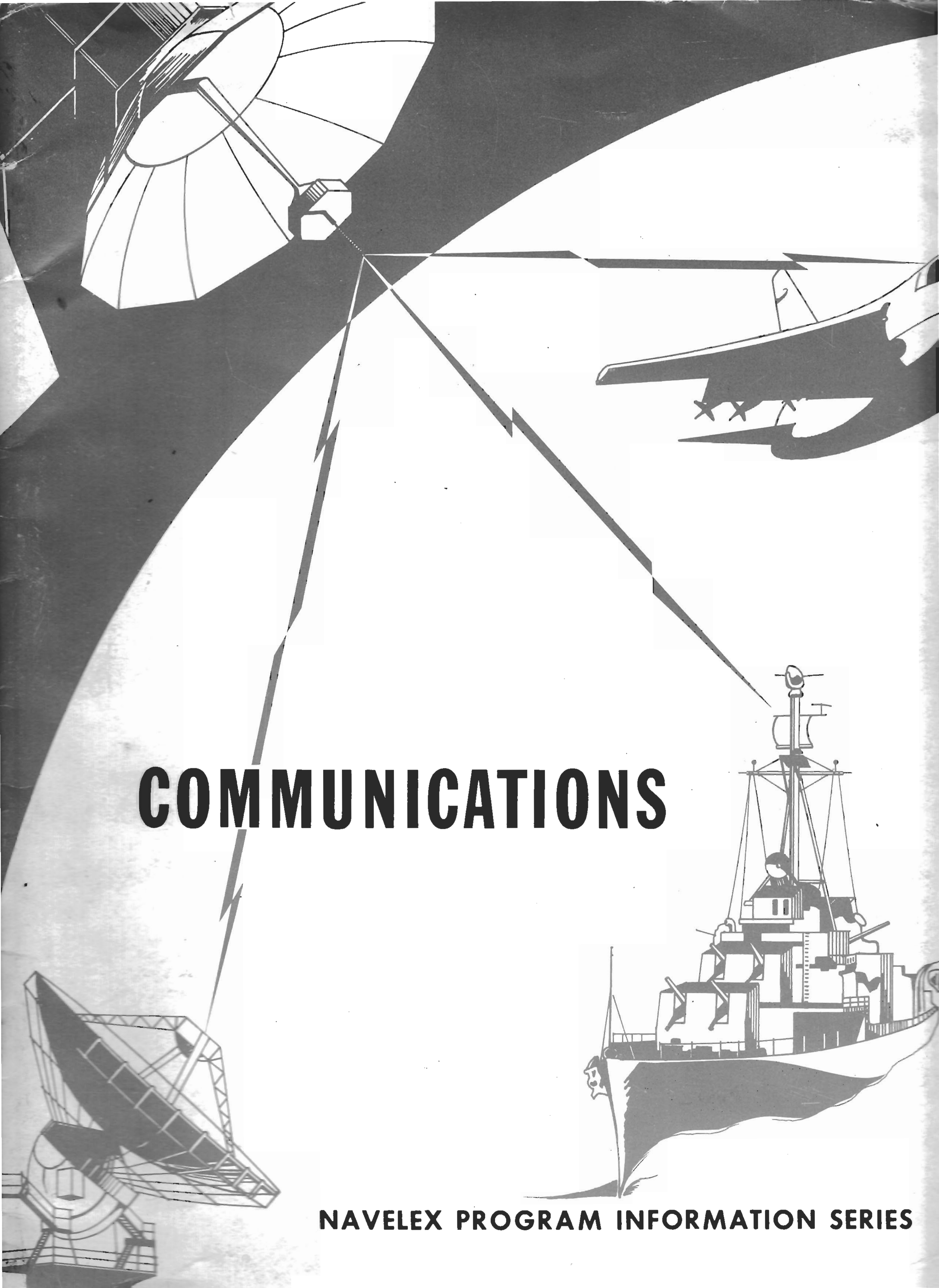
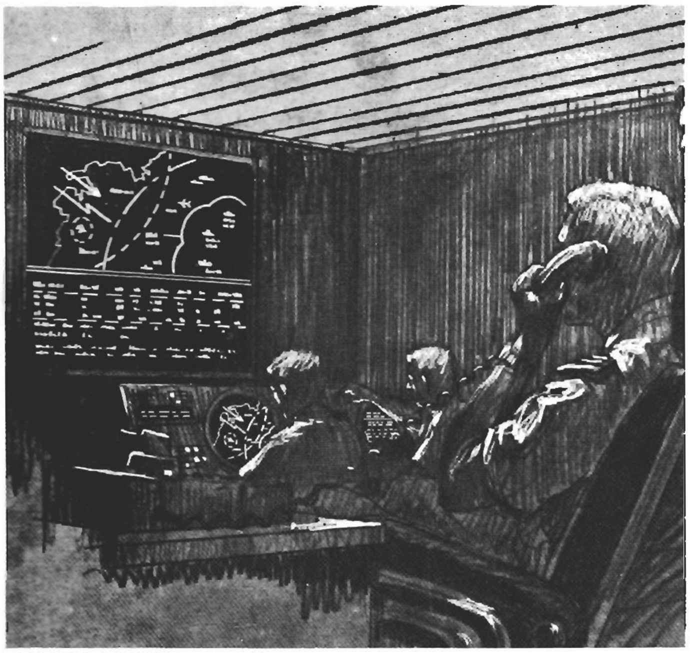


COMMUNICATIONS

NAVELEX PROGRAM INFORMATION SERIES

Naval Electronic Systems Command
Department of the Navy
Washington, D. C. 20360
1975

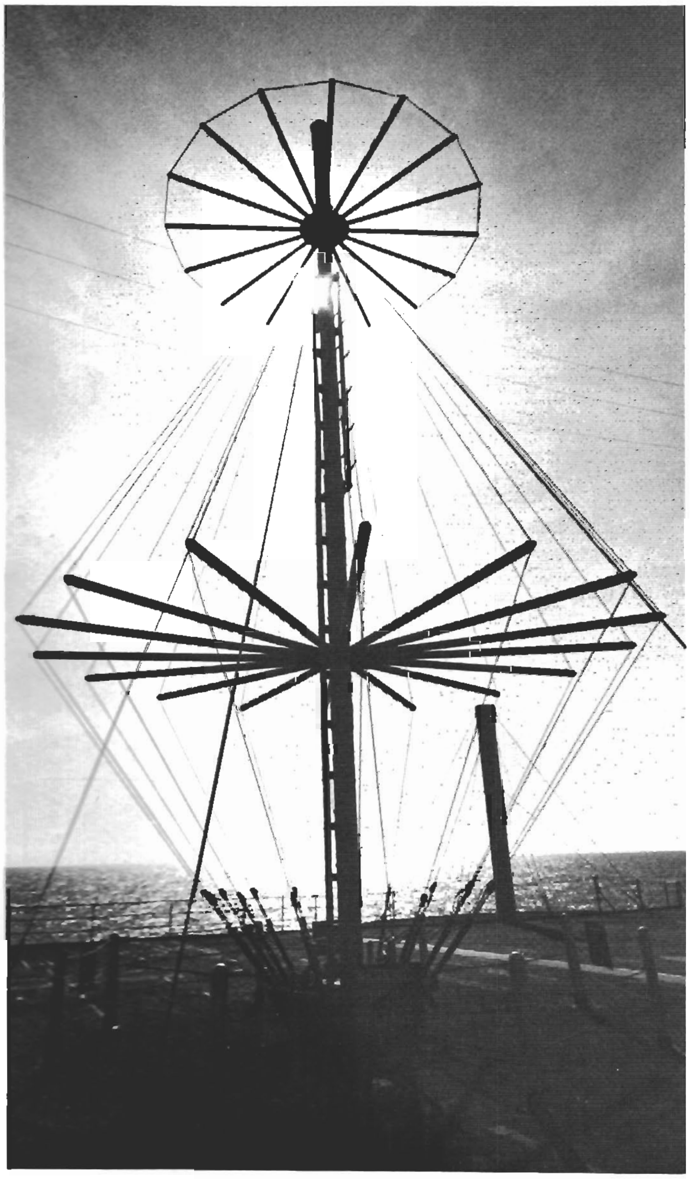


COMMUNICATIONS

In 1966 the Naval Electronic Systems Command was designated as the single manager for electronic systems in the Navy, with responsibility for the development, acquisition and material support of communications, command and control, REWSON, space, navigation and air traffic control systems. The NAVELEX Program Information Series describes important segments of the Command's activity. This publication presents the history, current status and program planning for communications equipment and systems.

Communications is the information transfer process by which a commander exercises direction over assigned forces in the accomplishment of his mission. It is a vital link in the increasingly sophisticated naval warfare systems now being developed and planned. To be effective, Naval communications must be simple to operate and maintain, as well as reliable, secure and rapid under wartime operating conditions.

NAVELEX's communications responsibilities include providing systems engineering support for the Naval Telecommunications System. This is the Navy's nervous system, a global network that spreads its circuits wherever mission requirements dictate, linking Navy and Marine Corps surface and air units and submarines to command headquarters, and interfacing with the communications facilities of the other U. S. services, our allies and commercial networks. Working closely with the Naval Telecommunications System Architect, NAVELEX translates program concepts and requirements into actual communications systems.



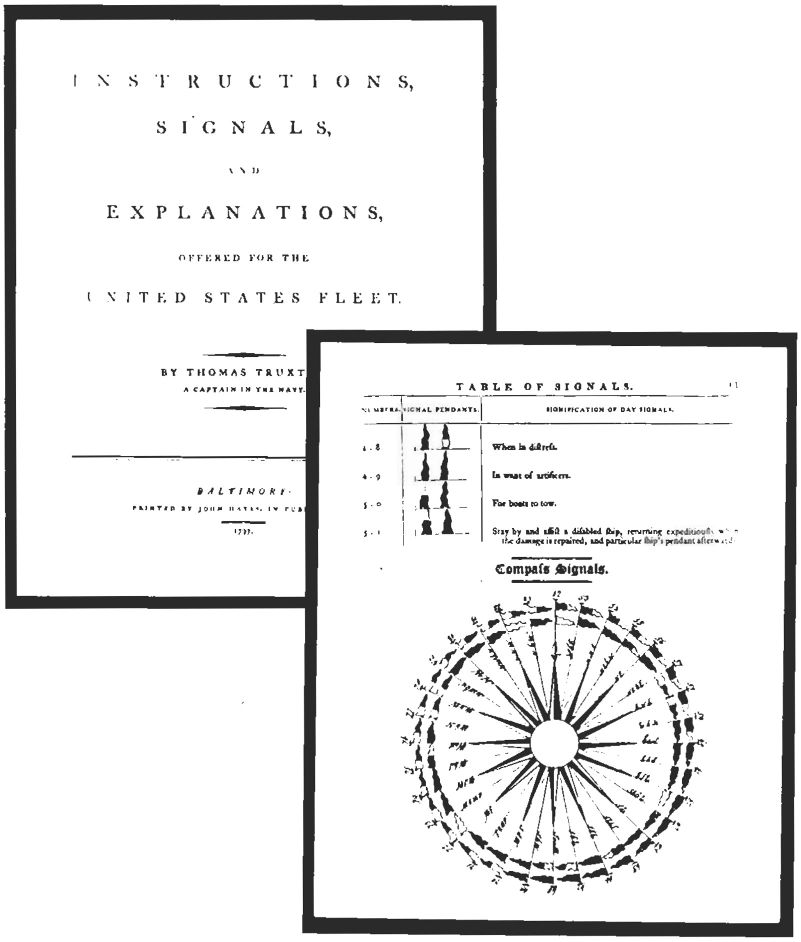
EARLY NAVAL COMMUNICATIONS

Until the present century, a ship's isolation was complete once she left port and disappeared over the horizon. Ships in company or passing could "speak to" each other by voice hail or signal using flags by day or lanterns by night. But once at sea orders or instructions from higher command not in company could not easily be altered. Although for centuries the oceans have been the great highways of the world they also have been silent barriers. The introduction of radio and the further development of electronics have bridged these barriers and provided the means for exercising command and control of ships at sea through long-range communications.

From the origin of the United States Navy the ability to communicate has been recognized as an essential element of naval operations. In 1776 the Continental Congress, which established the Navy, issued naval signal instructions based on the manipulation of sails and the positions from which flags were displayed.

Until the turn of this century and the advent of radio, naval communications were limited to visual signals with ranges of nine miles by day and sixteen miles by night under favorable conditions. The acute need for some means of rapid communications between the Navy Department and fleet units was graphically demonstrated during the Spanish-American War in 1898. Messages addressed to Commodore Dewey in the Western Pacific were transmitted by telegraph, but had to be delivered by courier ship from Hong Kong, since the Manila terminal of the submarine cable was in the hands of the Spanish. In the Atlantic messages for Admiral Sampson were delivered by courier ships from U.S. ports.

In view of the growing tendency to make naval strategic decisions in Washington which was evidenced during the war with Spain, and the unsatisfactory communications experienced between the Navy and Army during joint operations along the south coast of Cuba, the advent of radio was most timely and the Navy Department became interested in its possibilities immediately upon the conclusion of that conflict.



INSTRUCTIONS,

SIGNALS,

AND

EXPLANATIONS,

OFFERED FOR THE

UNITED STATES FLEET.

BY THOMAS TRUXT

A CAPTAIN IN THE NAVY.

