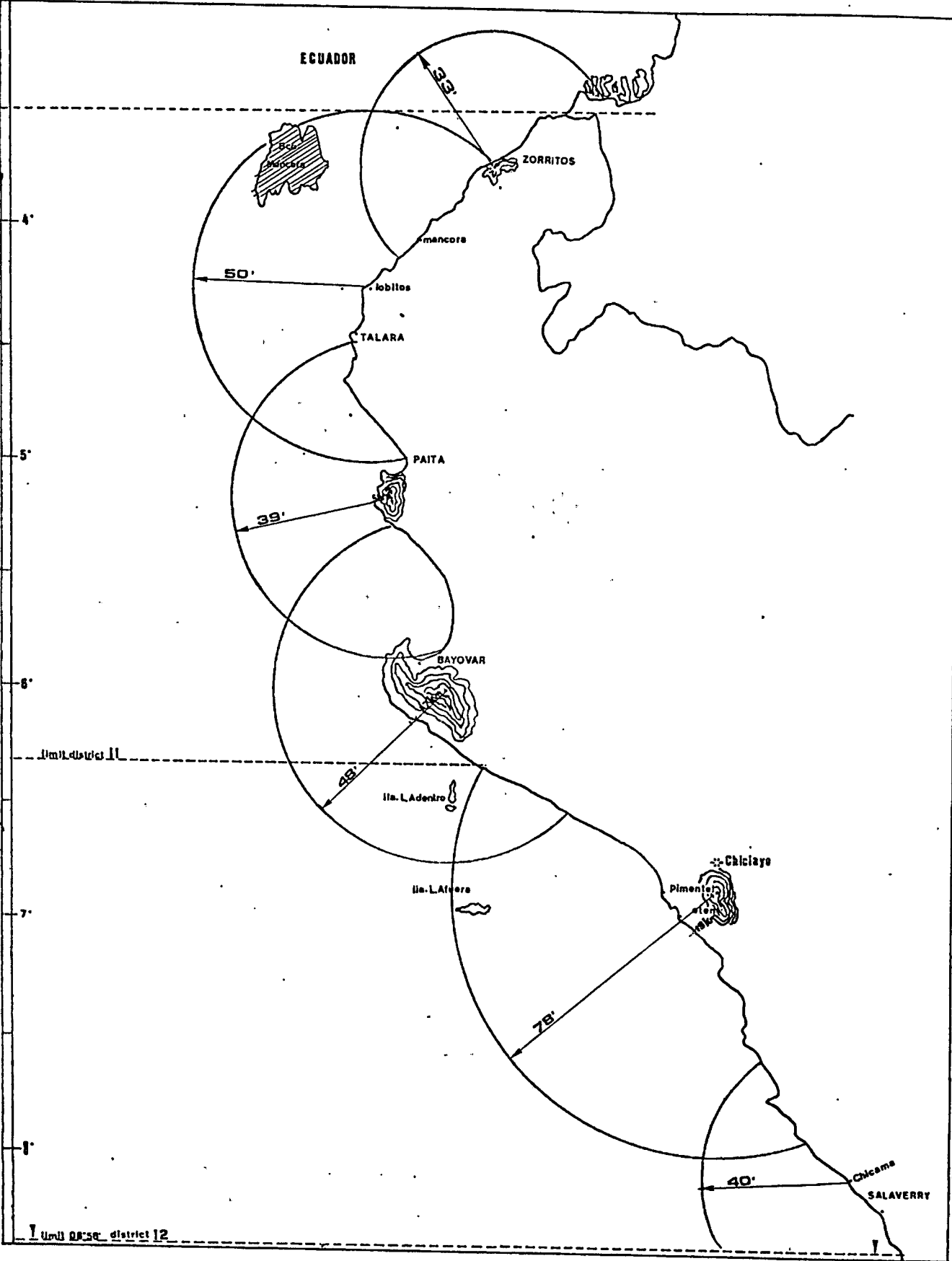


Fig. 1-6

CENTRAL ZONE

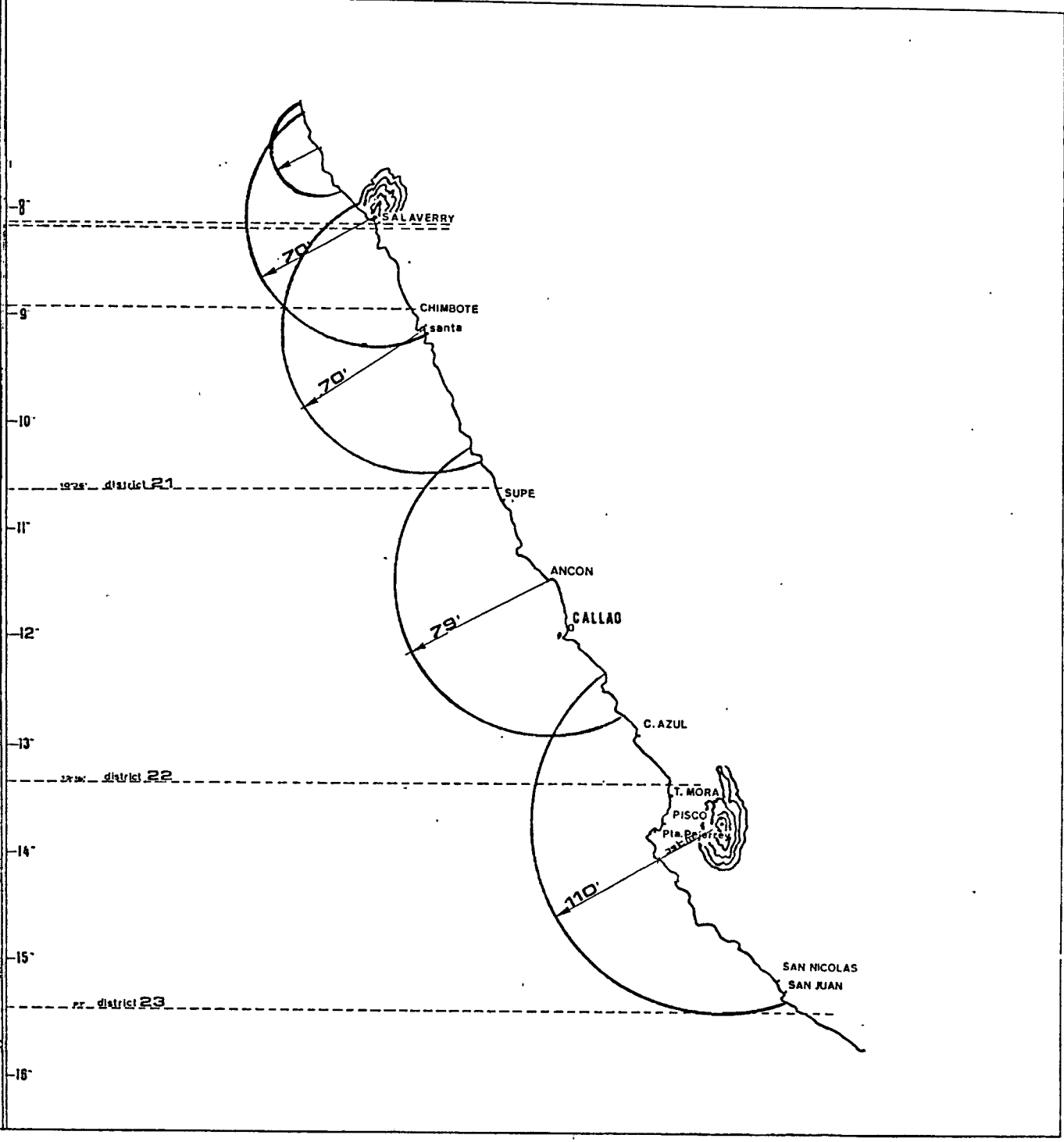


Fig. 1-7

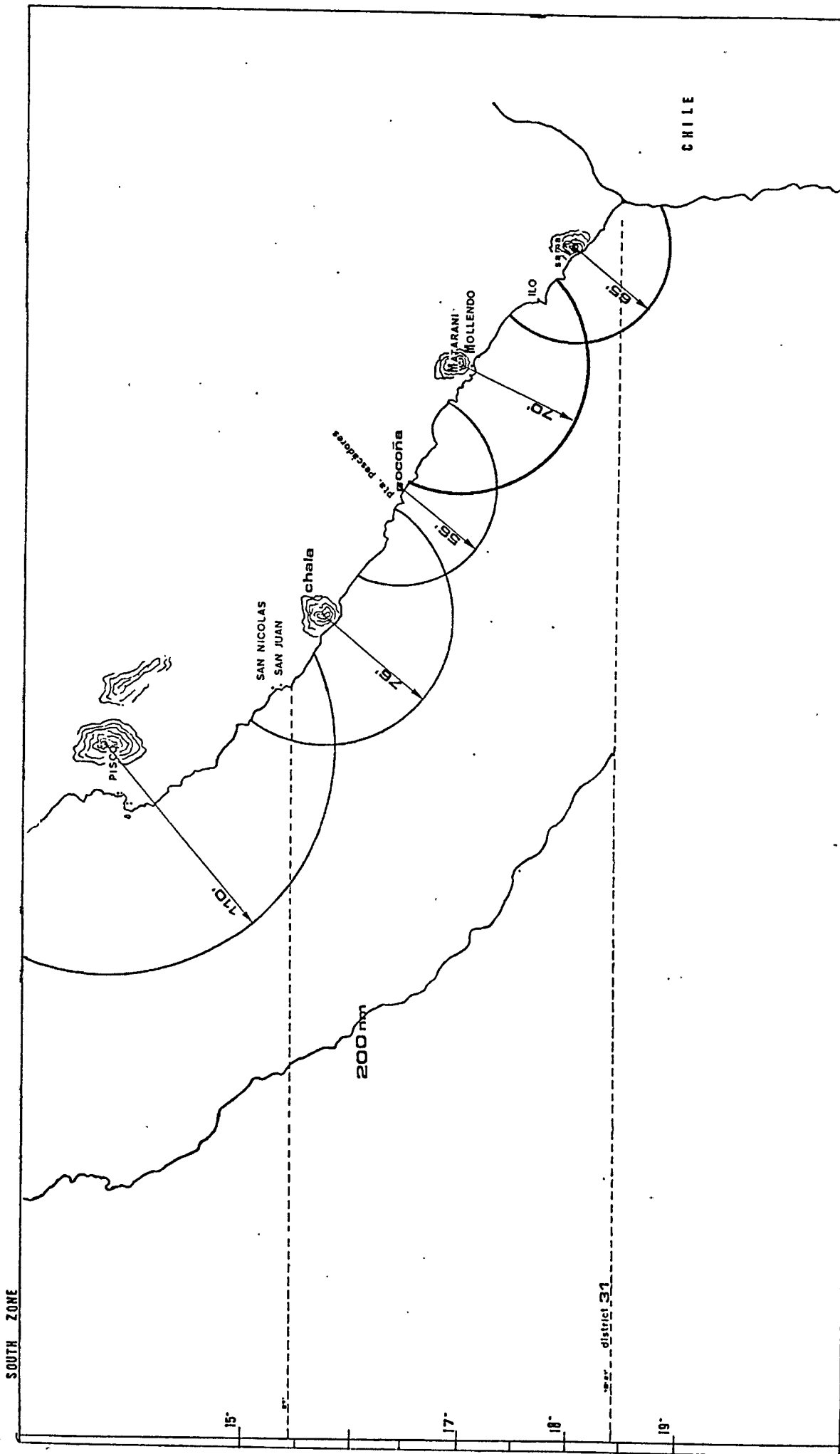


Fig. 1-8

hard environments and transmit, through different means, imageries, voices, data and any other signs commonly transmitted by microwaves links. As in chapter II, land-based radars can work 24 hours round the clock irrespective of weather conditions transmitting information from radar PPI's to a data processing center where it is processed, tracked and stored.

Furthermore, airborne and shipborne sensors covering areas which are not within radars range, perform a number of functions, whereby data can easily be transferred to a processing center.

The employment of a surveillance system allows for the utilization of different planning and control schemes, giving the reliability to cover the maritime interest areas.

This type of system entirely, satisfy as any other system the requirement for maritime area coverage and data transmission, the later having, high speed at great distances which give to maritime authorities reliability and flexibility on information in addition to, a computerized system assisting them when taking decisions.

Regarding Peruvian maritime surveillance requirements, taking into account the above considerations, it is possible to say that most of the interest areas will be covered by the system. Of course, a number of considerations have to be taken, as regards to equipment acquisitions, especially in communications network and radio communication equipment to be used. As far as the north zone, as well as the center and south zone are concerned, fishing areas near the coastal line, oil extraction fields, beaches exposed to smuggling activities especially in areas close to the borders, tanker routes as well as other traffic routes within 40 to 60 NM far from the coast and other activities carried out within this scope will be covered by the land-based radar network.

Considering ports will be included into the system, national and commercial functions must be carried out through the system, specially in those main ports with a high density of traffic.

On the other hand, zones more than 40 NM from the coast up to 200 NM will be covered by surveillance aircraft carrying on board

specialized sensors either to detect any target performing illegal activities within the above mentioned areas or identify and track any vessel crossing jurisdictional waters irrespective of their purposes.

This type of surveillance system adapts itself very well to Peruvian maritime surveillance necessities, mainly to detect targets anywhere at sea and transmit all kind of data from aircraft to ground, and ship and shore-based sensors to Coast Guard Headquarters as well as among surveillance units.

In Fig.1-9 is shown drafts on the areas and maritime activities to be covered by a highly sophisticated maritime surveillance system using land-based radar stations, airborne and shipborne sensors to detect targets and disclose illegal activities anywhere at sea, as well as the employment of a reliable and speedy data transmission network.

4.2.1.3 Pre-conclusion.

During the development of the present objective it has been decided, the alternative of employing maritime surveillance system Sensors and Communications links to satisfy the Peruvian Maritime requirements as regards to maritime surveillance function, broadly complying with such requirements taking into account the whole coverage of the maritime territory.

