

March 1989

COMMUNICATIONS

Actions Needed to Ensure Advanced High Frequency Radios Interoperate



**National Security and
International Affairs Division**

B-146858

March 20, 1989

The Honorable John P. Murtha
Chairman, Subcommittee on Defense
Committee on Appropriations
House of Representatives

The Honorable John Conyers, Jr.
Chairman, Legislation and
National Security Subcommittee
Committee on Government Operations
House of Representatives

As requested, we reviewed interoperability and standardization issues resulting from the Department of Defense's (DOD) efforts to develop advanced high frequency (HF) radio systems. Specifically, we examined servicewide efforts to develop and acquire new HF systems and improvements which are required to incorporate DOD interoperability standards in the equipment. This letter summarizes our review and identifies problems that need to be resolved before the systems are procured. Details of our review are discussed in appendix I.

Many joint military missions require interoperable HF radio systems. These missions could be adversely affected because the military services are independently developing and procuring new HF features that may not be interoperable. Although DOD has developed DOD-wide interoperability standards for various HF features, the services are continuing with independent development and procurement before the standards are incorporated or before systems are independently tested for interoperability.

Principal Findings

Although the establishment of interoperability standards represent progress, improvement is needed in testing and implementing the standards. For instance, the Air Force Automatic Communications Processor and the Army Short-Term Antijam (STAJ) systems will begin production in 1989, but no independent interoperability testing is planned between the two systems to determine whether the antijam standard was correctly implemented. Informal testing by the contractors revealed the systems may not interoperate in the antijam mode.

The Army and the Air Force are also buying automatic link establishment (ALE) equipment that automates functions which were previously

performed manually. Although the ALE standard was completed in September 1988, the two services plan to buy large quantities of the equipment before incorporating the standard.

The Army and the Air Force are also developing the first generation of advanced HF modems designed to accommodate secure, antijam communications. While development of the advanced modem standard is complete, the Air Force is developing an advanced modem without incorporating interoperability requirements. As a result, the modem may not interoperate with other advanced modems being developed for Army radios. The Army's advanced modems are designed to be interoperable.

These DOD programs developing antijam, ALE, and advanced modems represent the first generation of advanced features being added to HF radios. If these systems are acquired before the standards are incorporated and tested, there is no assurance they will be interoperable, and any changes required to make them interoperable would likely result in additional retrofit costs.

Conclusions

We believe DOD could reduce interoperability problems with these advanced systems and avoid potentially costly retrofits by

- delaying procurement of the Army's STAJ until the antijam standard is tested for antijam interoperability with the Air Force Automatic Communications Processor;
- delaying or limiting production of the STAJ, and limiting production of the Automatic Communications Processor, until the ALE standard is incorporated and tested; and
- ensuring the Air Force incorporates interoperability requirements in its modem development program.

Recommendations

We recommend that the Secretary of Defense direct

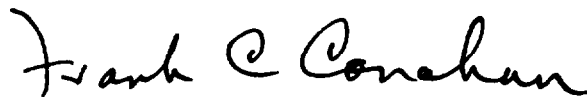
- the Secretary of the Army to (1) delay procurement of STAJ until the antijam standard is incorporated and tested for interoperability with the Automatic Communications Processor and then (2) delay or limit production of STAJ to the minimum amount practical until the ALE standard is incorporated and tested and
- the Secretary of the Air Force to (1) limit Automatic Communications Processor production to the minimum amount practical until the ALE

interoperability standard is incorporated and tested and (2) ensure the Air Force advanced modem development effort incorporates interoperability requirements with other advanced modems.

In accordance with one of the requester's wishes, we did not obtain official comments on a draft of this report. However, we discussed our findings with responsible agency officials and have included their comments where appropriate.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of the report. At that time we will send copies to the Director, Office of Management and Budget; the Secretaries of Defense, Army, Air Force, and Navy; interested parties; and make copies available to others upon request.

This report was prepared under the direction of Mr. Thomas J. Brew, Director, Command, Control, Communications, and Intelligence Issues. Other major contributors are listed in appendix III.



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Abbreviations

ALE	automatic link establishment
DOD	Department of Defense
HF	high frequency
STAJ	Short-Term Antijam

The Advanced High Frequency Radio Systems

New Advanced Features for HF Radios

DOD has concluded that HF radios provide a cost-effective flexible communications capability. These radios can communicate over both short and long distances in either voice or data modes. However, present HF radios do not have antijam protection, are difficult to use, and have relatively low-information passing capability. Because of recent advances in technology, the services are now improving their existing HF radios. New advanced features are designed to allow communications during enemy jamming, automate functions that traditionally required skilled operators, and increase the ability of HF radios to pass more information.