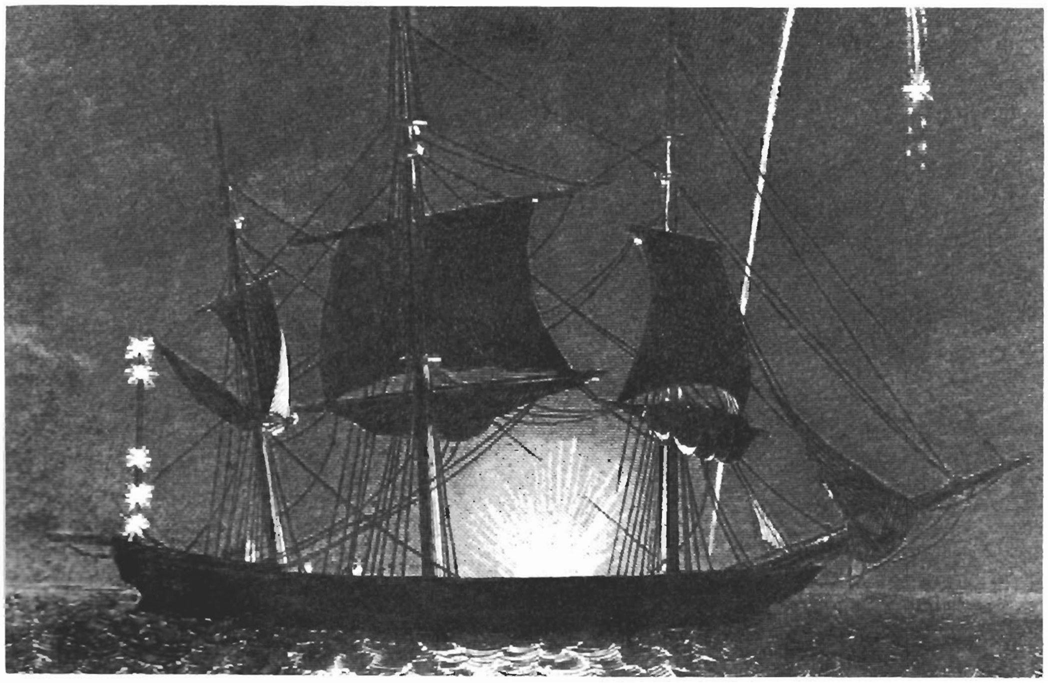
BALTIMORE:

TABLE OF SIGNALS.

	SIGNAL PENDANTS.	SIGNIFICATION OF DAY SIGNALS.
4 . 8		When in diſtreſs.
4 . 9		In want of artificers.
5 . 0		For boats to tow.
5 . 1		Stay by and aſſiſt a diſabled ſhip, returning expeditiouſly when the damage is repaired, and particular ſhip's pendant afterwards.

Compaſs Signals.

THE TRUXTON SIGNAL BOOK,
PRINTED IN 1799, WAS THE BASIS OF
NAVAL COMMUNICATIONS UNTIL THE CIVIL WAR



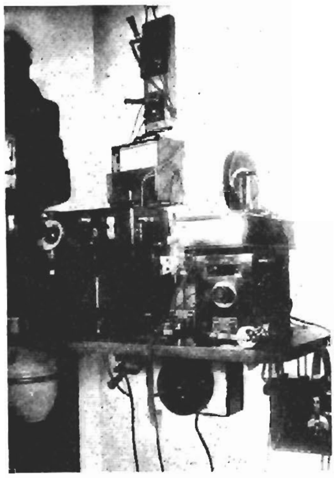
SIGNALLING AT NIGHT USING ROCKETS, LANTERNS AND FALSE FIRES

INTRODUCTION OF RADIO

Guglielmo Marconi had begun the engineering development of his commercial radio equipment in 1895, and soon thereafter was involved in a series of demonstrations, tests and commercial applications of his equipment. When the *New York Herald* invited him to report the 1899 America Cup Race, a board of four naval officers was appointed to witness and to report on the operation of the Marconi radio equipment. The board reached the conclusion that radio could be made useful in signaling between ships and shore, and would work under all conditions of weather. The Navy Department then undertook to arrange for further testing of the equipment aboard ship. Marconi proceeded to conduct tests involving the USS NEW YORK, MASSACHUSETTS, PORTER, and the Navesink Lighthouse. Although the tests were successful, reasonable arrangements for the installation of equipment in Navy ships could not be worked out with Marconi. The Navy Department then embarked on a deliberate program of comparative testing, resulting in an initial procurement of 20 "production" radio sets for installation in Navy ships in March, 1903. By the end of 1904, 33 U.S. Navy ships and 18 shore stations were radio-equipped. Although this new capability was not accepted with enthusiasm by all senior commanders, and still had rather serious operational limitations, primarily with respect to interference, a new dimension had been introduced into naval communications.

GROWTH OF RADIO COMMUNICATIONS

By the summer of 1907, radio equipment was installed in all naval surface vessels, and low-powered shore radio stations had been in operation for four years. Naval communications in 1912 had advanced sufficiently to permit sending messages from aircraft to ships and from submarines to shore, and Radio Research Laboratories had been established at the New York and Washington Navy Yards. In that same year the Naval Radio Service was established.

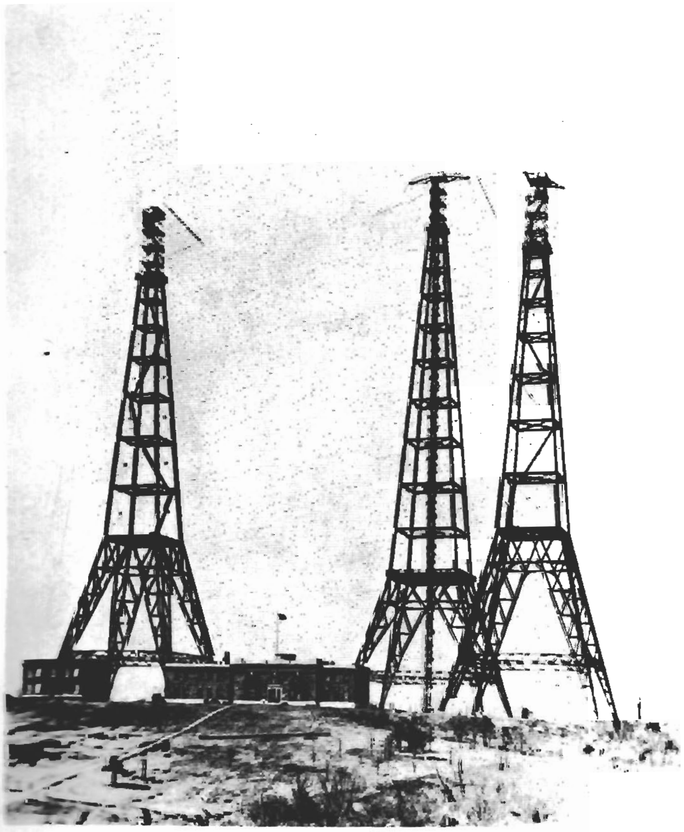


RADIO TELEPHONE EQUIPMENT INSTALLED IN USS CONNECTICUT, USED IN FIRST SUCCESSFUL SHIP-SHORE VOICE TRANSMISSION WITH NAVAL RADIO STATION, PT LOMA, CALIFORNIA, IN 1908

USS CONNECTICUT -- FLAGSHIP OF THE "GREAT WHITE FLEET," 1907

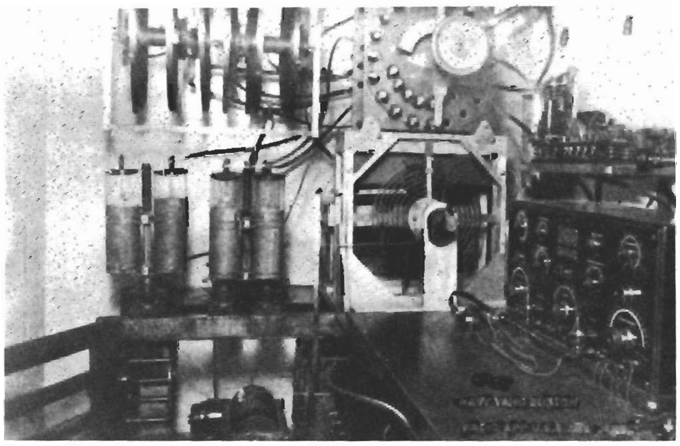
On February 13, 1913 the first Navy high-power radio station, known as Radio Arlington, was placed in commission. One 600-foot and two 450-foot towers, and a Fessenden 100-kW, synchronous rotary spark transmitter and a 35-kW Federal arc transmitter were installed. This radio station, in conjunction with a series of coastal relay stations, was intended to insure positive and rapid communications between the fleet and the seat of government in Washington, and represented an early effort to achieve command and control of naval forces.

This system was soon put to the test when in 1914 President Wilson ordered the Navy to land troops to seize and occupy the city of Vera Cruz, Mexico. Due to the large distances involved, the high-powered Arlington transmitters were unable to establish direct communications with the ships at Vera Cruz, and the relay station at Key West, the closest shore station, also was unable to reach them. Two-way communications were impossible, in any case, because the shipboard transmitters were not powerful enough to reach Key West. The problem was solved by stationing the USS BIRMINGHAM off Tampico, Mexico, as a relay station between Key West and the USS WYOMING at Vera Cruz, and techniques were worked out that enabled satisfactory day and night communications to be maintained throughout the entire operation. Local interference caused by the spark transmitters of foreign men-of-war at Vera Cruz started out to be a serious problem, but it was effectively circumvented by the commanders present working out a time-sharing plan which assigned interference-free periods of operation to each nation. This was the first recorded instance in which electromagnetic interference threatened to hamper naval operations, and it is noteworthy that the difficulty was so quickly resolved by cooperation among the parties involved.



NAVY RADIO TRANSMITTING ANTENNAS
ARLINGTON, VA. 1913

KNOWN AS "THE 3 SISTERS,"
FOR MANY YEARS THE WORLDS MOST
POWERFUL RADIO STATION

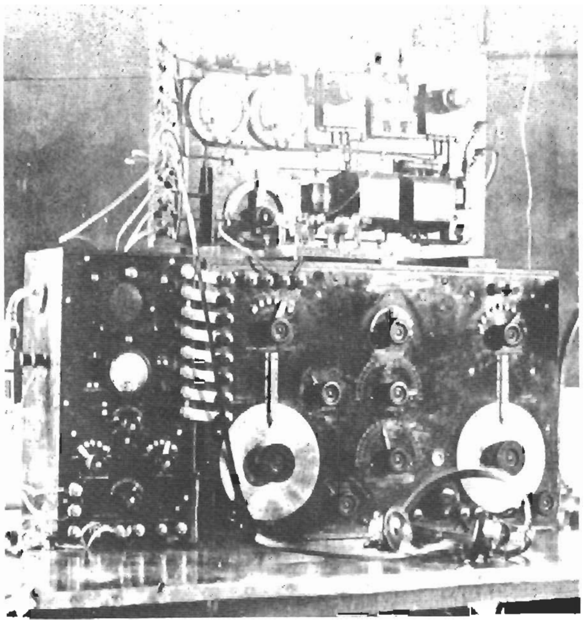


EARLY RADIO COMMUNICATION INSTALLATION—
BATTLESHIP USS NEW JERSEY (1914)

WORLD WAR I COMMUNICATIONS

When the United States entered World War I, the Navy was operating the world's largest radio network. The Naval Communications System handled not only all messages for U.S. Naval forces at sea, but also those between the War Department and the American Expeditionary Forces in France and all messages to and from Europe for the President, the State Department, and other government agencies. The Navy Radio Station, New Brunswick, transmitted President Wilson's "Fourteen Points" directly to a German radio station in January, 1918 and in October, 1918 the Chancellor of Germany addressed a message to the Director of Naval Communications informing the President of German readiness to comply with our terms.

Wartime operations resulted in the development of the "broadcast" method of delivering orders and information to the fleet. This required ships to copy definite schedules on which messages were transmitted with concealed headings, permitting the fleet to maintain radio silence until contact was made with the enemy. Another important wartime lesson learned was the need for strict radio discipline.



NAVY RADIO OPERATOR'S STATION, WINTER HARBOR, MAINE—1918

NAVY DEPARTMENT COMMUNICATION UNIT — 1919

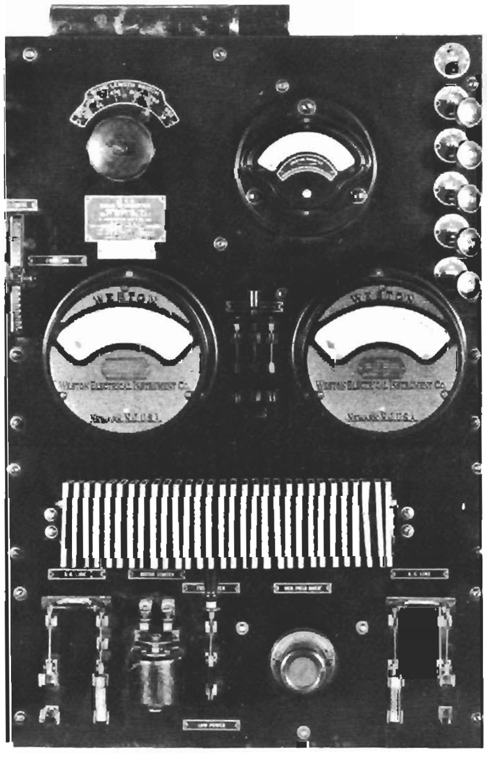
POST WORLD WAR I DEVELOPMENT

With the return to peacetime operations, it was apparent that naval communications urgently required greatly increased equipment reliability, the elimination of radio interference, and improved operator proficiency. Efforts to effect improvements in these areas were handicapped by the limited funds available for research and for the purchase of improved equipments.

