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A Functional Analysis of the Naval Weather Service System

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THESIS

A FUNCTIONAL ANALYSIS OF THE NAVAL WEATHER SERVICE SYSTEM

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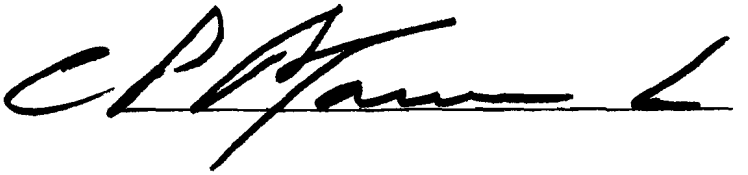
The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.



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Abstract of

A FUNCTIONAL ANALYSIS OF THE NAVAL WEATHER SERVICE SYSTEM

The Naval Weather Service Command (NAVWEASERVCOM) is a decentralized, task-oriented military hierarchy. The Naval Weather Service provides world-wide marine environmental prediction services to U.S. and NATO forces and incidentally to some civil interests. The Naval Weather Service system is very nearly unique in that it spans the scientific disciplines of meteorology and oceanography.

Several functions are common and basic to the operation of any environmental prediction service, military or civilian. An understanding of these functions is necessary for the proper operation of an environmental prediction service and facilitates the appreciation of, and utilization of the service on the part of the user. They may be categorized as operational or support:

Operational Functions	Support Functions
data acquisition	equipment
data processing	training and fleet liaison
product formulation	R&D
dissemination to users	management above the functional level

Environmental data is acquired from the national and international environmental prediction community as well as from U.S. and Allied military sources. Data acquired from

other environmental prediction agencies is, in general, of high quality and is moved quickly to the Fleet Numerical Weather Central Monterey, California (FLENUMWEACEN). Data acquired from the fleet is, in general, received at regional Fleet Weather Centrals (FLEWEACEN). That data is edited, catalogued, and transmitted via the Naval Environmental Data Network (NEDN) to the Fleet Numerical Weather Central for product formulation. Most analyses and forecasts are computer produced on a hemispheric or regional basis at FLENUMWEACEN and are distributed, transmitted computer-to-computer via high speed data links, to the regional Fleet Weather Centrals which are engaged in immediate fleet support. At these FLEWEACEN products are updated with local information. Analyses, and forecasts are then disseminated to the operating forces by a variety of means, mostly the assets of the Naval Communications Command. All products and services are tailored to meet the needs of the individual fleet operator.

PREFACE

Purpose and Scope. The purpose of this paper is to analyze the Naval Weather Service system by defining its functions; for the available literature does not convey the concept of interacting elements contributing to the operation of the larger whole.* This paper concentrates on articulating the contributions of the related actions to the Naval Weather Service system. The aim is for clarity of exposition. The purpose is to get across the big picture. The introspective format ensues formally from the rational foundations of the conceptual mode of inquiry.[1]

This paper addresses the Naval Weather Service system and not the scientific and technological process of oceanographic environmental prediction, which is another matter.

A rather extensive treatment of the structure of the Naval Weather Service (NAVWEASERV) is presented here because it is apparent that there is considerable unfamiliarity with it, although it is generally known that the Navy environmental

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*The "Report of the Panel on Environmental Monitoring" of the Commission on Marine Science, Engineering and Resources and the material prepared at the Headquarters of the Naval Weather Service (NAVWEASERVHQ) for the Panel and for the Marine Council's Interagency Committee on Ocean Exploration and Environmental Services for the development of the Federal Planning Guide for Marine Environmental Predictions (MAREP) constitutes the bulk of the available writings. The Manual of the Naval Weather Service Command, NAVWEASERVCOMINST 5400.1 of 1 May 1969 is as yet incomplete.

prediction program comprises the greater part of federal spending in marine environmental prediction.*

The functions that are basic to the operation of the Naval Weather Service overlap. To preserve continuity of thought in their analysis it is necessary to repeat to some extent in some chapters what is discussed in another chapter. Every effort is made to limit redundancy to that essential to clarity.

It has been said that the systems approach is a frame of mind.[2] This analysis of the Naval Weather Service can be interpreted as stripping the nonessential details from a collection of interacting elements and functions so that the structure of the interactions is laid bare for study.[3]

In order that this analysis be useful it is necessary that it allow for the more careful examination of the subject (and consequently that its problems might be attacked more intelligently). Hopefully the treatment accorded the Naval Weather Service system herein provides for the conveyance of the concept of the total system, its functions and

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*The Navy marine meteorological program in FY's 70 and 71 constituted about 90% of the total. No other agency has a comparable oceanographic environmental prediction program. The Federal Coordinator for Meteorological Services and Supporting Research, The Federal Plan for Meteorological Services and Supporting Research, Fiscal Year 1971 (Washington: U.S. Gov't. Print. Off., 1970), p. 27.

components and their interrelationships. If the method of study selected is worthy, each function will be defined clearly, it's contribution to the whole will be apparent, and components, inputs and outputs will be made visable.

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CHAPTER I

INTRODUCTION

Background. The concept of a functional weather service to meet Navy requirements has historical beginnings and precedence in the U.S. Marine Meteorological Service maintained by the Navy until assigned to the U.S. Weather Bureau by Presidential Order in 1904, and in the Aerological Service which the Chief of Naval Operations in 1910 directed the Bureau of Navigation to establish and maintain. As military technologies advanced and became more complex, particularly during and subsequent to World War II, naval operations have become more sensitive to the natural environment in which they are conducted.[1]

The Nature of the Need. All users of the ocean have a need for meteorological and oceanographic observations and predictions. It would be difficult to identify any maritime activity not dependent on such services, or whose operations could not be made safer and more efficient if these services were improved. National defense, marine transportation, offshore oil, gas, and mineral industries, fisheries, waste management, the protection of life and property along the sea shore, recreation all have a vital stake in marine environmental prediction. The need for marine environmental observation and prediction systems, in fact

goes beyond maritime interests, since the oceans are a major determinant of weather.[2]

The nation's security has been fundamentally tied to the ability of the Navy to operate on, above, and under the sea.[3] This ability to operate is facilitated to a significant extent by accurate environmental depiction and forecasting. The oceanographic environmental prediction services of the Naval Weather Service Command are designed to provide the support required for the conduct of assigned national security missions throughout the marine environment. The aim is to enhance U.S. capability for strategic deterrance, antisubmarine warfare, amphibious operations, mine warfare, surveillance of the oceans, and protection of essential shipping.

Defense Environmental Support. In fulfilling its mission to insure the nation's peace and security the Department of Defense requires worldwide environmental support. The requirements of military user groups are varied. Environmental support usually must be tailored to the particular weapon system being developed or employed; unique forecasts and analyses are used by command and control systems; specialized information such as ballistic data is required by a field army; underwater acoustic forecasts are required in antisubmarine warfare (ASW); and general environmental support is required in training and deployment of forces, and in contingency operations.[4]

The Army provides meteorological services in support of chemical, nuclear, surveillance, target acquisition, artillery and missile operations. Other general military meteorological service requirements of the Department of Defense are provided by the Air Force and Navy. To provide this service the Department of Defense maintains analysis and forecasting facilities in the United States and overseas. The Air Force operates a Global Weather Center at Offut Air Force Base, Nebraska, and forecasting centers in Europe, the Pacific and the Far East. The Navy operates a Fleet Numerical Weather Central at Monterey, Calif. and Fleet Weather Centrals and Facilities in Europe, the Pacific and the Far East. Specialized centers - such as the Navy's Naval Weather Research Facility, and the Air Force's USAF Environmental Technical Applications Center, Washington, D.C. - also fulfill unique military requirements. Defense observing facilities are operated to obtain data in direct support of military operations, and military communications networks are maintained to collect and exchange observations and to disseminate forecasts.

Synoptic Oceanography. Traditional oceanography is characterized by: (1) conceiving of an oceanographic expedition - determining what is to be investigated, (2) carrying out the expedition - collecting the data, and (3) developing the product of the expedition - publishing a scientific

report. An expedition normally lasts many months. Data collected from vast ocean areas over a prolonged period of time is frequently puzzling.[5] The Naval Weather Service practices synoptic oceanography rather than traditional oceanography. The term synoptic is a derivative of the Greek syn - together + opsis - a sight, and quite accurately describes the type of environmental monitoring and prediction the Navy needs. In effect an instantaneous picture is taken of the atmosphere and ocean at preselected times in order to effectively interpret the forces at work on air and water masses and the boundaries between them.[6]

The Coupled Fluid Medium. The unity of environment is a matter of work-a-day concern to NAVWEASERV meteorologists and oceanographers (herein after referred to as environmentalists or professionals), and to NAVWEASERV technicians. In the Naval Weather Service, environmental services are integrated, therefore multidisciplinary approaches are employed to total environmental prediction. The Forecast Duty Officer at each Fleet Weather Central and Facility crosses the boundaries of the scientific disciplines of oceanography, meteorology several times in the course of each watch. Some of his products are meteorological (storm warnings), some are oceanographic (ASWEPS).

Oceanographic services comprise approximately half of the total effort of the Naval Weather Service Command, the remainder being primarily meteorological. The separation of these two disciplines within the Naval Weather Service system is extremely difficult and, in general, would be artificial and distorting. In the Navy, meteorological and oceanographic data are acquired together by the same personnel. Such data is collected, processed and relayed together and prediction products are computed jointly in the same machine, based on that data. Products are disseminated to the fleet, in large part, on the circuitry used to process the raw data. Then, finally, these products (analyses and forecasts) are interpreted jointly and severely by a Naval Weather Service environmentalist and are applied by a fleet operator.[7]

Consequently this paper speaks to marine environmental prediction as did the Commission on Marine Science, Engineering and Resources and the Marine Council's Interagency Committee on Ocean Exploration and Environmental Services, but the focus is on oceanographic environmental prediction services as opposed to marine weather forecasting. Hopefully oceanographic services have been broken out sufficiently to provide visibility, but not to the extent that perspective is lost.

CHAPTER II

ORGANIZATIONAL CONCEPT

Organization. The Naval Weather Service Command is organized to provide global forecast services to meet Navy marine environmental prediction requirements and all DOD oceanographic environmental prediction requirements. The Naval Weather Service Command, under a Commander reporting directly to the Chief of Naval Operations, comprises a headquarters and assigned field activities.

Fleet Weather Centrals (FLEWEACEN), the Fleet Numerical Weather Central (FLENUMWEACEN), and Fleet Weather Facilities (FLEWEAFAC) are the line elements of the Naval Weather Service Command. See figure 1.[1]

FLEWEACEN's are assigned geographical areas of responsibility in which they perform the following functions: data processing, product formulation, and the dissemination of products to the users. See figure 2.[2]

FLEWEAFAC's provide assistance in the performance of assigned functions to the FLEWEACEN in their geographic areas. In addition they are assigned specialized tasks such as hurricane forecasting (FLEWEAFAC, Jacksonville, Fla.) Antisubmarine Warfare Environmental Prediction Service (FLEWEAFAC Keflavik) and ice reconnaissance coordination and forecasting (FLEWEAFAC Kodiak).