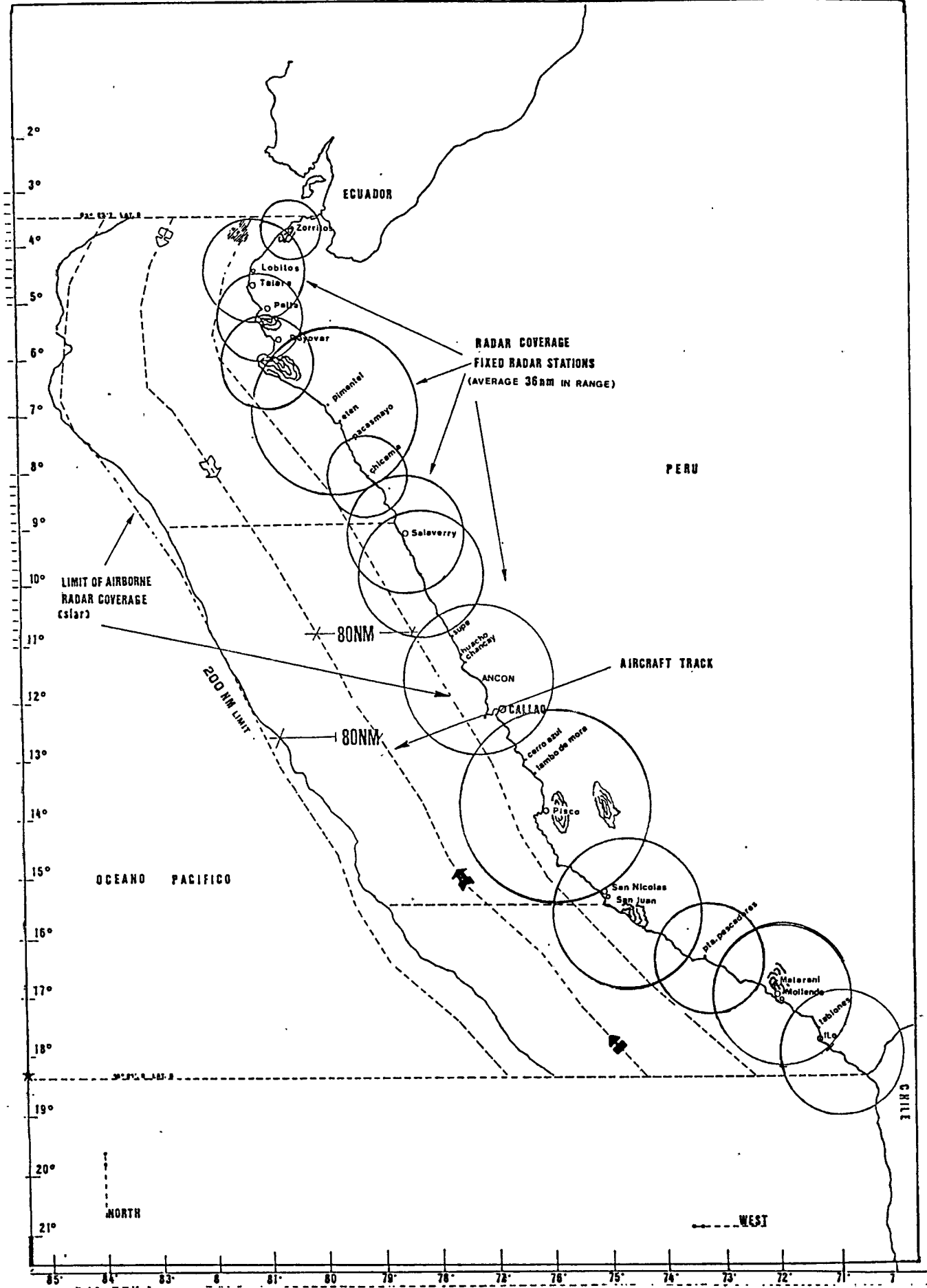


Fig. 1-9

4.2.2. It is vital to analyze the economical aspects for the acquisition and operation alternative of a sensors-based maritime surveillance system, in order to have judgement elements which allows for a decision on such alternative to be taken.

Maritime surveillance constitutes one of the most important Maritime Administration functions to secure of national maritime interest., At the same time, it is a basic structure for economic and social unfolding of countries. However, a number of factors make it difficult to establish a maritime surveillance system in Peru using modern and sophisticated methods to cover most of the maritime areas in which activities occur, as well as disclose potential infringements, transfer all type of data and its processing.

During the last few years, the control of maritime activities in Peruvian jurisdictional waters has mainly been affected by the difficulty to face new technological changes in shipping and fishing, and consequently the increasing of such activities as the Maritime Administration, not only has to overcome the geographical characteristics but also to employ new techniques to control them.

However, the installation of a new maritime system employing sophisticated equipment means great capital investments for the equipment acquisition and implementation of the system.

A major factor to be considered when implementing the maritime surveillance system is not only the technical performance of the system but also the costs of it. These costs are the actual acquisition and installation costs and the costs for operation and maintenance during its life time. Against the costs the benefits achieved from the system must be balanced, i.e, the benefits in some cases can be calculated in material values which are represented by incomes directly depending on the system performance. On the other hand, in many other cases it is not possible to put a price on the benefits, because they are of immaterial value; these factors, of course, are not without economical consequences but they are almost impossible to calculate. However, they have to be considered as benefits during project evaluation because some times there is a tendency to overlook them. The alternative of implementing a maritime surveillance system has great possibility for success if the system is well implemented, i.e, employing adequate technology and operating in such a way which allows for operational effectiveness and low operation costs. When a project is being planned the economical aspect, in most cases, is equal or more important than the other considerations regarding the feasibility of the project. This is well understandable particularly in our case due to lack of financial resources. In this respect, it is very important to decide on economic aspects of the project in order to take a decision.

4.2.2.1 It is vital to consider criteria, to analyse the economic aspects of the alternative to acquire and operate a sensors-based maritime surveillance system.

During the analysis of the economic aspects of a national maritime surveillance system, it is necessary to take into account the different services for which it is intended, as well as the investments involved. In this sense it is necessary to evaluate the acquisition and installation costs as well as operation during its life time. On the other hand, the benefits has to be analyzed against the costs, which means those benefits calculated in material value represented by incomes, and those of immaterial value which means costs without economical consequences.

The Peruvian Maritime surveillance requirements have been pointed out in chapter III; However, in the event of system implementation a technical-economic study at the highest level has to be made in order to evaluate the surveillance demand at a national level and investment costs taking into account a number of governmental and private organizations which could benefit as well the nation itself. Taking into consideration the established requirements in the aforesaid study, the acquisition and operation costs could be accurately fixed.

However, it is feasible to carry out the alternative analysis employing other criteria which in spite of being general criteria will allow for a general view of the economic characteristics of the project giving judgement elements in order to take a decision in this regard.

In order to carry out the economic analysis of the project, the author will analyse the investment characteristics. The first criterion to be considered the investment behavior from the point of view of magnitude in time. Another criterion will be the economic effort to be made taking, as before mentioned, into account not only the economic benefits but also those indirect consequences, considering for such a case the different national sectors contributing to the project.

From the economic point of view it is necessary to consider the time in which the system will be in operation, e.g, life time, as well as those costs for increasing the system performance.

Finally, considering the lack of economic resources, it is important to consider the alternative to implement the system by stages.

During the last few years, the maritime administration has been employing surveillance by conventional means, e.g, patrol vessels and radio communications links which actually, from the economic resources availability point of view, are feasible either to continue or make improvements in the same way which does not require significant investments.