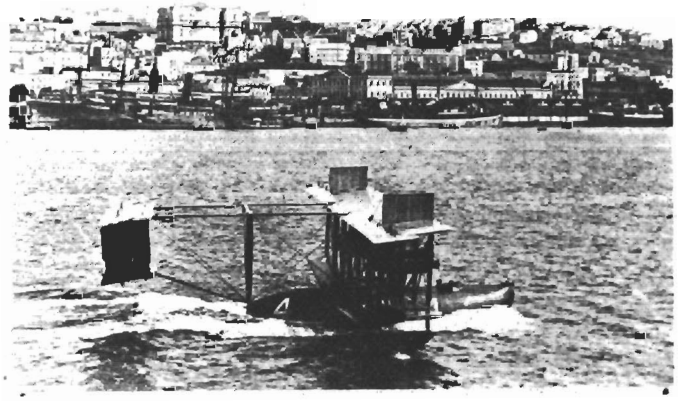
A tremendous boom in the civilian use of radio which occurred in 1922 had far-reaching effects on naval communications. At the beginning of the year there were only eight licensed broadcasting stations in the United States, but by May there were 279, and at the end of the year 569, with an estimated two million radio receivers in the country. Every one of these commercial stations was broadcasting on an assigned frequency between 500 and 1500 kHz, the same band used by the Navy. Interference naturally increased with the increased density of stations in the area. Along the coastal areas the Navy's high-powered arc transmitters disrupted reception on home receivers, and commercial broadcasting increased the difficulty of receiving messages transmitted by Navy radio.

As a result the Navy was directed to broadcast on a not-to-interfere basis with commercial radio. Meager funds appropriated for new Navy equipment had to be diverted to modify transmitters to reduce interference. In the long run the mutual interference forced the Navy to move to frequencies higher than those in the standard broadcasting band, which proved to be most beneficial.

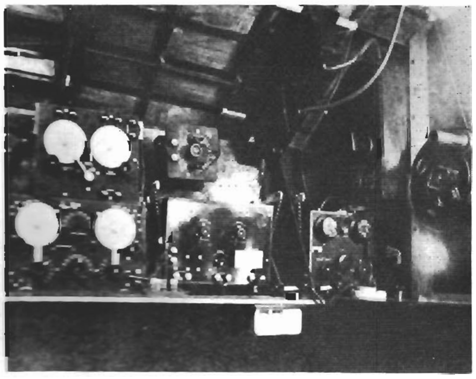
Several significant events occurred in Naval Communications between the two World Wars:



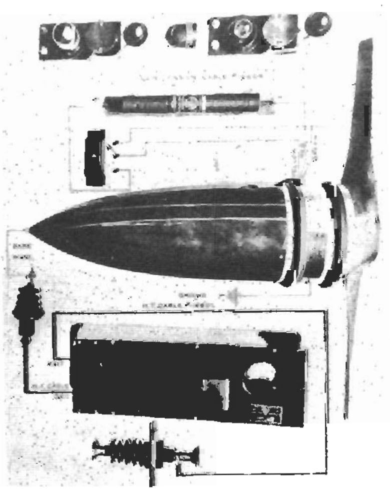
500 WATT NAVY SPARK TRANSMITTER—1919



NAVY NC-4 ARRIVING LISBON, PORTUGAL
MAY 27, 1919



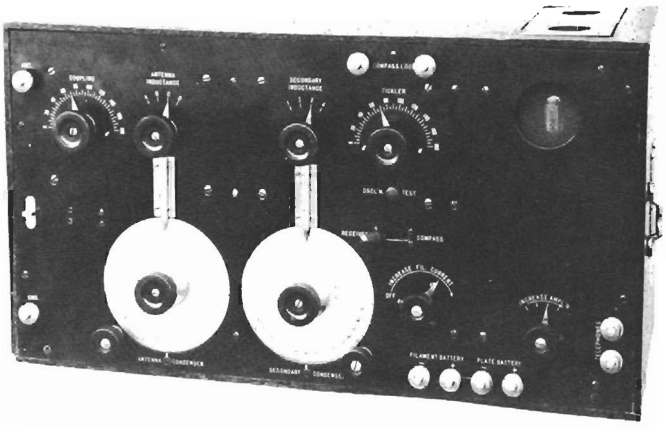
RADIO SET INSTALLED IN NC-4



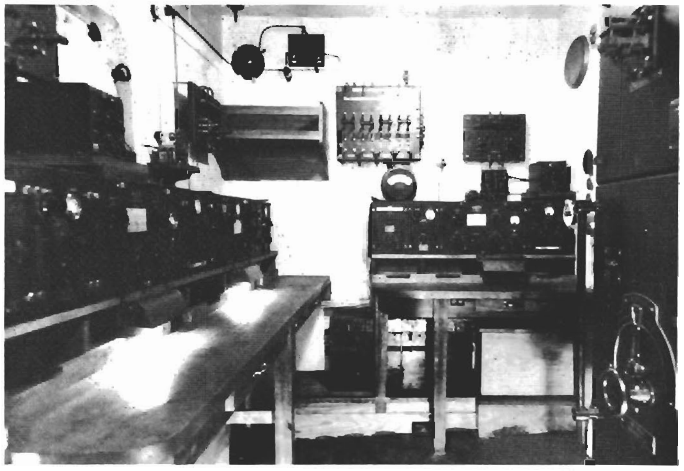
GENERATOR FOR NC—4
RADIO EQUIPMENT

- The Navy seaplane NC-4 completed the first Atlantic crossing by an airplane in May 1919. Radio communications were maintained with U.S. Naval radio stations or ships stationed along the route during the entire trip.
- Communications were made a part of the Battle Efficiency Competition in 1923, to encourage the interest of ships' commanding officers in that area of operations.
- The dirigible SHENANDOAH made her shakedown cruise across the United States in October, 1924 with a high frequency radio installed. She maintained reliable communications with the Naval Research Laboratory on a frequency of 3200 kHz, and her transmissions were received by a ship at a distance of 4200 miles.
- The Naval Research Laboratory developed the first crystal controlled transmitter in 1924; it was placed in service to handle traffic from Washington direct to Balboa, Canal Zone.
- The Naval Communications Service continuously expanded the services provided to mariners. These included time signals, hydrographic notices, meteorological reports, storm warnings, weather forecasts and obstruction reports. Radio direction finder services were rendered upon request.
- Material developments included improvements in vacuum tubes, the standardization of shipboard communications equipment, and research and development of high frequency equipment.
- The first of several high-powered vacuum tube transmitters was delivered to the Navy and installed in the Naval Radio Station, Cavite, Philippine Islands in 1932.

When the United States entered World War II there were 802 licensed radio broadcasting stations transmitting to more than 51 million receivers. Of the approximately 122,000 personnel in the Navy, about 1,500 officers and 10,500 enlisted men were engaged in communications.



RADIO RECEIVER BUILT BY WASHINGTON NAVY YARD FOR INSTALLATION IN THE WHITE HOUSE—1921



RADIO ROOM, USS DALLAS (DD199)—1925

WORLD WAR II OPERATIONS

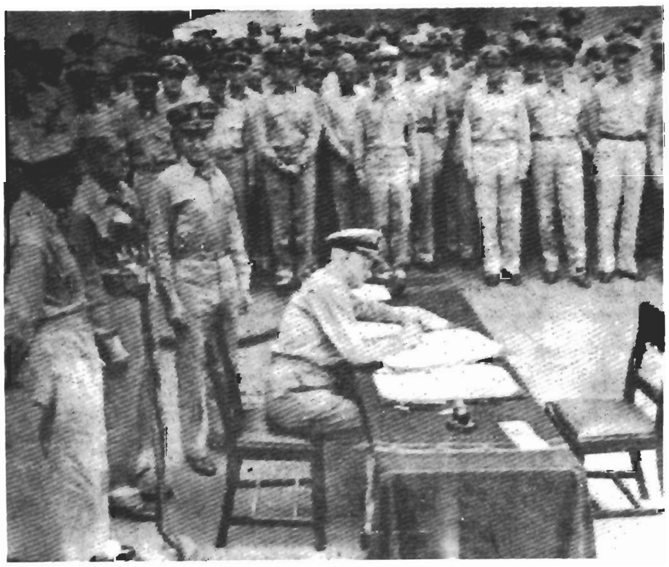
Until the outbreak of World War II development of naval communications equipment had been confined largely to the part of the frequency spectrum below 30 MHz, with the Navy depending almost entirely on its own research facilities for the development of radio equipment suited to its needs. When the United States entered the war, the Navy's need for radio equipment was so critical that it was necessary to reclaim receivers used during World War I and to convert them to the use of tubes and alternating current. Commercial designs were also adapted to ship installations, but most of the requirements for the rapidly growing fleet were met by new and vastly superior equipment. New techniques for handling large volumes of traffic were developed and higher frequencies utilized. The global aspects of the war spurred the expansion of circuits into systems and systems into world networks. In December, 1941 the Navy's first landline teletypewriter system linking activities at Washington, Norfolk, Philadelphia, New York, New London, Boston and Portsmouth, N.H., was established. The East and West Coasts were soon joined, and Hawaii was included in the teletypewriter network in 1945.

Secure communications between the ships of a task group or convoy and between surface ships and aircraft was facilitated by the development of the high frequency voice radio, with a range of something less than 30 miles. By 1941 many ships of the Navy, destroyers included, were equipped with the TBS – a low-powered, short-range voice radio dubbed "Talk Between Ships". Other types of radiotelephones were also in use. A portable set (the TBY) was eventually supplied to many merchantmen, and aircraft were provided with special radiotelephones.

Born with voice radio was the fighter-director system by means of which a destroyer carrying a trained fighter-director officer could summon friendly aircraft and coach the fighters into position to intercept attacking enemy bombers. TBS also enabled a destroyer to exchange words with a shore party equipped with "walkie-talkie" radio, responding to troop commanders' requests for fire support and receiving "spotting" information to correct the destroyer's fall of shot.

By 1944 there were more than 22,000 officers and 225,000 enlisted personnel engaged in U.S. Naval Communications. In that year radio photo (facsimile) equipments were installed at Naval Communications Stations at Washington, San Francisco, Pearl Harbor and Guam, and major fleet radio circuits were equipped with radio-teletypewriter equipments. In September, 1945 the Navy transmitted radio-photographs of the formal signing of the surrender document on board the USS MISSOURI from the USS IOWA in Tokyo Bay to the Naval Radio Station, Mare Island, California, a distance of 5100 miles.

RADIO RECEIVING AND DECODING ROOM, USS AUGUSTA (CA31), 1942



RADIO–PHOTOGRAPH OF SURRENDER CEREMONIES, 1945

POST WORLD WAR II DEVELOPMENT

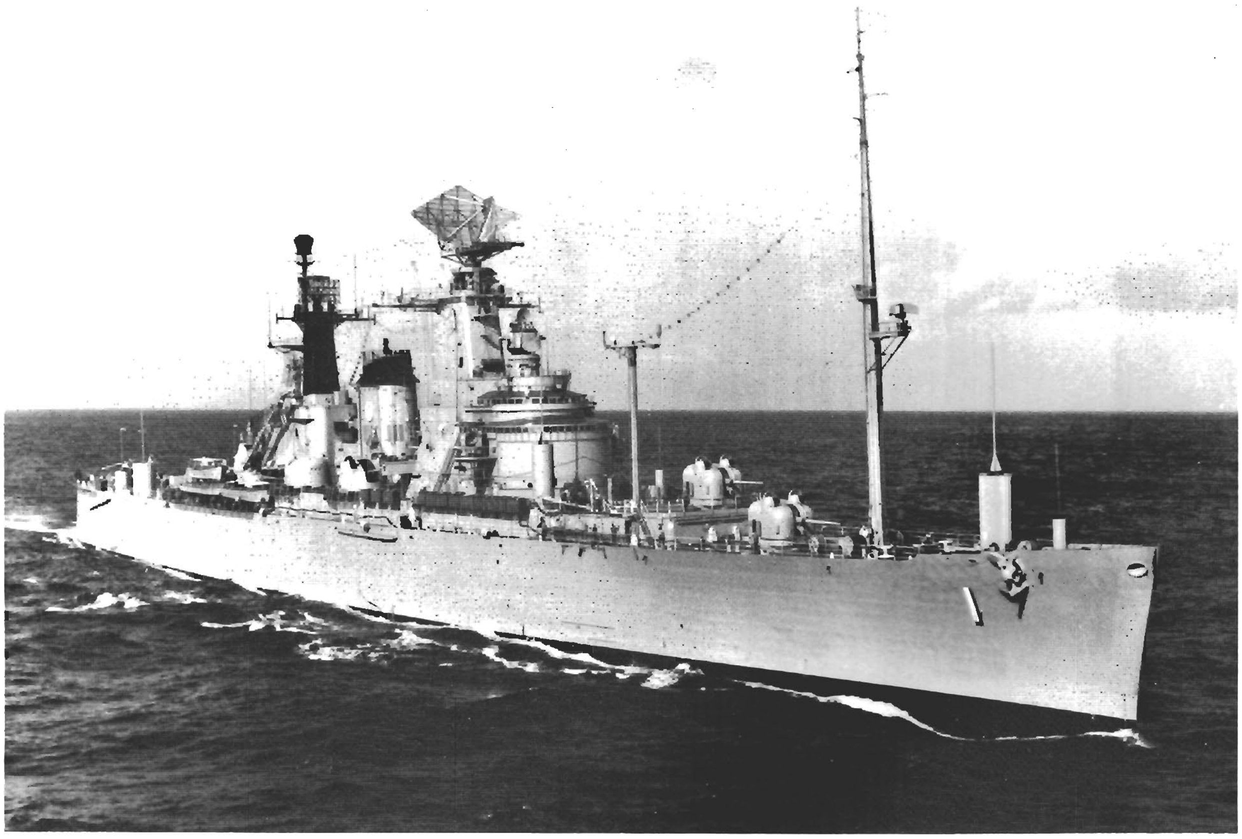
In the period since WWII the Navy has continued to improve existing communication systems and to develop new ones. The Naval Communications System within the United States was re-engineered in 1959 and automatic teletype switching systems were installed. Coastal communications stations were linked by overseas circuits to ships at sea, overseas naval commands and other Armed Forces systems. This network has proved to be flexible, expandable and reliable, enhancing the speed of message delivery through centralized control and relatively simple operational methods.