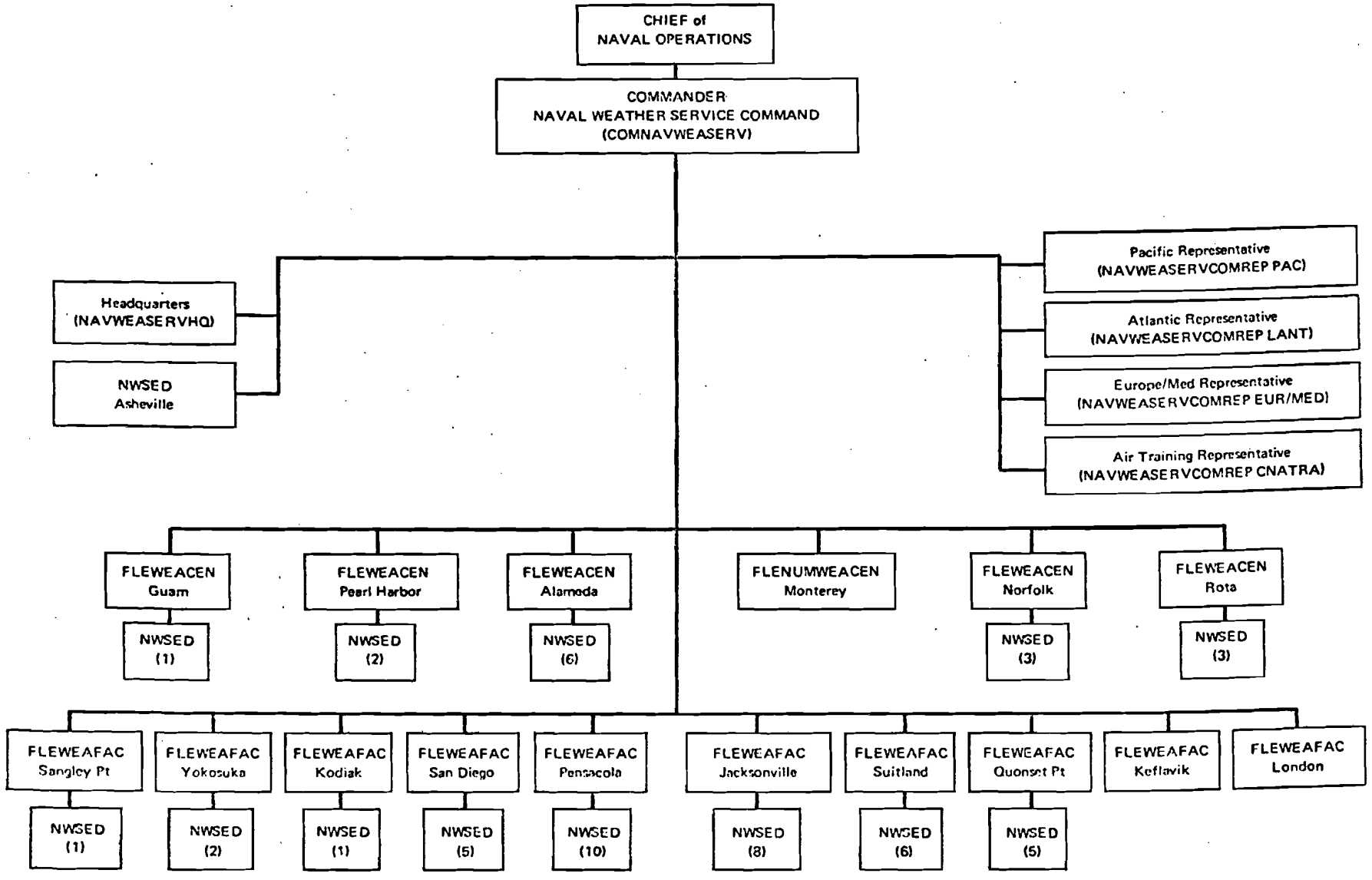

Figure 1

NAVAL WEATHER SERVICE COMMAND ORGANIZATION (Numerals indicate number of NWSEDs assigned)

NAVAL WEATHER SERVICE COMMAND
AREAS OF RESPONSIBILITY FOR SERVICES

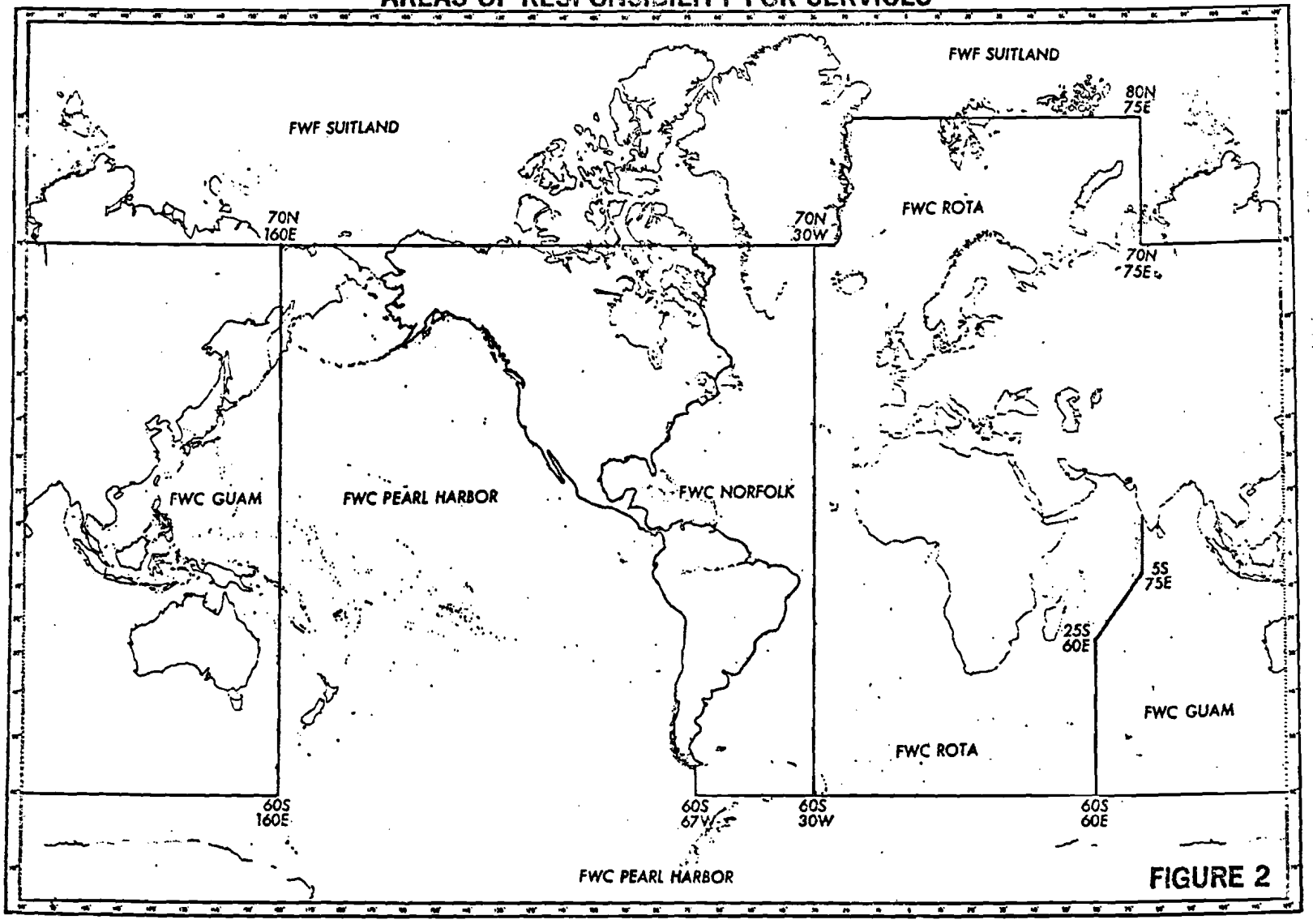

FIGURE 2

The Fleet Numerical Weather Central coordinates the Naval Weather Service electronic computer effort and operation of the Navy Environmental Data Network (NEDN). The NEDN includes high speed data links connecting computers at the FLEWEACEN and selected FLEWEAFAC. It is linked with the data networks of the U.S. Air Force and the National Oceanographic and Atmospheric Administration and provides world-wide coverage. FLENUMWEACEN produces a variety of meteorological and oceanographic computer analyses and forecasts for direct operational use and basic products in support of other elements of the Command.

Naval Weather Service Environmental Detachments (NWSED) are located at Naval Air Stations and other activities to provide specific local support services. They are organized under Officers-in-Charge who report administratively to designated FLEWEACEN/FLEWEAFAC, and are comprised of trained meteorological and oceanographic personnel.

NWSED Ashville, North Carolina is located at the National Weather Records Center (NWRC). Its function is the management of Navy climatological efforts at the NWRC and coordination of those efforts with the Air Force and NOAA in utilizing the joint computer facility and data files. Included in this function are the quality control of Navy meteorological records for climatological purposes, and the forwarding of reports

of observational and reporting errors to the command concerned. NWSED Ashville reports directly to Commander, Naval Weather Service Command (COMNAVWEASERV).

Marine Corps Meteorological Units are located at Marine Corps Air Stations and other USMC activities to provide local environmental support. They are comprised of Navy-trained Marine meteorological personnel and they function in a manner similar to the NWSED's but under USMC command.

The staff meteorologists of the Fleet Commanders in Chief and the Commanding Officer FLEWEAFAC London are assigned additional duty as Naval Weather Service Command Area Representatives (NAVWEASERVCOMREP LANT, PAC, EUR/MED). As such they assist the Fleet Commanders-in-Chief and COMNAVWEASERV in determining fleet requirements for environmental support, and in evaluating the support provided by the Naval Weather Service in response to those requirements.*

Units composed of varying numbers of meteorological/oceanographic personnel are assigned to staffs, ships and

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*The Fleet Commanders-in-Chief and the Chief of Naval Air Training's authoritative control over the product output of Fleet Weather Centrals and Facilities involves the effectiveness of meteorological/oceanographic services rendered, and responsiveness in satisfying requirements of the respective Commanders with due consideration given to the systemwide and servicewide aspects of the Command mission. Commander, Naval Weather Service Command, Manual of the Naval Weather Service Command, NAVWEASERVCONINST 5400.1, p. I-2-3.

other commands according to their specific requirements for environmental support. These units are normally integral components of the commands to which they are assigned, and they are staffed and equipped in accordance with their designated functions. Included here are the specialized units assigned to the Navy airborne weather reconnaissance (VW) squadrons and to the ice reconnaissance effort.