In this sense, surveillance could be improved easier and quicker by introducing new equipment and few changes to the current system than by implementing a sophisticated sensors-based system. It is obvious that, initial investments and risks could be reduced. However, to tackle the problem in this sense is not the best alternative

because, taking into account the necessity to have the Peruvian waters under strict control.

There would be a number of disadvantages, since most skills performed by a sensor-based system, nowadays vital for controlling activities at sea, could not be used.

Furthermore, as the current system involves the highest operational costs, it is very important to consider that a conventional surveillance system has a great disadvantage in countries with scarce economic resources because the patrol vessels have to be spread in a number of geographical points to cover strategic areas where maritime activities are carried out. Therefore the system does not guarantee good performance in cases of economic limitations.

The alternative to implement a sensor-based system will allow to the maritime administration the freedom to fully define and optimize its own system, therefore costs would be minimized.

To implement a sensor-based surveillance system in Peru requires very high initial investments the acquisition of sophisticated electronic equipment, the building of a number of radar stations and other necessary civil works, as well as the implementation of a communication network.

In compensation to the initial investments, for the sensors-based system, as compared with the current system, are comparatively low because the minimum energy consumption, minimum operator's requirements as radar stations are unmanned, proximity of radar stations to towns make easy

access to them reducing thus, maintenance and reparation costs.

Taking as a reference already implemented systems, it is feasible to name some countries performing very well surveillance functions controlling most of the activities carried out in their jurisdictional waters; Sweden, through the Coastguard, the Navy and the Administration of Shipping and Navigation, is performing surveillance functions in the Baltic Sea covering a large number of activities on both sides of its national territory. The United States, through the Coastguard Corps is performing the same functions in the Pacific and Atlantic Ocean as well as in the Caribbean Sea, embracing large areas of sea waters and covering most of the activities carried out at sea, West Germany as well the United Kingdom use the same system developing very good performance in their waterways and ports.

The costs of a maritime surveillance system are spread in a number of items. e.g, equipment acquisition and installation, operation, infrastructure, wire connections, telephone lines, communications network, special devices etc.

The approximate value of the whole system is the following:

-The total costs for a mobile radar station is	1 MUSD
-costs for a complete fixed radar station installed in a container is..	1.2 MUSD
-costs for a complete fixed radar	

station with increased performance
 against air targets and electronic
 counter-counter measures is..... 2.8 MUSD
 -equipment for presentation of radar
 information in a regional center is..... 1.2 MUSD
 -costs for the command center.....15 MUSD
 -microwave link system for
 transmission of radar information both,
 extracted radar data and other technical
 data between vessels, radar sites and
 the command center (including all
 required civil works, masts, power
 supplies etc) is.....23 MUSD
 -costs for a Side Looking Airborne
 radar (SLAR) included installation..... 0.7 MUSD
 -costs for airborne POD system with
 cameras..... 0.5 MUSD

In all the above costs aircraft are not included,
 which could be used at the initial stage.
 However, the above figures include all related
 documentation, training of personnel, tests, ver-
 rification and trial evaluations, in addition to
 technical support during installation and
 operation, spare parts and related services.

Taking into consideration all the above figures,
 the total cost for the whole system would depend
 on many factors, for instance, economic resour-
 ces, initial system characteristics, radar
 station needed initially, how enhanced the
 command center needed is etc.

Taking into account the investment behavior

from the point of view of magnitude in time and the alternative to implement the system by stages, it is feasible to implement it step by step considering minimum requirements for the first stage in order to evaluate results after certain period of time.

However, a precise and detailed calculation of costs is impossible to obtain at this early stage. This is obvious due to many options available when defining the system and the different levels of ambition to be considered.

According to propositions made in the present investigation, it will either be necessary to install 14 fixed radar stations to cover the entire coastline of Peru, or perhaps it will be enough to have continuous surveillance of the most important areas. In other words radar stations should be placed along the Peruvian coast according to priorities. Intermittent airborne surveillance could be relied upon in areas outside radar coverage.

The exact costs of the necessary infrastructure at each radar site and of the coastguard radar center depend upon what is available today, what could be of use and what has to be built up from the start. These figures obviously have to be worked out before each step during the build-up stages.

Having a system built-up in stages, the appraisal of economic benefits, could be made

after a short period of the first phase evaluation in order to know the behavior of the system before the next step. In this case the initial investments and risks would be minimum.

However, due to the cost of the whole project has to be known from the beginning of the project study it is possible to present some figures for planning purposes, as well as the project could be divided into three phases:

Phase one, would be a system test and analysis phase which include one complete mobile radar station and involve short investments. The station could be manned by two operators and communications with the local command center could be made through a normal telephone connection or via radio, which also means low operational costs. The total cost of a mobile radar station together with the training of personnel and the actual work of performing the trials and analysis for this stage will be approximately one million USD.

Phase two, which is when the off-shore system could start to be implemented, includes a number of unmanned fixed radar stations. At this stage, not only the fixed radar stations could be built up according to priorities but also information would automatically be transmitted to the coastguard center from where certain remote control could be initiated.

The cost of a complete fixed radar station installed in a container is 1.2 MUSD.

In the event of a radar with increased

performance against airborne targets and electronic counter-counter measures incorporated the costs will be approximately 2.8 MUSD ; The equipment for presentation of a radar information in a regional centre is 1.2 MUSD

The investment in phase two will be greater than in phase one. However to start this phase would depend on to the performance and benefits reached in phase one.

Phase three, which could be called the final implementation phase, includes a number of pieces of equipment to increase the system performance, for instance, the SLAR system, the IR/UV scanner system, polaroid cameras, shipborne equipment as well as necessary equipment and services for upgrading to coastguard centre with centralized computer-assisted functions.

The costs in this stage considering both, computerizing the central Coast Guard Centre for enhanced tracking of targets and replay facilities, and equipment for air surveillance will approximately 1.7 MUSD.

Therefore the approximately cost of the entire project considering for this purpose 14 fixed radar stations will be 38 to 52 MUSD.

In addition to this costs, the costs for a microwave link system has to be considered, it is roughly 23 MUSD.

The mobile radar station approach in phase one, is essential to work out the operational procedures and to verify the expected system

performance before entering into a substantial investment program that phase two and three would imply.

It is important to remark, regarding communications links, that investments in communication networks along the Peruvian coast have already been made by the Coastguard Organization.

It can also be stated, that the Peruvian Navy has a very well organized communications system within the entire Peruvian territory, therefore it could be used as an advantage reducing initial investment costs.

On the other hand, from the capabilities of a sensors-based system analysis it is feasible to appraise the system involving national and commercial interests, e.g, protection of territorial waters and economics zones, prevention of illegal fishing as well as illegal transport, coordination and rescue operations, prevention of environmental damages, navigation assistance, traffic separation, harbor traffic control, planning of piloting as well as control of naval operations etc. In this sense the author would like to point out, not only the Coast Guard Organization would benefit from the extensive surveillance system but also other organizations and authorities would directly or indirectly benefit from it. So it is feasible, to a certain extent, that they may be called upon to integrate economic efforts in order to find resources to make the project possible.

The alternative to implement a sensors-based will allow to the maritime administration the

freedom in defining and optimizing in major grade its own system, therefore minimize costs of operation.

The fact to implement a sensor-based surveillance system in Peru requires a very high initial investment because it include the acquisition of sophisticated electronic equipment, the building of a number of radar stations and other necessary civil works, as well as implementation of communication network among other.

