OPEN SYSTEMS JOINT TASK FORCE
CASE STUDY

of the U.S. Army's
INTELLIGENCE AND ELECTRONIC WARFARE
COMMON SENSOR (IEWCS)

15 November 1996

Open Systems Joint Task Force
2001 North Beauregard Street, Suite 800
Alexandria, Virginia 22311
(703) 578-6141
osjtf@acq.osd.mil

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)
15-11-1996

2. REPORT TYPE

3. DATES COVERED (FROM - TO)
xx-xx-1996 to xx-xx-1996

4. TITLE AND SUBTITLE
Open Systems Joint Task Force Case Study of the U.S. Army's Intelligence and Electronic Warfare Common Sensor (IEWCS)
Unclassified

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME AND ADDRESS
Open Systems Joint Task Force
2001 N. Beauregard St., Suite 800
Alexandria, VA22311

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME AND ADDRESS
Open Systems Joint Task Force (OSJTF)
1931 Jefferson Davis Highway
Crystal Mall 3, Suite 104
Arlington, VA22202

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
APUBLIC RELEASE
,

13. SUPPLEMENTARY NOTES

14. ABSTRACT
See Report.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:

a. REPORT	b. ABSTRACT	c. THIS PAGE
Unclassified	Unclassified	Unclassified

17. LIMITATION OF ABSTRACT
Public Release

18. NUMBER OF PAGES
70

19. NAME OF RESPONSIBLE PERSON
http://www.acq.osd.mil/osjtf/library/library_alpha.html
(blank)
lfenster@dtic.mil

19b. TELEPHONE NUMBER
International Area Code
Area Code Telephone Number
703767-9007
DSN
427-9007

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39.18

DISCLAIMER
Since the preparation of this case study, the user community has decided to modify their requirement relative to the type of system that they feel they need. Consequently, the IEWCS program has been completely restructured and will not go to production as originally planned. The "new" effort name is "Prophet" and is aimed at electronic mapping of the battlefield. The prophet system consists of three components: Prophet Ground, Prophet Air, and Prophet Control. These components will provide a comprehensive near-real-time picture of electronic emitters on the battlefield and provide the ability to detect, identify, locate, and electronically attack selected emitters. It should be noted that the lessons learned in the IEWCS relative to Open Systems Architecture are still as valid today as they were yesterday.

Acknowledgments

The development of this IEWCS Case Study has been possible only with the extensive cooperation and full support of the Army's PEO IEW leadership and staff, past and present. In particular, the authors' are most grateful for the significant cooperation and support of the program management staff of the Army's IEWCS Program Office, located at Vint Hill Farms Station in Warrington, VA. Of the numerous individuals whose contributions were important to this case study, the authors wish to specifically cite:

- MG William H. Campbell, USA
- MAJ Mike Groen, USMC
- Mr. Bill Hayden
- Mr. Al Henkell
- COL Melvin L. Heritage, USA
- Mr. Tom Hurt
- Mr. Bernie McDowell
- Mr. Allan Olson
- Mr. Mike Ryan
- COL (Ret.) Thomas Vollrath, USA

TABLE OF CONTENTS

Chapter 1
Executive Summary.. 1

Chapter 2
Introduction.. 5
Purpose of this Case Study.. 5
Overview of the Open Systems Approach.. 5
Background to the Army's IEW Systems Acquisition.. 6
IEWCS and the Open Systems Approach.. 8

Chapter 3
Development of an IEWCS Acquisition Strategy.. 11
Background.. 11
IEWCS Acquisition Goals.. 11
An IEWCS Systems Vision.. 12
An Open Systems Approach for IEWCS.. 13
Incorporation of an Evolutionary Systems Acquisition Strategy.. 13
Issues and Alternatives in the IEWCS Systems Acquisition.. 18
The Selected IEWCS System Design.. 19
Planning the Transition of Six Legacy Systems Into One Evolutionary System.. 21

Chapter 4
IEWCS Implementation of an Open Systems Approach.. 23
Introduction.. 23
Technical Issues and their Resolution.. 23
Management Issues and their Resolution.. 25
R&D and Production Cost Avoidance.. 27
Accommodation of Evolutionary Change.. 27

Chapter 5
Primary Results Achieved From an Open Systems Approach.. 29
Introduction.. 29
Improved Technical Capability.. 29
Substantial Life-Cycle Cost Avoidance.. 32
Shortened Development Schedule.. 32
Improved Operations and Support Accommodations.. 34
Greater Interoperability.. 34

Chapter 6
Secondary Results Achieved From an Open Systems Approach ... 37
Introduction ... 37
Technology Transfer to the USMC's MEWSS Product Improvement Program ... 37
Additional Intra- and Inter-Service Transfer of IEWCS Technology ... 39

Chapter 7
Lessons Learned and their Implications for an Open Systems Approach ... 41
Introduction ... 41
IEWCS Has Achieved a Significant Cost Avoidance ... 41
Important Technical Lessons Learned ... 41
Important Management Lessons Learned ... 42
Figure 7.1. Evolution of CHAALS through CHALS-X to CHALS-X(M) ... 44
The Biggest Payoff from an OSA ... 45

Chapter 8
Summary and Conclusions ... 47

Appendix A.1
The Open System Approach To Weapons System Design ... A.1-1
Why Open Systems? ... A.1-1
What Is The Open System Approach? ... A.1-1
Applying the Open System Approach to Weapons Systems Acquisition ... A.1-2
Conclusion ... A.1-2

Appendix A.2
Detailed IEWCS Life Cycle Cost Analysis ... A.2-1
Establishment of a System Development Basis ... A.2-1
IEWCS R&D Cost Comparison ... A.2-2
IEWCS Production Cost Comparison ... A.2-2
IEWCS O&S Cost Avoidance ... A.2-3
MEWSS-PIP Acquisition Cost Avoidance ... A.2-3

Appendix A.3
Points of Contact for Further Information ... A.3-1

Appendix A.4
References ... A.4-1

Appendix A.5
List of Acronyms ... A.5-1

LIST OF FIGURES

Figure 2.1 Typical Army CEWI Battalion as Fielded in 1987 6
Figure 3.1 Technical Standards Employed by Electronics Modules Considered in IEWCS Design 13
Figure 3.2 Selected IEWCS Common Hardware Components and Their Associated Standards 14
Figure 3.3 Selected IEWCS Common Software Components and Their Associated Standards 15
Figure 3.4 IEWCS Subsystems and their Platforms 18
Figure 5.1 Technical Performance Characteristics of IEWCS Compared to its Legacy Systems 28
Figure 5.2 IEWCS Cost Avoidance Profile 31
Figure 7.1 Evolution of CHAALS through CHALS-X to CHALS-X(M) 41

CHAPTER 1

EXECUTIVE SUMMARY

The open systems approach (OSA) is both a technical approach and a preferred business strategy that allows DoD to field superior combat capability quicker and at a more affordable cost. The OSA defines key interfaces using commercially supported specifications and standards. The systems development flexibility inherent in the OSA, and the more widespread availability of conforming commercial products, mitigates potential problems associated with a defense dependent manufacturing base. An OSA-based weapons system development serves to reduce direct research and development (R&D) investments by facilitating technology transfer of subsystems and components developed by others, as well as promote reuse of software components, and thereby can significantly decrease the time required to field an improved operational capability. In addition, life-cycle costs, which are dominated by operations and support (O&S) costs, are reduced by long lived, standards-based architectures that facilitate upgrades by incremental (evolutionary) technology insertion, rather than by large-scale (revolutionary) system redesign. The OSA-based design thereby serves to overcome system obsolescence and to maintain technological currency in the face of continuous improvements in available technology.

The Open Systems Joint Task Force (OS-JTF) has developed this Case Study of a recent weapons systems development that has successfully incorporated an OSA within its acquisition processes so as to provide a fully analyzed and well-documented example of an actual OSA-based system implementation. This study presents the U.S. Army's Intelligence and Electronic Warfare Common Sensor (IEWCS) and its application of an OSA-based technical architecture and systems procurement. This Case Study will detail how this particular program achieved the above benefits of an OSA while mitigating potential risks.

The IEWCS was developed to replace six separate and unique signals intelligence/electronic warfare (SIGINT/EW) legacy systems. Each of these legacy systems were technically limited in their ability to deal with the frequency spectral coverage of newer threat emissions and with advanced forms of modulation, such as spread spectrum. These legacy systems also lacked any meaningful degree of interoperability among themselves or with other Army battlefield systems. Furthermore, although each legacy system performed a functionally similar SIGINT/EW mission, they had virtually no commonality of hardware, firmware, or software. As a result, each system required somewhat different operations and support personnel and facilities.

To overcome these shortfalls, the Army's Program Executive Office (PEO) for Intelligence and Electronic Warfare (IEW) identified several generic criteria considered essential to the next generation IEW system and mandatory for the IEWCS development:

- IEW systems life-cycle costs must be lowered.
- IEW systems technical performance and flexibility must be improved.

- Rapid insertion of new technology must be facilitated in order to exploit technical advances in both hardware and software.
- Vendor independence must be achieved while maximizing the number of potential suppliers of IEW systems, subsystems, and components.

The PEO IEW considered five IEWCS acquisition alternatives, but only one, utilizing an OSA-based system design, proved feasible in terms of the available developmental budget and the acceptable time required to field an improved SIGINT/EW operational capability. The selected IEWCS design employed three highly flexible IEWCS subsystems incorporating common electronic modules and software. All subsystems used an OSA-based design approach with conformance to Versa Module Eurocard (VME) interconnection standards and the VMEbus (IEEE 1014) data transfer technology standard.

Each of the three IEWCS subsystems has been integrated together within three different Army tactical platforms to provide three highly diverse, but functionally identical and interoperable, IEWCS system configurations to support the SIGINT/EW mission of Army heavy divisions, light divisions, and airborne divisions. These three IEWCS system configurations and their associated Army tactical platforms are: the Ground-Based Common Sensor-Heavy (GBCS-H) carried within a standard tracked tactical vehicle, the GBCS-Light (GBCS-L) carried within a standard light tactical truck, and the Advanced QUICKFIX (AQF) carried on a standard Blackhawk helicopter.

The use of an OSA allowed PEO IEW to achieve each of the desired IEWCS development goals. Moreover, the use of an OSA-based implementation allowed PEO IEW to achieve necessary technical performance and manpower/supportability improvement, development schedule acceleration, and substantial cost avoidance over each phase of the IEWCS life cycle:

- Each IEWCS configuration, regardless of platform, can perform all of the specified SIGINT/EW missions. Each IEWCS configuration has demonstrated vastly superior technical and operational performance capabilities toward fulfilling these missions. All configurations use platform vehicles that are also utilized by other battlefield systems, and thus may be deployed and supported using normal unit operational personnel and procedures, thereby saving O&S costs. Compared to its predecessor systems, for an armored/mechanized division, the IEWCS requires 46 percent fewer operators, 65 percent fewer vehicles, and 60 percent less airlift, a significant improvement in manpower and supportability requirements.
- The IEWCS development has demonstrated a significant schedule reduction, permitting establishment of a new SIGINT/EW operational capability in a much shorter period of time. The research and development (R&D) time was reduced by 64 percent (requiring a total of 36 months including an 18 months schedule slippage due to additional time required to initiate the OSA process), while the engineering and manufacturing development (E&MD) time was reduced by an average of approximately 29 percent (a total of 72 months on average), relative to the typical Army program acquisition cycle time.

❺ The IEWCS acquisition has provided a substantial cost avoidance over each phase of its system life cycle. Given an estimated total R&D and production costs of approximately $845 million, the estimated cost avoidance for these two life-cycle phases alone is approximately $567 million. When combined with an estimated cost avoidance for the O&S phase of approximately $436 million, the OSA-based IEWCS acquisition represents a cost avoidance to the Army of over $1 billion.