Types of Advanced HF Features

The services are developing and procuring three types of advanced HF features. These are antijam capability, ALE, and advanced modems.

Antijam

Antijam devices provide communications systems with resistance to hostile electronic warfare activities. The antijam devices discussed in this report use the frequency hopping technique. In a frequency hopping system, both the transmitter and the receiver automatically, rapidly, and synchronously change operating frequencies in a pseudo-random pattern. Currently, fielded electronic warfare systems have little capability for jamming frequency hopping radios.

ALE

In the past, efficient operation of HF radios required skilled operators and the use of propagation charts to seek the best operational frequency. ALE devices enable more widespread and reliable use of HF radios because they automatically select the best frequency, determine channel availability, establish the link, and then signal the user to begin communications.

Advanced Modems

Conventional modems convert signals compatible with automatic data processing equipment to signals compatible with communications transmission equipment. Advanced modems provide the added benefit of increased data rates as well as the integration of both antijam and communications-security modes of operation. Communications-security devices encrypt, or encode, communications to reduce enemy eavesdropping and provide secure communications.

Efforts to Incorporate Advanced Features

The services have started several new, mostly independent, programs to incorporate these advanced features. The Air Force, Army, and Marine Corps programs will incorporate antijam, ALE, and advanced modems on their existing radios through the use of external components known as appliques. A Navy program, which was recently terminated, would have replaced current HF radios and developed new radios specifically designed to integrate the antijam and advanced modem features.

Air Force Advanced HF Programs

The Automatic Communications Processor is an applique to the standard Air Force HF radio, the ARC-190. These provide the radios with both antijam and ALE features. Production for the first 200 appliques began in August 1988. The Air Force plans to buy over 3,000 Automatic Communications Processors at an estimated program cost, including aircraft installation, of about \$223 million. In addition, the Air Force is developing an advanced modem for the ARC-190 radios called the Narrowband HF Modem.

Army and Marine Corps Advanced HF Programs

STAJ is an applique for the standard Army and Marine Corps family of HF radios, called Improved HF Radios. STAJ appliques provide the radios with both antijam and ALE capabilities. In addition, two advanced modems are being developed for Improved HF Radios, the Enhanced Miniaturized Terminal modem for backpack radios and the MD-1230 modem for vehicle mounted radios.

The Army and the Marine Corps plan to add the STAJ applique to about 9,000 radios. STAJ production is scheduled to begin in early 1989. The Army cost estimate for STAJ is approximately \$153 million, which includes the cost of the two efforts necessary for Improved HF Radios to use the antijam and automatic link features. These efforts are (1) the internal modifications to the radio that allows the radio to accommodate frequency hopping and (2) the attachment of the STAJ applique, called the STAJ controller, that actually performs the antijam and ALE functions. The Marine Corps' cost estimates to modify its radios is \$38 million; however, the Marine Corps does not plan to request funding for the STAJ controller until fiscal year 1992 or 1993.

Navy Advanced HF Program

The Navy's program, called the High Frequency Antijam Program, was terminated due to fiscal year 1989 cost constraints. Unlike the other service programs, this program was designed to replace existing HF radios with new radios that incorporate antijam and advanced modems as an

integral part of the radio system. DOD officials said the Navy will eventually initiate a new HF improvement program because it must be able to interoperate in an electronic warfare environment with the other services.

Standards Will Help Ensure Interoperability

In currently fielded HF radios, interoperability is ensured through standard technology and standard communications-security equipment. However, the advanced features being developed separately by the services do not use compatible technology. To maintain interoperability while using these advanced features, DOD has developed mandatory interoperability standards for HF systems with antijam, ALE, or advanced modems. An HF antijam standard has been developed and approved by the services, and a more advanced antijam standard is being developed for the next generation of HF radios. Also, the standard for ALE was completed in September 1988, and the standard for advanced modems was completed in November 1988.

Although the establishment of standards represents progress, improvement is needed in testing and implementing the standards. For instance, the Air Force's Automatic Communications Processor applique is already being produced, and the Army's STAJ will begin production in 1989. However, the services do not plan to conduct independent antijam interoperability testing between the two systems to determine whether the antijam standard was correctly implemented and ensure that the two radios will be interoperable in the antijam mode. Informal testing by the contractors revealed antijam communications problems between the two radios.