In compensation by the initial investment, as aforesaid, the sensors-based system operational costs against the current system are comparatively low because the minimum energy consumption, minimum operator's requirement considering that radar stations are unmanned, proximity of radar stations to towns make easy access to them reducing thus, maintenance and reparation costs.

On the other hand, due to the multi sector nature, the project would allow then to obtain requirements from those sectors at such a level of demand in order to justify the investment.

As the economic benefits of the project are given by a number of incomes coming from the system performance, in order to determine the exact economical value of the benefits gained from the sensors-based surveillance system, an elaborated investigation which is outside the scope of this feasibility study must be done.

However, some facts are available and can be used as a basis for the prediction of possible gains. The main sources of revenue could be considered in the following:

- (i) fines for illegal fishing
- (ii) fines for violations of maritime legislation
- (iii) fines for violation of contamination regulations
- (iv) fishing licences

The revenues coming from points i to ii will obviously be affected by an improved surveillance system based on sensors, because the possibilities to detect, track and identify offenders will be greatly enhanced already at the very early stage of the system implementation. It can be assumed that the possible technical improvements paired with an active enforcement will give good results.

On the other hand, the revenues from fishing licences are not directly dependant on the surveillance system, but could improve, if new methods of licensing were contemplated.

Finally, to the economic benefits must be added a number of immaterial value benefits, such as authority over national territorial waters and the EEZ, maintenance of law and order at sea rescue of lifes and vessels in distress and protection of the maritime environment in addition to the national safety and economy.

4.2.2.2 Pre conclusions

During the development of the present objective, the author has decided, that the alternative to implement a sensors-based surveillance system, from an economic point of view, represents very high initial investments whereby a total employment of the system is required in order to justify the investments. On the other hand, the great initial investments are largely compensated by its low operational costs and the low cost for increasing the system capabilities which could be justified with new benefits, which because of the long life of the system which would not decrease the performance during its life time.

The multi-sector characteristics will allow for a surveillance demand from the different stated sectors which will benefit from the system. In this sense, it would be feasible to meet economic efforts for the implementation of the system. A number of services could also be sold to private shipping related organization, whereby, some economic benefits may be obtained after implementing the system.

Finally, the system could be implemented in steps in order to verify the system performance before entering into substantial investments.

CONCLUSIONS

- 5.1 The Peruvian maritime surveillance system has a number of limitations to satisfy the requirements for covering the entire maritime territory, therefore the control of all the activities carried out at sea
- 5.2 It is necessary to find another alternative solution for the maritime surveillance requirements required by the Peruvian Administration not only to satisfy the necessity of giving full coverage to the Peruvian maritime territory but also to make a reliable and flexible system.
- 5.3 The objectives to be performed by a surveillance system, as well as the requirements requested by national organisms and international organizations, which have been pointed out in Chapter IV, are broadly satisfied by the alternative of implementing a sensor-based maritime surveillance system in Peru.

The areas to be covered by the system will depend on how many radar stations will be laid down along the Peruvian coast and air and shipborne sensors available to the system.

According to the proposed system, radar station will be able to cover areas nearby coastal, and an airborne radar system will work beyond the range of the coastal radar installations.

- 5.4 From an the economical point of view, the alternative to implement a sophisticated maritime surveillance system in Peru, refers to very high investments, by which it is required to maximize the employment of the system in order to justify the investment.
- 5.5 Due to a number of government and private sectors, which are involved in the maritime field, the alternative would allow them make an economic efforts in different sectors which could benefit from the system.
- 5.6 The feasibility to implement a highly costly surveillance system would not only correspond to the maritime administration level, but to government level, where not only the Ministry of Defense is involved, but also the public and private sectors.
- 5.7 The implementation of a sensor-based maritime surveillance system, as regards to national defense and safety, has been oriented for peace time application, and especially for maritime administration purposes, however the system can be upgraded

for military purposes by the addition of special devices to perform typically military functions.

5.8 The implementation of a sensor-based surveillance system will not only give total control of the jurisdictional waters but will also assist the maritime officers by using computerized system in making decisions.

RECOMMENDATIONS

- 6.1 It is necessary the Peruvian Maritime Administration through the Naval Ministry, to promote and support the implementation of a sensor-based maritime surveillance system along the Peruvian coast at the highest level of government.
- 6.2 The Maritime Administration should ask different system designers, and sensors and equipment producers for detailed information as regards characteristics, capabilities, system designs, costs, training of personnel maintenance, spare parts and payment for acquisition.
- 6.3 The project, on the implementation of a sensor-based surveillance system, has to be studied in depth by skilled persons in different fields, where the system involve might be used, i.e, professionals in economy, electronics, communications, computerized system informatics, and so on.

6.4 One alternative, as regards economic resources would be the system implementation by stages according to a designed plan and, would at the same time serve as an effectiveness test at an early phase of the implementation.

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ANNEX I

I.- THEORETICAL FRAME

1.1. GLOBAL PROBLEMATIC INTRODUCTION

1.1.1 Description of the problematic selected area

Many years ago, at the beginning of the past century, when human beings started to develop the shipping industry and consequently the seaborne trade, the maritime traffic has gone through the years, increasing to a large extent bringing, as a consequence, many problems which the coastal states have had to face.

Most of the problems which have arisen from the increasing maritime traffic through the different routes, have taken place since many international organizations issued regulations related to prevention of detriment, conservation and management of natural resources, whether living or not, prevention and control of marine pollution, and the safety of life at sea in behalf of the international community. Then, the coastal states have had to implement their national legislations in order to confront it.

Most countries which have adhered to the various international organizations and ratified their several conventions have not only developed or improved their own maritime administrations implementing its national legislations in order to enforce the provisions of such international

conventions on behalf of the international community, but also on behalf of their own people.

The Peruvian Maritime Administration, which is the responsible organization in charge of carrying out several tasks within the maritime field in order to protect the national interests at sea in their territorial waters and the Exclusive Economic Zone, must face one of its major tasks within the scope of their functions, which is the control of their national sea waters dealing with: safety of life at sea, maritime police, marine pollution, search and rescue, among others.

Therefore, the Peruvian Maritime Administration, through the Coast Guard Organization, has an important role within the strategy of the national economy, providing surveillance of their jurisdictional sea waters.

The Peruvian maritime territory has a litoral, of approximately 1200 nautical miles in length and 200 nautical miles in breadth, giving nearly a whole area of 240,000 square nautical miles (830,000 Km²). Many activities, such as fishing in shallow waters nearby the coastal line as well as in deep waters between 100 and 200 NM far away from land, oil exploitation on the continental shelf, and so on, are carried out in the aforesaid areas whereon, the Maritime Administration has to exert control and surveillance in order to prevent the infringement of national and international regulations and agreements, and illegal activities.

However, the Peruvian Maritime Administration has not yet developed a proper system to satisfactorily perform such functions in order to give surveillance

coverage of the most congested areas where maritime activities are developed, and to enforce such regulations and to prevent illegal activities.

Nowadays, the electronic field has, within communication and computing science, developed itself in such a way that, systems have been created for the purpose of performing surveillance functions, especially upon the areas wherein both, the distances and speed of communications are the main factors.