The IEWCS acquisition also illustrates the considerable potential offered by an OSA-based development to provide opportunities for technology insertion into other system developments across application domains and Service boundaries. Current intra- and inter-Service transfer of IEWCS subsystems and component technology includes the Airborne Reconnaissance Low and Guard Rail Common Sensor systems in the Army, various airborne systems in the Air Force and the Navy, the SSN-21 Seawolf submarine, Special Operations Forces, and the National Security Agency.

The most notable example of IEWCS technology transfer is to the U.S. Marine Corps (USMC) in an electronics suite upgrade to their Mobile Electronic Warfare Support System (MEWSS), known as the MEWSS Product Improvement Program (MEWSS-PIP). This upgrade utilizes all three IEWCS subsystems configured in a standard Light Armored Vehicle, to become in essence a fourth IEWCS platform configuration. The direct use of OSA-based IEWCS technology in the MEWSS-PIP acquisition has provided the USMC a cost avoidance of approximately $149 million to $481 million, depending on the specific cost avoidance baseline assumptions used. Additional cost avoidance benefits are expected to accrue to the Government as IEWCS technology is utilized within other Army and DoD systems development programs.

It is the intent of this Case Study that the Army's experience in successfully achieving an OSA-based systems acquisition can serve to provide helpful insights and lessons learned concerning this process. Chapter 2 provides a background to this study. The development of the IEWCS acquisition strategy is presented in Chapter 3, with OSA-based IEWCS implementation specifics detailed in Chapter 4. The results achieved by PEO IEW through the use of an OSA are described in Chapter 5. The results achieved by transfer of IEWCS to other systems and Services, including a significant cost avoidance by the USMC in their MEWSS-PIP development, are presented in Chapter 6. A number of important technical and management lessons learned and their implications for an OSA are discussed in Chapter 7. A summary of the Case Study results and important conclusions that may be drawn from the IEWCS experience are presented in Chapter 8. The Case Study also includes several appendices providing a further description of the applicability of the OSA to weapons system design, a detailed IEWCS life-cycle cost analysis, points of contact for further information, a list of references, and a list of acronyms.

CHAPTER 2

INTRODUCTION

Purpose of this Case Study

An open systems approach (OSA) to DoD weapons systems acquisition serves to facilitate the use of widely accepted, standards-based products, which are available from multiple sources. It is envisioned that an OSA-based systems design and acquisition can have profound effects on reducing the life-cycle costs of a system as well as on improving the overall system performance through incorporating the products available from the commercial marketplace wherever appropriate. The Open Systems Joint Task Force (OS-JTF) was chartered within the Office of the Secretary of Defense to establish an OSA as the foundation for all DoD weapons systems acquisitions. The OS-JTF has identified several recent weapons systems developments that have successfully incorporated an OSA within their acquisition processes. One such system was selected to be the focus of a case study so as to provide a fully analyzed and well-documented example of an actual OSA-based system acquisition. It is intended that this case study serve to promote knowledge about the issues and practices of an OSA acquisition methodology based on actual experience.

The following case study considers the Army's Intelligence and Electronic Warfare Common Sensor (IEWCS) system and its successful application of an OSA within its technical design and procurement processes. It is intended that this IEWCS case study provide detailed insights into the management of a successful OSA-based weapons systems acquisition and lessons learned concerning the necessary OSA tools and techniques needed by Program Managers (PMs), Program Executive Officers (PEOs), and other DoD systems acquisition decisionmakers. It is further intended that this case study serve as an OSA guide for use in:

- Providing a highly relevant example of an OSA-based weapons systems acquisition of value in self-study and for use in executive and systems engineering courses and seminars.
- Establishing lessons learned and associated technical and managerial trade-off issues through review and analysis of an actual OSA-based system implementation.
- Developing a model of the OSA process to assess potential benefits and cost avoidance in application to other weapons systems acquisitions.

Overview of the Open Systems Approach

The OSA is an integrated technical and business strategy that defines key interfaces for a system (or equipment) being developed. Interfaces generally are best defined by formal consensus (adopted by recognized industry standard bodies) specifications and standards. In addition, if the architecture is defined by specifications and standards used in the private sector, the DoD can be one of many customers and leverage the benefits of the commercial marketplace, taking advantage of the competitive pressures which motivate commercial companies to reduce prices and introduce new products developed with internal resources.

As a result, the OSA can permit weapon systems PMs to have access to alternate sources for key subsystems and components. In principle, DoD investment early in an OSA-based system's life-cycle can be reduced since at least some of the required subsystems or components are likely to be available, or are being developed without direct DoD investment. Production sources can be competitively selected from multiple potential vendors. The system design flexibility inherent in the OSA, and the more widespread availability of conforming commercial products, mitigates potential problems associated with a defense-dependent manufacturing base. Also, direct R&D investments toward product improvements can be reduced by technology transfer of subsystems and components developed by other DoD or Government programs. In addition, life-cycle costs are reduced by a long-lived, standards-based architecture that facilitates upgrades by incremental technology insertion, rather than by large-scale system redesign. The OSA-based design thereby serves to overcome system obsolescence and to maintain technological currency in the face of continuous improvements in available technology.

An effective open system (OS) architecture will rely on physical modularity and functional partitioning of both hardware and software. Physical modularity and functional partitioning should be aligned to facilitate the replacement of specific subsystems and components without impacting others. The subsystems and components described by the system design should be consistent with the system repairable level. Subsystems and components below the repairable level will normally not be under government configuration control; therefore, repairs below that level, if required, will be performed by the supplier. If the hardware and software are effectively partitioned, it may be possible to replace processing hardware with new technology without modifying applications software, while application software can be modified without necessitating hardware changes. Finally, although the most common emphasis of the OSA is on electronic systems, the OSA is widely applicable across other, non-electronic subsystems and components, from fasteners and batteries to jet engines. A more detailed overview of the OSA applied to weapons systems design is provided in Appendix A.1.

Background to the Army's IEW Systems Acquisition

Throughout the 1970-1980 timeframe, the Army's Intelligence and Electronic Warfare (IEW) capabilities to meet the battlefield commander's needs were supported by combinations of six separate and unique signals intelligence/electronic warfare (SIGINT/EW) systems. Portions of each system also supported various electronic intelligence (ELINT) and communications intelligence (COMINT) missions across the battlefield. These systems and their specific functionalities were:

- TEAMPACK (AN/MSQ-103)—Collect and report ELINT data (ground-based).
- TEAMMATE (AN/TRQ-32)—Collect and report COMINT data (ground-based).
- TRAILBLAZER (AN/TSQ-114)—Collect and report COMINT data (ground-based).
- TRAFFICJAM (AL/TLQ-17A)—Jam/deceive/harass communications links (ground-based).
- TACJAM (AN/MLQ-34)—Jam/deceive/harass communications links (ground-based).

❺ QUICKFIX (AN/ALQ-151)—Collect and report COMINT data, as well as jam, deceive, and harass communications links (helicopter-based).

These six systems as fielded in a typical Army Communications, Electronic Warfare, and Intelligence (CEWI) battalion in the late-1980's, along with their support vehicles, are illustrated in Figure 2.1. Throughout the 1980's, multiple and substantial product improvements were made to each of these systems in an attempt to maintain pace with the rapidly changing threat environment within which the CEWI battalions must operate. Each of these six systems continued to be developed and produced by separate program offices with little if any commonality among the constituent subsystems and components of each system. This lack of commonality resulted in IEW systems which performed the same type of mission that could not interoperate; lacked commonality of mission hardware and software; did not use common data bases and thereby could not exchange mission data between different systems to achieve cross-cueing; and, methodologies for operational sustainment or proficiency training for operator and maintenance personnel varied widely from unit to unit and from system to system.

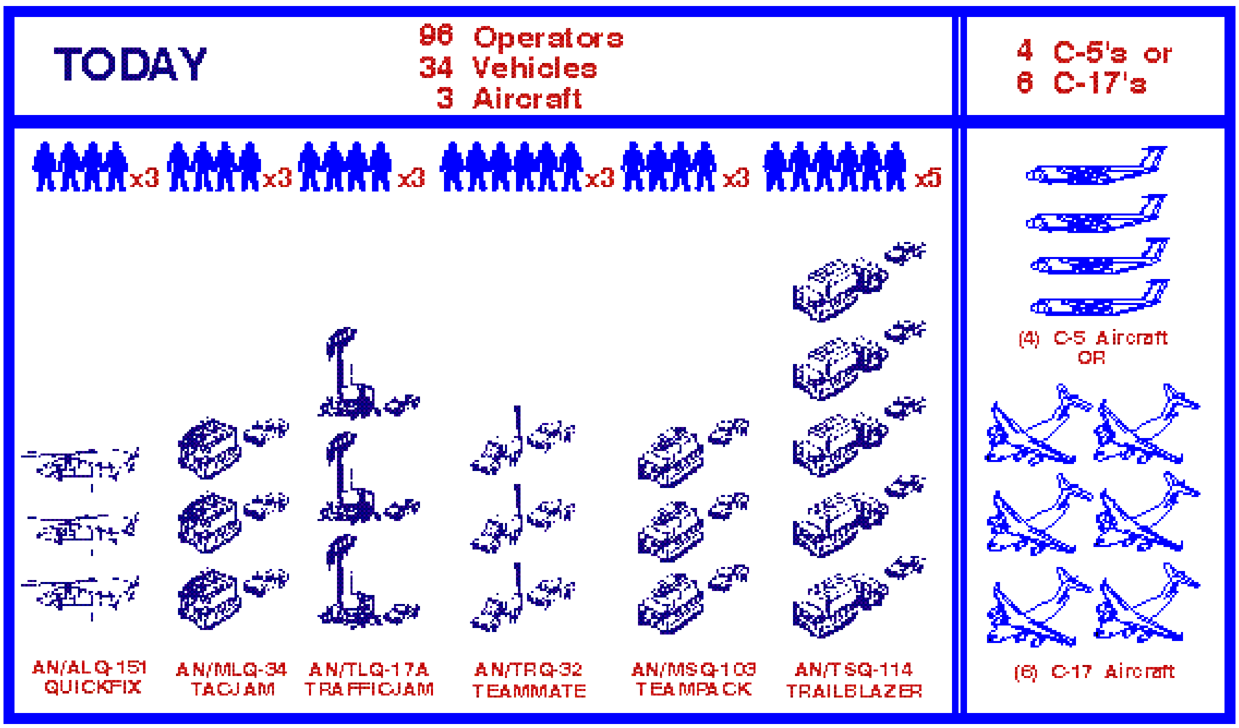


Figure 2.1. Typical Army CEWI Battalion as Fielded in 1987

Moreover, substantive changes in the threat frequency and modulation characteristics (e.g., use of spread spectrum technology), as well as intrinsic problems due to an increasing need for interoperability among the six systems, provided fundamental limitations to the continued effectiveness of the extant CEWI battalions within the emerging electronic battlefield. A military intelligence RELOOK study of this period offered the following general assessment:

> *"The IEW community lacks versatility and balance, has inadequate processing and communications capabilities, lacks deployability, uses outdated technology, and lacks precision targeting capabilities."*

At the same time, the Army's PEO for IEW systems was faced with a mandate to decrease the manpower requirements for the fielded IEW systems as well as to downsize the IEW PM organizations, while the funding levels for IEW systems modernization were being significantly decreased. These several concurrent challenges clearly indicated that a "business as usual" approach to the development of the next generation of IEW systems was no longer possible, and that a system development paradigm shift of the most basic nature was required.

IEWCS and the Open Systems Approach

Such a paradigm shift did occur within the Army IEW systems community over the 1987–1992 timeframe. This shift was motivated by the increasing realization within the PEO IEW organization that a totally different developmental approach to the next generation of IEW systems was required. A strong impetus for significant change in IEW systems acquisition was also fostered by the vision and leadership of the then PEO IEW, Major General (then Colonel) William H. Campbell. It became PEO IEW's vision that a totally new next generation system design and acquisition solution had to be found which would not be based on those rapidly obsolescent technologies employed in the development of the six predecessor Army SIGINT/EW systems.