Further, although the ALE standard was completed in September 1988, the Air Force and the Army plan to buy large quantities of this type of equipment before incorporating the standard.

Independent Testing Needed to Ensure the Antijam Standard Is Correctly Implemented

DOD Directive 5000.3 supports but does not explicitly require independent interoperability testing of product improvements before production. Air Force's Automatic Communications Processor will be the first production applique to incorporate the antijam interoperability standard. This applique should be interoperable with the Army's STAJ. However, no independent interoperability tests have been made nor are any planned. Based on contractor testing, antijam communications between the Automatic Communications Processor and STAJ appliques may deteriorate until interoperability is lost because the antijam standard was

implemented differently in the two systems. Without independent testing, production of interoperable equipment will not be ensured, according to DOD officials and contractor personnel.

The Army STAJ program manager agreed that independent operational testing is important. However, the manager noted that such testing is not planned because the Air Force and Army appliques are preplanned product improvements to existing radios rather than new radios. The manager also said the antijam appliques are to be produced in accordance with the antijam interoperability standard and that this should ensure interoperability. The manager said the contractors developing the Air Force and Army appliques should eventually correct the problems that are impeding antijam communications during additional contractor testing.

However, according to Army Regulation 70-10, operational testing is to be done by an organization that is independent of the developing, procuring, or user commands, and should be completed before the first major production decision to provide a valid estimate of the operational effectiveness of the system. The Army regulation specifically includes preplanned product improvements to existing systems, such as STAJ. The regulation also states that those systems that interoperate with equipment of another service may require joint service testing.

Officials in charge of HF communications from the Office of the Secretary of Defense, as well as other DOD officials involved with HF radio issues, agreed that the Air Force and Army appliques should be independently tested before production. These officials believe the potential for interoperability problems exist because: (1) DOD has never implemented the interoperability standard before and (2) the standard is not clearly written. According to these officials, the standard needs to be clarified because differing interpretations of the technical interface specifications by manufacturers could impede antijam interoperability. DOD officials said the standard will need to be clarified after independent interoperability tests are conducted.

Further, the informal tests conducted by the contractors support the need for independent testing. The STAJ contractor said antijam communications between the two systems were lost because of differences in the way each manufacturer interpreted and implemented the standard. The contractor said that independent testing was necessary before production to clarify ambiguous sections of the standard and to ensure that the standard is correctly implemented.

During discussions in late September 1988, DOD officials in charge of HF radio programs told us they support a delay in Army production pending independent antijam interoperability testing with the Air Force applique. The officials agreed that testing is needed (1) to ensure the standard is correctly implemented, (2) to avoid the cost of corrective actions after production, and (3) to ensure the standard is sufficiently clear. These officials said the Army is responsible for testing its applique's interoperability with the Air Force applique since the latter is already in production.

ALE Systems Being Procured Before Standards Are Incorporated

While the ALE interoperability standard was approved in September 1988, some services are beginning to buy ALE systems before incorporating the standard. For example, the Air Force began Automatic Communications Processor production in fiscal year 1988 and, based on our review of an August 1988 Air Force schedule, will continue procurement without incorporating the standard until all its requirements are met. The Army also plans to begin production of the STAJ ALE system in fiscal year 1989 without the standard and has not yet determined how or when it will incorporate the standard. The Air Force and the Army decided to begin production based on operational needs and program maturity. The Marine Corps, however, does not plan to buy STAJ until after the ALE standard is incorporated. The Air Force and the Army plan to incorporate the ALE standard after the hardware and software modifications are developed and tested.

In our August 1987 classified report to the Secretary of Defense, we recommended ALE and modem acquisition be restricted until interoperability standards were incorporated, except where specific exceptions were justified and approved, to avoid triservice interoperability problems. DOD implemented our recommendation that month. In November 1987, however, DOD exempted the Air Force and Army systems from the restriction. DOD required both systems to incorporate the standard at a later date.

DOD exempted the Air Force system from the ALE restriction based on the Air Force rationale of operational need and program maturity. Although DOD required that each request for an exemption contain sufficient technical and programmatic detail to enable independent analysis of the need to continue the program, a DOD official said it was not clear why the Air Force system was urgently needed. The official said ALE is only

an operator aid and not an essential communications element. The official said the waiver was granted because funding was available for the Air Force and it had a production contract for the system.