The USS NORTHAMPTON (CC-1) was converted to a command ship in 1953, with installation of the most modern communications systems available. In recognition of her capability, she was designated as the official National Emergency Command Post Afloat. The USS WRIGHT (CC-2) was also converted to a command ship with worldwide command and control capability.

Other developments included the construction of giant radio stations at Jim Creek Valley, Washington, and Cutler, Maine, the expansion of the use of single-sideband radio circuits, and the installation of militarized single-sideband equipment aboard ships. Research and development programs on relay systems resulted in the successful relay of operational traffic from Washington to Pearl Harbor in 1959, by bouncing radio messages off the moon – the forerunner of communication satellite systems.

The major problem facing naval communications since World War II has been the requirement to handle ever larger volumes of traffic. The extension of radioteletype broadcasts to ships at sea in 1947 was a significant step forward in traffic-handling ability, and by the mid-1950's the fleet's capability had been improved from the 10-25 words per minute level of continuous wave (CW) radio to 60 words per minute by teleprinter. Although manual coding and decoding was still required, a much greater volume of traffic could be transmitted. In the early sixties, on-line cryptographic equipment which automatically encoded and decoded the teleprinter channels electronically was added, which speeded delivery of clear text copy and eliminated the time and labor required for manual encryption and decryption.

As the Navy's participation in the Vietnam conflict increased the volume of radio traffic soared. Conversion from 60 word-per-minute to 100 word-per-minute teleprinters provided temporary relief, but by 1968 naval communication channels in the Western Pacific were again overloaded. A substantially increased flow of traffic was also facilitated by the introduction of multiplex teleprinter systems, first on fleet broadcasts and later on ship-shore circuits.



USS NORTHAMPTON (CC–1)

TRANSMITTER ROOM, USS ANNAPOLIS (AGMR–1)

84' DISH – NAVY'S MOON RELAY STATION – HAWAII

USS ANNAPOLIS (AGMR–1) – FLOATING COMMUNICATIONS STATION, 1970

NAVAL COMMUNICATIONS TODAY

The current Naval Telecommunications System is an evolution and expansion of the systems used in WWI, WWII, and Vietnam. Automatic message processing is now available in most communications stations ashore and has been introduced at sea. The frequencies used for communications continue to creep higher and higher, as evidenced by ultra-high frequency (UHF) replacing very-high frequency (VHF) as the primary band for tactical communications. As equipment reliability has improved, traffic has continued to increase, with a substantial volume of communications traffic now being in the form of data rather than narrative messages. Large amounts of data requiring prompt handling are generated by the Naval Tactical Data System (NTDS), ASW information and surveillance systems, intelligence data handling systems and various logistics reporting systems. In many cases computers are communicating directly with computers with little or no human interface, and more than ever before the Navy communications system must interface with groups outside the Navy.

AUTOMATIC MESSAGE PROCESSING

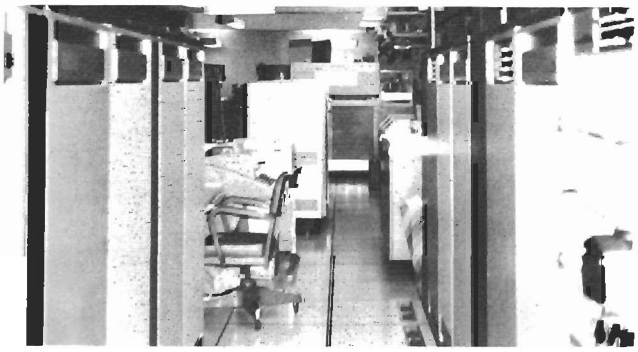
Several message automation systems - the Naval Communications Processing and Routing System (NAVCOMPARS), Local Digital Message Exchange (LDMX), and Message Processing and Distribution System (MPDS) - are in various stages of implementation ashore and afloat. They represent the first steps in developing an automated message processing capability within the Naval Telecommunications System.

Message centers ashore use the LDMX to automatically prepare, route and format outgoing messages; to validate, segregate and transmit messages; and to receipt, edit and internally distribute incoming messages. The NAVCOMPARS system installed at Naval Communications Stations incorporates all of the LDMX capabilities, and in addition maintains a real-time fleet locator; services messages for the fleet; formats, screens and distributes messages via several transmission media; and maintains broadcast control.

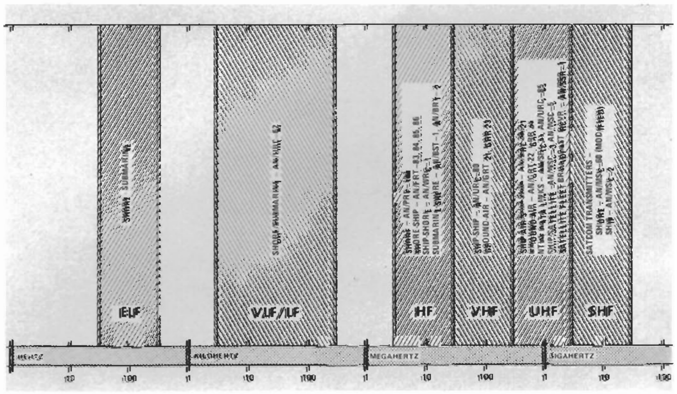
LDMX and NAVCOMPARS installations in service have significantly reduced the time from writer to reader and are reducing work load and manpower requirements at communications facilities. The Message Processing and Distribution System (MPDS) is an advanced shipboard communications subsystem now operational in the USS NIMITZ (CVAN 68) and planned for installation in the USS EISENHOWER (CVAN 69). It makes use of general purpose computers on-line with radio receiving and transmitting equipment to process, store and internally distribute data and narrative message traffic, and provides an automated message handling capability with fewer operations and maintenance personnel than are required in a comparable manual system.

RADIO FREQUENCY USAGE

Although the electromagnetic spectrum is virtually unlimited, only a relatively small portion is suitable for the transmission of radio waves for communications systems as we know them today. Various efforts to make more efficient use of the available spectrum by applying advanced technology are underway; these include techniques for transmitting information in less bandwidth, eliminating harmonics, selecting optimum frequency bands for equipment development, and applying stricter equipment design objectives and performance standards. The Navy's use of the frequency spectrum for communications is indicated in the accompanying chart.



LDMX INSTALLATION, OPNAV MESSAGE CENTER, PENTAGON



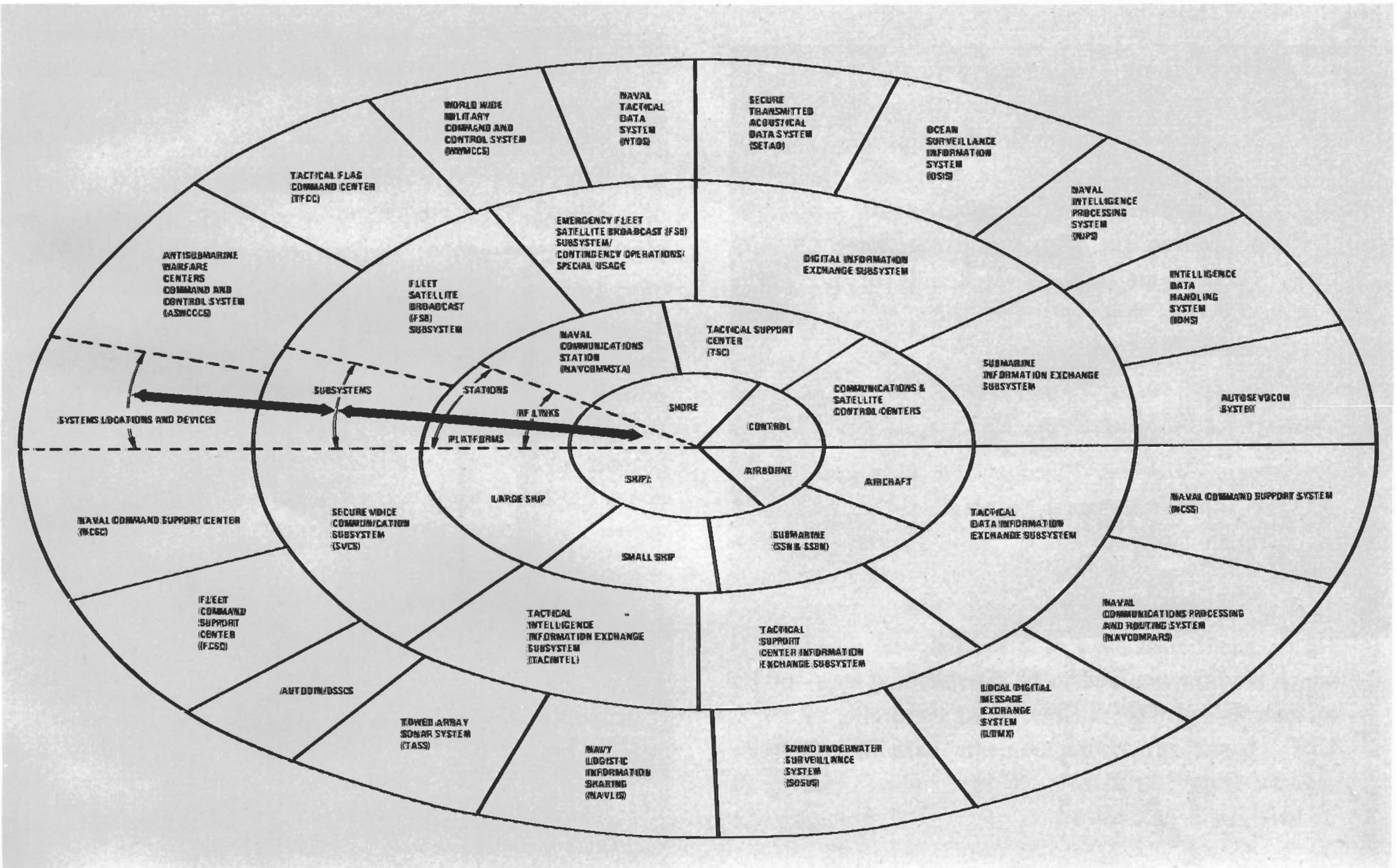
RADIO FREQUENCY USAGE IN THE U. S. NAVY

SYSTEM INTERFACES

Modern naval operations require effective communications with the forces of the other U. S. military services and interoperability with the communications systems of our allies. The wide variety of interfaces that the Naval Telecommunications System design must accommodate are pictured in the diagram below.

The Tri-department Tactical Communications Office is a DOD field organization jointly staffed by all of the services. It has initiated the TRI-TAC Program, which lays the foundation for maximum effectiveness and economy in the future development, programming and acquisition of joint communications equipment for tactical forces of the U.S. services. One TRI-TAC Program goal is to attain economies by identifying areas of parallel effort among the services, thus minimizing duplication. Some key features which are expected in TRI-TAC equipment are the automation of tactical switching and control facilities, improved quality and reliability of tactical communications, a capability for widespread communications security and simplification of the interfaces between the tactical systems of the U.S. services and with the Defense Communications System.

A major factor being recognized in the TRI-TAC Program is that "strategic" and "tactical" communications systems are blending in modern military operations. Communication systems in the tactical area must have automatic interoperability into the world-wide fixed systems that make up the Defense Communications System, and standards are being established that will allow such interoperability without complex interface problems.



NAVAL TELECOMMUNICATIONS SYSTEM INTERFACES

CONTINUED SYSTEM EVOLUTION

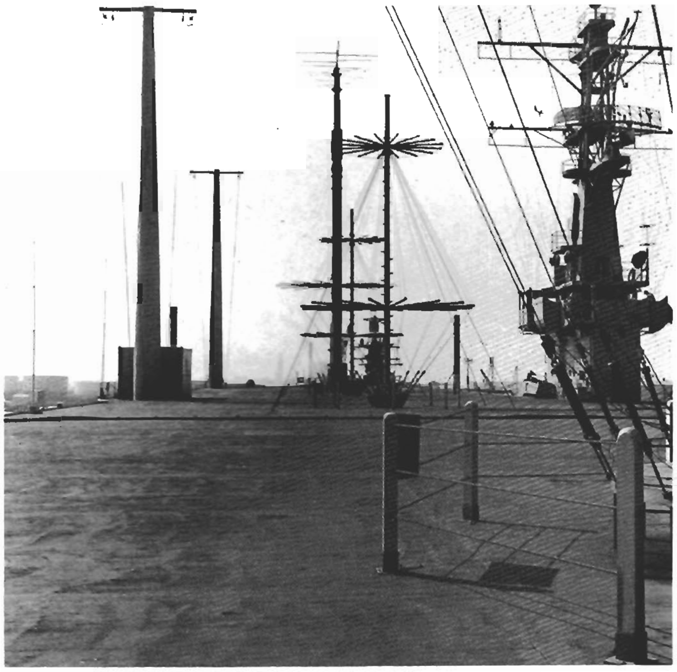
The Naval Telecommunications System is being evolved in accordance with a systems concept that is applicable to both shore and afloat units. It encompasses both narrative message handling and distribution and data transfer. Design goals for the developing system are increased information capacity, a high degree of interconnectivity, increased link reliability, resistance to jamming, and resistance to detection by undesired listeners. Priority is being given to system improvements which will result in a decrease in manpower requirements. The current thrust of communications system development is toward achieving full automation from the message originator to the action officer; automated systems will provide remote access for the originator, automatic message preparation, routing and transmission, and automatic message screening, write up and delivery at the receiving end. Replacement systems will exploit the use of new sections of the frequency spectrum and will capitalize on advancing technology in related areas, such as artificial earth satellites, computers and data handling systems. Some of the important problem areas being addressed are described below.