The surveillance system by electronical means, is a high-technology system which gives, whatever the operational requirements may be, a total control, not only on nearby areas to the coastal line, but also on the Exclusive Economic Zone up to 200 NM and more.

The aforesaid depends of course, on how sophisticated the system is, on the quantity of equipment, communication systems and data processing centers used in the system. The more sophisticated the system is, the more efficient the surveillance coverage range will be.

In the surveillance field, many types of equipment with different characteristics can be utilized.

Obviously, each piece of equipment could be operated independent of each other; however, the best performance is obtained when, all pieces or most of them work as a whole system, thus attaining a very well organized data source, communications network and a data processing center.

Actually, in a maritime surveillance system, it is feasible to use airborne, ship and shore-based sensors, which have been especially designed for

this purpose.

As regards airborne equipment, the Side Looking Airborne Radar could be mentioned (SLAR), which is a sensor especially designed for maritime surveillance, whose main applications are:

Surveillance of sea traffic, oil spill detection, fishery protection mainly in the high seas, and search and rescue operations.

The Infrared/Ultraviolet scanner system, is another piece of equipment used for the same end, which has the capability of detecting suspected oil discharges, surveys of accident sites and monitoring of pollution in ships wakes. Other piece of equipment can be added to the above mentioned sensors to increase their capability of storing and recording information in order to provide good evidence on what is going on in the area in question.

Regarding the ship and shore based equipment, in many situations an aircraft will co-operate and interact with surface units and land-based command centers, therefore all sensor systems in the aircraft must be interfaced to a microwave link on which, all types of imagery and information can be transferred to the ground at high speed.

Among land-based equipment can be mentioned the radar stations set out at different geographical points along the coastal line. However, they do have a limited range of coverage, which could depend on the radar characteristics, scanner height and the weather conditions in the operation area.

The land-based radar stations are mainly used for:

safeguarding the integrity in both, territorial and Exclusive Economic Zone waters, suppression of undesirable activities, maintenance of safe and efficient flow of shipping especially those associated with ports and crowded roadsteads. Data processing Centers must be implemented in order to receive and process the information coming from different sources.

Considering both, land-based radar stations and shipborne and airborne sensors as components of a surveillance system, a number of alternatives to build up such a system could be considered.

One of those alternatives could be: increasing the number of patrol vessels, and providing specially designed equipment for carrying out the surveillance functions. This alternative could be developed in arrangement with exploration aircraft.

On the other hand, the increase in air surveillance capability makes a joint effort with the patrol vessels available which gives another alternative.

As a results this would have a great advantage giving a larger range of coverage.

As regards the implementation of land-based radar stations interacting with both, surface and air surveillance units, they could be consider as a third alternative where the three maritime surveillance components would be used in the system. All the above mentioned possibilities to implement a maritime surveillance system have, to a certain extent, their advantages and disadvantages under the operational and economic point of view. However, the last alternative could represent the best solution for the surveillance requirements of the Peruvian Maritime Administration, because it

would cover the larger interest areas and would not be subject solely to one element of operation.

1.1.2 Interrelation of problems

Maritime surveillance constitutes one of the most important aspects within the scope of the Peruvian Maritime Administration because it include the major functions for which they are responsible.

Actually, such a maritime surveillance is carried out through both the Coast Guard Patrol Fleet and the Naval Air Force.

The former, is not only used for such a task, but also others that the Maritime Administration has to fulfill within the context of their functions. The latter has not the specialized sensors on board aircraft for such a task.

Taking into consideration several aspects in which the Peruvian surveillance is involved and the extent of the Peruvian maritime territory, the maritime surveillance to be set out in Peru has to fulfill certain objectives as regards to national and commercial interests:

- (i) Protection of territorial waters
- (ii) Protection of the EEZ
- (iii) Prevention of illegal activities
- (iv) Prevention of illegal transport
- (v) Co-ordination of rescue operations

- (vi) Prevention of environmental damages
- (vii) Navigation assistance
- (viii) Traffic separation
- (ix) Harbors traffic control
- (x) Planning of piloting.

The system must provide the capability to exert not only an effectiveness control upon merchant vessels allowed to sail into the Peruvian waters, but also take control upon them during their stay within Peruvian jurisdiction.

It must be capable of controlling that the foreign fishing vessels which are performing fishing duties within jurisdictional waters have the duly authorized licence for such an activity.

Also the system must be able to detect the following:

- (a) All types of vessels in territorial waters without permission from national authorities
- (b) National and foreign fishing vessels carrying illegal activities into prohibited zones
- (c) National and foreign vessels carrying out not only smuggling activities, but also those which can affect national safety

The system must also be able to cover large areas in order to detect people and/or vessels in distress as well as oil spills and noxious substances in the marine environment.

The system must also include traffic surveillance centers and traffic control centers in order to:

- (a) track and identify vessels and other sea targets within the surveillance areas
- (b) expose and analyse risks and threats
- (c) co-ordinate and control warding-off operations and remedial actions
- (d) inform co-operating authorities and organizations

Traffic management must be able to

- (a) detect, track and identify vessels within of traffic
- (b) analyse collision risks and traffic conflicts
- (c) supply navigation assistance and traffic separation
- (d) inform co-operating authorities and organizations.

In order to fulfill the above mentioned requirements, a number of alternatives, previously named, may be considered, namely

- (i) Air surveillance, implementing the already existent proposed aircraft with specially designed sensors for such a task, and performance of conjoint operations with surface surveillance units.
- (ii) Surface surveillance, increasing in number the current coast guard patrol fleet
- (iii) Acquisition of land-based radar which could be set out along the Peruvian coast
- (iv) Establishment of a system employing both,

air and surface units, and land-based radar stations making a joint effort as a whole system interfaced to a processing data center, regional centers and command control center.

All above named alternatives have a high costs, however, taking into account the maritime surveillance requirements, as before mentioned, and obviously, the area to be covered, the three first alternatives would have certain limitations in order to efficiently perform a surveillance task.

The last alternative has not the same limitations. However, we must take into account that the short-term costs will be higher due to a mayor factor to be considered when implementing a maritime surveillance system which is not only the technical performance of the system, but also the costs of it. Those costs are the acquisition and installation costs but also the costs for operation and maintenance of the system during its life time.

The employment of a MARITIME SURVEILLANCE SYSTEM utilizing sensors along the Peruvian coast is going to represent an alternative which will permit the use of high-technology, and consequently the Peruvian Maritime Administration will be able to act as soon as required without a waste of time and useless human and economic efforts, giving quicker, more reliable and safer information upon almost all jurisdictional waters. However, the PERUVIAN MARITIME ADMINISTRATION has not yet made a conscientious study of the implementation and operation of a surveillance system taking into

consideration the operational and economical appraisal of the project.

1.1.3 The most significant aspect that the problem represents

An economic and operational appraisal has not yet been made which can be utilized in the formulation of an acquisition and operation project on a conjointly maritime surveillance system, utilizing both airborne and shipborne sensors, and land based radar stations interfaced to a data processing center, which will satisfy the necessity to exert control within the territorial waters and the Exclusive Economics Zone.