Command Realtionships. The Commander, Naval Weather Service Command, as the central authority within the Department of the Navy for meteorological and associated oceanographic matters, is supported by the Chief of Naval Material, and has a unique relationship with the Oceanographer of the Navy.[3] With respect to Naval Weather Service system functions the Oceanographer of the Navy develops procedures and scientific applications relating to oceanographic environmental prediction; when developed, the Naval Weather Service Command provides the actual forecasting services to the fleet. To coordinate this division of effort, COMNAVWEASERV is ordered to report to the Oceanographer as Assistant Oceanographer for Environmental Prediction Services.[4]

The Naval Weather Service system embraces the Naval Weather Service Command, and elements of the operating forces, shore establishment, and Navy Department. Ships, aircraft squadrons, and shore activities to which no meteorological/

(IOC) of the United Nations. Liaison with agencies external to the DOD is accomplished through the Special Assistant to the Joint Chiefs of Staff for Environmental Services (SAES).[5]

CHAPTER III

SYSTEMS CONCEPT

Overview of Navy Oceanographic Environmental Prediction Services. The Naval Weather Service Command provides oceanographic environmental prediction services to U.S. and NATO forces, to civil interests on the Great Lakes, and to the U.S. Marine Fisheries Service.[1] The objective is to provide to naval forces the best possible environmental analyses and forecasts with direct tactical application. Fleet Weather Centrals Norfolk, Rota, Pearl Harbor, and Guam, acting as regional oceanographic centers, are directed in their mission by the Commander, Naval Weather Service Command and have authoritative guidance from Fleet Commanders. The Fleet Numerical Weather Central is the hub of the computer network that develops these services and is the seat of NAVWEASERVCOM's computer development program. Additional research and development is provided by the Oceanographer of the Navy, Chapter X.

Support of the Shore Establishment. Commands and activities ashore request necessary environmental supporting services from the most readily available NAVWEASERV activity, NWSED, FLEWEACEN, or FLEWEAFAC. Where necessary such requests are forwarded within the NAVWEASERVCOM to insure adequate

response. Weather (storm) warnings and forecasts are routinely provided to activities ashore, via normal administrative and operational channels, by designated NAVWEASERV activities.

Fleet Support. The Fleet Weather Centrals and Facilities are the chief sources of environmental information for the forces afloat. FLEWEACEN/FAC areas of responsibility are depicted in figure 2. The responsibility is for the provision of general environmental support services. Fleet units request environmental support from the FLEWEACEN/FAC in whose area of responsibility the requestor is located.

Most of the environmental support normally required by fleet units is provided on a regularly scheduled basis via Navy communications channels. The following types of support are routinely provided:

storm warnings (ocean areas)
high seas warnings (ocean areas)
small craft warnings (coastal and harbor)
storm surge, meteorological overtide
(coastal & harbor)
area analyses and forecasts (ocean areas)
radiological fallout forecasts
aviation weather (Air Stations & routes)
local severe weather (coastal & harbor)
satellite cloud photography (nephanalysis & APT)

Support services tailored for specific operations are also available to ships at sea on request. Requests are forwarded to the cognizant Fleet Weather Central or Facility.

These services are normally provided by addressed message and include, but are not limited to the following:

Optimum Track Ship Routing (OTSR)
Route Weather Forecasts (WEAX)
Antisubmarine Warfare Environmental Prediction Services (ASWEPS)
amphibious operation forecasts
ice forecasts
aviation forecasts
forecasts of specific parameters such as refractive index
ballistic winds and denities
various physical oceanographic parameters[2]

Various combinations of these factors are required for support of submarine and antisubmarine warfare, strike and mine warfare, logistics replenishment at sea, and amphibious operations. In tabular form fleet activities that require oceanographic support include:

Antisubmarine Warfare
- airborne ASW
- surface ASW
- submarine ASW
- undersea surveillance
- mining
- mine countermeasures
- near shore defense (harbor protection, antiswimmer)

Operation Support
- logistics
- search and rescue, salvage
- NBC defense

Command Support
- ocean surveillance
- reconnaissance and intelligence
- safe navigation

Strike Warfare
- surface attack
- airborne attack
- submarine attack
- amphibious assault

Systems Theory and the Management of the Naval Weather Service Command. The systems approach provides a framework for visualizing internal and external milieu factors as an integrated whole. It allows recognition of the proper place of the military hierarchy and of the technical functions.

The Naval Weather Service system is an open system. Data, money, material, personnel and energy enter it, are acted upon and leave it. The Naval Weather Service system is influenced by, and influences its milieu. It maintains dynamic equilibrum with its milieu. NAVWEASERVCOM has interplay with the Navy, the DOD, and has other national and international relationships. Factors effecting the Naval Weather Service system result from a number of causes, such as the expanding scope of naval operations, advancing technology, and changing managerial concepts. The system renews itself constantly, through a transposition process. The identity of the whole and its unity is maintained but the functions and the component parts of the integrated system change, adapt.

Systems analysis fosters a way of thinking, which on the one hand helps to dissolve some of the complexity, and

on the other hand helps recognize the nature of complex problems. It is important to recognize the integrated nature of the specific functions, including the fact that each can be viewed individually. But it is equally important to recognize that the Naval Weather Service system is a part of larger systems, national and international; world-wide in scope.

This analysis employs functions to describe the Naval Weather Service system. Functional analysis is particularly applicable for generalized argument concerning systems structure because it does not cloud the basic interrelations with overbearing, detailed formulations. Function definition is also desirable as an analysis tool because of its sensitivity in locating fallacious arguments. This type analysis is well suited to presenting the gist of the systems concept in an easily assimilated way.[3]

Integration of Scientific Disciplines and Work Functions. Within the scientific community in general there is a problem of communication between and among the managers, the various functions, and the traditional scientific disciplines i.e., between the project manager, the data processers and computer programmers, and the oceanographers and meteorologists.

> "Hence physicists talk only to physicists, economists to economists - worse still, nuclear physicists talk only to nuclear physicists and econometricians to econometricians. One wonders sometimes if science will not grind to a stop in an assemblage of walled-in hermits, each mumbling to himself in a private language that only he can understand."[4]

The Naval Weather Service Command, inter alia, employs the following: meteorological forecasters, oceanographic acousticians, computer programmers, electronic engineers, and communications specialists. Although there is similarity between the methods of the scientific disciplines there is difficulty of communication across discipline boundaries.

The structuring of the Naval Weather Service Command provides the overall framework within which their response to fleet requirements is integrated. In order that the interdisciplinary approach not degenerate into undisciplined, ad hoc, pragmatism; NAVWEASERVCOM is managed so as to integrate the separate scientific disciplines and the functions while allowing that they retain their essential distinctions. The Naval Weather Service Command is structured vertically and functions horizontally. Vertically as a military hierarchy, and horizontally as the basic functions which underly and cross both the scientific disciplines and the military hierarchy.

An example of the effectiveness of the integration of the scientific disciplines and work functions in the Naval Weather Service system is the carry over of meteorological methodology (conceptualizing and hypothesizing, and development of and use of ADP technology) into oceanography. Based on his often stated premise "Water is just thick air;" Capt.

Paul M. WOLFF, the founder and developer of FLENUMWEACEN (at first engaged principally in meteorology) innovated computer oceanographic techniques which lead the field and which have proved invaluable in naval operations.[5]

Channels and Layers. The Naval Weather Service Command is managed so as to develop an objective, understandable structure for decision making at each level. The concept being that if the system within which the Commander, and the Commanding Officers of the Fleet Weather Centrals and Facilities, and the Officers-in-Charge of the Naval Weather Service Environmental Detachments make decisions can be provided as an explicit framework, then good decision making should be easier to accomplish.

The organization functions in three layers. The lowest of which is at the working level of the underlying functions (data acquisition, data processing, product formulation, and dissemination to users). In this layer decisions for governing day-to-day functioning are largely programmed and automatic. Above that is a layer of non-programmed decision processes, carried out in a man-machine milieu, for monitoring the first level processes, and adjusting them. This layer is managed at the approximate hierarchial level of the FLEWEACEN Department Head. The uppermost functioning layer is one in which virtually all decisions are unprogrammed.

This layer is managed by the Commanding Officers of the Fleet Weather Centrals; and is supervised by the Commander, Naval Weather Service Command. Only the latter is remote. Management above these functioning layers is minimal.[6]

The Naval Weather Service Command is hierarchial in form. See figure 1. Like most military organizations, NAVWEASERVCOM is organized on a vertical line, relying on the superior-subordinate relationship. Orders and instructions go down the line, reports and requests come up the line. But, as indicated in the preceeding paragraph; technology, characterized by integrated data processing (ADP/EDP) and computer product formulation, cuts across superior-subordinate relationships.

The notion of functions as set forth in several layers deserves emphasis. This connotes horizontal working relationships cutting across traditional vertical hierarchial lines. Thus the system is task oriented, and responsibility is vested in managers whose influence cuts across military channels.

Conceptualization. The Panel on Environmental Monitoring of the Commission on Marine Science, Engineering and Resources noted that . . .

> "A number of Federal agencies conduct one or more of the following activities: acquisition of physical oceanographic and related meteorological data, the communication of such data, processing data, forecasting, disseminating analyses and forecasts."[7]

The Federal Plan for Meteorological Services and Supporting Research, Fiscal Year 1971 holds that . . .

> "Five distinct functions are common to all meteorological services, both basic and specialized. These are observing, analysis and forecasting, communication, dissemination to users, and general agency support."[8]

The Manual of the Naval Weather Service Command maintains . . .

> "Several functions are common and basic to the operation of any weather service system, military or civilian . . . They are generally categorized as operational or support as indicated below:
>
> | Operational Functions | Support Functions |
> |---|---|
> | Observations | Systems Support |
> | Analysis/Prognosis | Research"[9] |
> | Interpretive Services | |
> | Communications | |

This analysis identifies the operational functions of the Naval Weather Service system as:

data acquisition

data processing

product formulation

dissemination

Supporting the operational functions are support functions carried on, for the most part, within the Naval Weather Service Command. These support functions accomplish those ancilliary tasks which must be performed in order to operate an effective oceanographic environmental prediction service. They include:

equipment

training and fleet liaison

R&D

management above the functional level

Not all units of the Naval Weather Service Command have programs in each of the areas of the support functions. A significant amount of support is obtained from without the NAVWEASERVCOM i.e., systems support from the Chief of Naval Material (Naval Air Systems Command, Naval Ships Systems Command), the Commander of the Naval Communications Command, and from the Oceanographer of the Navy; and housekeeping from host commands, such as Naval Air Stations, on which Naval Weather Service units are tenant.

CHAPTER IV

DATA ACQUISITION

Overview. Timely and accurate weather and oceanographic observations are a fundamental naval requirement. Observations are used locally for immediate tactical application; operationally by the spectrum of naval activities when disseminated by FLEWEACEN/FAC in the form of collectives; analyses and forecasts; and for planning and research purposes when assembled in climatological files in the form of statistical records. Because weather patterns of hemispheric or global scale may affect conditions in a given location, world coverage is necessary. Obtaining such coverage is difficult because of the vast ocean areas which are largely devoid of reports. For this reason observations from Navy ships and aircraft are vital.