- *Interference.* A problem peculiar to the Navy is the interference resulting from transmitter intermodulation in a shipboard environment. Some ships have as many as 100 equipments radiating in the radio frequency band; the congestion of these equipments within the confines of even the largest ship aggravates the problem. There are literally thousands of non-linear junctions aboard ship where signals can mix to produce intermodulation products.

- *Frequency Crowding.* Design objectives and performance standards aimed at "conserving" the frequency spectrum are being tightened. New equipments must be continuously tunable over their entire frequency range or must meet minimum incremental tuning requirements for their particular band of operation. HF transmitters which are now required to be tunable in at least 100 Hz increments must be capable of 10 Hz tuning by 1975. UHF channelization requirements have already been reduced from 100 kHz to 50 kHz and an objective of 25 kHz has been adopted.

- *Radio Discipline.* It is obvious that no matter how "clean" naval communication equipment is by design, if enough of it is put into operation the frequency spectrum will be saturated. The practice of effective electro-magnetic discipline is required, and as a major step in enforcing it, the Director of Electromagnetic Programs, on the staff of the Chief of Naval Operations, has been charged with managing the use of the electromagnetic spectrum within the Navy.

- *Standardization and Commonality.* These characteristics are being stressed in the design of communications systems and equipments in the Department of Defense. A major Navy effort in this area is the Line-of-Sight Task Force Communications (LOSTFC) program which coordinates all development activity aimed at alleviating various shortcomings in task force communications. Improvements are being sought which will reduce the susceptibility to jamming, reduce the interference on board individual ships, reduce the spacing between channels to increase the number of circuits available, and increase reliability and streamline logistics by standardizing on a new UHF radio using modern design techniques, modular commonality and built-in test equipment.



ANTENNA MASTS ON DECK OF THE COMMAND SHIP USS (WRIGHT (CC-2)

NAVAL COMMUNICATIONS TOMORROW

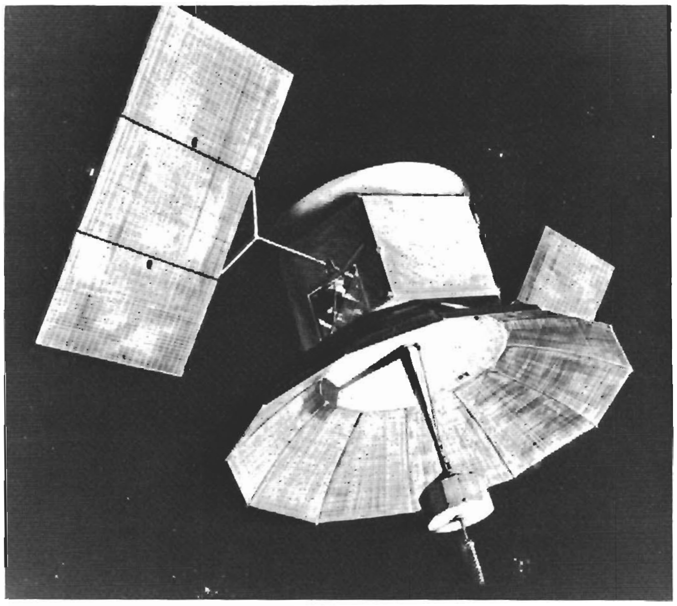
The communications system of the 1980's will reflect both a revolutionary and an evolutionary improvement over today's system. Satellite communications, in the form of the Fleet Satellite Communications System (FLTSATCOM) will be an operational reality providing a quantum improvement in both capability and reliability. Satellite communications will rank with the wireless and the telephone in the changes it brings to communications. As part of the evolutionary development, tomorrow's systems will reach into higher and higher frequencies in a continuing effort to relieve the crowding of the frequency spectrum, and message processing will become even more highly automated. Semi-automatic circuit and station discipline will continue to be essential, and on-line cryptographic devices will be an integral part of the system. The technology for all of these developments is available now, and the challenge is to convert it into simple, reliable, operational systems.

The key feature of satellite communications is the wide visibility of the satellite transponder itself, which will lead to many improvements in communications that will in turn greatly increase the effectiveness of command and control systems. Increased information capacity, a high degree of interconnectivity, resistance to jamming, and safety from detection by undesired listeners are all expected to be realized from satellite communications.

Operations with various experimental satellites in the last few years have demonstrated the great potential of such systems, and development work is moving ahead in all areas to make the FLTSATCOM system fully operational in the late 1970's. UHF SATCOM is unique in that it can be made available to all Navy platforms, including aircraft, submarines and small ships. Since UHF omni-directional antennas are small and UHF transmitters are lightweight, their simplicity results in a low cost-per-terminal. The broad economical access to UHF SATCOM makes this medium ideal for fleet broadcast. SHF frequencies can be used when required to accomodate more sophisticated modulation techniques, and to provide multiple access and more capacity.

FLEET SATELLITE COMMUNICATIONS SYSTEM

The Fleet Satellite Communications (FLTSATCOM) System will provide the Navy with a UHF global satellite communications capability. By the late 1970's, UHF SATCOM is expected to be the primary mode in the fleet for communicating beyond the line-of-sight, with HF being relegated to a back-up role. Development of the FLTSATCOM system is being managed by the Navy Space Projects Office in NAVELEX, and will make use of four communications relay satellites located equidistant from each other in synchronous orbit 22,500 miles above the earth's equator. When established this arrangement of satellites will provide full, worldwide communications coverage between latitutdes 70° N and 70° S. Communications over-the-horizon, via satellite, will be possible in the UHF and super high frequency (SHF) bands, which formerly were limited to use in line-of-sight applications.



FLEET COMMUNICATIONS SATELLITE

INCREASED AUTOMATION

FLTSATCOM will make possible a higher degree of automation throughout the fleet; a family of computer-based data exchange systems, making use of satellite capabilities and incorporating on-line crypto devices, is under development. A prototype information exchange system has been demonstrated in the fleet.

SYSTEM IMPROVEMENTS

Typical of the trend toward total communications system design is the Integrated Radio Room (IR^2), being provided for the TRIDENT submarine, the sea-based strategic deterrent system for the 1980's. The TRIDENT system will be characterized by long-range ballistic missiles, nuclear-powered submarine platforms, and its integrated communications, command and control system. The IR^2 is the central focus for the exercise of the exterior communications function required by the TRIDENT Command Control Communications System, and is to facilitate world-wide control of the TRIDENT weapon system. Applications of the IR^2 to other classes of submarines are being considered under separate but closely related projects.

The IR^2 development goal is a functionally optimized systems-engineered communications center that will meet CNO's requirements for system survivability and performance. It will make use of proven advances in technology to reduce the size and weight of components, to improve the man-machine interfaces, to reduce the numbers and required skill level of operators, and to provide automatic signal and message processing to meet the jamming threat.

NAVAL COMMUNICATIONS AND ADVANCING TECHNOLOGY

Since its earliest days, the Navy has recognized the importance of reliable, rapid and secure systems for communicating between individual ships, and for exercising positive command and control of the fleet from headquarters. The introduction of radio was a major step toward achieving both of these ends, although the first equipments were unreliable, had limited range, were subject to disruption by atmospheric conditions, and signals could be detected and intercepted by other forces.

The Navy's capabilities in communications have increased rapidly throughout this century, keeping pace with the steady advance of electronic technology. The range of communications has increased, equipment has been made more reliable, a variety of emissions have been introduced, including continuous wave, voice, radio teletype, facsimile, and high speed data transfer, and on-line encryption-decryption and relay by artificial satellite have been implemented.

Naval communications has thus been characterized by vast, continuous change. In the sections that follow, representative communications equipment and systems under the cognizance of the Naval Electronic Systems Command that are now in service and under development are briefly described, to indicate NAVELEX's role in providing systems to facilitate a secure exchange of information between Navy units anywhere in the world.

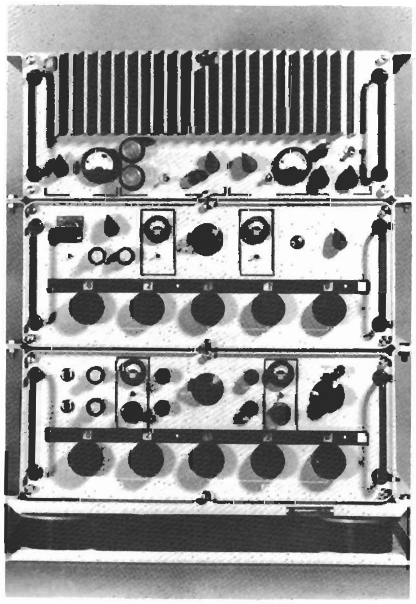
COMMUNICATIONS EQUIPMENT IN THE FLEET TODAY

AN/WRC–1 RADIO FAMILY

The AN/WRC–1 high frequency (HF) Single Side Band (SSB) radio family is typical of the radio equipment currently installed in the fleet. It consists of the radio set AN/WRC–1 ( )*, radio transceiver AN/URC–35 ( ), radio transmitters AN/URT–23(V) and AN/URT–24, and the radio receiver R1051( )/URR. It is installed in ship and shore applications, with the AN/URC–35 ( ) transceiver being suitable for vehicular use. The AN/WRC–1 family is used to conduct low-power, HF, ship-to-ship and ship-to-shore communications, primarily in voice and frequency shift keying (FSK) modes, although it does have a continuous wave (CW) capability.

The AN/WRC–1 operates on any one of the selectable pre-tuned channels spaced 0.1 kHz apart in the 2.0 to 29.9999 MHz frequency range (a maximum of 280,000 channels). Intelligence may be transmitted and received in upper side band (USB), lower side band (LSB), continuous wave (CW), compatible amplitude modulation (compatible AM), radio teletype (RATT) and independent side band (ISB) modes. Major components of the system are grouped to make up various communications configurations.

The equipment is designed to permit shipboard maintenance to be carried out by an Electronics Technician Third Class, who is required to isolate faults and to remove and replace faulty circuit components such as tubes, transistors, resistors, coils and capacitors. He also must be able to replace defective meters, indicator lamps, and fuses, and to tune and align the set. Specified complex modular assemblies, including such items as the frequency standard, RF amplifier, and transmit/receive mode selectors will be replaced by spare modules carried aboard ship, and the defective assemblies will be sent to a naval shipyard or repair facility for repair.

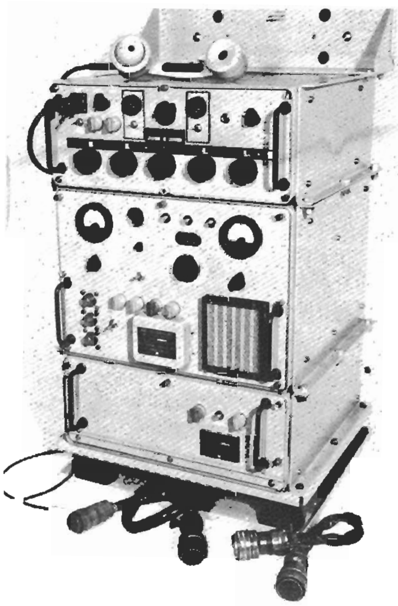


RF AMPLIFIER
AM–3007/URT

RADIO TRANSMITTER
T–827/URT

RADIO RECEIVER
R-1051/URR

AN/WRC–1B RADIO SET



RADIO TRANSMITTER
T–827/URT

RF AMPLIFIER
AM 3924(P)/URT

POWER SUPPLY
PP–3916/Uk

AN/URT–23(V) RADIO TRANSMITTER

*( ) is an identification of a series "generic" assignment

AN/URC–80(V) VHF MARITIME TRANSCEIVER

In a move intended to reduce the risk of collision at sea, the International Telecommunications Union in 1968 established the requirement that all ships have the capability to communicate with each other, and prescribed the frequencies and procedures to be used. Subsequently U.S. Public Law 92-63 was enacted which required that effective in January, 1973 all vessels operating in U.S. inland waterways must guard certain specified frequencies on their bridges and must be capable of communicating among themselves by VHF/FM (very high frequency/frequency modulation) radio. The AN/URC–80(V) VHF Maritime Transceiver has been installed in all Navy ships to satisfy both the International Telecommunications Union and PL92-63 requirements for bridge-to-bridge radio telephone communications.

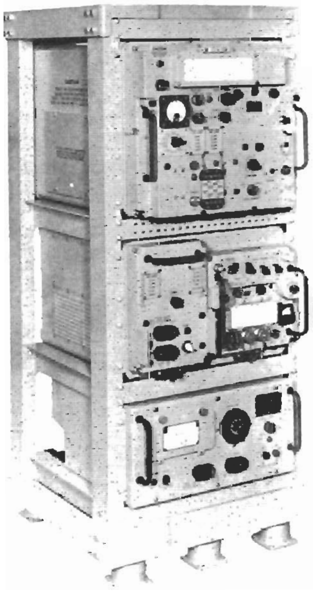
The AN/URC–80(V) system consists of a 25-watt FM transceiver, a control panel, speaker panel, and microphone. It uses only one crystal in a stabilized master oscillator, which permits instantaneous selection of any one of the 55 U.S. and international maritime channels. The transceiver is completely solid state, with no tubes, relays or moving parts, and is made up of plug-in modules which simplify trouble-shooting and facilitate repair. In the event of failure, the defective module can be replaced from ship's spares and the unit quickly returned to service.