1.2 Problems which are giving origin to this investigation

The increase in shipping and fishing industries, and other various activities which are performed in the sea areas belonging to the Peruvian state, has brought as a consequence the necessity to improve the control of the Peruvian territorial waters and its adjacent Exclusive Economic Zone which is important not only to protect the vested interest, but also to conform with international regulations and agreements. The high costs of a high-technology surveillance

system is one of the major problems which the Peruvian Maritime Administration has faced and therefore, the lack of an economical and operational criterion is a barrier in order to decide the acquisition and put into operation, a sophisticated surveillance system.

However, nowadays in spite of the present turbulent situation, it could be feasible to get some financing not only from international development agencies or credit from suppliers, but also the project could be self financed in part on a long term basis.

For this purpose we must consider that the costs must be balanced against the benefits achieved by the system. The benefits may, in some cases, be calculated from incomes in the form of fines for illegal fishing, offenses against maritime law and so on. On the other hand, it is not possible to put a price on the benefits because many of them are of immaterial value.

Therefore it demands, due to the importance of the project for the Peruvian Maritime Administration and consequently for the Peruvian nation, the attention from organisms in charge of protecting the Peruvian maritime interests to adopt such a highly technological system employing electronical means to ensure the national interest at sea.

1.2.1 Reasons for the problem selection

- (i) If an operational and economic appraisal on a maritime surveillance system is not made, then it will not be

feasible for the Peruvian Maritime Organization to support the acquisition project and the operation of a high technology maritime surveillance system.

(ii) The responsible organism in charge of securing the national interests at sea must consider certain requirements of surveillance which can not be fully satisfied with the current system in operation; Therefore, without a study on the project appraisal it could not consider the solution by means of utilization of a surveillance system using sensors interfaced through communications network to a data processing center.

(iii) Unless a project appraisal is made, the Peruvian maritime Administration will not be able to define neither the economical requirements nor the benefits.

Therefore, it would not be feasible to participate in an acquisition and operation project planning of a maritime surveillance system which is sensors-based.

(iv) The use of a maritime surveillance system employing both airborne and shipborne sensors and, land-based radar stations interfaced to a data processing center will give an entire control of the coastal waters through data communications network based on

radio links and telephone lines feeding information from radar stations, patrol vessels, pilots, off-shore services and other sources, into the computer system. Then the information will be processed, stored and displayed so that the operators can initiate and maintain an automatic vessels tracking process. All the above mentioned (systems) (processes) would permit them to have an accurate picture of the current situation at sea and disclose potential risk situations or illegal activities.

1.2.2 Problem definition

The problem is that there is no evaluation of an operational effectiveness and economic criterion of the operation and acquisition of a maritime surveillance system employing interfaced sensors through communications network to a data processing center which allow, the corresponding organism, to take a decision.

1.2.3 The significance of the problem

- (a) Having a project appraisal would allow the corresponding organism to take a resolution as regards acquisition and operation of a highly sophisticated maritime surveillance system to be operated within Peruvian jurisdictional

waters.

- (b) Having a project appraisal, the Maritime Administration could consider the solution regarding surveillance requirements within Peruvian territorial waters and the Exclusive Economic Zone, by means of a highly sophisticated maritime surveillance system
- (c) The project appraisal of a highly sophisticated maritime surveillance system will permit the author, to go in detail into surveillance requirements of his country, gain knowledge of highly-sophisticated equipment specially, designed for such a task, availability of such equipment in the world market, be aware of costs and go into detail about the necessity and reality of a maritime surveillance system from the point of view of the Peruvian Maritime Administration.

1.2.4 Investigation Theme

CRITERIA DETERMINATION FOR IMPLEMENTATION
AND OPERATION OF A MARITIME SENSOR-BASED
SURVEILLANCE SYSTEM IN PERU

1.3 FINALITY

As far as the investigation is concerned, it consists of making a diagnosis of the current situation of the maritime surveillance system in Peru taking into

consideration the Maritime Administration requirements and evaluating solution alternatives, which means the employment of a maritime surveillance system using specialized sensors on board aircraft, ships and shore-based stations interfaced to a data processing center.

Such an evaluation must be made in order to determine the operational effectiveness and set economic criterion.

1.3.1 ENDS

1.3.1.1 End No 1

To diagnose the current status of the Peruvian maritime surveillance system regarding to the national requirements in order to determine the satisfaction level of such requirements against the actual using system.

1.3.1.2 End No 2

Evaluate the alternative to employ a sensors-based maritime system to satisfy the Peruvian maritime surveillance requirements, taking into account effectiveness and economic criterion in order to give judgement elements for the acquisition and operation of a maritime surveillance system.

1.3.2 OBJECTIVES

1.4.2.1 Identify the National requirements in respect of protection of Peruvian

maritime interests, in order to know the maritime surveillance needs to be satisfied by the Maritime Administration.

1.3.2.2 To effect an comparative analysis between the national maritime surveillance requirements and the equipping feasibility in order to determine the current satisfaction level of such requirements.

1.3.2.3 Analyze the effectiveness of employing a sensors-based surveillance system to solve the Peruvian maritime surveillance requirements.

1.3.2.4 Analyze the economical aspects for the acquisition and operation alternative of a sensors-based maritime surveillance system, in order to have judgment elements which allows for a decisions on such alternative to be taken.

1.3.3 GOALS

1.3.3.1 Analyze the maritime administrative requirements directly connected with management and control of such activities carried through the jurisdictional sea waters in order to identify the surveillance functions to

be performed.

1.3.3.2 Analyze each maritime function taking into account the set out requirements in order to determine global surveillance needs.

1.3.3.3 Comparison of the surveillance requirements according to the current equipment the Maritime Administration has, in order to determine the present satisfaction level of such requirements.

1.3.3.4 Design a proper maritime surveillance system according to Peruvian coastal geographical conditions in order to evaluate its effectiveness and operation.

1.3.3.5 Determine the employment effectiveness of a sensors-based maritime surveillance system to solve the Peruvian maritime surveillance requirements in order to meet judgement elements which makes it possible to take a decisions on such alternative.

1.3.3.6 It is vital to consider criteria, to analyse the economic aspects of the alternative to acquire and operate a sensors-based maritime surveillance system.

ANNEX II

AIRBORNE SENSORS TECHNICAL CHARACTERISTICS

Side Looking Airborne Radar (SLAR)

- Antenna : 3 meters slotted wave-guided
vertical polarization
- Frequency : x - band 9.4 GHz
- Peak power : 10 kw.
- Ground resolution : 75 x 75 meters
- Displays ranges : 20-40-80 km. both sides
- Weight : 70 kgs.
- Power consumption : 28 VDC, 11 A

Infrared and Ultra Violet Scanner System (IR/UV)

- IR- Channel : 8-14 microns (thermal infrared)
- UV - Channel : 0.3- 0.4 microns
- Resolution : 5 milliradians or 2 meters
ground resolution at 1000 ft.
flying altitude
- Field of view : 80 degrees
- Weight : 58 kgm.
- Power consumption : 28 VDC, 12 A

SLAR and IR/UV display monitor adds 30 kg. and 28 VDC, 4A

Camera System

- Camera lens : 24 x 36 mm.
- Weight : 14 kgs.

- Power consumption : 28 DVC, 5 A
- Camera record : year, month, day and region,
hour, minute, second

latitude, degrees, minutes and
1/10 minutes and mission
longitude, degrees, minutes and
1/10 minutes

Quick look documentation System

One of the best advantages is that polaroid camera can be interfaced with IR/UV scanner system and polaroid photos create an easily and accessible file of events for each mission without delay of film processing.

