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United States General Accounting Office
Washington, DC 20548

August 11, 2003

The Honorable Jerry Lewis
Chairman
Subcommittee on Defense
Committee on Appropriations
House of Representatives

The Honorable John P. Murtha
Ranking Minority Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Subject: Challenges and Risks Associated with the Joint Tactical Radio System Program

The recent emergence of software-defined radio technology offers the potential to address key communications shortfalls and significantly improve military capabilities. The Joint Tactical Radio System (JTRS) program was initiated in 1997 to develop and apply this technology and to bring together separate service-led programs into a joint software-defined radio development effort. JTRS radios are intended to interoperate with existing radio systems and provide the war fighter with additional communications capability to access maps and other visual data, communicate via voice and video with other units and levels of command, and obtain information directly from battlefield sensors. As such, the JTRS program is considered a major transformational effort for the military and is expected to enable information superiority, network-centric warfare as well as modernization efforts, such as the Army's Future Combat Systems.¹ Although total program costs have yet to be determined, the Army's effort to acquire and field close to half of the estimated 250,000 JTRS radios that are needed is expected to cost \$14.4 billion.

You asked us to review the JTRS program to determine if there are either management or technical challenges and risks that could jeopardize a successful program outcome. We briefed your staff on May 5, 2003, on the results of our review. This report summarizes that information and transmits the briefing itself (see enc. I).

¹ The Future Combat Systems program is a major Army transformational effort, comprised of 18 networked weapon systems that will replace several current combat systems.

Challenges Facing the JTRS Program

We found that the JTRS Program has made considerable progress to date in planning and developing key aspects of the JTRS radios. At a fundamental level, a Joint Program Office has been established to bring together the services' individual efforts to develop software-defined radios. The program office was instrumental in developing a standard software communications architecture that provides a foundation for building JTRS radios and evolving an open systems approach to facilitate technology insertion. The program office has reduced risk by employing an evolutionary acquisition strategy, whereby improved communications capabilities will be delivered in increments.

However, the program still faces several managerial and technological challenges that could affect the Department of Defense's (DOD's) ability to develop and procure JTRS radios successfully. These include managing requirements and funding, maturing key technologies, integrating system components, testing, and developing secure communications. The most significant challenge we identified is the lack of a strong, joint-management structure.

The current JTRS management structure is made up of a Joint Program Office, designated service-led program clusters, and other DOD organizations carrying out several related acquisition activities.² The Joint Program Office is responsible for developing the communications architecture, radio waveforms, and security components, while the services are primarily responsible for developing, acquiring, and funding the actual radios. This structure, while preferable over individual service efforts, is still fragmented, making it difficult to resolve interservice differences involving requirements and funding, and hampering the production of key program documents, as in the following examples:

- It has been difficult to get the services to commit the funding necessary to execute the JTRS program.
- The program management structure has been unable to get the services to reach agreement over new and changing requirements expeditiously.
- Key program documents, such as the *Concept of Operations* and *Migration Plans*, have not effectively provided a joint vision for how JTRS capabilities will be developed and used.

As a consequence, several program development efforts, such as handheld radios, have been delayed by more than a year. In the meantime, the Army has purchased more existing radios with fewer communications capabilities, which may further delay the delivery of JTRS capabilities to users.

Technology maturity is another significant challenge facing the JTRS program. Our work on best practices has shown that programs that move to product development

² Clusters are radio development efforts that are organized around weapons platforms, such as ground vehicles and helicopters, as well as fixed-wing aircraft and maritime systems.

with immature technologies have greater difficulty meeting cost, schedule, and performance requirements than programs that mature technologies before moving into product development.³ The initial JTRS radio development, for helicopters and ground vehicles, was allowed to proceed into the Systems Development and Demonstration phase with technology readiness levels lower than those recommended by best practices. Further, technologies that are critical to several JTRS variants—such as miniaturized components, batteries, and multimodal antennas—are not sufficiently advanced to meet requirements and will take several more years to mature. Examples of other technological challenges include the development of complex software, the difficulty of integrating radios with host platforms, and a compressed testing schedule. In addition, developing encrypted capabilities and secure communications will be difficult because of the complex nature of the radio.