AN/URC-80(V) VHF MARITIME TRANSCEIVER

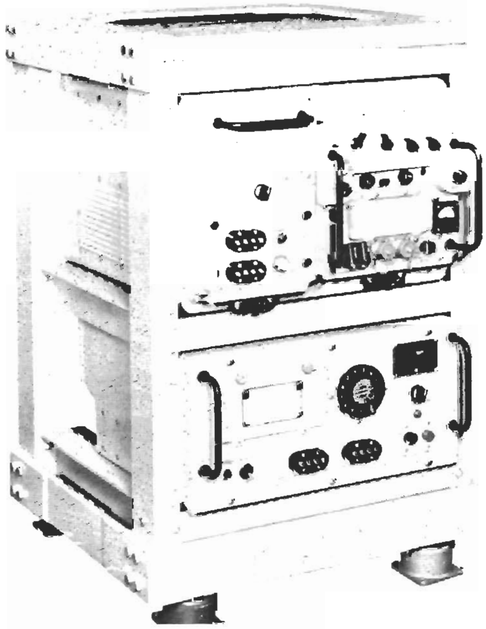
AN/SRC–20/21 UHF RADIO SETS

AN/SRC–20/21 radio sets are the Navy's basic UHF equipment, and are widely installed throughout the fleet. They are used for surface-to-air and ship-to-ship communication, and are designed for installation either aboard ship or ashore, providing AM transmission and reception in the ultra high frequency (UHF) band on any one of 1,750 channels spaced 100 kHz apart. The equipment incorporates complete remote control and automatic retransmission features, and is designed for easy maintenance.

The radio set AN/SRC–20 consists of a 15–20 watt transceiver (AN/URC-9), a 100-watt UHF linear amplifier (AM-1565/URC), and a shipboard control unit (C-2384/SRC). The AN/URC-9 is capable of functioning as a separate equipment in the event of amplifier failure or in a limited power application. The AN/SRC–21 omits the 100-watt amplifier, and is installed in applications where a 15-20 watt output is sufficient. More than 5500 AN/SRC–20/21 and AN/URC–9 equipments have been installed to meet general equipment requirements in the operating forces.



RADIO SET AN/SRC-20



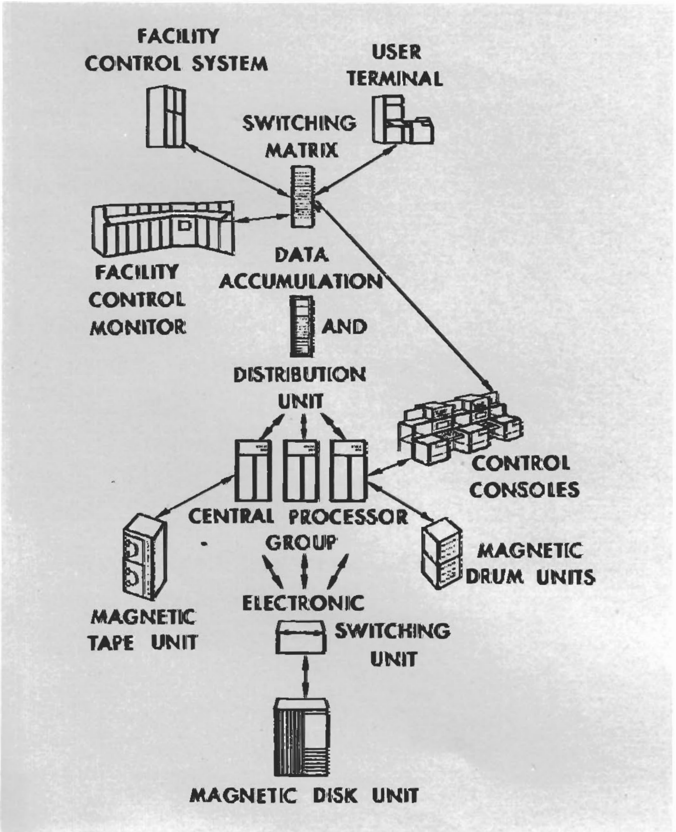
RADIO SET AN/SRC-21

AN/SYQ-6 MESSAGE PROCESSING AND DISTRIBUTION SYSTEM (MPDS) AND AN/SSQ-67 FACILITIES CONTROL SYSTEM (FCS)

The MPDS is an integrated data processing system which uses general purpose computers on-line with radio receiving and transmitting equipment to process, store and internally distribute message traffic, and the FCS is a combination of subsystems which provide centralized equipment control and monitoring capabilities to communication circuit control operators. Combining MPDS and FCS components with conventional radio and terminal equipment will provide ships with an expanded communications capability, while reducing the number of operations and maintenance personnel required.

MPDS user terminals provide the functions of message display, printout, retrieval, composition and editing at locations convenient to the principal recipients or originators of message traffic. The equipment installed at these terminals includes teleprinters and receive/transmit units, along with the electronic devices required to interface with the central processors.

The MPDS is operated from a control console, where radiomen monitor system performance and intervene in response to alarms which indicate a need for human assistance in solving particular problems. The FCS operator assigns equipment configuration and frequencies, connects test equipment to determine signal quality, and takes steps required to minimize the effects of jamming. He identifies equipment degradation and initiates action to correct deficiencies before degradation is sufficient to interfere with efficient operation of the MPDS.

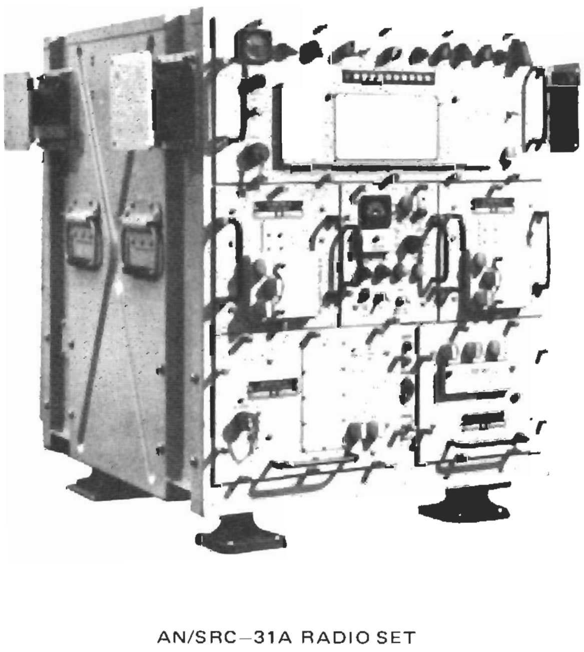


MPDS/FCS SYSTEM

SHIPBOARD COMMUNICATIONS FOR THE NAVAL TACTICAL DATA SYSTEM (NTDS)

The AN/SRC–31 radio set, which with certain modifications is designated as the AN/SRC–31A and B, was developed as a shipboard system to provide the UHF radio frequency (RF) functions required for inter-ship subsystems communications of the Naval Tactical Data System (NTDS). It is a miniaturized, modular, solid state transceiver operating in the 225–400 MHz range, capable of AM, FM and frequency shift keying (FSK) transmission, and is automatically tunable to 3500 channels in 50 kHz increments. Ten pre-set channels may be locally or remotely selected.

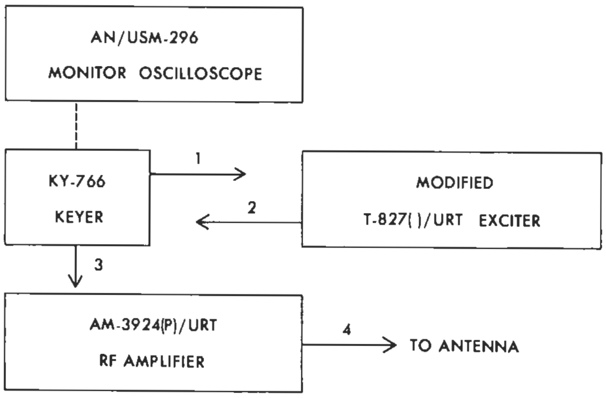
The follow-on equipment being procured to meet expanding NTDS communications requirements, the AN/URC–85, also incorporates 3500 channel UHF transmitters, operating in the same frequency range, with power outputs of 30 watts AM and 100 watts FM. Each AN/URC–85 set includes two UHF transceivers. This equipment is designed so that failures and malfunctions can be corrected by replacing printed circuit boards and modules to return the system to specification requirements. This concept requires that each ship having the AN/URC–85 installed be provided with a complete set of spare plug-in printed circuit boards. Failed printed circuit boards are to be returned to a designated overhaul point ashore, where they are repaired and returned to the supply system.



AN/SRC–31A RADIO SET

AN/BRT–2 SUBMARINE RADIO TRANSMITTER

The AN/BRT–2 transmitter set is currently being procured for installation in all submarines. The components of this transmitter are the KY–766/BRT–2 keyer, mounted in a fixed configuration with a modified AN/URT–23(V) radio transmitter, a modified T-827( )/URT exciter, an AM-3924(P)/URT amplifier, an AN/USM–296 oscilloscope for monitoring the system, and an appropriate submarine antenna. The special characteristics of this transmitter are an increased reliability over previous equipments, and an upgrading in test and monitoring equipment which aids in fault isolation procedures and facilitates operation at peak performance. The transmitter operates in the 2.0 to 29.9999 MHz (HF) frequency range, with the capabilities previously described for the AN/URT–23(V) in the section on the AN/WRC–1 family.

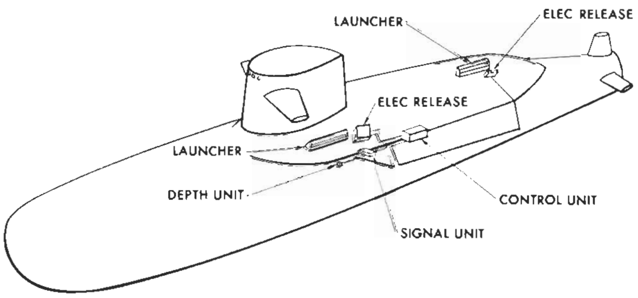


BLOCK DIAGRAM OF THE AN/BRT – 2 TRANSMITTING SET

SUBMARINE EMERGENCY COMMUNICATIONS (CLARINET MERLIN)

CLARINET MERLIN is an emergency submarine communications system. Transmitter bouys, which are part of the AN/BST–1 transmitting subsystem, are automatically launched from the submarine when an "in extremis" environment is sensed, and transmit a pre-selected message. Recieving subsystems, AN/FRR-87's located at Naval Communications Stations, automatically detect and record the keyed CW signals.

Upon detection of a signal the AN/FRR-87 shore subsystem automatically alerts operating personnel, who then copy the message by means of an audio output. The operator can play back the automatically received message recorded on a cassette tape recorder. Two AN/FRR-87's are maintained "on-line" at each shore site, with two of the four fixed emergency frequencies coupled through to each of them. A third AN/FRR-87 is provided as a "hot spare", to be available for immediate substitution in case of failure of either of the on-line receivers.



CLARINET MERLIN TRANSMITTER (AN/BST – 1)

LOW FREQUENCY COMMUNICATIONS

Operational control of the POLARIS/POSEIDON Fleet Ballistic Missile submarines is exercised through VLF (very low frequency) and ELF (extremely low frequency) communications. These low frequencies (below thirty kilohertz) are used because they can penetrate ice and water, insuring communications with submarines, and have good stability and are not susceptible to ionospheric disturbance. They require a great deal of power to send a long range signal, however, and need large antennas. Several transmitting sites are located in the United States, with others in Australia and the United Kingdom.

VLF CONTROL CONSOLES AND TRANSMITTER, NAVAL COMMUNICATIONS STATION, CUTLER, MAINE

AN/URC-62 MULTIPLEX COMMUNICATION SYSTEM (VERDIN)

Verdin is the primary submarine communication system, scheduled for installation in all submarines, submarine tenders and rescue ships, 13 aircraft carriers, 2 cruisers, 8 Naval Communications Stations, and 12 aircraft units. It can transmit and receive up to 4 channels of encrypted information in the VLF/LF region of the frequency spectrum making use of the minimum shift keying (MSK) technique. This is a form of phase shift keying which is considered the optimum for use at VLF frequencies, because it can handle the same quantity of information as frequency shift keying (FSK) within a narrower bandwidth. The VERDIN equipment is also compatible with CW and FSK modulations.