In addition, it became increasingly clear that the next generation systems could no longer be based on disparate and non-interoperable hardware and software technology. It was noted that commercial electronics equipments were becoming increasingly capable in addressing many of the Army's requirements. Such equipments, based on commercially-developed technical standards, were becoming available off-the-shelf to provide a viable solution to meet the Army's need for technically capable configurations of common components that readily supported insertion of newer technology as it became available.

The basis for this solution was also reinforced by the emerging adoption of a horizontal technology integration (HTI) system design methodology within Army systems and a variety of acquisition reform initiatives across all of DoD, especially in the preferred use of commercially-developed equipments within military systems wherever possible. The selection of a single IEWCS system solution to replace all six predecessor systems was perhaps motivated even stronger by the realization that the many common technical functionalities of the legacy systems could share a set of common modules that could be packaged to meet the specific platform and mission needs of the CEWI battalion. In addition, these common modules could be based on standard, commercially-available components with an evolutionary growth path or upgrade potential far beyond that previously available to the IEW system designer.

The generalized use of common modules for the IEWCS system was enabled by adapting an OSA-based system design philosophy. This approach permitted an overall evolutionary rather than revolutionary solution to the next-generation IEW system design. This approach also served to facilitate use of commercial design standards and protocols that could permit rapid insertion of the most recent technology into the baseline IEWCS architecture. In addition, this OSA-based system design philosophy would facilitate maximum commonality of IEWCS components within the supported forces (rather than create unique vehicle and command, control, and communications structures) through commonality/standardization at the lowest possible level and maximum re-use of all hardware and software components. It was this OSA-based design philosophy that was the foundation to the IEWCS development and permitted the successful fielding of a new generation IEW system that could rapidly adapt to changing technical threats and counter-threat responses so as to provide a never before possible electronic warfighting capability.

The following sections of this IEWCS Case Study examine the several technical and management aspects of the IEWCS acquisition as well as the results achieved by application of an OSA to this specific acquisition. A number of technical and management lessons learned are also provided which are mostly of a ubiquitous nature and should generally apply across the board within most OSA-based weapons systems acquisition scenarios.

CHAPTER 3

DEVELOPMENT OF AN IEWCS ACQUISITION STRATEGY

Background

The developmental focus for each of the six predecessor tactical SIGINT/EW systems to the IEWCS was the exploitation and engagement of classical EASTBLOCK forces. Within the fast-paced and changing geopolitical environment of the 1980's, most notably the dissolution of the EASTBLOCK threat, the Army recognized a rapidly approaching worldwide shortfall in IEW capability to meet these changing threats. Specifically, each of the six legacy systems was becoming functionally obsolete within the context of an increasingly complex electronic battlefield made possible by significant advances in communications technology readily available to a new generation of potential hostile forces. Each of the legacy systems were limited in coverage of the frequency spectral range of newer threat emissions as well as in the ability to deal with more advanced forms of modulation, such as spread spectrum. These systems could not detect, process, locate, nor jam newer emitters that used newer frequency ranges, signal modulations, and data formats.

In addition, the military intelligence community was becoming increasingly concerned with the emergence of a more sophisticated threat capability based on advanced communications technology available off-the-shelf from the commercial marketplace (such as digital cellular telephony) where a new generation of commercially-developed communications products would be available every 12–36 months. When encountered in the electronic battlefield, each generation of products would require an increasingly robust and flexible SIGINT/EW capability counterforce. To properly address this threat required an IEW system capability significantly beyond that available from straightforward extension any existing Army IEW technical architecture and operational configuration.

The six legacy systems also mostly lacked any meaningful degree of interoperability among themselves or with other Army battlefield systems. Such a lack of interoperability was a critical deficiency with respect to the emerging SIGINT/EW mission requiring time-sensitive interaction. Furthermore, although each was computer-based and performing a functionally similar SIGINT/EW mission, they had virtually no commonality of hardware, firmware, or software. Each required different operator and maintenance personnel training. In addition, a revised National Military Strategy, reduced resources for new systems acquisitions, and a declining operational force structure all served to accentuate emerging shortfalls in the Army's IEW capabilities.

IEWCS Acquisition Goals

The Army's PEO IEW met these shortfalls by developing a series of highly flexible system configurations to provide a set of highly diverse, but functionally identical and interoperable, IEW system modules to Army light divisions, heavy divisions, and airborne divisions. In addition, the IEWCS system design goal was to achieve the highest possible levels of commonality and increased supportability across units, substantially expanded SIGINT/EW warfighting capability, and improved technical performance. Two principal IEWCS acquisition goals emerged:

- Lower overall IEW systems life-cycle costs.
- Improved IEW systems technical performance, platform mobility, and operational flexibility.

A number of secondary IEWCS acquisition goals were also desired. These included the ability to rapidly insert new technology to exploit technology advances in both hardware and software, vendor independence, and the maintaining of the maximum number of sources of supply of IEWCS subsystems and components. It was believed that these goals would provide required flexibility in both technical capability and operational utilization necessary to meet future SIGINT/EW threats. A lowering of system acquisition management costs through consolidation of the six legacy program offices into a single IEWCS program office was also a highly desirable acquisition goal.

An IEWCS Systems Vision

The overarching vision for IEWCS was to provide a superior SIGINT/EW mission capability within a common system that could be deployed on light, heavy, and airborne platforms. This common system would be more robust, deployable, supportable, and cost-effective through use of subsystems and components that are standardized, commercialized, interoperable, and interchangeable.

An IEWCS systems vision was established by PEO IEW as a performance-based IEW systems requirement. This vision provided a basis for a complete replacement of the existing IEW system acquisition methodology that utilized revolutionary improvement with each new generation of capability, each of which took ten years or more to develop and field. No longer could the Army's IEW community continually develop new, individual, and typically non-standard systems that were often obsolete before they could be fielded. Instead, a completely new IEW system acquisition strategy was to be followed. This new strategy would utilize evolutionary improvement of a readily modifiable system capability through rapid insertion of new common module technology into an evolveable baseline IEWCS architecture. The basic elements of this strategy were to:

- Significantly improve the Army's ability to rapidly and accurately identify, locate, report, and/or jam technologically sophisticated targets.
- Consolidate communications intelligence and electronic intelligence mission requirements and functions across platforms.
- Support heavy, light, and airborne forces with common equipment and capabilities using organic platforms.
- Reduce personnel required for operation and maintenance.
- Reduce personnel skill levels required.
- Incorporate an OSA to facilitate technological change.

An Open Systems Approach for IEWCS

The innovative design insight that permitted realization of the IEWCS system vision was the recognition that it was feasible to employ commercially-available common modules within an industry standards-based implementation framework. This recognition emerged from within both the government IEW technical/management and vendor community, and was encouraged by concurrent acquisition reform initiatives within both the Army and DoD. This recognition, and the emerging technical capabilities of commercially-available common modules, supported the decision to proceed with the selected IEWCS design philosophy.

An OSA served to enable this design philosophy and permitted a subsystem and component commonality/standardization at the lowest repairable level. This OSA-based design philosophy was applied to the IEWCS technical, operational, and systems architectures. Simply put:

- The **IEWCS Technical Architecture** provides the standards profile and the interface specifications, specifying a minimal set of rules governing the arrangements, interaction, and interdependence of the various system parts or elements whose purpose is to ensure that a conformant system satisfies a specified set of technical requirements.
- The **IEWCS Operational Architecture** implements the SIGINT/EW mission operational concepts and functionalities, specifying required tasks/activities, operational elements, connectivities, and information/data flows.
- The **IEWCS Systems Architecture** describes the parts of the IEW system and the technical characteristics of each part, specifying each system, subsystem, and interconnection providing for or supporting the SIGINT/EW warfighting mission.

It was envisioned that this OSA-based IEWCS system design approach would make possible a highly adaptable SIGINT/EW operational capability, resilient enough to integrate commercial technology and subsystem/component upgrades at minimal cost, while sustaining maximum functional performance throughout the life of the system. The OSA-based design philosophy would thereby serve to cost-effectively meet all of the principal and secondary IEWCS acquisition goals.

Incorporation of an Evolutionary Systems Acquisition Strategy

Previous IEW system designs were generally "custom" acquisitions from a single system integrator, initially competitively selected, but thereafter locking the Government client into the incumbent vendor due to the typical use of proprietary hardware and software that was usually not elsewhere available. In the 1989–1992 timeframe, the PEO IEW conducted a series of studies performed by the Jet Propulsion Laboratory and others to examine the feasibility of utilizing commercial standards and components rather than using military specifications and program-unique components. It was concluded that an evolutionary IEW systems acquisition strategy based on commercially-available common modules and commercial design standards was not only feasible but mandatory to achieve overall acquisition goals.

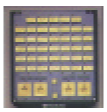
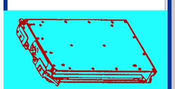
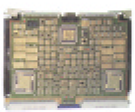
The selected IEWCS system design approach extended the PEO IEW common module conceptual baseline to incorporate current state-of-the-art hardware and software technologies as were being developed within the military research and development organizations as well as advances in industrial computer design, software, and system design techniques. The evolutionary design approach also incorporated the commercially-developed Open Systems Interconnect (OSI) protocols and interfaces (e.g., use of the Versa Module Eurocard (VME) interconnection standard) to permit maximum utilization of current and future hardware and software component availabilities.

The IEWCS evolutionary systems acquisition strategy served to:

- Incorporate individual subsystems and components at the lowest possible common level that are interchangeable and interoperable, and that can be utilized in any future IEWCS system. Compared to the relative inflexibility of each of the six predecessor systems, the IEWCS subsystems and components would be adaptable to most capably meet new and emerging threats.
- Ensure an OSA-based design of each IEW system platform to accept common operator workstations, communications, and other peripheral devices with a host common bus as the backbone of the platform. Using a commercial-standard common bus/backbone combined with commercial OSI protocols would afford a bigger segment of industry the opportunity to develop new sensors and other IEW system components that can easily and economically be added to each platform. Moreover, the software developed for use within each IEWCS subsystem could be reused as new module technology was inserted. In contrast, the subsystems and components within each of the predecessor systems were generally vendor-unique and required significant development to incorporate any new element of hardware and software.
- Promulgate the potential for integration of new and existing subsystems and components into a host system known and understood by all industry vendors. With a judicious selection of a growing commercial standards-based technology, the quantity of vendors who can potentially offer improvements and new sensor capability would also tend to increase. The introduction of new vendor-proposed off-the-shelf products that work in accordance with these requirements would be enhanced and tend to reduce custom design approaches, thereby serving to reduce the costs and risks of modifications and production schedule achievement. In contrast, the modification of either hardware or software components within each of the six predecessor systems would typically incur substantial development costs and schedule risks.

An essential element of such an evolutionary acquisition strategy are the procedures and processes used in selection of the baseline commercial technical standards to which all system components and subsystems must conform. Over the period 1987–1991, the Army's PEO IEW conducted a number of studies and surveys of both contemporary commercial and military practice in order to identify what technical standards and standard module products would best meet IEWCS program needs. The selection was guided by a developing awareness of what commercial standards and products were being used in comparable, but previously unknown and unrelated, technology applications across DoD.

These PEO IEW-sponsored analyses were oriented to the common module level of specificity. Two candidate module families were the Standard Electronic Module-Enhanced (SEM-E), based on a FutureBus+ (IEEE 896.1) interconnection technology standard and the VME, based on the VMEbus (IEEE 1014) interconnection technology standard. Representative technical standards for these two type of common module technologies are illustrated in Figure 3.1.