Recommendations for Executive Action

While significant accomplishments have been realized, management and technological challenges exist that could impair JTRS's success. We recommend the Secretary of Defense take steps to strengthen the joint-program management structure to facilitate program funding and requirements outcomes and assure configuration management of JTRS. In strengthening the structure, the Secretary should consider (1) establishing centralized program funding, (2) realigning the Joint Program Office under a different organizational arrangement, and (3) placing the cluster development programs under the Joint Program Office control. We also recommend that the Secretary of Defense take action to ensure the JTRS Program realizes its full potential by (1) directing the completion of key program documents detailing the program's vision; (2) making sure key enabling technologies, such as networking capabilities, are adequately addressed; and (3) assessing the impact that the continued purchase of existing radios may have on JTRS.

Agency Comments and Our Evaluation

In written comments to a draft of this report (see enc. II), DOD concurred with our findings and both of our recommendations. However, DOD disagreed with one of the options we suggested for implementing our recommendation on strengthening the JTRS joint management structure. While DOD supports consolidation of all research, development, test, and evaluation funding for JTRS, it believes that procurement and integration funding is best left in the individual service budgets. We agree that this would be a good first step, but we also believe funding needs to be closely monitored as the program progresses towards procurement.

³ U.S. General Accounting Office, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, [GAO-01-288](#) (Washington, D.C.: Mar. 8, 2001).

Scope and Methodology

To assess the status of the program, we reviewed relevant DOD and service program documents and interviewed key officials. In examining the program, we analyzed technological and management factors that could affect the program's success and key program development efforts as well as projected funding and schedule profiles. We conducted our work from October 2002 through April 2003 in accordance with generally accepted government auditing standards.

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We are sending copies of this report to the Secretary of Defense; Secretary of the Air Force; Secretary of the Army; Secretary of the Navy; Commandant of the Marine Corps; the Director, Office of Management and Budget; and interested congressional committees. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

Should you or your staff have any questions on matters discussed in this report, please contact me on (202) 512-2811 or John Oppenheim at (202) 512-3111. Principal contributors to this report were Joel Christenson, Gary Middleton, John Swain, Hai Tran, and Nicole Volchko.



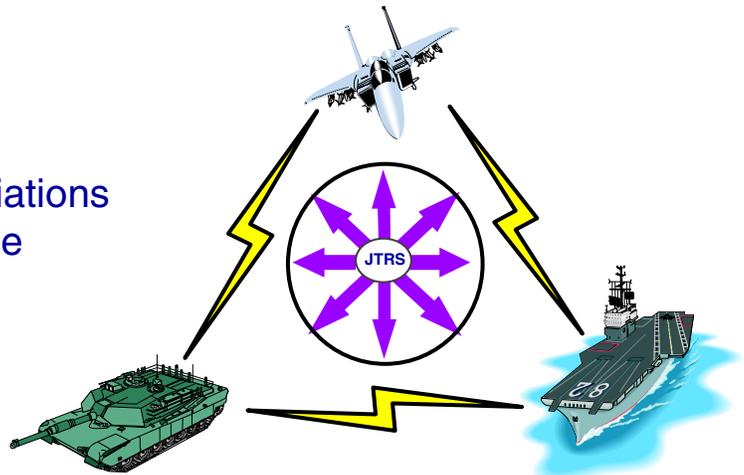
Paul L. Francis
Director, Acquisition and Sourcing Management

Enclosures



Joint Tactical Radio System (JTRS) Program

Briefing to the
House Committee on Appropriations
Subcommittee on Defense
May 5, 2003





Focus of Review

- Are there challenges and risks associated with the JTRS program that could jeopardize a successful outcome?



