NAVAIRDEVCEN TECHNICAL REVIEW

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TACAMO STRATEGIC COMMUNICATIONS SYSTEM DEVELOPMENT AT THE NAVAIRDEVCEN

TACAMO, an acronym for the phrase "Take Charge And Move Out," is a complex airborne communications system flown aboard Navy EC-130Q aircraft. TACAMO aircraft are an asset to the United States' Minimum Essential Emergency Communication Network (MEECN). The primary mission of TACAMO is to provide a survivable means to relay general war plan execution and termination messages from the National Command Authority to single integrated operational plan forces in the Atlantic and Pacific Oceans during trans- and post-attack phases of a nuclear war.

Figure 1 illustrates the role of an Atlantic Ocean TACAMO in the MEECN. The TACAMO communications system provides the following capabilities under control from four operator positions: very low frequency (VLF)/low frequency (LF) receive and VLF transmit; high frequency (HF) and ultra high frequency (UHF) receive and transmit; TACAMO message processing; communications security; interior communication; and message and system control and monitor functions.

Uplink messages are received from airborne command posts (ABNCP), the National Emergency Airborne Command Post (NEACP), the Alternate National Military Command Center, the Emergency Rocket Communications System (ERCS) and various fleet and Air Force satellite communications (AFSATCOM) systems and demodulated by TACAMO using the following frequency ranges and techniques: VLF/LF - spread spectrum minimum shift key , frequency shift key (FSK), continuous wave (CW); HF - Voice, FSK, and CW; and UHF - AFSATCOM, fleet satellite communications, and line-of-sight voice.

The received messages are input to the TACAMO message processing system (TMPS) for security and priority identification, classification, formatting, editing, display, and storage. Downlink messages are antijam coded, modulated, and encrypted via the VERDIN transmit terminal and transmitted to the ballistic missile submarine (nuclear propulsion) (SSBN) fleet via the 200 kW, dual trailing wire, VLF system.

As originally instituted in 1962, TACAMO provided an interim communications capability until a survivable, landbased, extremely low frequency (ELF) system could become operational. At the time, TACAMO was planned as a temporary, quick-reaction communications system installed in basic C-130 HERCULES airframes converted to derivatives (EC-130 G/Q) for the TACAMO mission. It provided airborne operation of high power VLF transmitters for connectivity with the Navy's SSBNs. The system envisioned to take its place was the SANGUINE version of the ELF project. SANGUINE was considered to be highly electromagnetic pulse and jam resistant and particularly useful in conventional warfare, throughout the spectrum of limited nuclear options, and in nuclear or non-nuclear wars at sea. By 1975, when the accuracy of Soviet intercontinental ballistic missiles was seen to be improving and multiple independently targeted re-entry vehicle warheads were deployed, it became apparent that the SANGUINE concept no longer provided the desired level of survivability and that the TACAMO concept remained the most viable, survivable alternative. TACAMO thus transitioned from an interim to a permanent system.

Naval Air Development Center involvement in the TACAMO system began in 1960 with the demonstration of the feasibility of VLF communication from an airborne platform using a long-trailing wire system. Subsequent NAVAIRDEVCEN contributions included confirmation of the validity of an orbital manuever to increase the vertical effective radiated power from the long-trailing wire antenna, development of the dual trailing wire (counter poise) antenna, development of improved tensile strength long-trailing wires, participation in EC-130 weight reduction and service life assessments, and analyses of aircraft alternatives to the EC-130.