Board/ Module Type	Size (inches) Surface Area (inches 2)	Standard for Board Format		Bus Interface	Interface Connector (I/O Pins)	Environmental	Thermal Design	Comm'l Vendors	Commercial Tech Insertion			
		Mechanical	Electrical						PCI/SCI	64 Bit CPU	ATM	Massively Parallel Processing
SEM E 	6.68 (h) 5.88 (d) 0.60 (w) 74.62 (a)	Commercial IEEE 1101.4 MIL-STD-1389 (MIL-STD-2205 is Future Bus)	NONE	Future Bus+ IEEE 896.1	250 or 396	↑	Conduction Cooled	Raytheon	NO	NO	NO	NO
SEM EX 	9.14 (h) 5.89 (d) 1.16 (w) 102.29 (a)	NONE	NONE	Unique Interfaces	No Standard Number	MIL-STD-810 MIL-E-5400	Conduction Cooled	NONE	NO	NO	NO	NO
6U VME 	9.18 (h) 6.30 (d) 0.80 (w) 109.88 (a)	MIL-B-29536 Commercial IEEE 1101.2 Conduction IEEE 1014 Convection	MIL-B-29536 Commercial IEEE 1014	VME 32 IEEE 1014 VME 64 [2] IEEE 1014	VME 32: P_1 - 96, P_2 - 96 ▼ VME 64 [1]: P_0 - 42, P_1 - 128, P_2 - 128	↓	Convection Cooled or Conduction Cooled	Radstone Digital, E-Systems, Raytheon, Martin-Marietta Westinghouse DY4 . . . ~200 plus	YES	YES	YES	YES

1 - Migration from 32 bit to 64 bit is backward compatible

2 - VME 64 has a bridge to FutureBus+ defined by IEEE 1014.1 offering the user the greatest migration paths available in any one Standard.

Market

SEM-E - Mil

SEM-EX - Vendor Specific

VME (6U) - Mil, Rugged and Commercial

Figure 3.1. Technical Standards Employed by Electronics Modules Considered in IEWCS Design

A critical juncture occurred in 1992 when PEO IEW selected the VME-based interconnection technology standard for the IEWCS system. A number of other hardware and software component standards and interface specifications were also finalized at that time. A summary of the resultant technical architecture describing the standards profile and interface specifications for the common hardware and software components are illustrated in Figures 3.2 and 3.3, respectively.

An early payoff of this selection decision occurred when IEWCS developers learned of a multi-channel direction finding (DF) receiver and processor that had been developed by a U.S. Air Force (USAF) program which used the VME-based interconnect technology that appeared to be of direct application to IEWCS needs. In fact, it was determined that this technology had a significant potential to achieve the desired IEWCS technical capabilities through a direct product transfer without extensive R&D expenditures or technical efforts. As such, this technology offered a schedule acceleration of over five years in development of a multi-channel DF subsystem. This USAF-developed subsystem was based on VMEbus technology standards and was directly compatible with the selected IEWCS technical architecture (reference Figure 3.2). The relatively straightforward insertion of this multi-channel DF

System	LAN	BUS	Processor	Chassis	Graphics	Monitor	Keyboard	Disk(s)	Imagery
JSTARS-BLK I (I)	ETHERNET 802.3	SCSI VME 1553 B	M680X0 Family Distributed	17 Slot VME	Chromatics 6U VME	IBC 19" Raster X2	Flex Key	MILTOPE 3802R Winchester 560 MB	MITEC 6U VME
JSTARS-BLK IIA (I)	ETHERNET 802.3	SCSI VME 1553 B	M680X0 Family Distributed	17 Slot VME	Chromatics 6U VME	TBD	Flex Key	MILTOPE 3802R Winchester 560 MB	
JSTARS-BLK II (I)	ETHERNET 802.3	SCSI VME 1553 B	M680X0 Family Distributed	17 Slot VME	Chromatics 6U VME	TBD	Flex Key	MILTOPE 3802R Winchester 560 MB	
JSTARS-BLK II (II)	ETHERNET 802.3	SCSI VME 1553 B	M680X0 Family Distributed	17 Slot VME		TBD	TBD	TBD	
Airborne Recon Low-M	ETHERNET 802.3	VME SCSI	SUN SPARC (1E) Growth (2E)	VME		BARCO 1280x1024 Rugged X4	SUN (STD)	Dual 760 MB Removeable HD	MITEC ELT 8U
GRCS IPF-1	FDDI LAN (Dual Token Ring)	VME SCSI	MICRO-5 (Three Concurrent) Sun SPARC 1E	VME		SONY 19' Color X27	SUN	5400 MB (1800MB for each Micro-5) 380 MB/WS	
GRCS IPF-2	FDDI LAN (Dual Token Ring)	VME SCSI	MICRO-5 (Three Concurrent) Sun SPARC 1E	VME 19" & Full ATR		SONY 19' Color X27		5400 MB (1800MB for each Micro-5) 380 MB/WS	
HAWKEYE	ETHERNET 802.3	VME SCSI	SUN SPARC (1E/2E)	VME		1280x1024/ 70HZ (Video Board 1152x900 70HZ)	SUN (STD)	1.2 GB Removeable	
IEWCS-H	ETHERNET 802.3	VME SCSI 1553B	SUN SPARC (2E) M680x0 Family	17 Slot VME	Integris 6U VME	BARCO 19' 1280x1024 Rugged (Removeable CCAs) X3	SUN (STD) (17") Solaris With Integrated Trackball	760 MB Removeable HD (Growth to 1.2 GB) CHS Common	CHS Common
IEWCS-L	ETHERNET 802.3	VME SCSI 1553B	SUN SPARC (2E) M680x0 Family	17 Slot VME	Integris 6U VME	BARCO 19' 1280x1024 Rugged (Removeable CCAs) X2	SUN (STD) (17") Solaris With Integrated Trackball	760 MB Removeable HD (Growth to 1.2 GB) CHS Common	CHS Common
IEWCS-AQF	ETHERNET 802.3	VME SCSI 1553B	SUN SPARC (2E) M680x0 Family	17 Slot VME	Integris 6U VME	BARCO 19' 1280x1024 Rugged (Removeable CCAs) X2	SUN (STD) (17") Solaris With Integrated Trackball	760 MB Removeable HD (Growth to 1.2 GB) CHS Common	CHS Common
MITT	ETHERNET 802.3	VME SCSI	SUN SPARC (2E)	VME	PEX PSI TECH 6U VME	SUN 1280 x 1024 19'	SUN (STD)	3 EA? 1.2 GB	PSI Tech 24 Bit Paragon Software
UAV-SR	ETHERNET 802.3	VME SCSI	M6803C M6803C M6801C M18051	VME	M5336 TBGSE Motorola	Interstate Electronics 19'	Flex Key	200 MB Miltope HD	

Figure 3.2. Selected IEWCS Common Hardware Components and Their Associated Standards

System	HOL	O/S	GUI	DBMS	Mapping Capability	Networking Protocols	Other Aspects	Gold Cup/Liberty Cap Compliance
JSTARS-BLK I (I)	ADA	VxWORKS	MOTOROLA Custom Windows (GKS)	Custom by MOTOROLA	ATCCS EMAPS	TCP/IP	Custom Design Spatial and Time Correlation, Algorithms	N/A
JSTARS-BLK IIA (I)	ADA	VxWORKS	MOTOROLA Custom Windows (GKS)	Custom by MOTOROLA	DMA DTED, DFA	TCP/IP	Custom Design Spatial and Time Correlation, Algorithms	N/A
JSTARS-BLK II (I)	ADA	VxWORKS	MOTOROLA Custom Windows (GKS)	Custom by MOTOROLA	DMA DTED, DFAD	TCP/IP	Custom Design Spatial and Time Correlation, Algorithms	N/A
JSTARS-BLK III (I)	ADA	VxWORKS	MOTOROLA Custom Windows (GKS)	Custom by MOTOROLA	DMA DTED, DFAD	TCP/IP	Custom Design Spatial and Time Correlation, Algorithms	N/A
Airborn Recon Low-M	COMINT: ADA IMINT: C (SUN SPARC 1E)	SUN O/S UNIX	X-WINDOWS MOTIF (Screens by UNIX)	SYBASE SQL RDBMS	DMA DTED	TCP/IP	Custom Design Spatial and Time Correlation, Algorithms	N/A
GRCS IPF-1	ADA, FORTRAN, Assembly (MICRO-6 with SUN SPARC 1E)	SUN O/S UNIX	GRAMM	Possible SYBASE SQL RDBMS	Limited Custom Graphs	TCP/IP (Modified)	Full SIGINT Emitter Location/Classification	No
GRCS IPF-2	ADA, FORTRAN, Assembly (MICRO-6 with SUN SPARC 2E)	SUN O/S UNIX	GRAMM	SYBASE SQL RDBMS	DMA	TCP/IP (Modified)	Full SIGINT Emitter Location/Classification	No
Smart File Cabt Subsys (GRCS Family)	SPC New Code: ADA FASTRACK Reuse: C	SUN O/S UNIX	X-WINDOW MOTIF	SYBASE SQL RDBMS	DMA DTED (WDBII)	TCP/IP	Query, Time and Los Analyses	No
HAWKEYE	ADA (SUN SPARC 1E/2E)	SUN O/S UNIX	X-WINDOW MOTIF	Custom (SQL Features)	DMA, DTED (WDBII)	TCP/IP	Suite of Tools for Operator	N/A
IEWCS-H	ADA (SUN SPARC 2E)	SUN O/S UNIX	X-WINDOW MOTIF (Screens by Telesue)	SYBASE SQL RDBMS	DMA DTED, DFAD (WDBII)	TCP/IP	Maximized Reuse of Smart File Cab (GRCS) VCC/Nuclear (JSTARS) HAWKEYE/AMBISS Algorithms (PMSW) CHALS-X/TJ-A/ HU MMI (PMSW) NDI MMI (Other DoD)	Yes (N/A)
IEWCS-L	ADA (SUN SPARC 2E)	SUN O/S UNIX	X-WINDOW MOTIF (Screens by Telesue)	SYBASE SQL RDBMS	DMA DTED, DFAD (WDBII)	TCP/IP		Yes (N/A)
IEWCS-ACF	ADA (SUN SPARC 2E)	SUN O/S UNIX	X-WINDOW MOTIF (Screens by Telesue)	SYBASE SQL RDBMS	DMA DTED, DFAD (WDBII)	TCP/IP		Yes (N/A)
MITT	C, C++	SUN O/S UNIX	X-WINDOW MOTIF	Interbase SQL Based RDBMS	DMA DTED, DFAD (WDBII)	TCP/IP	ASPO Correlation: Paragon Imagery	(N/A)
UAV-SR	C, PLM51 (will translate to ADA)	UNIX O S	X-WINDOW MOTIF Data Cube	UNIX Based SQL Based RDBMS	DFAD (100 x 100 km) DTED W2BII	TCP/IP	Assessing Algorithms	Required

Figure 3.3. Selected IEWCS Common Software Components and Their Associated Standards

receiver and processor, when combined with the anticipated future potential and growth of widely available VME-based module technologies, served to strengthen the wisdom of selecting VME-based commercial common module products for the IEWCS technical architecture.