Briefing Structure

- JTRS background
 - Program details
 - Factors affecting program success
 - Summary observations
 - Options to increase likelihood of JTRS program success
-



JTRS Background

Introduction

- JTRS was born out of a desire to address key shortfalls in tactical battlefield communications capabilities, and bring separate service-led, software-defined radio programs together into a joint development effort.
 - Many legacy radios do not interoperate with one another, are out of date, and are expensive to maintain.
 - Recent emergence of software-defined radio technology in the commercial sector provides DOD with new opportunities to address past problems and increase communications capabilities.
-



JTRS Background

Intended Impacts

- JTRS:
 - Is a major transformational effort for the military
 - Enables information superiority, network-centric warfare, and modernization efforts such as the Future Combat Systems
 - Combines functions and uses common components, reducing the unit cost and number of radios needed (250,000 JTRS radios, compared to 750,000 legacy radios currently in use)
 - Increases communications capabilities
 - High data throughput, improved interoperability, and networking
-



JTRS Background

Program Objectives

- Develop a family of interoperable, digital, modular, software-defined radios that:
 - Provide voice, data, video capabilities as needed
 - Interoperate with legacy systems (32 legacy waveforms to be developed such as Link-16)
 - Utilize a common, standard software architecture
 - Provide flexibility to fit radios into a broad range of platforms
 - Supply new wideband networking capability—Wideband Networking Waveform (WNW)



JTRS Background

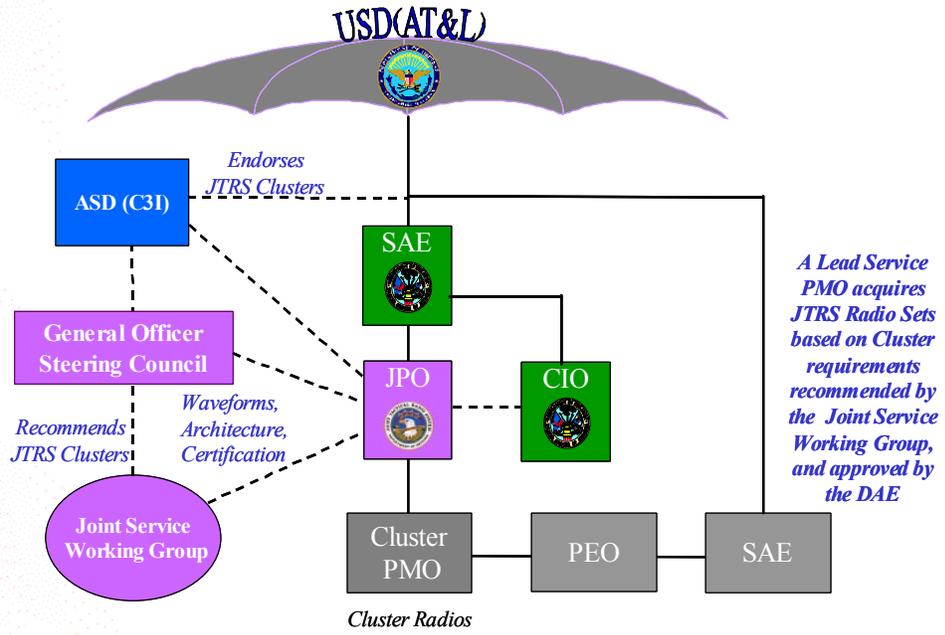
Acquisition Strategy

- Employ an evolutionary acquisition approach, fielding capabilities in blocks and allowing for technology insertion
- Develop software communications architecture to provide foundation for building interoperable radios
- Assign development and acquisition responsibilities to different organizations—the Joint Program Office (JPO) to develop architecture and manage waveform acquisition, while services manage and acquire radios
- Migrate and field radios in a phased approach as new platforms are produced and as legacy systems are retired



JTRS Background

Program Management Structure





JTRS Background

Program Management Structure

- The JPO, which reports to the Army Acquisition Executive, is responsible for:
 - Evolving the open systems architecture,
 - Developing waveform applications and associated cryptographic algorithms,
 - Certifying compliance of hardware and software waveforms, and
 - Ensuring overall joint interoperability.
- Radio development and acquisition is conducted through service-led clusters, based on grouping platforms with similar requirements.
 - Each cluster to be considered a separate acquisition program; currently two acquisition programs have ACAT 1D designations (Cluster 1 and JPO/waveform).



JTRS Background

Program Management Structure

- A Joint Service Working Group and General Officers Steering Council monitor, guide, and coordinate development of JTRS and provide forum for resolving issues.
- Additional guidance and planning are facilitated through Integrated Product Teams.
- Funding of JTRS (JPO and clusters) is not centralized but comes from individual service budgets.