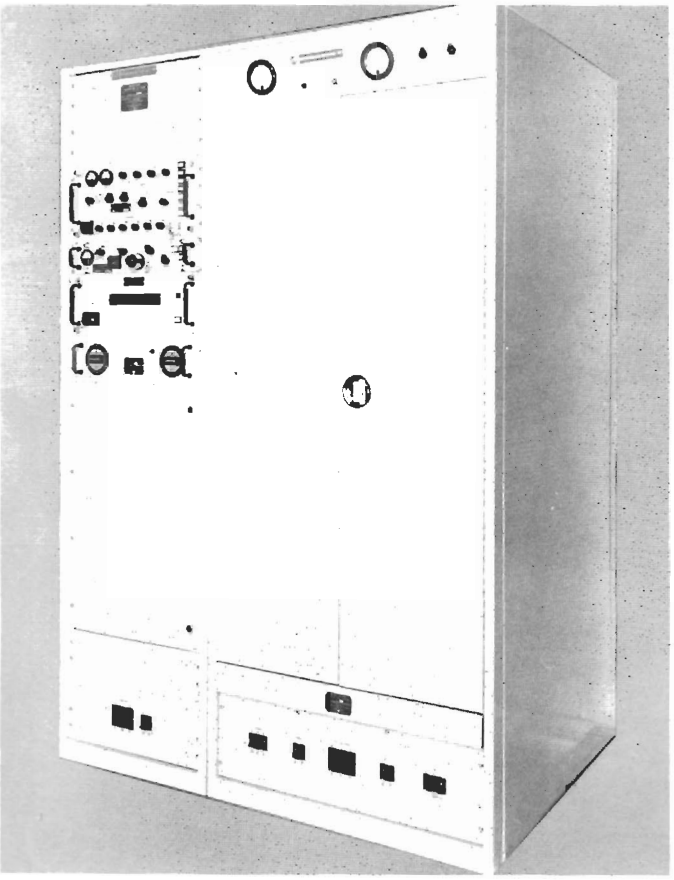
The major components of the VERDIN System are:

- The AN/URT-30 Digital Data Transmitting Set (Shore)
- The AN/WRR-7 Digital Data Receiving Set (Shipboard)
- The AN/ART-50 Digital Data Transmitting Set (Airborne)

VLF ANTENNA ARRAY NAVAL RADIO STATION, CUTLER, MAINE

AN/FRT-83, 84, 85 AND 86 HF RADIO TRANSMITTERS SETS

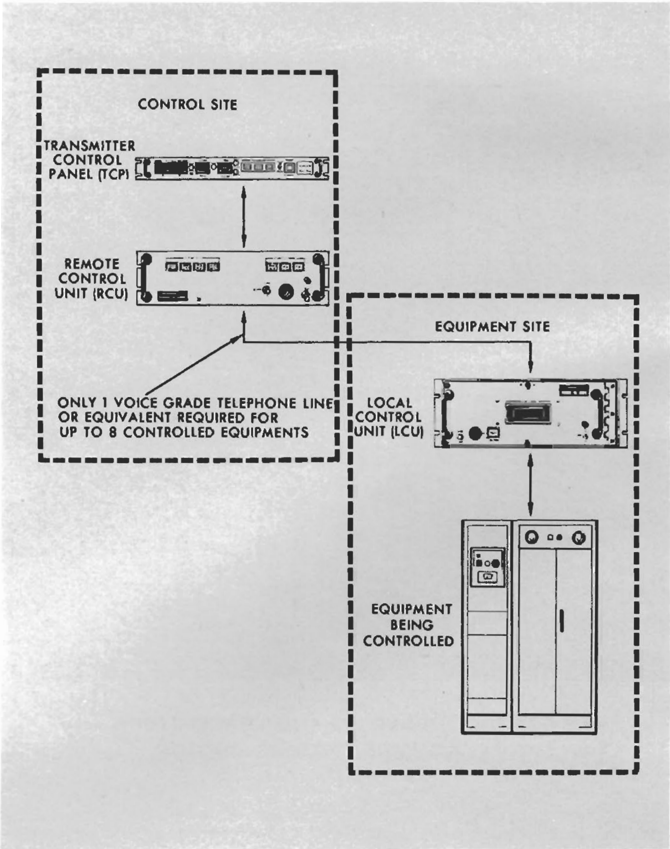
The AN/FRT-( ) equipment group comprises four separate transmitters; the AN/FRT-83, AN/FRT-84, AN/FRT-85 and AN/FRT-86 each consist of a Modulator Oscillator Group (MD-777/FRT), an RF Linear Amplifier-Power Supply Group (AM-60XX/FRT) and an Antenna Coupler Group, and develop respectively 1 kW, 10 kW, 40 kW and 200 kW of peak power. The transmitters operate in the frequency range of 2.0 to 30 MHz, and are the standard transmitters broadcasting in the HF spectrum to the fleet from all of the Naval communications facilities ashore. Over 250 of these transmitters have been installed in shore applications all around the world. Each equipment can provide CW, AM, single sideband, two independent sidebands, frequency shift keying, or facsimile emissions.



AN/FRT–84(V) TRANSMITTER

AN/FSQ-98 REMOTE CONTROL SYSTEM

The AN/FSQ-98 Remote Control System is being installed at Tactical Support Centers around the world to provide them with the capability to remotely operate AN/FRT-83, 84, 85, and 86 transmitters located at naval communications facilities in their general area. Each AN/FSQ-98 can control up to ten RF transmitters; one system consists of a Display and Entry Unit and a Remote Control Unit at the remote site, and a Multiplexer Demultiplexer Unit and Local Control Interface Units at the transmitter, with the remote and transmitter sites being connected by a data link. Tactical Support Centers support maritime air operations, with emphasis on the ASW mission.



AN/FSQ–98 REMOTE CONTROL SYSTEM
(CONTROLLING SINGLE TRANSMITTER)

AIR TRAFFIC CONTROL COMMUNICATIONS

The AN/GRT-21, 22 and AN/GRR-23, 24 equipments are shore based VHF and UHF transmitters and receivers for conducting air traffic control ground-to-air voice communications. The AN/GRT-21, 22 transmitters are solid state equipments, designed to have a very high mean time between failures, with replaceable modules for simplified and quick repair. The AN/GRT-21 operates in the VHF range, on 680 channels at frequencies between 116 and 149.95 MHz. By changing nine modules in the transmitter, it can be readily converted to an AN/GRT-22, broadcasting on 3500 channels in the UHF range between 225 and 399.95 MHz.

Similarly, the AN/GRR-23 and 24 are solid state equipments, identical except for three interchangeable modules which are changed to switch from VHF to UHF operation and back again. All adjustments required for channel changes and periodic peaking of the receiver are accessible from the outside of the receiver. These transmitters and receivers are normally operated continuously at unattended sites. Operating consoles are at remote locations where Navy or FAA air traffic controllers communicate with aircraft. Both transmitters and receivers have the provision for switching to emergency battery power if AC power is lost, which gives them the capability of transmitting at a 10 watt output level.

U.S. MARINE CORPS "MANPACK" TRANSCEIVER

The Marine Corps AN/PRC-104 "Manpack" transceiver is a lightweight unit using advanced circuit design and microminiaturized solid state devices to achieve high performance and ruggedness in an extremely small package. Designed for field use, the unit weighs less than 12.5 pounds, including a silver-zinc battery, and stresses maximum reliability and simple operation. The transceiver is capable of 20 watts of output power, transmitting either voice or CW signals in a single-sideband mode in the HF band, being tunable from 2 to 29.999 MHz in 100 Hz steps. A mean-time-between-failures of 2500 operating hours has been specified for the AN/PRC-104, with a mean-time-to-repair of less than fifteen minutes to be achieved by replacing faulty modules.

AN/PRC-104 HIGH FREQUENCY SSB MANPACK TRANSCEIVER

RECEIVER

EXCITER

LPA

AN/GRR-23/24

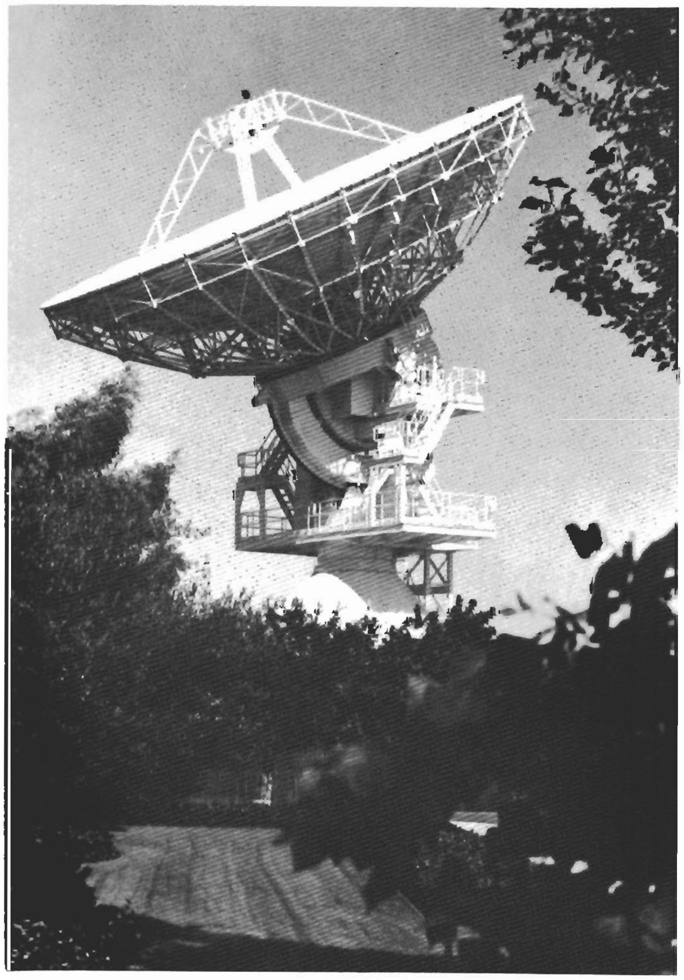
AN/GRT-21/22

AN/GRT–21, 22 and AN/GRR–23, 24

COMMUNICATIONS SYSTEMS FOR THE 1980'S

SATCOM FLEET BROADCAST TRANSMITTER

The major equipment changes required to shift the fleet broadcast to the FLTSATCOM system will involve the introduction of SHF transmitters ashore for the uplink and new UHF receiver systems aboard ship for the downlink. The SATCOM Fleet Broadcast Transmitter will be the AN/MSC-60 (modified SATCOM terminal, with a 60-foot dish antenna, redundant high-power SHF transmitters, and various equipments required to facilitate the interface between landline or microwave links and the terminal. Six of these terminals will be procured to carry the uplinks of broadcasts to the four operational satellites. The uplink stations will be located in areas of satellite coverage overlap to provide for broadcast back-up in all areas. Each AN/MSC-60 (modified) SHF uplink terminal will transmit fifteen teletype fleet broadcast channels to a communication satellite. The satellite will retransmit those signals in the UHF band to permit reception aboard ship.



AN/MSC-60 TRANSMITTING ANTENNA

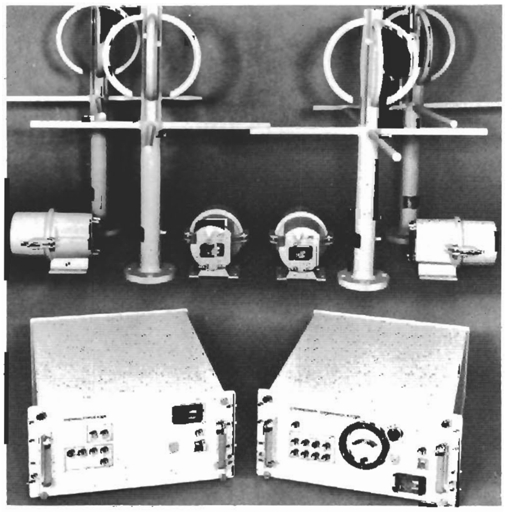
UHF SHIPBOARD SATCOM TERMINALS

The new receiving system, the AN/SSR-1 Satellite Signal Receiving Set, will be installed in virtually all ships to copy the UHF downlink. The system includes four omni-directional antennas, the receiver and a time-division demultiplexing unit. Installations will be made to complement the existing ship HF radio equipment, so that either can be used with the installed teleprinter and associated processing equipment.

Other UHF shipboard SATCOM terminals are the AN/WSC-3 and AN/WSC-5 transceivers. The AN/WSC-3 terminal, a compact, single-channel transceiver, will be widely installed in both surface ships and submarines. It is housed in one cabinet, weighs less than 50 pounds, and is a completely solid-state design. It transmits and receives signals in the 225-400 MHz range; twenty channels of a total of 7000 available may be preset.

AN/WSC-5 multi-channel transceiver systems will be installed in aircraft carriers and other platforms with large communications needs. Its operating characteristics are similar to those of the AN/WSC-3, but it can handle up to four circuits in its shipboard version and up to seven circuits ashore.

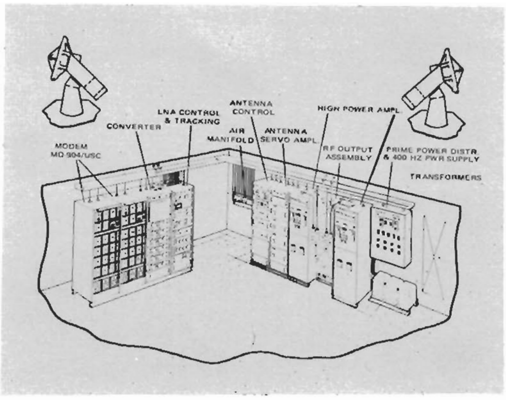
Two antennas will be installed in most ships with the single and multi-channel terminals. The antenna pairs are installed either fore and aft or port and starboard, so that complete hemispherical coverage can be obtained. They are slaved to the ship's gyrocompass to maintain the proper azimuth for pointing at the satellite. Elevation can be adjusted manually, as changes are required infrequently. Since the antennas have a beamwidth of 40°, correction is not needed for roll and pitch.



AN/SSR–1 RECEIVING SYSTEM

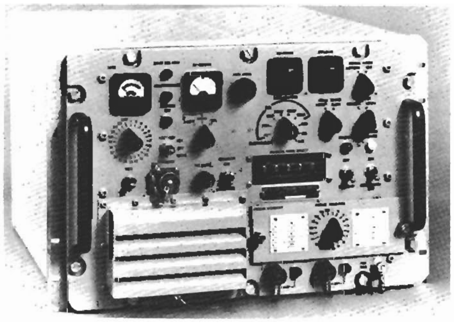
SHF SHIPBOARD SATCOM TERMINALS

A shipboard SHF terminal, the AN/WSC-2 transceiver, is being developed for flagships and other major combatant ships with large communication requirements. It will operate in ship-to-ship, ship-to-shore, and ship-to-shore-to-ship modes, and will transmit and receive voice, data and teletype signals from satellites of the Defense Satellite Communication System and future military satellite programs. These terminals also use two antennas on each ship, but since they are parabolic reflectors, they will require stabilized mounts and drive systems to precisely point their narrow beams at the satellite.