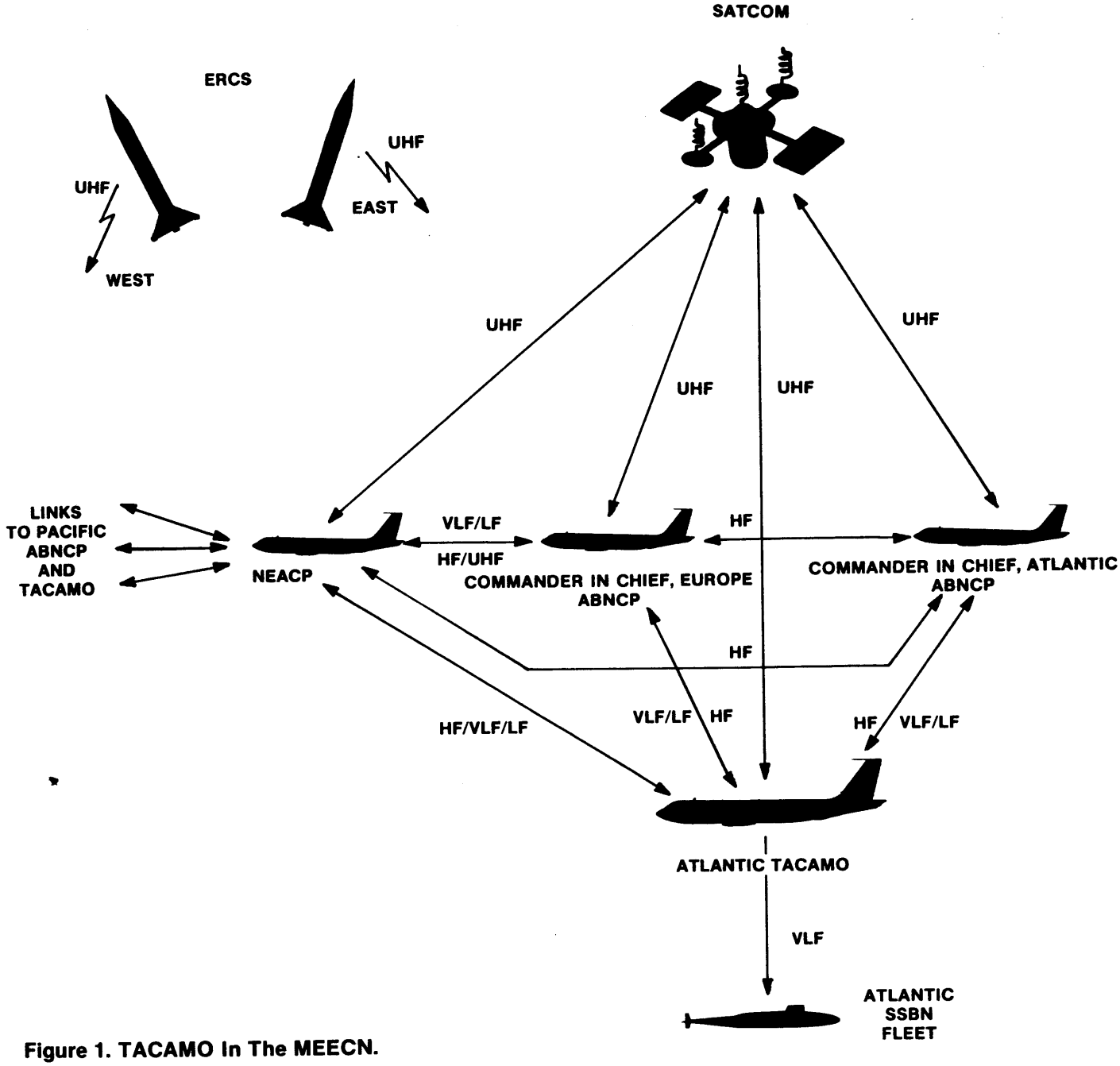

Figure 1. TACAMO In The MEECN.

Current initiatives underway at the NAVAIRDEVCEN in support of TACAMO include development of integrated and operational support plans for the EC-130, definition of a system safety program for the EC-130 fleet, and execution of a TACAMO reliability assessment program aimed at improving the reliability of the TACAMO communications system. The NAVAIRDEVCEN is designated as the lead laboratory for the development of a new airframe, the E-6A, to meet future TACAMO mission requirements. The Center is also in the early stages of identifying and analyzing the requirements and technological opportunities for a preplanned product improvement program, the TACAMO communication equipment suite.

The need for a new TACAMO aircraft is driven by the expansion of the TACAMO mission to include airborne coverage of the Pacific Ocean. In addition, the current fleet of EC-130 TACAMO aircraft are approaching the end of their extended service lives. Thus, the Navy selected the E-6A in order to obtain the economic benefits of procuring an in-production aircraft. The communication system will be transplanted from the present EC-130 TACAMO aircraft in order to capitalize on existing capabilities for communication and support.