While at sea all major commissioned naval vessels make weather reports that supplement the observations largely supplied by the Basic Meteorological Service of the National Weather Service (NOAA). Approximately 45 vessels have sophisticated equipment for detailed surface observations, and about 40 of these are equipped to make upper air

observations.* A limited number of buoy mounted automatic stations, now in the research and development stage, are deployed and report regularly. In addition all large Coast Guard cutters make weather reports while at sea and more than 40 vessels are equipped to make upper air observations when required.[1]

Aircraft reconnaissance provides weather information at altitude along a continuous path, and instruments projected from the aircraft supply data to the surface, at the surface, and below. This method of observation is used principally over ocean areas, but may be used over any data sparce area where it is politically possible to do so. Both the Navy and the Air Force operate weather reconnaissance squadrons. There are two types of aircraft environmental reconnaissance: synoptic flights are flown at scheduled intervals over established tracks to furnish data for basic analysis and forecasting; and special reconnaissance, which is done to investigate tropical storm areas and to obtain data on the position, intensity and movement of hurricanes, typhoons, and severe storms. Most of the nation's airborne weather reconnaissance

*The fleet is receiving new and more precise devices such as the near surface reference temperature device (NSRT), air and surface expendable bathythermographs (AXBT, SXBT), and airborne radiation thermometer (ART). These devices provide higher quality data. They have an additional benefit too, they allow the fleet operator to make on-scene forecast verification and to adjust accordingly.

is done by DOD. Airborne environmental reconnaissance is very expensive.[2] The NOAA supplements this effort to a limited extent with aircraft which gather information on hurricanes in the Gulf of Mexico, in the North Atlantic, and the Carribbean Sea. These aircraft, funded under research activities, coordinate their efforts with the Air Force and Navy under the procedure established in the National Hurricane Operations Plan.[3]

Scarcity of Oceanographic Observations. Environmental information flow within the Naval Weather Service system can be conceived of as:

acquire
process
formulate products
distribute products within the system
disseminate products to users.

The focus of attention of the management of this flow has of necessity been on acquisition. Processing, product formulation, and distribution, primarily in terms of data link and computer capabilities have not been the more significant problems. NAVWEASERV has equipment that is adequate in terms of capacity, computational speed, and flexibility of input-output devices. Further, as science's understanding of the natural processes involved in the marine environment advances, sophisticated computer programs are developed to incorporate these

advances into FLENUMWEACEN's methodology.[4] A real stumbling block has been the acquisition, transcription, and introduction of data suitable for input to the central processing unit (FLENUMWEACEN's computer complex). It is difficult to acquire sufficient quantities of high quality and timely oceanographic data in most areas of the world.*

In order to expand the data base OCEANAV Instructions of the 3160.4 series specify that all U.S. Navy ships obtain and transmit collective SST observations every odd hour. U.S. Coast Guard stations, light ships, and towers also furnish SST reports. Naval weather reconnaissance aircraft equipped with airborne radiation thermometers (ART) acquire SST data. Although more SST data is received than any other parameter, not enough is obtained for most ocean areas. A recent report issued by NAVOCEANO indicated that four times the amount of SST data now received is needed in most regions for analysis and prediction purpose.[5]

Sources of bathythermograph (B/T) data used to determine sub-surface temperature fields, sonic layer depth, sound channels and vertical gradients for sonar ranging purposes are extremely limited. Navy ships equipped with mechanical or

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*Only about 1,000 unique ship reports, 125 ocean temperature versus depth soundings (bathythermographs), and 15 shipboard radiosonde soundings (which contain pressure, temperature, humidity, and wind measurements in the atmosphere) are available to FLENUMWEACEN every 12 hours. Ibid., p. II-29.

expendable B/T acquire and transmit observations every six hours in accordance with OCEANAV Instructions of the 3160.9 series. Tactical aircraft report B/T data obtained during ASW missions. Approximately 50 commercial and Military Sea-lift Command (MSC) ships are equipped with B/T systems under the ship-of-opportunity program. Coast Guard ships occupying ocean stations transmit B/T reports every six hours. Foreign, academic, and NOAA research ships also transmit B/T data. The number of B/T reports should be greatly increased for all ocean areas. Both NAVWEASERVCOM and NAVOCEANO intend to equip additional ships-of-opportunity in order to increase the daily input of B/T data. Other potential sources of such data are being pursued. For example data is being exchanged with friendly foreign nations.[6]

Data Sharing. In so far as it is possible to do so the Naval Weather Service's requirement for environmental observations at any given location is met in one of two ways; either the Navy makes the observation itself or it assures access to a satisfactory observation made by another agency. Prudence requires that the NAVWEASERV give consideration to all sources of environmental information. In times of increased international tension one or another of the alternate sources of data may drop out of the system. Backup must be available. The system must be able to adapt. Techniques,

methods and accuracies relating to the data acquisition function have been sufficiently standardized throughout the world to facilitate the exchange of observations among environmental prediction agencies to the mutual benefit of all.[7]

In providing world-wide service to the nation's defense forces, the weather organizations of the Department of Defense rely where possible on information gathered by the Basic Meteorological Service, National Weather Service (NOAA) and the environmental services of other nations. Most environmental observations made by the Department of Defense are made available to NOAA and to the World Meteorological Organization (WMO).[8] The concurrent need for environmental data of NOAA, of the Air Weather Service and of the Naval Weather Service requires that the federal government ensure that the functions of its principal data users be coordinated. Under the overall supervision of the Federal Coordinator for Meteorological Services and Supporting Research (Department of Commerce) marine environmental data is collected from the surface by ships and by maritime land stations; it is collected from the upper air by balloon and by radar, weather reconnaissance aircraft, and pilot reports, and by environmental satellite

systems.* The Basic Upper Air Observation Network (balloon) is composed of Department of Commerce facilities with Air Force and Navy participation at military bases in the United States and overseas as well as on ships at sea. The Navy funds the Meteorological environmental monitoring program aboard Coast Guard Ocean Station Vessels and contributes to the support of the upper air observing program aboard mercantile shipping and in the Trust Territory of the Pacific Islands.[9]

Because many areas of interest are not sufficiently covered by normal ocean traffic very expensive special observing schemes are sometimes necessary. For the Navy this usually involves sending an aircraft to sample the area in question, although a ship of opportunity may be used. A limited number of automatic stations and buoys are used for essential observations at unmanned or inaccessable locations. The difficulty, the effort required, and the high cost of taking special synoptic measurements have kept this effort at a fairly low level. In order to prove economically feasible an expansion of the environmental monitoring network must be accompanied

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*The major source of oceanographic data is the six hourly synoptic weather reports transmitted by ships at sea. The principle oceanographic elements of these reports are sea state and sea surface temperature, the latter from the ship's condenser injection temperature.

by a lowering of datum point costs. The goal is to obtain data which has the required accuracy at low enough costs to be within allowed budget limitations.[10]

Functional Interfaces. Data acquisition involves a number of oceanographic and meteorological instruments, the men that operate them, and the means by which the data acquired is introduced into the system. Problems of the man-machine interface have been widely discussed in the literature of the management sciences.[11] This interface exists between the man and his instrument and between the man and his introduction of environmental data into the system.[12] The interface between instrument and environment is important too. The instrument must be reliable, accurate, calibrated, and well maintained.

The data acquisition function also embraces all of the administrative and organizational problems involved in obtaining high quality input from unskilled, frequently disinterested mariners who have their primary duty to perform, and who frequently see environmental data acquisition as a nuisance.[13]

NAVWEASERVCOM environmentalists and technicians are assigned to some fleet units. The close parallel between the provision of environmental services on-scene and fulfilling observational requirements in so far as practicable by trained environmental technicians is common to the national

and the international environmental prediction community. That is not to say that most Navy environmental observations are taken by Naval Weather Service technicians. They are not. Most U.S. Navy environmental observations are taken by the fleet. But where NAVWEASERVCOM technicians are aboard aircraft carriers or flag ships to provide on-scene environmental support services and to assist in the application of environmental considerations to the tactical situation, then these same technicians are also used to observe the environment.[14]

As noted most Navy marine environmental data is obtained by general service personnel, sailors with little or no training in the environmental sciences and perhaps little appreciation of the fundamental importance of environmental observations. These men must be taught and motivated. Personnel turnover is high. Training observers is a continuous job, but improvement of data acquisition is achieved by motivating those sailors who collect the data. They are taught "how" and "why" in brief schools at the regional FLEWEACEN and individual performance is improved thereby.

Acquiring oceanographic data in this way is functional. It is apparent that using existing technology and applying minor improvements and refinements, constitutes the cheapest and most expedient approach to the problem of data acquisition. There is little doubt however that the final solution

to the problem of conventional data acquisition lies in completely automating the process. The installation of "black boxes" on ships, both mercantile and naval, that will automatically sample the environment and report while making a record for archival purposes is the goal to be strived for.[15] A great deal of work has already been accomplished in this direction. Navy, NOAA, and Coast Guard are all active in this endeavor.

CHAPTER V

DATA PROCESSING

The Pervasive Function. The several functions of the Naval Weather Service are inexorably interwoven with data processing (screening, collating, and relating the data that is acquired in day-to-day operations in order to develop meaningful information for immediate use and for product formulation).

Data Processing Overview. The amount of environmental data to be processed by the Naval Weather Service is staggering.[1] The vertical range of environmental observations is from the bottom of the oceans to an altitude of approximately 60,000 feet. With such a magnitude of constantly changing environmental information to be collected, evaluated and compiled on a strict time schedule it is imperative that reliable communications and data processing be maintained. Data late for product formulation wastes much, and sometimes all, the effort expended in its acquisition. Both input and output have a high rate of perishability in most applications of environmental prediction.[2]

In so far as possible the Naval Weather Service uses automated techniques for collection, processing, relay and distribution of data and for the prediction of environmental

conditions and effects on sensor and weapon systems. Environmental data of all types is fed to FLENUMWEACEN's computers. That collected by the regional Fleet Weather Centrals is edited, catalogued and transmitted by the Naval Environmental Data Network (NEDN) to Monterey for product formulation. Data also is forwarded to the National Weather Records Center (NWRC), NAVOCEANO, and to the National Oceanographic Data Center (NODC) for research programs and for archiving.