Digital cassette recorder

- Data cassettes : DC-300 Type
- Capacity : 17 m byte/ cassette (memory)

ANNEX III

COMMAND AND REGIONAL CENTERS CHARACTERISTICS

Command and Regional centers consist of the following hardware blocks:

- a) Colour Displays Console
 - Colour PPI
 - Communication Panel
 - Text display unit
 - Operator Panel 1
 - Operator Panel 2
- b) Monochromatic Display Console
 - Monochromatic PPI
 - Communication Panel
 - Text display unit
 - Operator Panel 1
 - Operator Panel 2
 - Radar Remote control Panel
 - Site supervision panel
- c) Logging Printers
- d) Computer and Interface cabinets
- e) Text Terminals

The radio control panel provides access to radio traffic on 15 radio stations/channels and the telephone control panel gives access to communication on fixed lines or the public network. Cassette recorder is available for maintaining a record of radio and telephone traffic together with time-clock information.

Data base system can display information between 100

and 200 vessels, depending on specific features equipment.

(see attached figures) console, display etc.

- PPI, is a vectorial graphic display, which could be either a 16" diameter, monochrome, long persistence or a 24" diameter, multicolor, short persistence cathode ray tube.
- An alpha-numeric display terminal with a keyboard
- Depending of the PPI-type, coastlines are shown together with a reference grid and targets can be tracked with symbols of various shapes
- Specifics technical equipment features differ depending of the builder, however they are almost the same.

PROCESSING AND STORAGE

Target tracking, per centre

- Radar inputs : max. 6
- Number of targets : normally 100
- Data stored per target : max. 160 characteres
- Plots from each radar : max. 120/s. (time)
- Method of initiation : automatic-semi automatic o normal

Track storage

- Storage time : minimum 24 hs.
- Interval : every 6 minutes
- Play-back speed : 30 or 300 times faster than real time.

Input devices

- Rolling ball

- Push buttons
- Software controlled function keys
- Alpha-numeric keyboard.

Computer-Generated reference information.

Maps

Total No. of segments

stored : max. 2000
 displayed : max. 500

Total area stored : max. 2048 x 2048 km².

Resolution : approx. 30 m.

Additional

Text for maps : max. 600 characteres
 Territorial limits, economic zones, waterways etc. : total approx. 600 segments and points stored
 200 displayed at one time

Presentation

Vector graphics display, PPI

- Diameter : 16", option 23" colour
- Scales : 1: 100,000, radius aprox 16 km.
 1: 200,000, radius aprox.32 km.
 1: 500,000, radius aprox.80 km.
 1: 1'000,000, radius aprox.160 km.
- Symbols : Standard configuration
- Target tables : 4 alpha numeric characteres

- Time, real or play : month, date, hour, minutes
back
- Time prediction : hours minute

Alpha-numeric display terminal

- Display size : 12" diagonal
- Text capacity : 20 lines /- char/line

Colour graphics display subsystem

- Screen size : 20" diagonal
- Type : Raster Scan
- Resolution : 512 x 640 pixels
- No. of colours : 8

RADAR

Antenna

- Frequency range : 8.5-9.6 GHz
- Aperture : 4.5 x 0.5 m²
- Beam width, hor. : 0.6
- Beam width, vert. : 4
- Gain : 40 dB
- Side lobe ratio : 28 dB
- Rotation rate : 40/20 or 26/13 rpm
- Polarization : horizontal

T/R (transmission/ receiver unit)

- Frequency : 8.5 - 9.6 GHz
- Agile bandwidth : 450 MHz
- Peak power : 200 kw.
- Noise figure : 10.5 dB

Radar Extractor

Plot extractor

- Resolution : 1024 range bins
- Number of sub areas : 128, max.
- Plot extraction capacity : 100 per sec.

Target extractor

- Stationary tracks : 72
- Auto-initracted tracks : 36

ANNEX IV

AIRBORNE SENSORS SYSTEM CHARACTERISTICS

1. Standard functions

1.1. Display functions

- Split screen display
- Raw radar video
- True motion
- North/stem oriented
- Bearing compensation of two-axis radar for pitch and
- Off-centering
- Scaling
- Bearing scale
- Heading marker
- Range ring
- Synthetic symbols and vectors
- Electronic map
- Alpha-numeric tables
 - .Run craft, marker and vector data
 - .Navigation data
 - .Target data
 - .Data entry field.

1.2 Operational functions

- Manual tracking of up to 16 targets
- Target data calculation based on latest two consecutive measurements and dead reckoning
- Electronic map navigation with own position update

- Average : 3.0 us
- Line patterns : 8 types
- Line and matching : "Perfect". over/back
step function

4.2. Symbol and character generation

- Symbol and character, Fixed: 200
Programmable: 200
- writing directions : 4
- symbol/character sizes : 7 (2.7, 4, 5.3, 6.7, 8.1
9.4, 10.8 mm)
- circles and arcs : yes
- time to draw-small symbols : 1.0 us
-small charact. : 1.8 us.

4.3 Radar Presentation

- Presentation of one radar
picture
- Range : 1-512 km.
- Off centering : 0.512 km.
- Calibration rings : yes
- Drawing time - radius : 50 us.

4.4. Display

- Deflection band with : 3 MHZ
- Video band with : 20 MHZ
- Line with : . 35 mm.
- Refresh rate,
alphanumeric area : 50 HZ
graphic area : 20 HZ
- Intensity levels
(programmable) : 8

- using radar pictures references (map correction)
- Target data transmission (selected targets or full target data table).

2. Operation

Main tasks of operator are:

- Radar control and operation (mode selection, range selection, search sector definition)
- Target detection and evaluation
- Target tracking (manual initialization and tracking)
- Target position determination (absolute and /or relative coordinates)
- Target
- Navigation support

3. Interfaces

- Radar video, sync, antenna bearing and logical signals.
- Compass (synchro)
- Doppler radar and /or airspeed indicator
- Data link
- Power supply.

4. Performance Data

4.1 Vector generation

- Addressable points : 4064 x 4064
- Average drawing time across screen : 25 us or 100 hs.
- Positioning time across screen : 6.5 us

- Blinking frequencies : 3 (.6,1.2,2.4 HZ)
- Phosphor, alphanumeric area : green "medium persistence"
- graphic area : green "very long persistence"

4.5. Typical "overall" performance

Together with the raw radar video the following synthetic information can be presented simultaneously:

1. In the graphic area
 - * appr. 1000 medium size vectors (Electronic map)
 - * 200 300 symbols (plots, markers, target symbols etc.)
2. In the alpha numeric area
 - * normal messages /tables containing 200- 300 characters

If conflict of capacity arise, then the electronic map will be " truncated " in the peripheral areas

3. Installation

Some of the outstanding features of the systems and low weight, low volume and low power consumption all cabin equipment fits into 19 inch standards to facilitate installation design.

The structural modifications in the airframe are kept to a minimum. Two small apertures for SLAR - wave guides, one hole for the vertical camera, one opening for the IR/UV scanner with the same standards size as for conventional

and two mounts for the SLAR antenna an required.
Total weight of SLAR, IR/UV, Cameras, Display
monitor, Data Storage unit and racks is
approximately 235 kgs. with a total power
consumption of 1000 w.
Installation time : around 4 weeks.