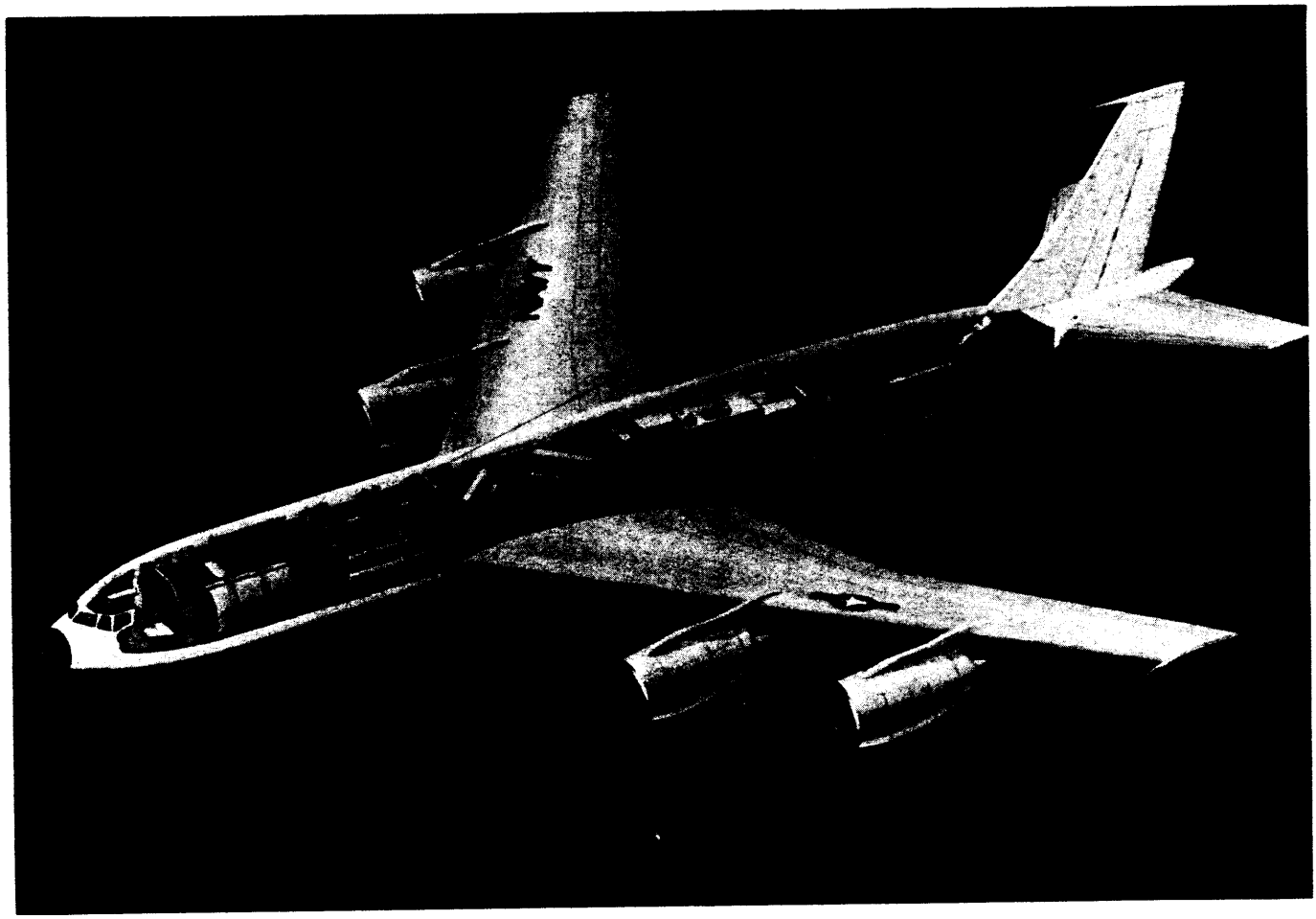

Figure 2. The E-6A TACAMO Aircraft.

The E-6A is a Boeing 707 variant having an airframe configuration and many subsystems similar to the Air Force E-3A. Figure 2 is an artist's rendition of the new E-6A system. The E-6A will utilize CFM-56 engines with integrated thrust reversers for maximum power, fuel efficiency and limited access, short runway capability. The wing is larger and the engine pylons will be strengthened to accommodate the larger propulsion system. A new rudder kicker system will stabilize the take-off path if an outboard engine fails.