The NEDN is an interconnected system of digital computers and associated on line communication equipment which serves to relay data, to process, distribute, and display data and analyses and forecasts throughout the world. The NEDN ties together NAVWEASERV's field activities and allows for additional adaption and interpretation at regional FLEWEACEN/FAC, by Naval Weather Service Environmental Detachments (NWSED's), and by NAVWEASERV units assigned to staffs, and other activities having a specified environmental requirement.[3] See figures 3 and 4.[4]

The Fleet Numerical Weather Central at Monterey is the master center receiving and processing all inputs. FLENUMWEACEN takes inputs from NOAA, from the Air Force's Automatic Weather Network (AWN) - with control at Tinker Air Force Base, Oklahoma City - as well as from the Naval Weather Service's own sources. FLENUMWEACEN follows a rigid synoptic schedule in formulating and distributing prediction products

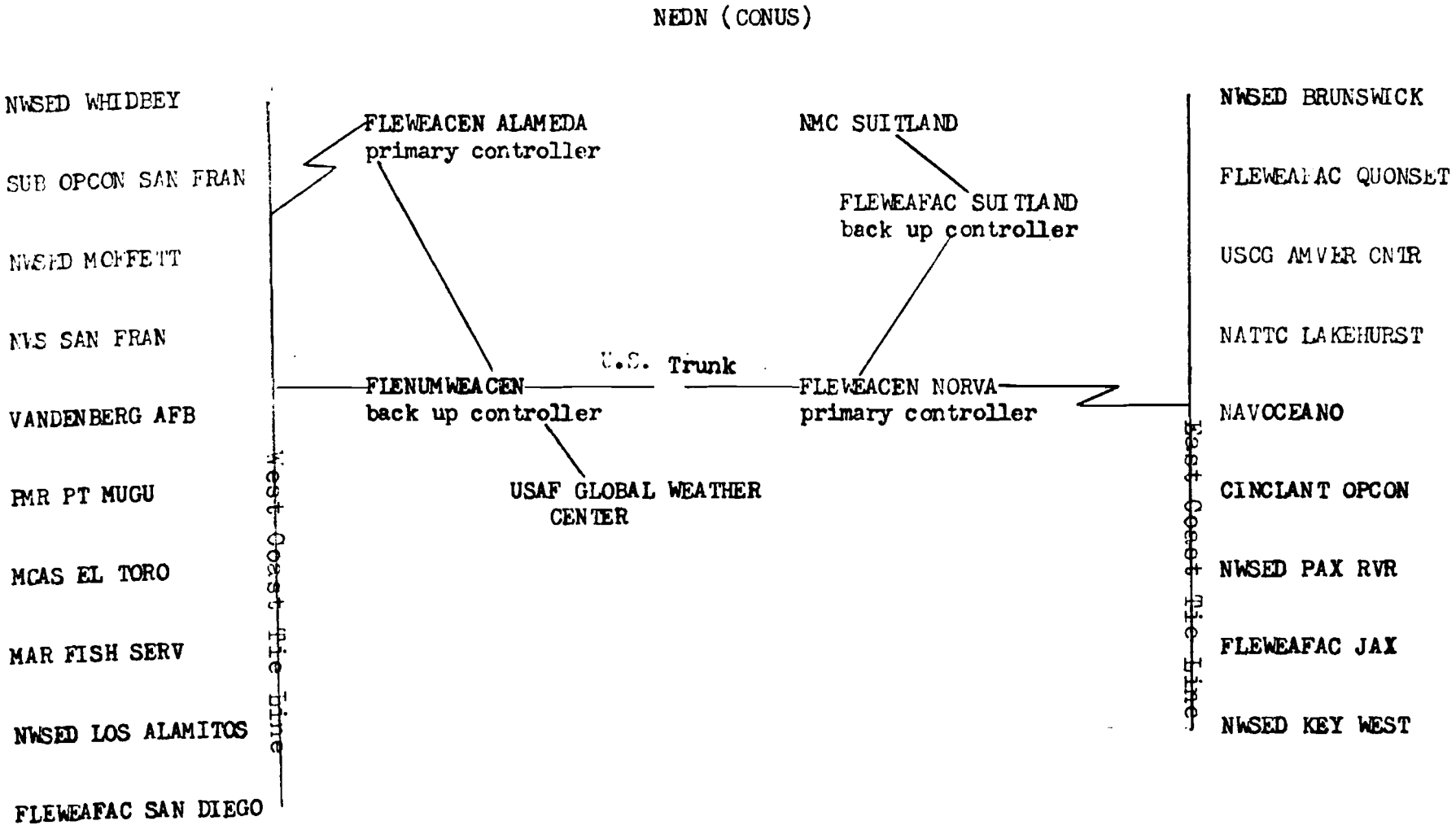
NEDN (CONUS)
NWSED WHIDBEY
SUB OPCON SAN FRAN
NWSED MOFFETT
NWS SAN FRAN
VANDENBERG AFB
PMR PT MUGU
MCAS EL TORO
MAR FISH SERV
NWSED LOS ALAMITOS
FLEWEAFAC SAN DIEGO
West Coast tie line
FLEWEACEN ALAMEDA
primary controller
FLENUMWEACEN
back up controller
USAF GLOBAL WEATHER
CENTER
U.S. Trunk
NMC SUITLAND
FLEWEAFAC SUITLAND
back up controller
FLEWEACEN NORVA
primary controller
East Coast tie line
NWSED BRUNSWICK
FLEWEAFAC QUONSET
USCG AMVER CNTR
NATTC LAKEHURST
NAVOCEANO
CINCLANT OPCON
NWSED PAX RVR
FLEWEAFAC JAX
NWSED KEY WEST

Figure 3

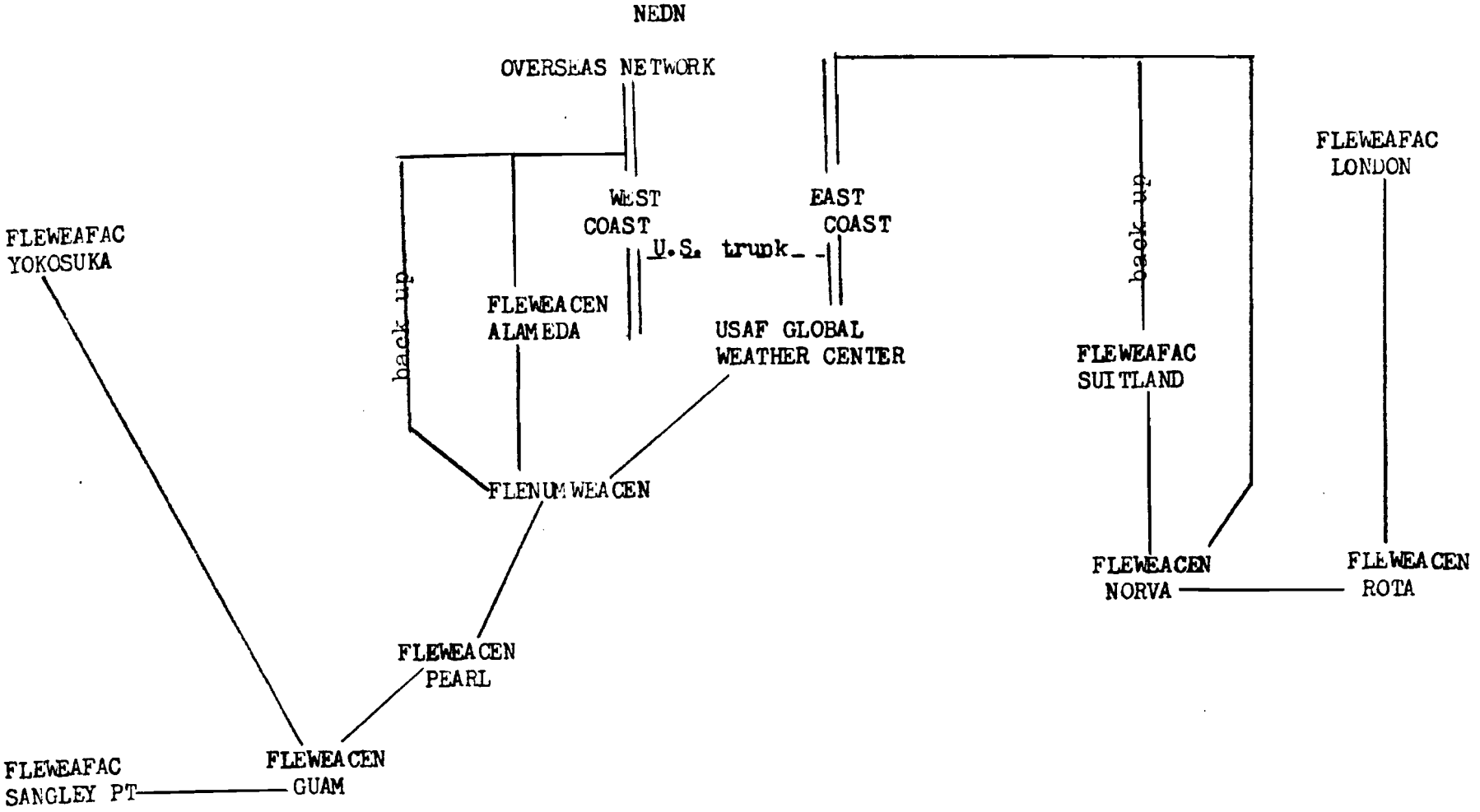
NEDN
OVERSEAS NETWORK
WEST COAST
EAST COAST
U.S. trunk
back up
back up
FLEWEACEN ALAMEDA
USAF GLOBAL WEATHER CENTER
FLEWEAFAC YOKOSUKA
FLEWEAFAC LONDON
FLEWEAFAC SUITLAND
FLENUMWEACEN
FLEWEACEN NORVA
FLEWEACEN ROTA
FLEWEACEN PEARL
FLEWEAFAC SANGLEY PT
FLEWEACEN GUAM

Figure 4

to NEDN main trunk terminals at FLEWEACEN's Norfolk, Va.; Rota, Spain; Pearl Harbor, and Guam.

Environmental Communications. For the most part the Naval Communications Command supports Naval Weather Service requirements for specialized operational communications, but basic support is received from a mix of international communications systems and the national systems of the Federal Aviation Administration (FAA), NOAA, U.S. Air Force, and U.S. Coast Guard. These services are timely and efficient, allowing the Naval Weather Service Command to focus its resources and professional skills on the functional areas of data acquisition and product formulation.

Close cooperation exists between the federal agencies in the environmental data processing effort.[5] Through automatic communications networks weather and oceanographic data is exchanged on a timely basis. In the United States basic weather observations are collected and distributed principally by teletypewriter systems operated by either the FAA or the National Weather Service. Teletypewriter systems have for more than 40 years been the principal means of collecting data and distributing forecasts. Facsimile systems are used extensively to distribute weather maps and other graphical depictions. Weather maps prepared in NOAA's

National Meteorological Center (NMC) are distributed to CONUS FLEWEACEN/FAC by means of the Department of Commerce facsimile system.

The specialized communications systems established to meet defense requirements contribute to the nation's basic meteorological service as high speed data sources from overseas as well as a means of collecting and making data from military sources available to all users.[6] In addition to the complex of the Naval Communications Command, in which NAVWEASERVCOM is a common user, the following exclusively environmental networks can be identified: All are component networks of the Defense Communications System (DCS) -- Automatic Weather Network (AWN), Manual Weather Teletype Network, USAF Facsimile Network, CONUS Meteorological Teletype System (COMET), and the Navy Environmental Data Network (NEDN) (portions of the Manual Teletype Network and COMET have been asorbed by the DOD Automatic Weather Network).[7] The Air Force is the principal source of surface and upper air data from overseas. This data is processed at the Global Weather Center. Navy extensions at the Global Weather Center and at the National Meteorological Center (NMC) of the National Weather Service are used for data exchange.

The requirement for access to the processed data of foreign environmental services is met by arranging for drops on the appropriate circuitry and by the operation of radio receiving equipment to copy foreign broadcasts.