Issues and Alternatives in the IEWCS Systems Acquisition

The establishment of an IEWCS acquisition strategy involved a consideration of several alternate approaches to IEWCS system development. The basic alternatives considered, from least acceptable to most preferred, and associated issues in their consideration include the following:

- **Alternative 1.** Apply only minimal upgrades to the six existing legacy systems. Accept increasing technical performance shortfalls and continuing lack of interoperability between SIGINT and EW operations. Accept increasingly difficult equipment supportability and continuing dependence on a single incumbent vendor for each system. Accept that continuing operations and support (O&S) staffing resources will not comply with Army downsizing guidance. This alternative was clearly unacceptable!
- **Alternative 2.** Develop and apply major modifications to the front-end sensor hardware in each of the six legacy systems to achieve new SIGINT/EW technical performance requirements. Accept that systems functionality would not be able to keep up with future threat technical environments. Accept that most hardware and software would continue to be non-standard and incompatible. Since each of the legacy systems are technically unique and have few, if any, elements in common, accept that there would be negligible hardware or software reuse potential. A significant problem with this approach was that it was determined that, in some cases, it was not practical to adapt the new hardware into the older systems technology. Most of the disadvantages of Alternative 1, specifically including difficult supportability, would also apply to this alternative as well.
- **Alternative 3.** Simultaneously, but independently, develop a total upgrade of each of the legacy systems incorporating improved front-end sensor hardware and corresponding improvements to all other system components. Each of these upgrades would utilize the best available components appropriate to each specific system without consideration of any common system development. A subset of this alternative would be to upgrade only a fixed subset of these systems, such as TRAILBLAZER, TEAMMATE, and QUICKFIX. In any case, this acquisition alternative would clearly be far more expensive in the near-term than Alternative 2, while maintaining most of the disadvantages of Alternative 1. Although each of the upgraded legacy systems would be distinct, this alternative would offer achievement of improved operational performance within a shorter time period. Most interoperability, commonality, and supportability requirements would not be met and would remain serious shortfalls. This alternative was seriously considered by PEO IEW, but cost of simultaneous upgrade of only three of the legacy systems would have significantly exceeded available PEO IEW resources.
- **Alternative 4.** Fully upgrade one legacy system at a time to utilize a common module approach wherever practicable. This alternative would have a near-term cost advantage of spreading upgrade costs over a number of years, but also spread the total system upgrade completion unacceptably into the far future (the PEO IEW estimated an earliest completion in the year 2005). Accept that system

interoperability, commonality, and supportability would be strained due to the mixed technology nature of this development approach, especially during the extended transition period until all systems were fully upgraded. Accept that continuing technology upgrades to each of these systems would be required to maintain pace with increasing threats, and could add to the total developmental cost. Accept that O&S staffing resource requirements would not meet Army personnel downsizing goals.

- **Alternative 5.** Initiate development of one set of IEW common sensors and signal processors that could perform the technical functionalities of each of the six legacy systems and that could be configured to meet each of the Army's light, heavy, and airborne SIGINT/EW missions and platforms. Allow horizontal insertion of both government- and commercially-developed common module technology that would be enabled by full adherence to an OSA-based technical architecture. Conform to a widely accepted commercially-developed technical standard, serving to maximize opportunities for continuing capability upgrade via insertion of improved technology. Permit common module and subsystem interchangeability among SININT/EW missions and platforms, thereby achieving maximum reuse of hardware and software, also serving to achieve the desired interoperability, commonality, and supportability goals. This was the alternative IEWCS system acquisition strategy that was selected by PEO IEW. The decision to initiate this development alternative, however, created a $10 million cost impact to the IEW program and an 18-month schedule delay with a higher associated possible risk of program termination. A strong program leadership hand became mandatory to achieve the required success in the face of high programmatic and technical risk.

The Selected IEWCS System Design

Upon the selection of an OSA-based common module acquisition strategy and of the VME-based commercial technical standards, an overall IEWCS system design was initiated in conformance with the technical architecture illustrated in Figures 3.2 and 3.3. Over the 1992–1994 timeframe, the IEWCS design evolved to support a configuration of three major subsystems, each addressing one component of the SIGINT/EW mission:

- CHALS-X (Communications High-Accuracy Location System Exploitable), to perform precision targeting against hostile communications systems.
- TACJAM-A (Tactical Jammer-Advanced System), to support both active electronic countermeasures (ECM) and passive electronic support measures (ESM) against hostile communications and non-communications electronic systems.
- CMES (Common Modular Electronic Intelligence System), to perform precision targeting against hostile non-communications systems.

In turn, the IEWCS system and these three component subsystems would be configured to each reside in three different Army tactical SIGINT/EW platforms:

- Ground-Based Common Sensor-Heavy (GBCS-H), carried within a standard Army tracked tactical vehicle known as the Electronic Fighting Vehicle System (EFVS). [Note: The EFVS is also used as the platform for several other Army tactical systems such as the Command and Control Vehicle (C2V)].

- ❺ GBCS-Light (GBCS-L), carried within standard electronic enclosures mounted on a standard Army light tactical truck known as the High Mobility Multipurpose Wheeled Vehicle (HMMWV) or the M1097 truck.

- ❺ Advanced QUICKFIX (AQF), carried on a standard Army Blackhawk helicopter (EH-60A).

The IEWCS subsystems and their platforms are illustrated in Figure 3.4. While each of the predecessor IEW systems required unique and somewhat non-standard military vehicles, the three IEWCS configurations each fit into standard military platforms that are each also used in other non-IEW systems and missions. This system implementation decision served to significantly lower ensuing O&S costs for all IEWCS platforms compared to those of the six predecessor systems. In addition, this development approach allowed IEWCS carriers to be deployed and supported utilizing normal unit operational procedures, unlike the platform vehicles of the predecessor systems that were unique and had to be supported and often deployed differently. Moreover, the use of standard military platforms for each of the IEWCS configurations gave military commanders increased deployment flexibility which served to positively effect the operational deployment of the supported unit.

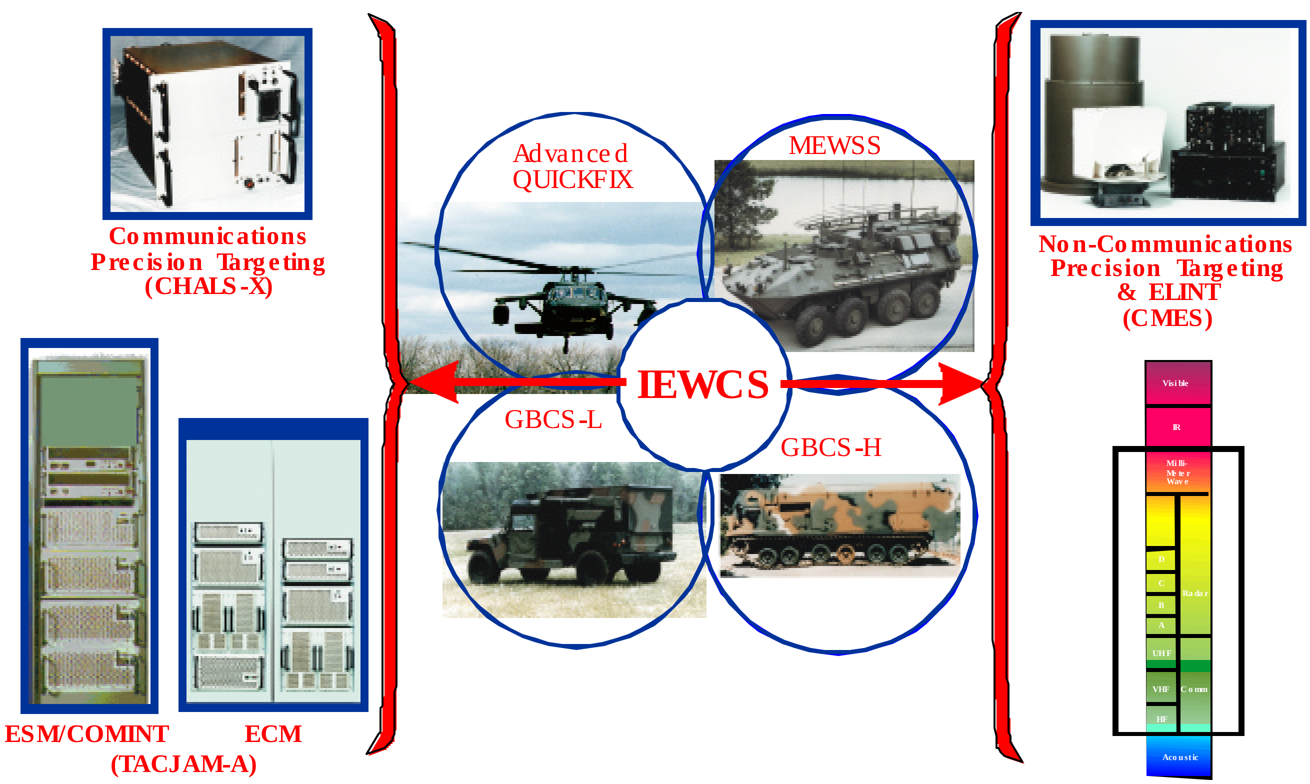


Figure 3.4. IEWCS Subsystems and Their Platforms

Other than those platform-unique chassis and configuration items necessary to adapt the IEWCS system installation into each of these three platforms, the IEWCS system within each of the platforms is physically, functionally, and operationally identical. Each IEWCS system, regardless of platform installation, can perform all of the specified SIGINT/EW missions, and to that extent, are operationally interchangeable. This approach also permitted a high degree of interchangeability among IEWCS O&S personnel.

In addition, since each IEWCS system installation was based on the same common module hardware and software products, each IEWCS technology upgrade would be equally applicable to all three platform configurations. All IEWCS systems also used functionally identical common workstations, mission data links between units, and the SINCGARS combat net radio. This overall design approach served to assure a high level of interoperability and maximum supportability.

Planning the Transition of Six Legacy Systems Into One Evolutionary System

One stimulus to the decision to acquire a single IEWCS system to replace the six legacy Army SIGINT/EW tactical systems was the concurrent downsizing of the Army IEW development community. A single IEWCS Program Office with a single Program Manager was established in the 1989 timeframe at the Army's Vint Hill Farms Station facility in Warrington, VA, replacing the six predecessor program offices and their six independent Program Managers. All transition planning was thereby centered into a single program office, achieving not only the Army's program management downsizing objectives, but centralizing all subsequent program management activities.

The PEO IEW decided to pursue two separate acquisition activities in the transition to a single IEWCS system:

- Based on an urgent requirement expressed in an Operational Needs Statement (ONS) from the 82nd Airborne Division, the development of an interim GBCS-L was initiated. It was planned that the GBCS-L (Interim) would be fielded with the 82nd Airborne Division prior to completion of the full IEWCS technical development. These interim units would be subsequently retrofitted with the full IEWCS technology. The use of an OSA-based development strategy made this approach cost-effective in that the technology utilized in the interim GBCS-L development supported direct insertion of improved IEWCS modules as they became available. In addition, much of the software developed for the interim GBCS-L implementation could be reused across all final IEWCS configurations.
- Three Engineering Development Models (EDMs) of each of the GBCS-H, GBCS-L, and AQF configurations of the IEWCS would be produced for technical and user testing (TT/UT). This set of nine IEWCS systems would be tested together to demonstrate the satisfaction of the requirement for interoperability and synergy. Upon successful completion of TT/UT, production approval and type classification Standard would be sought for the GBCS-H and AQF. The GBCS-L (Interim) would initially be type classified Limited Production Unit, but upon upgrade and retrofitting to the full IEWCS technology, a type classification Standard would also be sought. This ambitious simultaneous development of three major IEWCS subsystems was greatly facilitated by the OSA-based acquisition strategy in that all employed compatible and interoperable common modules and common software components. It was planned that all these activities would be completed by FY1996 (and they were!).

The IEWCS transition activities were also dependent on the concurrent development and/or configuration modification of the two ground-based IEWCS platform vehicles (EFVS and HMMWV) by other Army development commands. The AQF helicopter platform was evolved from the existing QUICKFIX platform via the material change process. In each case, developmental risk was minimal due to limited use of any specialized IEWCS installation configurations and the use of IEWCS components and subcomponents that are interchangeable and interoperable due to the OSA-based acquisition strategy.

As of late-FY 1996, the overall development and fielding of the IEWCS system have been proceeding successfully and on schedule. The system and each of its three component subsystems (CHALS-X, TACJAM-A, and CMES) has currently passed acquisition Milestone 2 for each of the three platform implementations (GBCS-L, GBCS-H, and AQF). In addition, the CHALS-X and CMES subsystems are now in production (acquisition Milestone 3), while the TACJAM-A subsystem is now in low rate initial production. The projected Milestone 3 dates for the GBCS-L, GBCS-H, and AQF implementations are during FY 1997, FY 1999, and FY 1998, respectively.