The E-6A flight deck design will be improved over other 707 variants with the incorporation of: ring laser gyro technology in triple redundant inertial reference units; a new flight management system with expanded sensor inputs and display capability; a newer, more reliable weather radar; an AIC-27 intercom system which is highly reliable, flexible, and expandable and which exceeds TEMPEST requirements; a high and low radar altimeter system for antenna positioning and orbiting; a new ground proximity warning system; and expanded pilot/copilot interoperability capability over the E-3A. Increased survivability and availability will be achieved through: electromagnetic pulse hardening of the system; installation of a threat warning system; and enhanced logistics flexibility through maximum commonality with existing military and commercial support systems.

Although the mission avionics will be transplanted from EC-130 assets, numerous improvements are specified. Among these are rerack and rewiring of the AN/USC-13(V)21 communication system to improve the reliability and maintainability of the integrated system. The number of HF radios will be increased from two to five and the existing intercom system will be replaced with the AIC-27 for compatibility with the flight deck. Approved operational safety improvement programs will be implemented in the production equipment to maintain configuration compatibility with fleet assets in service. Special attention is being directed to the human factors aspects of the retracking of the communication system. Crew comfort will be improved substantially through the

reduction of noise levels and improvement of the climatic environment. Crew efficiency will be increased through improved equipment layouts for both operation and maintenance.

The NAVAIRDEVCEN, acting as the lead laboratory for the E-6A program, has been instrumental in developing the procurement package and detailed specifications, as well as providing design and effectiveness assessments for the E-6A program. The NAVAIRDEVCEN is providing the NAVAIRSYSCOM with technical support for program reviews, assistance in planning for test programs, and preparation of the Defense Systems Acquisition Review Council documentation for the production go-ahead milestone.

The next step in the evolution of the TACAMO system will be the initiation of a preplanned product improvement program on the communication equipment suite. TACAMO enhancements currently under consideration include: development of a data bus based system architecture, addition of a terminal for connectivity via MILSTAR, incorporation of a consolidated very low frequency (CVLF) terminal for improved VLF transmit/receive capability; replacement of the 200 kW tube type VLF power amplifier with a solid-state version; relacement of the TMPS and improvement of the long-trailing wire antenna and reeling system.

The NAVAIRDEVCEN is currently analyzing TACAMO system requirements, identifying the functional capability and alternative design approaches needed to meet future requirements. In addition, technology investigations supportive of the development of a VLF solid-state power amplifier, HF system improvements, and improved long trailing wire configurations, as well as technical monitoring of the CVLF and MILSTAR programs are being performed by the NAVAIRDEVCEN in anticipation of the start of the TACAMO Communication System Improvement Program.

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VOICE INTERACTIVE TECHNOLOGY CONTINUES AT THE NAVAIRDEVCEN

Voice interactive technology offers a new dimension in man-machine interface. At the NAVAIRDEVCEN this technology is being applied to aircraft systems to allow the aircrew to tune radios, change equipment modes, request status reports, and receive alerts and warnings without the use of hands or remembering the meaning of tones. Communications, maintenance, and data entry/retrieval applications are also being pursued. Voice recognition and synthesis refer to the understanding of speech by a computer.

Speech recognizers can be of isolated word, connected word, or continuous speech types. They can be either speaker dependent (trained) or speaker independent. Isolated word recognizers require the entry of individual words or short phrases with pauses between them. The words or phrases are usually limited to between 1/4 second and 1 1/2 seconds, with 100 to 250 millisecond pauses. Connected word recognizers can typically accept up to five words with no pauses between those five words. Continuous speech recognizers accept natural speech, however, the technology has not reached this capability yet. Most currently available recognizers are of the isolated word type. A few connected speech recognizers are available now but these are more expensive than isolated word recognizers.

Speaker dependence is a characteristic of all but a very few units. This dependence requires the training of the recognizer by the user. The user speaks each word to be recognized one or more times. This training material is then stored for future use. Speaker independent recognizers are available; however, they are usually limited in vocabulary size and are less accurate than speaker dependent types.

Most speech recognizers use a frequency analysis and pattern matching technique. The speech to be recognized is separated into 16 or more frequency bands, and the energy in each band is measured. These measurements are then compared to a previously stored reference pattern, and the closest match is determined. Other recognizers use a technique known as linear predictive coding. Linear predictive coding uses frequency and amplitude change parameters which are then compared to the reference patterns like the previous technique. Linear predictive coding is also used in vocoders and speech synthesizers to digitize speech.