Program Details

	JPO (ACAT ID)	Cluster 1 (ACAT ID)	Cluster 2		Cluster 3	Cluster 4	Cluster X
Platform	N/A	Helicopters & ground vehicles	Handheld	Manpack	Maritime & fixed station	Airborne	Embedded
Lead Service	Army	Army	Special Operations	Special Operations	Navy	Air Force	Army
Deliverables	33 waveforms (21 + WNW contracted to Cluster 1) and 26 Cryptographic algorithms	Aviation set (4 channel), Ground vehicle radio (3 channel), 21 legacy waveforms, and WNW	Handheld set (1 and 2 channel)	Manpack set (2 channel)	Maritime – fixed station set (4 channel)	Aviation sets (8 channel)	TBD
Other Services	Marine Corps, Air Force, and Navy	Air Force and Marine Corps	Air Force, Army, Marine Corps, and Navy	Air Force, Army, Marine Corps, and Navy	Air Force	Navy, Army, Marine Corps, and Special Operations	TBD



Program Details

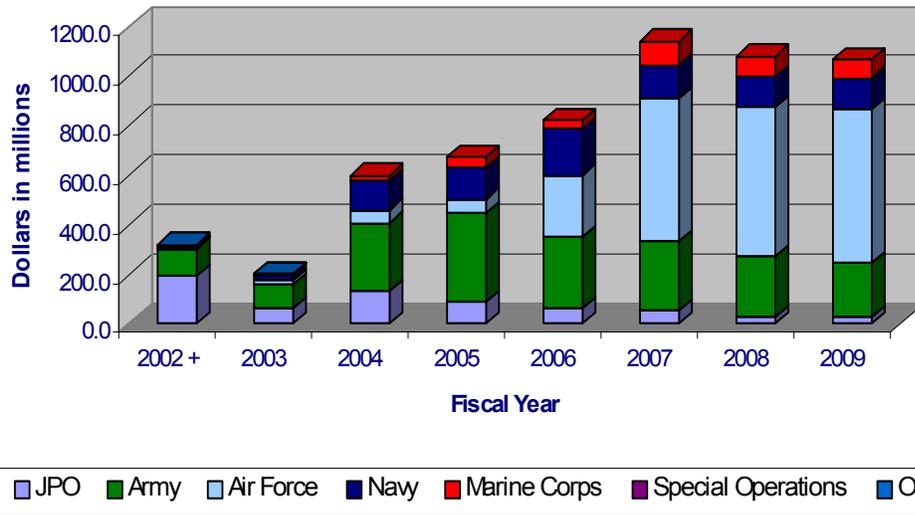
	JPO (ACAT ID)	Cluster 1 (ACAT ID)	Cluster 2		Cluster 3	Cluster 4	Cluster X
Total acquisition cost	\$796.3 million*	\$14.4 billion*	Unknown	Unknown	Unknown	Unknown	Unknown
Required number of radios	N/A	138,913	72,692	44,175	7,467	9,540	47,270
Program initiation	4 Q 97	2 Q 01	TBD	TBD	3 Q 02	3 Q 02	TBD
Milestone B	3 Q 02	3 Q 02	3 Q 03 (Delayed)	2 Q 04	1 Q 04	4 Q 04	2 Q 04
Milestone C	1 Q 07	2 Q 06	2 Q 06	4 Q 06	4 Q 06	4 Q 07	1 Q 07
Full-rate production	N/A	3 Q 07	N/A	N/A	1 Q 09	4 Q 08	2 Q 09
Possible interim radios (I) or alternate radios (A)	N/A	N/A	Multiband inter/intra team radio (I)	Multiband, multimission radio (I)	Digital modular radio (I) or multifunctional information distribution system (A)	Multifunctional information distribution system (I)	TBD

* Current estimate, base year FY2002 dollars



Program Details

Identified JTRS Program Funding*



* See slide number 29 for information supporting this chart.