CHAPTER 4

IEWCS IMPLEMENTATION OF AN OPEN SYSTEMS APPROACH

Introduction

The decision to adopt an open systems approach in the development of the IEWCS system was a bold stroke forced by the need to overcome current and future shortfalls in achieving the Army's tactical SIGINT/EW mission and tempered by the realities of the IEW budget limitations and DoD's programmatic guidance for acquisition reform. The technical and management paradigm shifts necessary to successfully accomplish an OSA-based IEWCS development within the Army's evolving systems development environment were substantial. Several of these issues and their resolution with respect to both the technical and management challenges are presented in this section.

Technical Issues and their Resolution

A fundamental challenge to the IEWCS system designers was to develop individual subsystems and components at the lowest possible common level that are interchangeable and interoperable. This in turn required the selection of appropriate commercial standards upon which to base the IEWCS technical architecture. To this end, several market surveys were conducted by PEO IEW and for PEO IEW by the Jet Propulsion Laboratory (JPL). In 1991, JPL recommended a set of hardware and software standards for IEWCS implementation (Report JPL D-8980, see Appendix A.4). In late-1991, PEO IEW decided to accept the JPL recommendations and selected various sets of commercial and military computer hardware, interconnect, and software standards, including:

Backplane	VMEbus (IEEE Standard 1014)
Data Bus	VME Sub-Bus (IEC Standard 821)
	MIL-STD-1553
Local Area Network	Ethernet (IEEE Standard 802.3)
Operating System	UNIX
Applications Program Interface	POSIX.4 (IEEE Standard 1003.4)
Data Base Management System	SQL Standard
Graphical User Interface	OSF/MOTIF
Language	ADA and C++

Each of these standards represents publicly available documents defining specifications for interfaces, services, protocols, and data formats as established by a consensus process, and, as such, are either accredited or widely-used de facto open system standards recognized and supported by the commercial community. These standards are utilized by the three major component subsystems of IEWCS as follows:

- CHALS-X: VMEbus, VME sub-bus, and Ethernet
- CMES:VMEbus, MIL-STD-1553, and Ethernet
- TACJAM-A: VMEbus, MIL-STD-1553, and Ethernet

The judicious selection of these standards to achieve interchangeability and interoperability among the IEWCS subsystems and components was critical to the long-term success of the overall open system architectural design. A complete description of the common hardware and software components and their associated standards used in the IEWCS and other PEO IEW programs is presented in Figure 3.2 and 3.3, respectively.

It was the intent of the IEWCS system designers that through use of an industry standard open systems architecture with a common bus, a greater segment of potential vendors will have the opportunity to develop more system components (e.g., sensors, signal processors, memories, communications modules) that can readily and economically be added to any of the IEWCS platform configurations. Through this use of an OSA-based architecture, the requirements for integration of new and existing commercial item (CI) subsystems into a host system are known and understood by all vendors. In addition, through such an OSA-based implementation, conformant system hardware and software components developed by other government programs can be incorporated within IEWCS configurations as a non-developmental item (NDI). Moreover, through such accommodation of vendor-proposed off-the-shelf CI products and appropriate NDI components that work in accordance with the selected standards, system customization can be significantly reduced, thereby serving to reduce costs and inherent risks associated with specialized modifications.

An additional benefit of the OSA-based implementation includes the ready facilitation of technology transfer of hardware and software components from other conformant systems into IEWCS as well as from IEWCS to other system development programs. This benefit has provided valuable cost avoidance in IEWCS development (such as permitting the transfer of the Air Force 8-channel DF receiver and processor technology to IEWCS) and has enabled cost avoidance in other PEO IEW system developmental (such as the Airborne Reconnaissance Low program). Perhaps the most compelling illustration of the value of such relatively easy technology transfer made possible by the OSA design is shown in the transfer of IEWCS hardware and software components to the U.S. Marine Corps Mobile Electronic Warfare Support System Product Improvement Program (MEWSS-PIP), described in detail in Chapter 6 of this Case Study.

To date, these intended goals of a commercial standards-based OSA design have, for the most part, proven realizable and are believed by the PEO IEW staff to be the source of considerable developmental cost avoidance. The selection of a VME standard backplane remains highly credible throughout the foreseeable future, and the number of commercially-developed VME-based products of potential use in IEWCS systems continues to increase. In a similar fashion, the selection of the real-time extension to the portable operating system interface (POSIX), known as POSIX.4, as the application program interface (API) also remains highly credible throughout the foreseeable future as a strong technology transfer enabler.

Another opportunity for cost avoidance was found in the development of software across the three major IEWCS subsystems. There were three principal opportunities in this area. The first of these was inherent in the subsystems design due to the utilization of many common hardware modules for each of these subsystems within each of the three IEWCS platforms, wherein, to the maximum extent possible, common software was developed once that was appropriate to any of the IEWCS configurations. As opposed to a traditional computer-based system acquisition wherein significant new software development is normally required for each major variation or applications environment, IEWCS was able to incorporate common hardware modules throughout its constituent subsystems and applications platforms. The overall cost savings due to this OSA-based design approach cannot be easily quantified, but clearly represents a distinct advantage of the IEWCS system development process.

The second opportunity for software development cost avoidance was in reuse of previously developed software from one of the six legacy systems or other PEO IEW systems development programs. It is estimated that of the approximately 151,000 source lines of code used to implement IEWCS, approximately 102,000 source lines of code, or 67 percent, were obtained from other sources. The IEWCS program office has estimated that this software reuse has provided a developmental cost avoidance of approximately $7.6 million. In addition, a third opportunity for software cost avoidance exists in that it is intended that most, if not all, of current IEWCS software can be reused in the next generation of hardware modules. This potential for future IEWCS software development cost avoidance again cannot be readily quantified, but the current evolutionary development program for the CHALS-X(M) from the CHALS-X may provide a near 100 percent level software reuse. These IEWCS experiences in achieving a relatively high level of software reuse dramatically illustrate the potential for the OSA-based design approach wherein new generations of computer hardware which conform to established commercial software operational standards are able to readily reuse previously developed software, providing a higher level of system technical performance with a minimal investment in the development, integration, and testing of new software.

Management Issues and their Resolution

The initial challenge to the PEO IEW was to develop and enforce a commitment to the OSA-based system implementation process throughout the IEWCS program office and the traditional IEW vendor community. This proved to be a difficult challenge, but was successfully achieved over the 1988–1992 timeframe by a determined and constant leadership as well as by demonstrable technical successes via a series of incremental advances. The transition from a traditional acquisition management environment (i.e., implementing a “stovepipe” approach) to that required by an OSA-based acquisition management environment required a considerable change in mindset and emphasis. A relatively high degree of informal, but mandatory, discipline and control practices were established to ensure that close adherence to the critical standards utilization policy was followed. To this end, a Conformance Management policy was developed to ensure that no exceptions nor extensions to the selected standards were utilized, and that interface profiles were closely followed.

Concurrent with the establishment of these policies, PEO IEW was also challenged by the reorganization of the IEWCS Program Office from six “stovepipe” system Program Managers to a single IEWCS Program Manager and three managers of the separate platform IEWCS configurations, in addition to mandated program office staff reductions due to a sweeping downsizing of all Army PEO organizations. PEO

IEW was also impacted by the Army mandate to consolidate technology developments by establishing HTI managers within and across PEO organizations. The OSA-based implementation approach for IEWCS development did permit a substantially smaller Program Office management staff than was necessary for the six predecessor programs. As such, the OSA-based development tended to prove invaluable in allowing PEO IEW to adjust to and accommodate each of all organizational changes that it encountered during this period.

From a programmatic standpoint, another significant management challenge arose with the initial decision to proceed with an OSA-based common module IEWCS development approach (described as **Alternative 5** in Chapter 3). This decision in effect created a $10 million cost impact to the IEW program and an 18-month schedule delay necessary to replan the program and to conduct the required market surveys, while also providing the program a high visibility to the Army acquisition authorities. Again, the determined and committed leadership from the PEO IEW and the personal belief that this was the correct decision provided a level of confidence sufficient to overcome all programmatic obstacles raised by this relatively high program cost increase and schedule slippage. In the end, the confidence in this decision to adapt an OSA was shown to be correct in that the IEWCS achieved substantive cost avoidance and schedule improvement.

It is the nature of the IEW system acquisition environment that a relatively closed set of established vendors are the only source considered. These vendors are typically large system integration contractors who possess the specialized security clearances and systems experience that characterize this peculiar applications domain. The Government's intent to employ an OSA-based rather than a traditional acquisition approach did not change this symbiotic relationship between PEO IEW and their established suppliers, nor served to effectively open the market for other vendors. At the onset of the IEWCS acquisition, this traditional systems integration vendor community tended to reluctantly accept the Government's OSA commitment, but in time, proved a willing and able partner in the IEWCS development. Non-traditional second- and third-tier commercial sources of supply were considered and utilized, and, in so doing, allowed some cost avoidance that may not have been possible had only traditional Government sources of supply been utilized.

Although considered, there were no special nor extraordinary management techniques used to implement this OSA-based development. Similarly, it was reported that technical prototyping demonstrations to assess the feasibility of new technology were generally not required nor used during the evolution of the IEWCS technical architecture. The Program Office did develop specialized project management software, but as the IEWCS development progressed, it proved unworkable due to its complexity and inability to simultaneously update and coordinate the hundreds of ongoing activities. As a result, this automated project management support attempt was abandoned within the first three years. Required project planning, scheduling, and control was mostly done manually and via e-mail. Although IEWCS developmental management goals were clearly established, specific performance measures (other than milestone achievement) were not generally established to gauge the progress toward the goals. This did not seem to impede progress since the goals were unambiguously defined, were not subject to different interpretations, and the management was determined to reach them.

R&D and Production Cost Avoidance

The OSA-based technical architecture of the IEWCS system represents a distinct departure from the design approach employed in the six predecessor systems. It was envisioned that this OSA-based design would also offer significant cost advantages. This promise was realized and many opportunities for cost avoidance due to the OSA-based implementation were exploited. This is perhaps best illustrated by considering the overall costs associated with the R&D and production phases of the IEWCS life-cycle.

The following summary comparison considers actual overall cost of the IEWCS for the R&D and production phases against the corresponding estimated overall cost of a hypothetical non-OSA development of an SIGINT/EW system of equivalent technical performance as the IEWCS. A detailed presentation of these assumptions and a cost analysis of the complete IEWCS acquisition through all phases of its life-cycle (including the O&S phase) are presented in Appendix A.2.

	IEWCS-like SIGINT/EW System Capability without an OSA-Based Design	**Actual IEWCS System Using an OSA-Based Design**
R&D Costs by Major Subsystem:		
CHAALS/CHALS-X	$ 66.0 M	$ 66.0 M
CMES	54.3 M	7.0 M
TACJAM/TACJAM-A	195.0 M	165.0 M
Subsystems Integration	—	75.0 M
Platform Integration	81.7 M	49.0 M
Total R&D Costs	$ 397.0 M	$ 362.0 M
Production Costs by Major Subsystem:		
CHAALS/CHALS-X (138 units)	$ 191.9 M	$ 99.1 M
CMES (150 units)	347.4 M	135.0 M
TACJAM/TACJAM-A (198 units)	475.2 M	248.4 M
Total Production Costs	$1,014.5 M	$ 482.5 M
Total R&D and Production Costs	$1,411.5 M	$ 844.5 M

Accommodation of Evolutionary Change

The use of an OSA-based system implementation provides an inherent opportunity for relatively seamless accommodation of evolutionary change. The physical modularity and functional partitioning tend to facilitate the replacement of specific subsystems and components without modifications to or impact on other hardware or software components. This aspect of the OSA has been effectively exploited by the IEWCS system designers in their incorporation of new technology as it has become available over the years since the current IEWCS developmental initiation in 1992.

This characteristic accommodation of evolutionary change is illustrated by the systematic incorporation of improved system operational software beyond that originally specified. The initial selected operating system was UNIX; over the 1992–1996 period, the operating system evolved to a POSIX-based application program interface, currently a POSIX.1 compliant (per the Open Software Foundation (OSF) standard OSF-1) real-time extension known as POSIX.4 (per IEEE Standard 1003.4). The ensuing multi-operating system programming environment provides considerably greater portability to IEWCS applications than does the

UNIX operating system. However, this change in operating system did not require significant changes in any IEWCS applications programs nor IEWCS hardware modules, and its insertion into the IEWCS development was relatively seamless.