No single one of the supporting communications system meets all of the requirements. Each provides a unique contribution. The mix of international and national communications systems, including the special role of the NEDN, is essential because of the global nature of marine environmental prediction. The mix has evolved over the years under the constraints of funding and the state of the art.

Real Time Data Processing. The demand for increased amounts of data, greater collection speed and more computer products has led to the increased use of high speed digital data links as replacement for some teletypewriter and facsimile networks.

The highly perishable nature of synoptic environmental information requires real time handling and processing from the time of observation to the time of ultimate delivery of the finished product to the user. Accordingly provision is made for the automation or semi-automation of the following:

the collection of environmental information and the elimination of noise there from

sorting, correlation and further processing of the information

generation of displays to allow human monitoring, decision making and intervention

distribution of the data and of the analysis and prediction products to the points of dissemination to the user.

Environmental data processing as practiced by the Naval Weather Service, the Air Weather Service, and the National Weather Service is among the few real time data processing systems. The NEDN and the computers are integral parts of the Naval Weather Service system. Whereas typical application of modern high speed data processing calls for collection of data over some prolonged period of time to be processed as a batch, real time processing requires processing of current information for product formulation.

CHAPTER VI

PRODUCT FORMULATION

Analysis and Forecasting Overview. The Fleet Weather Centrals and Facilities provide oceanographic environmental prediction services to the operating forces including refined products developed for specific application to ASW/USW. Based on their analysis of oceanographic conditions, predictions are developed depicting in detail the anticipated state of the oceans and its effect on sensors and weapons. Analysis and forecasting techniques developed within the Service and at NAVOCEANO are used in deriving operational products. Although restricted by insufficient data, a complex model is programmed in the computer. It is based on theoretical considerations, empirical equations, and historical data.[1]

The Naval Weather Service strives to formulate products which are tactically meaningful, for if the fleet operator must devote excessive time to convert or otherwise interpret the products provided they will, in all probability, simply be ignored. The fleet operator does not have the time to make complex adaptive computations in a rapidly changing tactical situation. NAVWEASERV endeavors to deliver a tool that is ready to use.

ADP and Centralized Product Formulation. Numerical environmental prediction was instituted by the Naval Weather Service at Monterey, California in 1958 in order to improve forecasts by placing product formulation on a firm scientific basis through the use of the classical laws of physics. The numerical approach is concerned with the mathematical development of the fundamental fluid equations into models suitable for producing products on electronic computers in time to meet real time operational schedules.

Oceanographic analysis and prediction is carried out in an integrated meteorological/oceanographic program. Rapid and pronounced changes in the upper layers of the ocean (those which most significantly effect ASW/USW) are linked to action in the atmosphere. Oceanographic forecasting is based to a large extent on synoptic meteorological analyses and forecasts and upon models of the quantitative (numerical) interaction between the atmosphere and the ocean. This relationship allows reconstruction of oceanographic parameters that display correlation with observed meteorological values.[2]

Centralized product formulation is practiced by most advanced weather services in the world today. Centralization is recognized as the most efficient and economical method of performing this basic function. Modern communications and electronic data processing (EDP) make it technologically possible and economically advantageous for direct

computer-to-computer exchange of data and products between the primary and regional processing centers. Moreover, the Fleet Numerical Weather Central, the Global Weather Center, and the National Meteorological Center each use information obtained from the other.

Oceanographic Products, General. A variety of oceanographic products are developed by the Naval Weather Service Command: synoptic oceanographic analyses and forecasts, converted products/tactical indices (depictions and forecasts of environmental effects on specific sensor systems), Optimum Track Ship Routing (OTSR), and oceanographic outlooks for specific ocean areas. These products are produced in chart, numerical and textual form using both objective (numerical) and subjective (hand) techniques.

Most oceanographic products are computer formulated. The computer product list includes: sea state analyses and forecasts, ocean thermal structure analysis, layer depth, thermocline gradient, transient thermoclines, temperatures at standard depths, temperature and sound speed profiles, sound propagation loses, convergence zones, and other sonar forecasts, and "zoom" programs (detailed large scale features).[3]

Optimum Track Ship Routing. OTSR was developed by NAVOCEANO in 1955. It was made operationally available to

the fleet and to other government operated and chartered ships by the Naval Weather Service in 1958. Service is provided from FLEWEACEN's Norfolk, Alameda, and Guam. OTSR endeavors to select a route which will provide the optimum combination of environmental factors relative to the routed unit's mission. In general this route will provide the most rapid crossing consistent with safety, passenger and crew comfort, and desired operating weather.

Oceanographic Outlook. Oceanographic outlooks for specific areas are prepared on request. The outlook is usually provided a week to a month prior to the scheduled commencement of the exercise or operation that it is to support. It is to a large extent based on climatological data and upon information which changes little with the passage of time, such as bottom composition. It is stressed that certain vital information contained in the outlook may change significantly over a short period of time. Updating the information contained in the outlook is based on the synoptic situation at the start of the operation/exercise.

The general format of the Oceanographic Outlook is:

area

time period

SST (usually includes a chart, mini-plot, of the area with an indication of expected variability)

subsurface thermal structure (SLD with expected variability, GRD, afternoon effect)

bottom

currents

sea state

ambient noise

sonic conditions (of anticipated tactical interest).

Marine Climatology. The Climatological products of the Naval Weather Service provide support to the operating forces, and to research and development, test and evaluation. Numerous Navy activities use climatology and hydroclimatology in their mission planning, in research and in studies. The Naval Weather Service supports these activities by the publication and distribution of data and summaries; the provision of services responsive to inquires and requests for specific information; processing data to unique user specifications; and supporting research to improve understanding of the environment and its effect on naval activities, and to develop more effective services. Fleet Weather Centrals and staff meteorologists provide tailored services to military users drawing on the resources of the Naval Weather Service Command and of NOAA for fast, flexible response to the environmental problems of military planners.

The major source of climatological data for the Naval Weather Service is from a contract with NOAA at the National Weather Records Center (NWRC). This Navy contract accounts for about 25% of the Center's work load.[4] Navy work includes quality control and archiving of Navy observations; collection, conversion to machine processable form, and archiving of world-wide marine observations; and preparation of world-wide marine climatological atlasses and reports.

In conjunction with the Air Weather Service, the Naval Weather Service Environmental Detachment Ashville, North Carolina (NWRC) has a continuing program to provide the needed climatological data. Once tabulated this data is available to the public through the National Technical Information Service. The new joint use computer system at NWRC has provided large capacity, mass memory files, allowing immediate access to a large amount of frequently used data, retrievable either by date or by location. Selected data is also maintained in the processing system at the Air Force Global Weather Center, and at FLENUMWEACEN.

Oceanographic Products Most Significant in ASW/USW. The four oceanographic environmental prediction products most significant in ASW/USW are sea surface temperature (SST), sonic layer depth (SLD), thermocline gradient (GRD), and sea state. These products together with domain considerations, sound channels, and the bottom form the basic

input to the formulation of the converted products, the tactical indices.

SST. The basic oceanographic analysis is the sea surface temperature (SST) chart. A composite chart is developed at FLENUMWEACEN. It provides day-to-day continuity for synoptic sea surface temperature analysis; as the density of reports does not permit preparation of an analysis based soley on data from a single day.[5]

The major purpose of the composite sea surface temperature chart is to provide a firm data base from which to establish major oceanographic features such as currents and water mass boundaries. The SST analysis is the basis of the model from which is predicted sonic layer depth, and from there to the converted products -- such as sonar range estimates.

Water Masses (Domains). SST is an aid in identifying water masses. Much like air masses, water masses are formed in source regions and assume specific thermal characteristics. When a water mass moves into a new environment it retains many of its former characteristics. Water masses can be identified in areas other than their source by thermal classification, permitting the development of empirical relationships between the patterns of the SST and the sonic layer depth (SLD). These relationships are based on knowledge of

the structure in the source region and the modifications of the water mass while moving to and within its new environment.

Water masses or domains show representative bathythermograph/sound velocity (BT/SV) profiles, which together with bottom considerations determine sound propagation characteristics. The computer attempts to describe each by an approximation which forecasts bathythermograph traces and associated sound velocity profiles for grid points. These points may be changed seasonally. Other points can be added for specific operations or exercises.

SLD. Sonic layer depth is, in all probability, the most important single environmental parameter determining sonar conditions in the open sea.[6] The SLD chart is based on a five day composite analysis utilizing SST analyses and bathythermograph (B/T) reports. The sonic layer depth chart provides the information necessary for the basic determination of sound propagation in the upper layers of the ocean.

GRD. The synoptic vertical temperature gradient analysis is prepared daily using the same model correlation principle as used for the sonic layer depth analysis. Vertical temperature gradient is obtained from B/T data used in the preparation of the SLD chart. The gradient below the layer (GRD) chart delineates areas of change in terms of degrees Fareheit per 100 feet, for the first 100 feet below

the sonic layer. Temperature gradient provides a good measure of the vertical sound velocity distribution, which determines ray curvature, thus determining the range of direct path sound propagation and the strength of the surface duct, the mixed layer.

Sound Channels. Sound channel information is of vital importance in ASW operations since the presence of a sound channel may result in phenemonal detection ranges. This product is formulated as three parameters to describe the sound channel: depth of the axis, thickness, and maximum angle above and below the horizontal of sound rays trapped within the channel.

Sea State. Sea state is one of the most critical factors in echo ranging. At FLENUMWEACEN wind wave charts are formulated numerically. Synoptic sea state charts are prepared based on the wind field. Wind speed, direction, and duration are computed at grid points over the oceans based on surface pressure patterns to which appropriate corrective factors are applied. Significant wave height and period are computed for each grid point utilizing known relationships between wind and wave characteristics, with corrections made for fetch limitations. Finally the values are contoured by an incremental plotter.[7] The computer product may be subjectively hand modified at local up date, for the most

reliable sea height charts have proved to be those formulated by subjective modification of computer developed wave fields.

The Bottom. Bottom composition and bathymetry charts provided by the Naval Weather Service are derived from National Intelligence Summaries and Hydrographic Office Publications. Selected bathymetric readings are highlighted. Major topographic features are indicated. Bottom composition data is, in general, limited to the bottom surface, details of bottom composition in depth being mostly unavailable at this time.

CHAPTER VII

DISSEMINATION

Dissemination Overview. Oceanographic forecasts which are developed on a routine basis at FLENUMWEACEN are distributed via NEDN to Naval Weather Service Command field activities for local up date and dissemination to the fleet. From NAVWEASERV field activities engaged in immediate fleet support products are disseminated to users by a variety of communications systems, such as: the Fleet Broadcasts, facsimile (FAX), digital data link, U.S. Mail, and local hand delivery. Some products are broadcast as gridded and coded messages to back up facsimile transmission, in order to service non-FAX users, and in order to disseminate classified tactical indices. Voice systems (including telephone answering devices and radio telescribers) and closed circuit television are used extensively in local applications.