Total = \$5,908.0 million



Factors Affecting Program Success

JTRS Knowledge Development

- JTRS is a large, multi-faceted, and complex program that will take time to reach its full capabilities.
 - Program success will mean developing, producing, and delivering joint tactical radios that are affordable, interoperable, and offer enhanced communications capability.
 - GAO's best practices work has shown that complex weapons programs are more likely to reach a successful outcome when a high level of knowledge exists about critical facets of the product being developed at key junctures during its development.
-



Factors Affecting Program Success

JTRS Knowledge Development

- The knowledge-based process followed by leading commercial firms can be broken down into three key knowledge points:
 1. A match must be made between user needs and the available resources—technology, engineering, time, and funding—before system development is launched. The results achieved from this match are balanced and realistic requirements, sufficient investment to complete the development, and a firm commitment to deliver the product.
 2. A product’s design must demonstrate its ability to meet performance requirements and be stable about midway through development.
 3. The developer must show the product can be manufactured within cost, schedule, and quality targets and demonstrate it is reliable before production begins.
 - To date, the JTRS program has made considerable progress in acquiring knowledge on several key aspects of product development, but it also faces numerous technical and management challenges that could affect a successful outcome.
-



Factors Affecting Program Success

Positive Developments

- DOD recognizes the need for a transformational, joint, interoperable radio solution to enable network centric operations.
 - The evolutionary acquisition strategy for developing and delivering JTRS radios can provide improved capabilities at reduced risk.
 - As technology advances, enhanced capabilities should be able to be added because of the open systems architecture.
 - DOD envisions upgrades being delivered through new software, much like desktop personal computers.
 - Development of a software communications architecture provides a foundation for building compatible radios and may become the standard for software programmable radios.
 - Architecture has received strong support from commercial sector and is currently going through certification process by the Object Management Group.
-



Factors Affecting Program Success

Positive Developments

- Demonstrated JTRS concept
 - Recent test conducted of small network of prototype JTRS radios in a field environment exercise
 - Established Integrated Product Teams and Joint Services Working Group to facilitate coordination and knowledge sharing
 - Clusters have also established ad hoc communications arrangements to augment formal channels
 - Cluster 1 program office has recognized product development risks and defined risk management processes
 - DOD has emphasized competitiveness in contract awards to address affordability
 - Cluster 1 prime contractor is responsible for qualifying two subcontractors to develop and build Cluster 1 JTRS radios
-



Factors Affecting Program Success

Management Challenges

- **Managing requirements:** Ensuring the services jointly identify and coordinate requirements of JTRS has been problematic since the program began. Joint program management process has been unable to effectively resolve some interservice differences.
 - ORD has gone through several iterations since the program began
 - Disagreement exists between Army and OSD over new and changing requirements for Cluster 2 and proposed Cluster X radios. As a consequence, initiation of Cluster 2 development has been delayed more than a year.
 - Other differences in meeting requirements have recently surfaced and have slowed progress of Clusters 3 and 4 (e.g., how to fold the Multifunctional Information Distribution System program into JTRS).
 - Further requirements changes (e.g., bringing other information data systems like the Joint Tactical Terminal into the JTRS program) may hinder JTRS progress.
 - Army, as the service acquisition executive, has greater clout over requirements determination than other services.



Factors Affecting Program Success

Management Challenges

- **Concept of Operations:** Should provide vision for how JTRS capabilities will be used in an operational environment and should guide key aspects of the program such as requirements definition and fielding strategies.
 - JTRS Concept of Operations has not sufficiently provided this perspective.
 - According to program officials, Concept of Operations does not reflect the joint vision of JTRS but instead reflects service-centric, radio-replacement perspective.
 - Services are currently revising Concept of Operations, to be issued later this year



Factors Affecting Program Success

Management Challenges

- **Funding:** Ensuring service funding commitments to cluster radio development efforts and articulating overall JTRS program costs has been difficult.
 - Services have been slow to commit funding to the program, although situation has gotten better over time.
 - However, services (except for some limited Army funding) have not committed funding to Cluster 2 development.
 - Restriction on Special Operations Command funds further hampers program.
 - Acquisition costs still undefined for major components of the program.
 - JPO must rely on funding by the Army for its activities and has been unable to meet staffing goals.
- **Migration planning:** Creating a road map for integrating JTR sets into the services in the most timely, cost efficient, and productive way has been difficult.
 - An *Acquisition Decision Memorandum* called for a joint migration plan by October 2001; still no plan has been issued, although the services are working on one.