Another illustration of this accommodation of evolutionary change is in the ability of the IEWCS design to facilitate steady increases in the system repairable level, i.e., that level below which the subsystems and components are not under Government configuration control and where repairs, if required, are performed by the supplier. The initial IEWCS design established the system repairable level as the VME card component. Since 1992, although the level of complexity for many VME cards significantly increased in terms of processing power and memory capacity, requiring fewer individual VME cards, the system repairable level has been maintained as the VME card. More recently, these VME-card based processing elements and memories have been replaced with even more compact, but fully VME-compliant, single-card computer modules (including memories), currently single-card-based Sun workstations. With this change, the IEWCS system repairable level has been raised to the workstation module level. However, these IEWCS processor hardware component changes did not require any significant changes in IEWCS system nor applications software, nor to the VME-based common sensor modules within the individual subsystems.

CHAPTER 5

PRIMARY RESULTS ACHIEVED FROM AN OPEN SYSTEMS APPROACH

Introduction

The development and subsequent fielding of the IEWCS system utilizing an OSA promises to provide a substantial improvement in SIGINT/EW warfighting capability, a relatively large acquisition cost avoidance, and a marked decrease in the overall development schedule leading to an improved (i.e., more timely) fielding of the improved operational capability. The IEWCS development serves to illustrate the strong advantage offered by an OSA in providing improved technical performance, lowered developmental cost, and faster time to deployment over the traditional system acquisition approaches. In addition, there are several significant associated benefits accrued in the areas of operations and support, especially in the areas of reduced manpower and supportability requirements, as well as in achieving interoperability among the IEWCS units. These primary results are described in the following section. A detailed analysis of the estimated total cost avoidance throughout the IEWCS life-cycle is provided in Appendix A.2.

In addition to these major technical, cost avoidance, and schedule improvements, it is worth noting other systems management and budgeting opportunities associated with the OSA-based systems acquisition that proved of significant value:

- Due to the overarching systems vision of the PMO and the open systems architecture, the IEWCS system acquisition tended to be more manageable in light of responding to potential budget reductions. For example, the GBCS Heavy could be deferred without significant program impact when the IEWCS system budget was reduced.
- The IEWCS program office demonstrated an ability to maintain required acquisition budgets by developing additional revenues from other program offices through transfer of IEWCS technology.
- The IEWCS program office was able to garner Congressional support for continued IEWCS acquisition funding by demonstrating the value of IEWCS technology to other DoD programs.

Improved Technical Capability

Each of the three major component subsystems of the IEWCS (i.e., CHALS-X, TACJAM-A, and CMES) has vastly superior technical and operational performance capabilities in fulfilling the Army's SIGINT/EW mission compared to those of the six predecessor legacy systems. The IEWCS can meet the broad frequency spectral range associated with newer threat emissions and deal with the newer forms of modulation. For example, five of the six legacy systems covered a relatively narrow band within the HF and VHF spectrums (30 to 88 MHz), while the sixth, TEAMPACK, covered portions of the UHF and SHF spectrums. Each of the three major component subsystems of IEWCS covers an identical and much broader spectral range from HF to the EHF bands, as is illustrated in Figure 5.1.

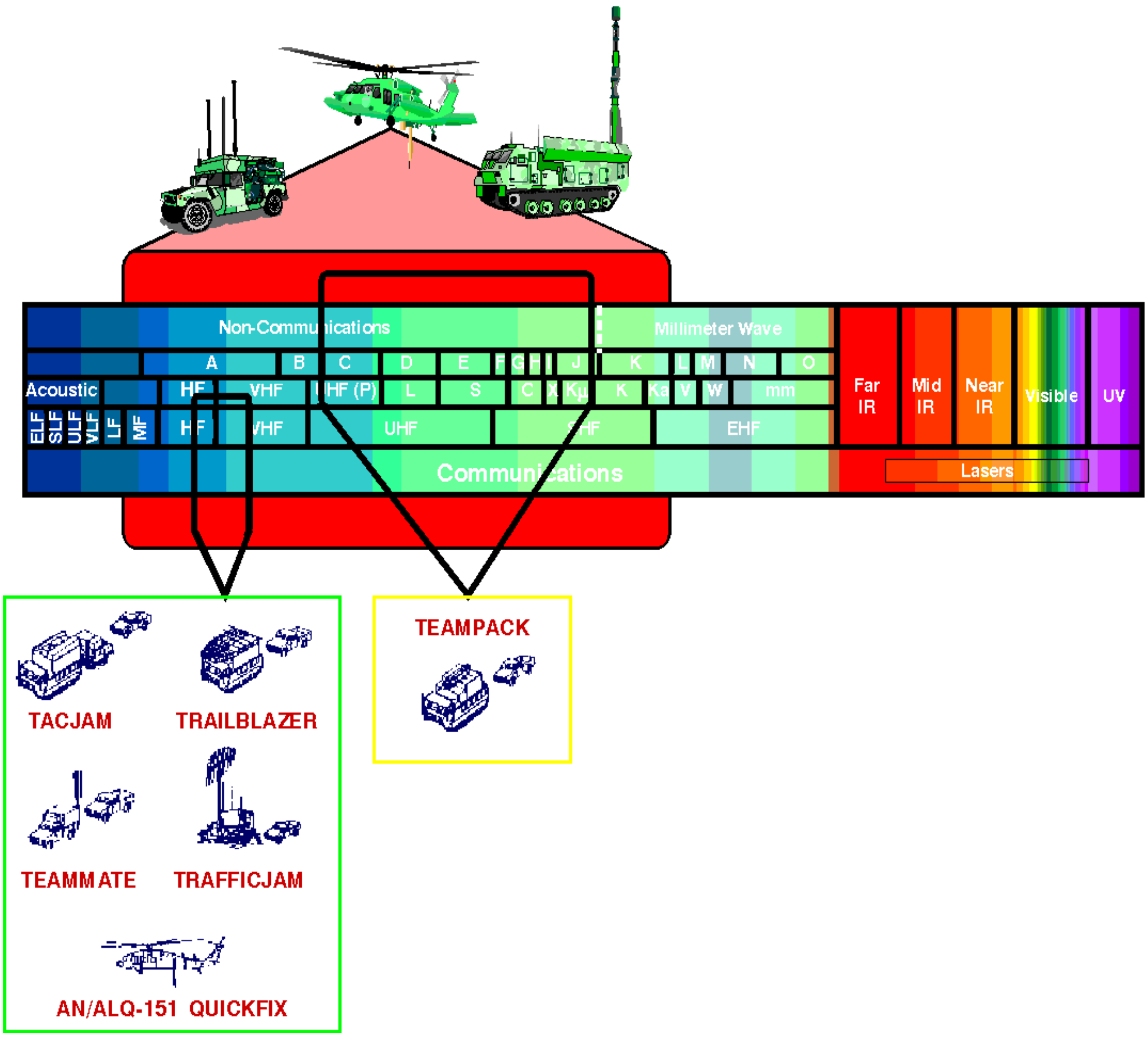


Figure 5.1. Technical Performance Characteristics of IEWCS Compared to its Legacy Systems

In general, these increased performance capabilities have been greatly enabled by the relatively easy technology insertion made possible by an OSA-based system design permitting rapid exploitation of current state-of-the-art sensor and processor module technology. Moreover, the VME-compatible, standards-based, plug-in technology that is commercially available for consideration by IEWCS system implementers permits these greatly increased capabilities with little or no Government developmental investment. The IEWCS system designers are thereby able to leverage $9–12 billion in commercial integrated circuit R&D, design, and manufacturing investment as well as the most prolific of industry commercial-standards-based technology developments. The IEWCS system components all make extensive use of commercial information technologies including processors, memories, backplanes, data communications media and protocols, and local- and wide-area networks.

In addition, this currently available off-the-shelf technology, and that which is soon to be available, does make possible a technological and operational robustness and flexibility of high potential value in addressing future electronic battlefield requirements in a timely manner. Moreover, since each of the three IEWCS subsystems can inherently perform the same SIGINT/EW operational functions and use similarly trained operations and maintenance personnel, a high degree of mission flexibility and backup among Army SIGINT/EW units can be accommodated.

Specifically the technical benefits of the OSA-based development of the IEWCS have included:

- Full interoperability among the three major IEWCS subsystems and the three IEWCS platform implementation configurations (i.e., GBCS-H, GBCS-L, and AQF) through extensive use of standards-based interoperable modules. This in turn promoted increased operational effectiveness.
- Maximum commonality between the three IEWCS platform vehicles (i.e., EFVS, HHMWV, and EH-60A) and the supported force.
- A highly evolvable and fully supportable system due to:
  - Commonality of commercial hardware, firmware, and software, thereby reducing the number and types of spares required to support the fielded system.
  - Subsystem and component interchangeability among individual units and platforms.
  - Easily upgradeable subsystems and components to meet evolving threat through technology insertion, such as the ability to incorporate more powerful processors as necessary to accommodate more computationally intensive algorithms.
  - Flexible operational support with multiple sources of vendors and maintenance services over the life of the system, offering increased competition and lesser dependencies due to few numbers of suppliers and vendors.
- Ready insertion of compatible, standards-based non-developmental items produced by commercial or government-sponsored developmental programs, offering a high potential for hardware and software reuse.
- Substantial size and power consumption reductions due to higher levels of component integration and consolidation of multiple component cards to a single card, also permitting more functions or component capabilities per chassis.
- Easy reconfiguration of each of the major subsystems to meet special mission needs.

Substantial Life-Cycle Cost Avoidance

In addition to the greatly improved technological capability of the IEWCS system, the greatest benefit incurred by the IEW PEO through the use of an OSA-based system acquisition is in direct avoidance of a substantial portion of the overall system life-cycle costs. These overall life-cycle costs may be considered in two parts: acquisition cost avoidance, and operations and support cost savings due to an operational return on investment. The following cost avoidance summary presents all costs expressed in FY 1996 dollars, with cost avoidance measured with respect to those costs which would have been incurred if the Army elected to develop and field six separate systems using a traditional closed systems approach to replace each of the six legacy IEW systems. A detailed development and analysis of these costs is presented in Appendix A.2. It is noted that the IEWCS developmental cost avoidances shown include the $10 million initial cost increase associated with the PEO IEW decision to utilize an OSA.

Total acquisition cost avoidance:

Total R&D cost avoidance	$ 35.0 M	
Total production cost avoidance	532.0 M	$ 567.0 M
Additional administrative cost avoidance experienced:		6.2 M
Total operations and support cost avoidance:		436.0 M
Total Army cost avoidance for IEWCS:		$ 1,009.2 M

The time-phasing of each of these cost avoidance areas over the potential 20+ year IEWCS system life is illustrated in Figure 5.2. This IEWCS system acquisition profile further shows the utility and promise of an OSA-based system design towards managing cost as an independent variable. There are also significant economies of scale through sharing, for example, in use of several of the IEWCS modules in the Army's Airborne Reconnaissance Low program. However, the greatest cost avoidance payoff will occur as an operational return on investment due to:

- Approximately 46 percent fewer required operators, 65 percent fewer vehicles, and 60 percent less required airlift capacity.
- Shared testing, operator training, and logistics costs due to commonality of components and lesser operational personnel specialization.
- Common maintenance tasks and skills among major IEWCS subsystems permitting shared personnel and facilities.