Costs Associated With Retrofitting to the Standards

Air Force and Army officials said they plan to retrofit the two systems to comply with the ALE standard. The standard was completed in September 1988. In August 1988, the Air Force contractor estimated that \$19 million would be needed to retrofit all Automatic Communications Processor appliques with the proposed standard. Furthermore, the Air Force estimated that it would take 5 years of development and testing before the Air Force could begin to implement the ALE standard in the appliques. Based on our review of this production schedule, all units will be bought before the standard is incorporated.

Under the August 1988 plan and using Air Force cost estimates, the Air Force will produce 200 Automatic Communications Processors in fiscal year 1988 at a cost of about \$39,000 a unit. It will then increase production to 800 units a year at a cost of about \$32,500 a unit, until the Air Force requirement for 3,163 units is completed in 1992. Using these unit cost estimates, the total production costs, not including aircraft installation costs, would be about \$103 million. The ALE standard would then be retrofitted into all 3,163 units at a cost of about \$6,000 a unit, or \$19 million for all units. This would bring the cost to produce and retrofit all the Automatic Communications Processors to about \$122 million.

DOD officials said that at the time the exemptions discussed above were granted, they were not aware of the cost and time necessary to retrofit the ALE standard in the two systems. The officials said that, based on the recent Air Force cost estimate of \$19 million to retrofit the Automatic Communications Processors, they can no longer support their exemption. The Army has not yet estimated the cost to retrofit its system.

We examined the potential to restrict production of Automatic Communications Processors until the ALE standard is incorporated to encourage the Air Force to incorporate the standard as early as possible and to avoid much of the retrofit cost. We used a restricted production rate of 200 units a year, which is the first year production rate, in our analysis for illustrative purposes. We did not determine the optimum annual production quantity. The Air Force has not determined the minimum

number of units that could be produced before incorporating the standard. Such an analysis would need to consider the urgency of requirements, unit costs at various quantities, retrofit costs, potential to accelerate incorporation of this standard, and impacts of terminating an ongoing production line.

We discussed with Air Force officials the possibility of limiting Automatic Communications Processor production to the first year production rate until the ALE standard was incorporated. They said that restricting production would increase unit costs. Our examination, however, showed that the expected increase in unit cost would be more than offset by the avoidance of retrofit cost for incorporating the ALE standard. For example, at 200 production units a year, only 1,000 units would be produced in 5 years without the ALE standard. Including estimated higher unit cost and retrofit cost for this initial 1,000 units, the total production cost for 3,163 units is estimated at \$115.8 million. This is about \$6 million less than producing all units and subsequently retrofitting them with the ALE standard. After reviewing a draft of our analysis, a DOD official said the Air Force is now examining ways to incorporate the standard in 3 years. If the Air Force incorporates the ALE standard in 3 years instead of 5 years, savings over the current plan would increase to about \$11 million.

The Army also plans to begin buying STAJ ALE units without the standard. The Army ALE device will be located in the STAJ applique. The Army plans to begin buying the STAJ modification kits for the radios and the STAJ appliques early in calendar year 1989. An Army official said a formal analysis had not been performed to determine when the Army could begin implementing the standard.

The Marine Corps acquisition approach is different. It plans to procure the radio modification kits necessary to make the fielded radios ready for the STAJ applique, then procure the appliques after the ALE standard is incorporated—about 1992 or 1993. As previously mentioned, Improved HF Radios must be modified to accommodate the STAJ frequency hopping capability.

If the Army adopted the Marine Corps acquisition approach, there would be time to implement and test the ALE standard before STAJ production, which would avoid retrofit costs. Over 3,000 Army radios need the modification kits. Retrofitting the STAJ applique with the ALE standard could involve greater changes and costs than anticipated by the

Army. For example, although no formal cost estimate exists, a STAJ program official said he believed that no hardware changes were necessary and that modification costs would be minimal. However, a STAJ contractor representative said that the system will require significant hardware and software modifications to implement the standard. The representative said no cost estimates were available as of November 1988. As with the Air Force system, hardware modifications may result in cost increases.

We discussed with an Army official involved with the STAJ program the possibility of not buying the controller until the ALE standard is incorporated. The official said that the Army wants to begin STAJ production to obtain the antijam protection provided by the controller. As a result, the official said the Army does not plan to take action to stop or delay STAJ production until the ALE standard is incorporated. As previously discussed, the Army has not obtained cost estimates for incorporating the standard in the system after production begins.