Factors Affecting Program Success

Management Challenges

- **Schedule:** Direction from DOD leadership is trying to accelerate development schedules to field capabilities and meet anticipated needs.
 - Cluster 1 schedule is rated medium to high risk by program office, due to a compressed test and evaluation phase which leaves little room for error.
 - Other clusters have taken a significant amount of time to get started.
 - **Waiver process:** Balancing immediate service needs to acquire legacy radios with longer-term service JTRS requirements.
 - DOD-wide waiver process was created in 1998 to minimize purchases of legacy radios or development of other radios that are not JTRS compliant.
 - Since January 2003 alone, more than \$75 million approved for purchases of legacy radios to satisfy immediate requirements.
 - Army made a significant number purchases of handheld radios via this process while reducing its requirement for JTRS radios.
 - Additional funding for legacy radios may increase costs and delay delivery of JTRS capabilities to users.
-



Factors Affecting Program Success

Technology Challenges

- **Technology readiness:** Continued focus needed on maturing and integrating technologies into JTRS
 - Cluster 1 approved at Milestone B with technology readiness levels lower than those recommended by best practices.
 - Additional technological advances will be needed for handheld and embedded radios such as miniaturization, batteries, and heat dissipation.
 - Furthermore, advanced antennas that can operate over different frequencies and transmit and receive with other radios on-the-move are essential.
 - Antenna development is not a part of JTRS program, although some research and development efforts are underway elsewhere in DOD.



Factors Affecting Program Success

Technology Challenges

- **Waveforms:** Adapting waveforms, developing new WNW, and transitioning from legacy waveforms to WNW
 - Waveform development is software intensive
 - Cluster 1 developing 22 waveforms (21 legacy + WNW)
 - WNW development complex (operating frequency, channel bandwidth requirements, hardware processing requirements)
- **Software Communications Architecture:** Architecture provides a core framework for software applications to operate on different JTRS platforms but alone is not sufficient to ensure interoperability
 - JTRS program must closely manage cluster development efforts to ensure similar interpretation of the architecture, and it must evolve the architecture to meet evolving requirements
 - Clusters 2 and 3 are evolving existing radios into software communications architecture-compliant as an interim capability, but will begin distinct development efforts for the longer term to achieve JTRS capabilities



Factors Affecting Program Success

Technology Challenges

- **Portability:** Ensuring waveform and other software capabilities are available to all JTR sets in “plug and play” format.
 - Each cluster must adapt “core” waveforms for use in its particular radios.
 - **Integration:** Two key sets of integration issues must be adequately addressed—integrating hardware and software components into a workable radio that meets requirements and integrating radio sets into a broad range of different platforms.
 - Radio set integration: Cluster 1 technology readiness assessment highlighted the lack of a hardware and software integrated radio.
 - Platform integration: Cluster 4 must plan for over 65 distinct aircraft platforms.
 - **Testing:** Testing process required to ensure interoperability among diverse set of radios.
 - JPO has established consortium of testing components to coordinate testing, but aggressive testing schedules planned for some clusters.
-



Factors Affecting Program Success

Technology Challenges

- **Security/encryption:** Developing, integrating, and certifying security into JTRS sets.
 - Requires development of new cryptographic algorithms.
 - Must go through a National Security Agency certification process, which can be lengthy and is outside control of JTRS program.
 - **Networking:** Development and fielding of networks will be essential to realize full capabilities of JTRS.
 - Services have other network programs underway (e.g., Army Warfighter Information Network-Tactical), but it is not clear whether they are well coordinated and aligned with JTRS.
 - **Spectrum management:** Obtaining spectrum certification for JTRS radios will be challenging because current spectrum approval process has never addressed the multi-channel, multi-mode, multi-frequency nature of software programmable radios.
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Summary Observations

- JTRS is a critical program to the military's transformational efforts.
 - The concept of JTRS and what it can provide for the military is very promising.
 - To date, significant accomplishments have been realized such as the software communications architecture, open systems approach, demonstration of prototype radios, risk management processes, and contract competitiveness.
 - However, progress (particularly, in starting several of the clusters) has been hampered by difficulties in reaching a match between user requirements and resources.
 - The lack of a strong joint management structure has made it difficult to resolve funding and requirements issues and produce key documents that articulate the JTRS vision (Concept of Operations, migration plans).
 - Success will also depend on key enablers that have not been incorporated into JTRS development efforts and it is not clear they are being adequately addressed elsewhere in DOD—development of networking capabilities and advanced antennas.
 - Furthermore, the services are spending large amounts of money on legacy radio purchases which may have significant impacts on JTRS.
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Options to Increase Likelihood of JTRS Program Success