AN/WSC–2 TERMINAL

AN/WSC–5 TRANSCEIVER



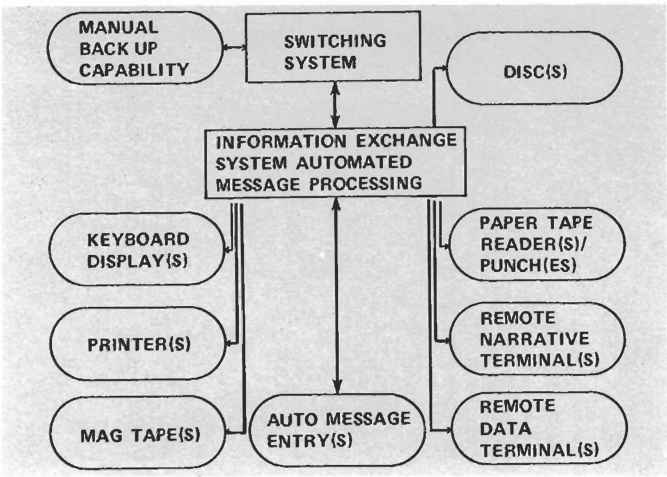
AN/WSC–3 TRANSCEIVER

DIGITAL INFORMATION EXCHANGE SYSTEMS

A family of digital information exchange systems incorporating on-line cryptographic devices is being developed which will substantially reduce operator workload while vastly increasing the efficiency and effectiveness of naval communications. The elements of these systems will be functionally modular packages that can be assembled as building blocks to provide a variety of systems with selected degrees of automation dependent upon a particular ship's requirements. Functions that can be automated are traffic screening, storage, retrieval, internal distribution and high speed ship to shore/ship message transfer. Automatic switching will permit traffic receipt or transmission by either FLTSATCOM or via high frequency circuit.

The heart of the digital information exchange systems is the AN/UYK-20 computer processor. Small ships will be equipped with a teletypewriter or paper punch and use a magnetic tape cassette for storage. Larger ships may be equipped with high speed printers, disk or tape storage, keyboard displays and remote terminals, while communication stations ashore will have facilities similar to large ships but with a greater storage capacity.

In addition to handling the Fleet Broadcast and ship-to-shore traffic, information exchange systems will provide dedicated circuits for special subscribers. Fleet and Task Force Commanders and specially designated units will be provided tactical data, tactical intelligence and ASW information over such circuits. Because of the unique conditions under which they operate, submarines will be provided a dedicated circuit on which to request and transmit traffic.



INFORMATION EXCHANGE SYSTEM INTERFACES

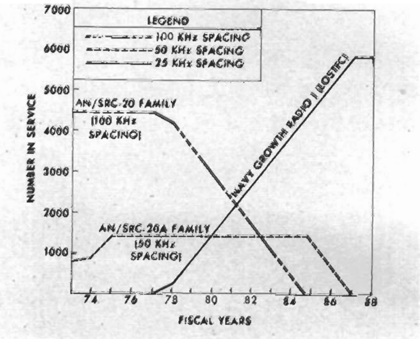
ANTI-SUBMARINE WARFARE CENTERS COMMAND AND CONTROL SYSTEM (ASWCCCS)

The Anti-Submarine Warfare Centers Command and Control System (ASWCCCS) will join all ASW elements into an ocean-wide team for the optimum employment of ASW forces. ASWCCCS features central computer support and several remote shore terminals linked via full period digital transmission lines and secure voice communication channels. Central computer support will be provided at the Fleet Command Support Center and will furnish computer computation, file handling, data storage, and display outputs for remote terminal centers. Four Force High Level Terminals (FHLT) under the operational control of the numbered Fleet Commanders will be established, 14 High Level Terminals (HLT) will be co-located at Tactical Support Centers, and two Low Level Terminals (LLT) for naval control of shipping will be set up. ASWCCCS will make use of existing display and processing equipment within the Tactical Support Centers, and all communications systems will be off-the-shelf items.

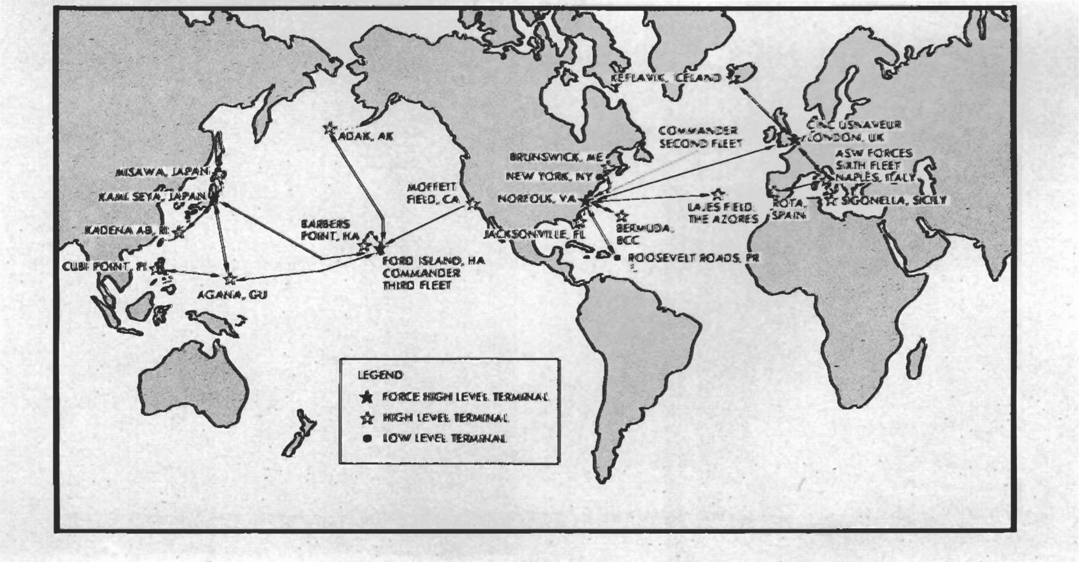
THE NAVY GROWTH RADIO

The first phase of the Line-of-Sight Task Force Communications (LOSTFC) program is the development and acquisition of a multimode/multiplatform UHF growth radio to fill practically all of the UHF radio requirements that can presently be foreseen. This radio is being designed for use aboard ships, aircraft, submarines and ashore and will replace all existing UHF equipment. It will be made up of several high performance, high reliability modules. By combining various modules with the basic equipment, it will be possible to develop an entire family of UHF equipments including full multiplex transceivers with spread spectrum capability. To increase the number of UHF channels available, the bandwidth per channel will be reduced to 25 kHz, instead of the 100 kHz now possible with current equipment; the number of UHF channels will thus be increased from the 1750 now available to 7000. Other advantages expected from fleet introduction of the Navy Growth Radio are:

- State-of-the-art improvements can be installed into any module without affecting its operability or interchangeability in field service.
- The quantity and variety of spare parts can be drastically reduced, as spare parts will be required for only one type of radio instead of many.
- Operational time will be increased by the 100% solid state design, which will increase the mean-time-between failures.
- Mean-time-to-repair will be reduced through use of the Built In Test Equipment (BITE) and easy replacement of failed modules.
- Training time for technicians will be reduced, since only one standard piece of equipment will be involved in many applications.



SCHEDULE FOR PHASING IN NAVY GROWTH RADIO



WORLD-WIDE ASWCCCS CIRCUITS

REFERENCE DATA

JOINT ELECTRONICS EQUIPMENT DESIGNATION SYSTEM

INSTALLATION

A	Piloted aircraft
B	Underwater mobile, submarine
D	Pilotless carrier
F	Fixed ground
G	General ground use
K	Amphibious
M	Mobile (ground)
P	Portable
S	Water
T	Transportable (ground)
U	General Utility
V	Vehicular (ground)
W	Water surface and underwater comb.
Z	Piloted-pilotless airborne vehicle combination

TYPE

A	Invisible light, heat radiation
C	Carrier
D	Radiac
G	Telegraph or teletype
I	Interphone and public address
J	Electromechanical or inertial wire covered
K	Telemetering
L	Countermeasures
M	Meteorological
N	Sound in air
P	Radar
Q	Sonar and underwater sound
R	Radio
S	Special or combinations of types
T	Telephone (wire)
V	Visual and visible light
W	Armament
X	Facsimile or television
Y	Data Processing

PURPOSE

B	Bombing
C	Communications
D	Direction finder, reconnaissance and/or surveillance
E	Ejection and/or release
G	Fire control or searchlight directing
H	Recording and/or reproducing
K	Computing
M	Maintenance and/or test assemblies
N	Navigational aids
Q	Special or combination of purposes
R	Receiving, Passive detecting
S	Detecting and/or range and bearing, search
T	Transmitting
W	Automatic flight or remote control
X	Identification and recognition

EXAMPLE OF NOMENCLATURE ASSIGNMENT

```
AN/WRC–1
   ||| |
   ||| └── Model Number 1
   ||└──── Purpose – Communciations
   |└───── Type – Radio
   └────── Installation –Water surface
                          and underwater
```

FREQUENCY BANDS

Designation		Frequency Range	Wavelength (Upper frequency)
Extremely low frequency	(ELF)	30 to 300 hertz	1,000,000 meters
Voice frequency	(VF)	300 to 3000 hertz	100,000 meters
Very-low frequency	(VLF)	3 to 30 kilohertz	10,000 meters
Low frequency	(LF)	30 to 300 kilohertz	1,000 meters
Medium frequency	(MF)	300 to 3000 kilohertz	100 meters
High frequency	(HF)	3 to 30 megahertz	10 meters
Very-high frequency	(VHF)	30 to 300 megahertz	1 meter
Ultra-high frequency	(UHF)	300 to 3000 megahertz	10 centimeters
Super-high frequency	(SHF)	3 to 30 gigahertz	1 centimeter
Extremely high frequency	(EHF)	30 to 300 gigahertz	1 millimeter

MODULATION

In order for a radio frequency signal to convey intelligence, some feature of the electromagnetic carrier wave must be varied in accordance with the information to be transmitted. The process of combining the intelligence with the radio frequency carrier to produce this variation is called modulation. Several forms of modulation are used in naval communications.

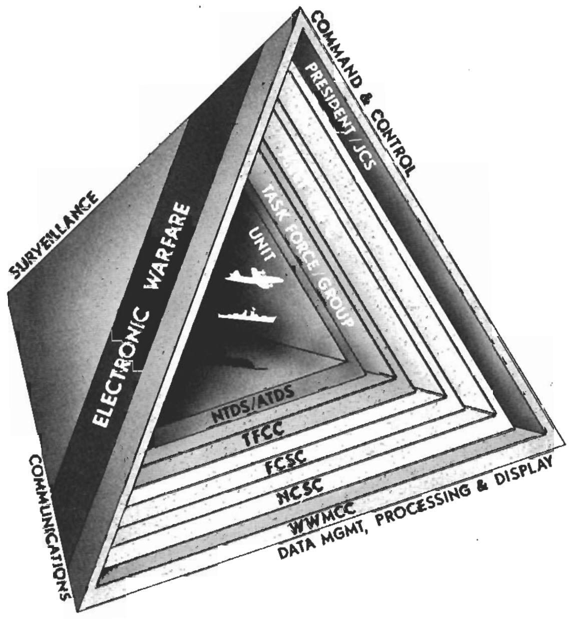
- Amplitude Modulation (AM). The amplitude of the carrier wave is made to vary in accordance with the intelligence.
- Frequency Modulation (FM). The frequency of the transmitted wave varies with the intelligence.
  - Frequency-Shift Keying (FSK). A form of frequency modulation in which the modulating wave shifts the output frequency between predetermined values.
- Phase Modulation (PM). The angle of a sine-wave carrier deviates from the original (no signal) angle by an amount proportional to the instantaneous value of the modulating wave.
  - Phase-Shift Keying (PSK). A form of phase modulation in which the modulating function shifts the phase of the carrier between pre-determined discrete values.

SINGLE SIDEBAND TRANSMISSION

An amplitude modulated (AM) radio frequency signal may be considered to consist of a carrier, an upper sideband, and a lower sideband. The intelligence is carried in both sidebands, although only one is required for communication. When the other is eliminated by filtering, single sideband (SSB) transmission results: either the upper sideband (USB) or lower side-band (LSB) can be transmitted. As the carrier is not necessary for the transmission of intelligence, it too may be filtered out. The carrier must be reinserted at the receiver, however, to acquire the proper demodulated frequencies.

MULTIPLEXING

A technique for broadcasting a number of signals simultaneously on one circuit is known as multiplexing. Each signal is modulated into its assigned frequency slot at the transmitter; the multiplexed signals are carried as if they were a single side-band signal, and the individual signals are demodulated at the receiver.



The NAVELEX tetrahedron symbolically depicts the broad matrix of electronic systems and equipments required to support the Naval operating forces, and the command relationships between the Various mission arenas.

Command and Control is at the apex of the tetrahedron; electronic equipment and systems must be developed, procured, and supported for use at all levels – from the commander of the individual ship, aircraft, submarine, or Marine Corps unit to the President and Joint Chiefs of Staff–in controlling the forces under their command. The Command and Control function is supported by the development of appropriate surveillance, communications, and data management, processing, and display systems. Surveillance and Communications system developments also directly support implementation of NAVELEX's Electronic Warfare mission.

NAVELEX addresses further responsibilities as the central manager for Navy and Marine Corps electronic technology by carrying out a vigorous research and development program, and by developing, procuring and providing support for electronic systems for navigation, air traffic control, and a variety of other requirements.

NAVAL ELECTRONIC SYSTEMS COMMAND