After detailed discussions regarding this report, DOD officials said that they would support a recommendation to reduce Automatic Communications Processor production until the ALE standard is incorporated and tested. The officials also said that the Office of the Secretary of Defense and the Air Force generally agree that production should be limited until the ALE standard is successfully incorporated.

Regarding STAJ, DOD officials said they would support a recommendation to limit or delay production based on the potential cost necessary to incorporate the standard. The officials said this decision could be made after the antijam standard was successfully incorporated and cost estimates to incorporate the ALE standard were available.

Independent Modem Development Efforts Could Create Interoperability Problems

The services are currently developing the first generation of advanced HF modems designed to accommodate secure, antijam communications. While development of the advanced modem standard is complete, the services are developing advanced modems that may not be interoperable. DOD completed its modem interoperability standard (Military Standard 188-110, Change Notice 2) in November 1988, and placed a moratorium on purchasing modems until the interoperability standard was completed; however, no restrictions were placed on the development of modems.

The Army has been developing a modem, the MD-1230, for its vehicular radios since 1982. This is the first modem to accommodate both antijam and communications-security modes of operation into one box. The MD-1230 design is the basis for the HF modem interoperability standard. The National Security Agency, in conjunction with the Army, is developing a separate advanced modem for Army backpack radios. This modem is called the Enhanced Miniaturized Terminal, which is intended to be interoperable with the MD-1230.

The Air Force is also developing an advanced modem for its HF radios. According to an official with the Air Force program office, this modem—the Narrowband HF Modem—is not designed to be interoperable with the Army's modems. The official said the Air Force modem has not been developed to be interoperable with the proposed standard because the standard is only required for production and is not required for the development phase. A DOD official in charge of HF programs said modem development was not restricted to allow the services technological flexibility. The official said that DOD's position was that service development efforts should not be restricted as long as service modems met the modem interoperability standard before production. Furthermore, the official said that new digital technology should eventually allow modems to incorporate the interoperability standard through inexpensive software modifications. However, cost estimates had not been developed to verify that this was the case with the Air Force modem.

Because there is no restriction or standards for modem development, the services can independently develop modems that may not be interoperable. Although DOD and the Air Force recognize the need for interoperability, no action has been initiated to preclude development of an incompatible Air Force modem. As a result, the modem may have to be modified before production to be in compliance with the restriction on modem procurement. The Office of the Secretary of Defense officials said they would direct the Air Force to ensure that interoperability requirements are considered during the design phase and incorporated before production.

Conclusions

The DOD programs developing antijam, ALE, and advanced modems represent the first generation of advanced features being added to HF radios. The antijam and ALE features the Army, Marine Corps, and Air Force will soon buy will be used on about 75 percent of DOD's HF radios.

Unless interoperability standards are successfully tested and effectively incorporated, these radios may not be interoperable.

DOD is developing and has developed standards to promote interoperability but the services are beginning to buy some of these advanced features without the standards. Incorporating the standards after production will be costly. Deferring system acquisition to incorporate standards will delay enhancements but will not diminish current HF radio capability since only the advanced features, and not the radios, would be affected.

Objectives, Scope, and Methodology

As requested by the former Chairmen, Subcommittee on Defense, House Committee on Appropriations and the Legislation and National Security Subcommittee, House Committee on Government Operations, we reviewed interoperability and standardization issues resulting from DOD efforts to develop advanced HF communications systems. Specifically, we examined servicewide efforts to develop and acquire new HF systems and improvements, which are required to incorporate DOD interoperability standards in the equipment. We also identified problems that need to be resolved before the systems are procured.

During our review, we discussed interoperability and standardization issues with officials and reviewed planning and program documents, budget documents, and studies and cable traffic at the Organization of the Joint Chiefs of Staff, the Office of the Secretary of Defense, Chief of Naval Operations, Air Staff, the Department of Army, and the Defense Communications Agency in Washington D.C., and the National Security Agency in Maryland. We also performed work at the Joint Tactical Command, Control, and Communications Agency and the Army's STAJ program office, Fort Monmouth, New Jersey, and the Automatic Communications Processor program office, Scott Air Force Base, Illinois.

Our review was performed from July 1987 to November 1988 in accordance with generally accepted government auditing standards.

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