- Strengthen joint management structure to facilitate program funding and requirements outcomes and assure configuration management of JTRS. For example, consider:
 - Establishing centralized program funding
 - Realigning JPO under different/rotating/independent leadership
 - Putting cluster programs under JPO control
 - Complete principal documents (Concept of Operations, migration plans) and ensure they provide joint vision for the program
 - Ensure that the key enablers that will be necessary for JTRS to reach its full capabilities are adequately addressed, such as the
 - Need for networking capabilities and
 - Need for technology advances (e.g., miniaturization, batteries, antennas)
 - Examine current radio waiver process and assess potential impact that continued waiver purchases of legacy radios may have on JTRS
-



Joint Tactical Radio System (JTRS) Program

Backup Slide



Program Details

Identified JTRS Program Funding

Millions of Dollars	FY02 +	FY03	FY04	FY05	FY06	FY07	FY08	FY09	TOTAL
JPO RDT&E	\$192.5	\$62.9	\$134.7	\$91.6	\$62.8	\$55.9	\$28.8	\$27.3	\$656.5
ARMY RDT&E	110.9	95.6	270.8	194.1	122.5	82.6	57	31.4	964.9
ARMY PROCURE	0	0	1.9	159.2	165.6	194.4	185.1	189.8	896
AF RDT&E	4	18.3	54	52.1	112.8	77.9	52.6	37	408.7
AF PROCURE	0	0	0	6.8	134.8	486	537.5	567.6	1732.7
AF O&M	0	0	0	0	0	11.5	11.7	11.8	35
NAVY RDT&E	8.8	19.9	87.9	84.1	57.7	11	9.7	7.1	286.2
NAVY PROCURE	0	0	26	40.6	127.2	123.2	112.7	117.4	547.1
NAVY O&M	0	2.6	2.8	3	3.1	3.2	3.3	3.4	21.4
USMC RDT&E	0	0.6	8.1	8.7	4.1	3.7	1.6	1.6	28.4
USMC PROCURE	0	0	13.9	33.1	32.5	90.9	80.7	73.2	324.3
SOCOM	5	0	0	0	0	0	0	0	5
OTHER	1.2	0.6	0	0	0	0	0	0	1.8
TOTAL	\$322.4	\$200.5	\$600.1	\$673.3	\$823.1	\$1,140.3	\$1,080.7	\$1,067.6	\$5,908.0

Comments from the Department of Defense

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
6000 DEFENSE PENTAGON
WASHINGTON, DC 20301-6000

July 29, 2003

NETWORKS AND INFORMATION
INTEGRATION

Mr. Paul L. Francis
Director, Acquisition and Sourcing Management
US General Accounting Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Francis:

This is the Department of Defense (DoD) response to the GAO draft report, "Challenges And Risks Associated With The Joint Tactical Radio System Program," dated June 23, 2003 (GAO Code 120182/GAO-03-879R).

The DoD has reviewed the findings of the GAO and appreciates the efforts of the GAO staff to present different viewpoints regarding the management and implementation of the JTRS program. We have reviewed the draft report and, with the inclusion of the below comment, concur with the GAO findings and recommendations.

The DoD concurs with the recommendation to strengthen the joint program management structure. The DoD supports the consolidation of all related Research, Development, Test and Evaluation (RDT&E) funding, but does not agree with the consolidation of procurement and integration funding. These latter funding elements are best left in the individual Service budgets. We concur with the recommendation to take action to ensure the JTRS Program realizes its full potential.

My Point of Contact for GAO Code 120182/GAO-03-879R is Mr. Vic Russell, assigned to Communications Programs Directorate. He can be reached at 703 607-0274 or e-mail vic.russell@osd.mil.

Sincerely,

Dr. Michael S. Frankel
Deputy Assistant Secretary of Defense
(C3, Space and IT Programs)



(120182)

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