General Fleet Dissemination. In general environmental depictions are unclassified and are disseminated in the clear via facsimile broadcasts for the use of all maritime interests.[1] Sea surface temperature (SST), sonic layer depth (SLD), gradient below the layer (GRD), and sea state are so broadcast. Fleet Weather Centrals also disseminate oceanographic environmental services to fleet units at sea by radio teletype (RATT)

graphic messages, depicting fields of various environmental parameters and tactical indices. All Navy broadcasts - RATT, voice, or facsimile - are primarily for the support of U.S. naval forces and are subject to change in content or schedule on minimum notice. Other users are cognizant of this.[2]

Converted products (tactical indices) are normally classified and are transmitted via the Fleet Broadcasts and covered NEDN circuits. Selected converted products are transmitted in the clear, but such products require a classified locator grid for positioning. RATT can of course be encoded allowing secure transmission of tactical indices and environmental information, the disclosure of which would cause a breech of security.

Dissemination to Air ASW Forces. Oceanographic services are normally provided ASW aircrews in the form of a face-to-face briefing. Direct environmentalist-to-operator contact insures responsiveness to fleet needs. The aircraft commander receives an oceanographic services briefing folder which he takes with him on the flight for reference. The packet usually contains the following:

general environmental depictions

bottom composition and bathemetry

sea state prognosis

SST prognosis

SLD prognosis

forecast BT/SV profiles

GRD prognosis

sound channel analysis

sonar detection range estimates

ambient noise estimates

instructions for oceanographic reporting

forecast of radio propagation anomaly and magnetic activity

provision for comments and verification of the service

Mobile ASWEPS Teams. Mobile ASWEPS Teams provide on-scene dissemination to and support of tactical ASW commanders. The Teams interpret the products received from the regional FLEWEACEN to emphasize factors of particular interest to the commander, format them to meet his individual requirements, update these products with locally acquired data, and prepare tailored forecasts and briefings aboard the flag ship. Additionally they oversee the acquisition of data from the region of interest.

Prior to an operation, a briefing is held and the commander is informed of expected environmental conditions in the operating area. Environmental effects on sensors and weapons systems are discussed. The commander may then combine environmental information, mission requirements, and target intelligence

qualitatively and quantitatively to formulate tactics. This includes the geometry of force employment in order to realize predetermined effectiveness. These are preliminary decisions in which the NAVWEASERV environmentalist participates.

On station, the commander will confirm or revise predetermined tactics based at least in part on observation of environmental "truth" by the Mobile ASWEPS Team. This may be accomplished by observing the sea state, by measuring the ambient noise, or by dropping a bathythermograph. In the press of an engagement all that the commander really needs are short, simple estimates which he can apply based on his judgement. But in order that he might be able to do that, it is necessary that he be prebriefed and be provided a good fundamental understanding of the application of the environmental sciences to ASW/USW. Dissemination of oceanographic environmental support services by the Mobile ASWEPS Team contributes toward the attainment of that end.

Display. Displays of environmental prediction products are maintained in the Fleet Commander's flag ship, in FLEWEACEN/FAC, in ASW Operational Control Centers, and in other command posts. Displays vary in content depending on the method of transmission and on what the commander has asked for, but may include detailed, large scale representation of existing and predicted oceanographic conditions and tactical

indices (such as sonar range estimates for hull mounted, variable depth (VDS), and aircraft sonars, and recommended sensor settings). Information is presented as computer printouts, plastic overlays to daily status charts, static wall display, or by other means. Displays are designed to facilitate decision making.

CHAPTER VIII

EQUIPMENT

The accurate measurement of atmospheric and oceanographic parameters, which is vital to optimum Navy operations in the total environment, is possible only with properly installed, maintained and operated equipment. This equipment is unique, and it varies from relatively simple but precise instruments to highly complex electronic devices. The Naval Weather Service provides the necessary guidance and technical assistance to ensure effective and economical equipment installation, operation, and maintenance. This function is executed within their assigned area of responsibility by designated Fleet Weather Centrals and Facilities and the Pacific Missile Range (PMR). NAVWEASERVCOM's meteorological and oceanographic equipment program is staffed by specially trained, experienced officers designated as Meteorological and Oceanographic Equipment Technical Liaison Officers (MOETLO). Additional personnel include a select group of civilian engineers and military technicians.[1]

The Commanding Officers of ships and stations are ultimately responsible for the maintenance of assigned meteorological and oceanographic equipment. The services of the Naval Weather Service Command's meteorological and oceanographic equipment program are available to assist with

maintenance problems beyond the capability of onboard technicians and facilities. The program is operated by NAVWEASERVCOM under the technical guidance of NAVAIRSYSCOM (AIR-540) and NAVSHIPSYSCOM.

Assisting the fleet to do installation planning, check-out, and to maintain meteorological/oceanographic observing devices is a function of the maintenance departments of designated Fleet Weather Centrals and Facilities. The maintenance department operates a repair facility where major repair or rebuilding operations are completed on meteorological and oceanographic equipment. These same facilities may also furnish technical assistance to the unit which owns and operates the equipment. Maintenance is performed locally on the station or on board ship if it is possible to do so. Emphasis is placed on preventative maintenance and on swift emergency action to restore vital equipments to operation. The maintenance department of these Fleet Weather Centrals and Facilities, under the MOETLO, provides maintenance training, repair parts and procurement assistance for fleet oceanographic observing instruments. A ship and squadron visitation program is carried out to advise in maintenance matters and in observation reporting codes. Meteorological Oceanographic Equipment Technical Liaison Officers (MOETLO) also provide equipment operator training at the FLEWEACEN/FAC or in ship or

squadron spaces. Fleet units request NAVWEASERV assistance with maintenance problems beyond their capability as outlined in NAVWEASERVCOM Instructions of the 13950.1 series.

CHAPTER IX

TRAINING AND FLEET LIAISON

Training of NAVWEASERVCOM Personnel. Training of NAVWEASERVCOM personnel in observation, communications, maintenance, data processing, computer programming, and similar technical skills is accomplished at Navy schools. Professional level training is provided at the Naval Postgraduate School, Monterey, California. Civilian colleges and universities are used for special or doctorial training. Assistance to and guidance of FLEWEAFAC, NWSED, and Mobile ASWEPS Teams is provided by FLENUMWEACEN and the regional FLEWEACEN.

Fleet Training and Liaison. Perhaps the support function to which the application of the environmentalist's effort most clearly results in obvious benefit is that of training and fleet liaison. NAVWEASERVCOM provides fleet personnel schooling and guidance in the acquisition of environmental data and in the application of environmental support services.* Specific working knowledge and general background knowledge is

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*Fleet Weather Centrals conduct formal schooling for shipboard quartermasters-of-the-watch (QMOW) in synoptic environmental observation, encoding, recording and transmission. Based on input from NAVWEASERVCOM, schooling in the tactical application of environmental factors is provided at the Destroyer School, at the Submarine School, and at the Replacement Air Groups (RAG).

provided. Fleet Weather Centrals maintain a small oceanographic library stocked with reference manuals for issue to the fleet.

NAVWEASERVCOM participates in the environmental education of the operator for it is the tactician's appreciation of the arena of encounter, together with a knowledge of the nature of his adversary that will determine whether or not he can accomplish his mission. In order that he be aware of the degradation of weapons systems performance caused by environmental considerations and in order to improve operational effectiveness the fleet operator is continuously appraised of where such degradation is expected and how serious it is expected to be. In order that such environmental support services be effectively utilized each Fleet Weather Central maintains close liaison with the fleet units it is assigned to support. Time for environmentalist-operator cross training is at a premium so liaison is intensive in order to be efficient. The goal is that the environmentalist remain cognizant of the operator's problems (such as equipment maintenance, crew turnover, and large area forecasts which are not specific enough); and that the operator have an understanding of the capabilities and limitations of the environmentalist (the importance of sufficient high-quality data, the simplifications of the mathematical models employed, the vagaries of the sea and atmosphere and of complicated electronic sensor/weapons systems).

Environmental forecasts (ASWEPS, surf forecasts for amphibious assault, meteorological forecasts for air strike warfare) form an important part of mission planning. Even so it is important to obtain environmental observations in the area of operations, which may be remote, where forecasts lack accuracy, or where an accurate forecast may have deteriorated during transit time. An adequately trained operator will be able to sample his environment, to compare it to what he was told to expect, and to adjust accordingly. He will be able to recover from a bad forecast.*

Fleet Liaison to Assure Responsiveness. It is evident that environmental support of naval missions over the forseeable future requires that the Naval Weather Service maintain close liaison with its fleet customers. Each field activity of the Naval Weather Service Command carries out fleet liaison that can be compared to market research. Continuous working level contact is maintained in order to keep abreast of evolving fleet requirements for environmental prediction products so that the Service might remain responsive. This

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*In July 1968, after working closely with the RAG for more than a year, the Officer-in-Charge of the Naval Weather Service Environmental Detachment (NWSED) Patuxent River, Md. compiled Oceanographic Environmental Services, Applications and Techniques (U), NDW-NATC 3360/2, the text of a two-weeks course of instruction in the application of the environmental sciences to air antisubmarine warfare.

liaison is dedicated to ascertaining the adequacy of present services, the specific products/services needed, and the best way to respond to this need. Thus as a result of fleet utilization, evaluation and feedback, the Naval Weather Service is able to effect improvements and adjustments to insure that forecasts are reliable and are presented as useful tactical indices.[1]

CHAPTER X

R&D

Background. Navy environmental research functions are designed to improve environmental support to naval operations and include the development of automatic weather stations and shipboard instruments for observing and recording environmental conditions at sea. The Navy performs about two thirds of its environmental research and developmental work itself and contracts for the remainder.[1]

In the Department of the Navy, the Naval Air Systems Command, under the Chief of Naval Material, is responsible for most of the supporting meteorological research. The research is conducted at the Engineering Development Laboratory, Johnsville, Pa.; Navy Weather Research Facility, Norfolk, Va. and Suitland, Md.; Naval Ordnance Laboratory, White Oak, Md.; Naval Avionics Facility, Indianapolis, Ind.; and at the Naval Research Laboratory, Washington, D.C. (where both meteorological and oceanographic supporting research is done, as is the case at FLENUMWEACEN). Basic or pure oceanographic research is a function of the Oceanographer of the Navy.

COMNAVWEASERV has working relationships with NAVOCEANO, with NAVAIRSYSCOM (AIR-540), with the Naval Weather Research Facility, and with the academic community in order to

integrate the development of systems for the operation of which he will be responsible. The Naval Weather Service benefits from research programs encompassing both basic and applied research, the requirements for which are validated by the Commander of the Naval Weather Service Command. All research is related in some degree to the improvement of the environmental support services provided to the fleet; however much of the basic research in meteorology is designed to increase understanding of atmospheric processes and the interaction of the atmosphere and the ocean.[2]

Applied Research in NAVWEASERVCOM. Research and development within the Naval Weather Service Command is applied research and is directed toward numerical and long range environmental predictions, both meteorological and oceanographic. Applied research is defined as those supporting research and development functions which have as an immediate objective the improvement of services to the fleet. FLENUMWEACEN is the focal center of the computer development program of the Naval Weather Service Command, ongoing research and development in numerical methods is aimed at enhancing the physical realism of the models and expanding their application. Particular emphasis is given to the development of products that are simple for the fleet to apply.

Supporting Oceanographic R&D by NAVOCEANO. Under the Oceanographer of the Navy, NAVOCEANO is responsible for developing oceanographic prediction techniques and instruments and applying them to naval operations on an experimental basis. As these are developed and proved of value to the Navy the prediction technique and/or system is transferred to COMNAVWEASERV for application in support of naval operations on a full time basis.[3]

CHAPTER XI

MANAGEMENT ABOVE THE FUNCTIONAL LEVEL

Management and general supervision and coordination of the entire spectrum of environmental support to naval operating forces is focused at the Headquarters, Naval Weather Service Command, Washington Navy Yard, Washington, D.C.

Under responsibility implicit and explicit in his mission statement COMNAVWEASERV acts as the central point of contact and authority within the Department of the Navy for meteorological and related oceanographic matters.[1] He provides guidance and direction and coordinates all elements of the Naval Weather Service system. The Commander coordinates with and assists the Fleet Commanders-in-Chief and the Chief of Naval Air Training in their authoritative control over the product output of the Fleet Weather Centrals and Facilities.

COMNAVWEASERV budgets for and allocates operating funds to NAVWEASERVCOM field activities; and for other functions such as the observations aboard Coast Guard Ocean Station Vessels. He acts as a Navy Program Element Sponsor in the preparation of the Five Year Defense Plan. He provides the Naval Material Command, bureaus, Navy Comptroller and other commands and offices with operational requirements for support consistent with approved programs.

COMNAVWEASERV ascertains the present and future requirements of the Department of the Navy for Meteorological and short term oceanographic forecasting support, including research, technical equipment and allowances, material maintenance, intelligence, supplies, communications, and publications; he initiates action and collaborates with cognizant commands, bureaus and offices to monitor and meet these requirements.

COMNAVWEASERV maintains liaison with and provides Naval representation to various committees, groups and organizations of a military, governmental, commercial, scientific, or professional nature, with regard to meteorological and related oceanographic subjects. He collects, evaluates and utilizes information pertaining to systems, equipment, techniques, procedures, and research and development efforts of other meteorological agencies.

COMNAVWEASERV provides professional and technical advice on meteorological and assigned oceanographic matters to the Chief of Naval Operations. He develops, prepares, maintains, reviews, and submits to the Chief of Naval Operations, meteorological research and development requirements and associated documents. He appraises the capabilities and efforts of the Navy to provide meteorological and specific oceanographic services including readiness, utilization of resources, and operating efficiency thereof in support of objectives

established by the Chief of Naval Operations. COMNAVWEASERV reviews operations plans/orders of major commands and joint/combined plans and policies and initiates suitable measures to insure that meteorological and oceanographic support is provided for and is in consonance with policy.

COMNAVWEASERV maintains liaison with governmental public information services concerning meteorological and assigned oceanographic activities of the Navy. He initiates, reviews, and recommends action on proposals to establish or disestablish Navy meteorological activities or billets. COMNAVWEASERV reviews Military Construction Projects pertaining to the Naval Weather Service Command. COMNAVWEASERV inspects field activities of the Naval Weather Service Command and provides technical inspection assistance to other Navy activities. He inquires into, and reports on matters of discipline, efficiency, readiness, and effectiveness as related to meteorological and assigned oceanographic functions.

Management, supervision, administration, and logistic support are considered an integral part of units at the functional level. Decisions which must be made at the Commander's level are those decisions with external ramifications and those which may create conflict in the accomplishment of the various functions, or among the various FLEWEACEN. Management of the Naval Weather Service system requires recognition of the economic, political, and competitive

milieu, plus perception of the niche occupied by the Naval Weather Service in the larger system of national and global environmental prediction agencies.

CHAPTER XII

CONCLUSIONS

In order for the Naval Weather Service to be quickly responsive to the needs of the fleet for environmental support, to adapt, to diversify into new product lines, COMNAVWEASERV has delegated significant authority and responsibility to his field activities. Commanding Officers of FLEWEACEN/FAC enjoy a substantial degree of autonomy. Decentralization minimizes administrative delays in responding to fleet requirements. The Naval Weather Service Command is decentralized to an extent unusual for a military organization.[1] It is recognized, however, that decentralization could not be effective unless adequate controls are maintained to insure that decisions do not deviate too far from established policy. To that end effective communication is maintained with the field; NAVWEASERVCOM Area Representatives report directly to COMNAVWEASERV and provide liaison with Fleet Commanders-in-Chief and the Chief of Naval Air Training; and COMNAVWEASERV inspects to insure the maintenance of high professional standards and regards discipline, efficiency, readiness, and effectiveness.

In implementing his responsibility for the functioning of the Naval Weather Service system COMNAVWEASERV originates, promulgates, and maintains current policies and directives.

Extensive background information and broad policy discussions are provided to facilitate the decision making process at each level of the Command. All decisions made at subordinate levels come under the control of the Commander's policy. In this sense the Commander's policy is a statement of the basis for reaching decisions at any point in the system. Specifically, statements of policy, directives and procedural information provide guidance in the various functional areas entailed in the operation of the system (data acquisition, data processing, product formulation, and dissemination to users). The Commander's treatment of each subject generally includes, where applicable, background information, policy statement, and specific directive. Frequent meetings and constant communication, written as well as oral, insure that the Commander's estimate of the milieu, the budget situation, the activities of other environmental agencies, and the state of the art in technology and in the environmental sciences are passed to the field.

Basic to decentralization is the flow of meaningful information from the field to the Headquarters. In order to establish broad guidelines for future activity and to make specific decisions on programs and projects the Commander must be appraised of conditions in the field. This interchange of information between the Headquarters and the field allows for the development of the premises which underly

decisions concerning system-wide functional adjustments. Inputs to the Headquarters from the FLEWEACEN/FAC include applied research into the needs of the fleet. The more aggressive FLEWEACEN/FAC Commanding Officers are frequently cognizant of the development of fleet needs as soon as the fleet operator himself.[2] Close liaison with the fleet is maintained. Environmentalists and technicians visit the fleet, and fleet operators visit the Fleet Weather Centrals to discuss the responsiveness of the Naval Weather Service to fleet needs. Problems thereby uncovered are promptly acted upon, and the benefit of lessons learned is passed to Headquarters and throughout the Service.

Throughout the system information flows in all directions: top-down, bottom-up, and horizontally; it provides an effective control mechanism, and allows COMNAVWEASERV to assign authority and responsibility for most functional decisions to the Commanding Officers of the FLEWEACEN/FAC. With efficient communication the Commanding Officers of the Fleet Weather Centrals are provided with more nearly complete information on which to base more effective decisions.

This information flow serves as a basis for planning, for the adaptation of the Naval Weather Service to the evolving needs of its milieu. The management of the Naval Weather Service Command is characterized by planning at the functional level. FLEWEACEN/FAC do their own planning.

Planning is not done arbitrarily at the Headquarters and dictated to the field activities. If planning is to be intelligent, realistic and enthusiastically supported it must be done by those who are going to have to live with it. The Headquarters engages in high level planning. Headquarters establishes policy and promulgates guidelines. Implementative planning is done at the functional level, then these plans are submitted to the Headquarters for review in order to insure that they conform to policy.[3] Planning, organization, communication and control is integrated throughout the Naval Weather Service Command. The Command is structured to adjust to the dynamic situation in which it operates. The structure identifies responsibilities, discourages empire building, and provides for adjustment as the situation changes. This operative theory of management provides a conceptual framework for integrated decision making, a framework within which subordinates operate.

The decentralized structuring of the Naval Weather Service Command contributes to making it more than a mechanistic, impersonal organization. It is structured so primarily to respond efficiently to the needs of the fleet. Beneficially, decentralization serves to develop creativeness and adaptiveness on the part of management at the functional level and to provide a basis for growth and training of personnel; for there is the dichotomy of narrow professional skills

(meteorology, oceanography, environmental equipment engineering) in contrast to the more general knowledge required to manage. It is also a means of relating the environmentalist and the technician to the Service, increasing both the individual's morale and organizational productivity through participative processes. The Naval Weather Service Command appears dedicated to decentralization. Improvements in the information-decision system have not operated to centralize the Naval Weather Service Command.

Elsewhere the integration of functions, the application of the systems concept, automatic data processing, and more effective information-decision systems have been a force for centralization of decision making, along with an expanded staff at the headquarters level, and fewer personnel with duties of more programmed content at the functioning levels. It is apparently the view of those agencies which have centralized/recentralized that they had previously been forced into patterns of decentralization because they lacked adequate control. With the maturing of the management sciences, with better information they argue that it is possible to centralize decision making. Speed and flexibility are feasible despite large size, headquarters need not depend on the field for judgement and experience input.[4] HOOS has noted that this leads to the shrinking of job opportunities in the field, downgrading and so on.[5]

The Naval Weather Service Command provides the opportunity for the ambitious and creative manager in the field to distinguish himself. The manager at the functional level, the Commanding Officer of the FLEWEACEN/FAC, receives inputs of goals and constraints from Headquarters; insofar as possible he is provided with the wherewithall and with full information in order that he might make decisions for the effective and efficient functioning of the Naval Weather Service system in his area of the globe.

NOTES

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5. Wyle, Peter K., Oceanography, An Introduction To The Marine Environment (New York: John Wiley & Sons, 1970), p. 27.

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both atmosphere and ocean are used to prepare ocean and weather analyses and forecasts. The Navy distributes both oceanographic and meteorological 'products' over a single worldwide communications system." The Panel on Environmental Monitoring of the Commission on Marine Science, Engineering and Resources, "Report of the Panel on Environmental Monitoring," Panel Reports of the Commission on Marine Science Engineering and Resources, Volume 1, Science and Environment (Washington: U.S. Gov't. Print. Off., 1969), p. II-13.

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7. See the U.S. Department of Commerce Manual of Marine Meteorological Observations, Circular M, (Washington: U.S. Gov't. Print. Off., 1963) for details.

8. Navy oceanographic data is broadly distributed. More than 90% of the Navy's oceanographic information is made available to other users, further much of the Navy's classified data is of little use or interest to other agencies. Institute of Naval Studies, Center for Naval Analyses, University of Rochester, The Navy's Role in the Exploitation of the Ocean (Project BLUE WATER), Phase I, p. xiii.

9. The Federal Coordinator for Meteorological Services and Supporting Research, The Federal Plan for Meteorological Services and Supporting Research, (Washington: U.S. Gov't. Print. Off., 1970), p. 19.

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11. As for example by Carzo, R., Jr. and Yanouzas, John N., Formal Organization, A Systems Approach (Homewood 111.: Richard D. Irwin and The Dorsey Press, 1967) and Johnson, Richard A., et al., THE THEORY AND MANAGEMENT OF SYSTEMS (New York: McGraw Hill Book Company, 1967).

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