Shortened Development Schedule

The use of an OSA-based system development also had a positive impact on the overall IEWCS developmental schedule. The following summary presents the actual developmental schedule experienced by the IEWCS program compared to the standard 101-month developmental period

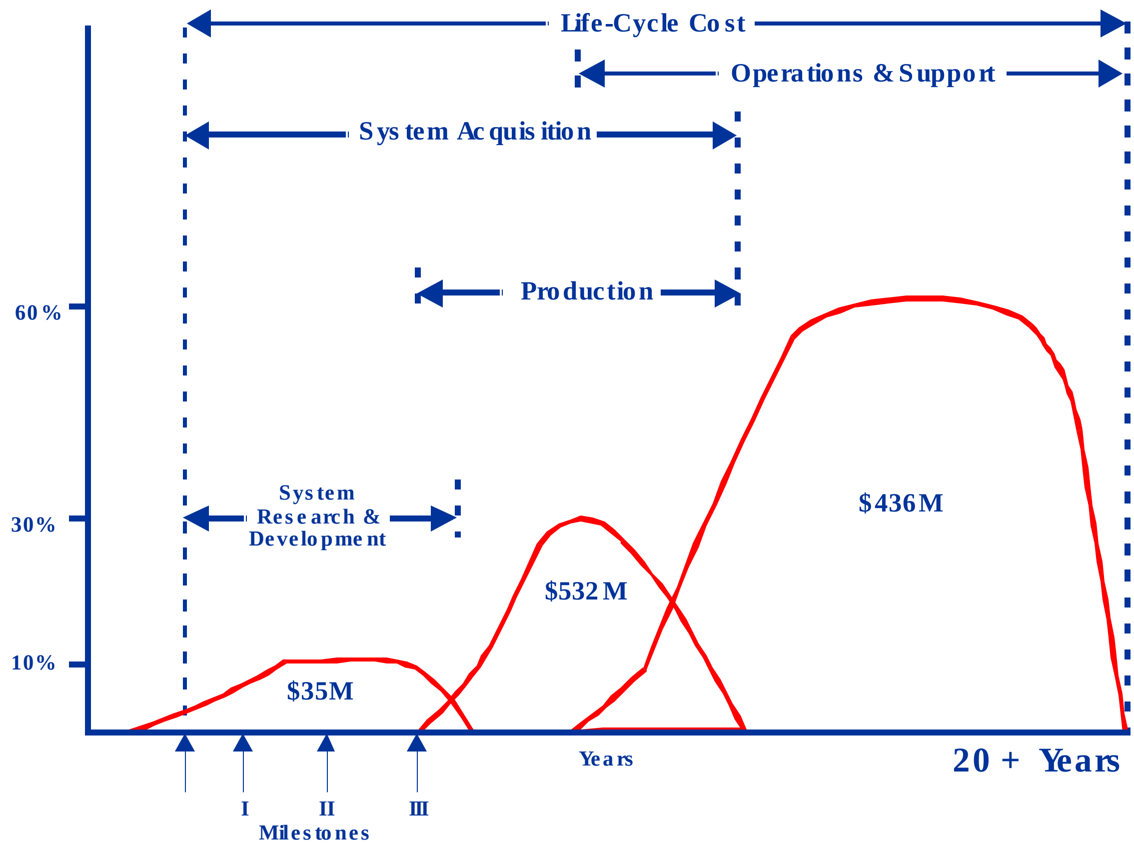


Figure 5.2. IEWCS Cost Avoidance Profile

associated with other Army major system acquisition with respect to research, development, and acquisition (RDA) cycle time and engineering and manufacturing development (E&MD) cycle times:

- RDA cycle time to meet the next generation threat reduced by 64 percent (total 36 months).
- E&MD cycle time for the GBCS-Light reduced by 39 percent (total 62 months).
- E&MD cycle time for the GBCS-H reduced by 18 percent (total 83 months).
- E&MD cycle time for the AQF reduced by 29 percent (total 72 months).

It is also noted that the 36-month RDA cycle time includes the 18-month additional schedule time associated with the initial PEO IEW decision to utilize an OSA in the IEWCS development. During this initial RDA period, the then ongoing IEW system development was restarted, market surveys were conducted, and hardware and software standards were selected. Overall, this significant improvement of the OSA-based system implementation over the traditional approach in achieving an improved operational capability in a more timely fashion is a distinct advantage of the OSA.

Improved Operations and Support Accommodations

In addition to those IEWCS system operations and support benefits described in the technical capability and cost avoidance improvement sections, several additional operations and support enhancements should be experienced through the system life-cycle. These include:

- Common methodologies for conducting sustainment and proficiency training for operator and maintenance personnel can be applied across all IEWCS subsystems and platforms, from unit to unit and from system to system, as well as across the three IEWCS platform vehicles and others within the supported force. These common methodologies can also be applied to other Army system developments utilizing IEWCS technologies (e.g., the Airborne Reconnaissance Low system) and to those of other Services (e.g., the USMC's MEWSS-PIP).
- Although each of the three IEWCS platforms is mission specific, their commonality of technical capability and inherent interchangeability provide a high degree of deployment flexibility and backup capability to the field commander in tailoring the force to meet changing battlefield requirements.
- The overall system design operational life-cycle can be achieved, and potentially extended, through the ready availability of system components from multiple commercial vendors throughout the foreseeable future, with the ability to seamlessly accommodate improved technology and revised components to replace those made technically obsolete and no longer available.
- Additional standards-based technology will most likely be developed by other Government programs or commercial sources, and would be readily available as NDI and/or CI products with plug-in compatibility to meet future performance enhancement and system supportability requirements.
- New SIGINT/EW roles and missions, as well as future declines in IEW force structure, can be more readily accommodated through timely insertion of technical enhancements and system reconfigurations with new system components readily available from multiple vendors.

Greater Interoperability

A primary rationale for considering an OSA-based design in any weapons system acquisition is the potential for life-cycle cost avoidance, although the potential for interoperability among similar platforms and mission-specific systems, as well as other battlefield systems, will always remain another important attribute. In addition to those interoperability benefits described in the technical capability and cost avoidance improvement sections, several additional interoperability benefits should be experienced throughout the IEWCS system life-cycle. These include:

- All three major component subsystems will use common databases and therefore can keep or exchange mission data between different subsystems and platforms to achieve sensor-to-sensor cross-cueing.

- ❺ Each of the three platform subsystems will use similar display terminals and display formats to permit cross-training of operators and flexibility of personnel assignments.
- ❺ The incorporation of IEWCS system technology within the SIGINT/EW systems (as well as other battlefield systems) fielded by other component services of the US (e.g., the USMC's MEWSS-PIP) and its allies will improve joint and international theater interoperability.

CHAPTER 6

SECONDARY RESULTS ACHIEVED FROM AN OPEN SYSTEMS APPROACH

Introduction

The primary benefits of the IEWCS system to the Army's SIGINT/EW mission seem clear, and the cost avoidance advantages of the OSA-based acquisition strategy to the Army's systems procurement budgets seem impressive. Another advantage of this OSA-based acquisition offering potentially even greater importance are those DoD-wide cost savings and benefits due to technology transfer to other systems and programs and cross-service utilization of IEWCS-developed technology. This chapter presents one example of IEWCS system technology transfer to the U.S. Marine Corps (USMC) in the development of an electronics suite upgrade to their Mobile Electronic Warfare Support System (MEWSS), designated as the MEWSS Product Improvement Program (MEWSS-PIP). This secondary cost avoidance due to the wholesale incorporation of IEWCS component technology within the MEWSS-PIP serves to demonstrate the considerable potential value achieved by this aspect of an OSA-based system design from an overall DoD perspective.

Technology Transfer to the USMC's MEWSS Product Improvement Program

Throughout the 1970's–1980's timeframe, the USMC had a ground-mobile tactical IEW capability based on several systems with many known deficiencies. These USMC-developed legacy systems were technically obsolete, could not support the Marine's battlefield mobility requirement, and suffered most of the related operational and support problems experienced by the six somewhat equivalent Army legacy SIGINT/EW systems. In the late 1980's, the USMC developed and fielded the original MEWSS, as well as initiated development of a companion system, known as the ELINT Support System (ESS). Both of these new systems were envisioned to be deployed as additions to existing Marine Corps IEW assets. In addition, these new systems were to be deployed within the USMC standard Light Armored Vehicle (LAV) to achieve the desired mobility requirements.

The electronics suite of the original MEWSS was predominately 1970's to mid-1980's technology, and was technically obsolete with respect to emerging battlefield requirements. An upgrade of this ground-mobile tactical IEW capability within the MEWSS-PIP was begun in the early 1990's. Unfortunately, the initial MEWSS electronics upgrade was unsuccessful in achieving its desired technical goals. This shortfall was primarily due to budget limitations. For example, compared to the Army IEW developmental budgets, the Marines were constrained by a relatively small IEW component within their RDA budget of approximately $25 million per year. Even over a decade, the USMC could clearly not even come close to the Army's IEWCS development expenditure of approximately $360 million.

Through liaison offices at the Army's PEO IEW facility, the USMC learned of the IEWCS development. In early 1993, the Marines determined that a significant cost savings, schedule advance, and warfighting improvement could be achieved through an alignment with the Army's IEWCS program. Accordingly, the USMC adopted the complete IEWCS systems technology for the MEWSS-PIP, and in essence, became a fourth IEWCS weapons platform. The only variance to the IEWCS technology insertion process was that the Marines would use their standard LAV as the MEWSS-PIP platform. The USMC thereby piggybacked on the Army's IEWCS investment to use the same open systems architecture, subsystems, and components. The Army also agreed to provided support to this second iteration of the MEWSS-PIP in areas of testing, training, and logistics.

The SIGINT/EW mission capability offered by the IEWCS system exceeded the MEWSS-PIP technical requirements developed by the Marines. Moreover, the IEWCS system capability also encompassed the ELINT mission requirements of the ESS in a single multi-function platform, thereby giving the MEWSS-PIP an enhanced mission capability beyond that which the Marines had felt they could reasonably acquire due to budget restrictions.

Through their determination that the Army-developed IEWCS system technology could accommodate their requirements, the Marines were able to adopt the specific IEW systems products of the Army's considerable technology investments at a fraction of the actual developmental cost. The only systems R&D cost incurred by the USMC was approximately $12.5 million necessary to adapt the IEWCS system to the LAV platform. The actual cost avoidance by the USMC in this MEWSS-PIP development may be estimated by postulating hypothetical alternative acquisition scenarios that might have been pursued had the Marines not elected to utilize the IEWCS technology. It is noted that these hypothetical acquisition scenarios are for illustrative purposes only in developing potential acquisition cost avoidance and do not represent actual USMC plans.

Under one such assumed MEWSS-PIP acquisition scenario, the Marines would have pursued a "bare-bones" SIGINT/EW electronics suite development totally independent from the Army's IEWCS, used a traditional non-OSA technical architecture and predecessor system technology, and achieved their only original technical performance goals that were significantly less than those of the IEWCS. Given this possible scenario and that the Marines had the resources to pursue it, it can be calculated that the USMC achieved a cost avoidance of approximately $149 million through use of IEWCS technology while achieving a greater than anticipated technical and operational capability (a cost analysis is shown in Appendix A.2).

Under another assumed MEWSS-PIP acquisition scenario, the Marines would have also pursued a new SIGINT/EW system development totally independent from the Army, but using the same OSA-based system developmental rationale selected by the Army, would have achieved a system technical architecture and performance capability exactly comparable to that of the IEWCS. Given this possible scenario (and again that the Marines had the resources necessary to pursue it), it can be postulated that the Marines would have had to make a R&D investment comparable to the Army's estimated $362 million IEWCS R&D expenditure, albeit that the Marines would have developed a system configured for only the LAV platform vehicle vs. three different platform implementations for the Army. In this case, it can be calculated that the USMC achieved a cost avoidance of approximately $481 million (this cost analysis is also shown in Appendix A.2). It is noted, however, that for either of these possible MEWSS-PIP alternative acquisition scenarios, it must be considered unlikely that the available USMC budget would have supported the required level of R&D investment or procurement expenditure necessary to otherwise achieve a SIGINT/EW capability comparable to that of the IEWCS.

In addition, the selected MEWSS-PIP acquisition strategy will provide several other direct benefits to the USMC, including:

- The Marine Air Ground Task Force (MAGTF) will use 50 percent fewer vehicles, 50 percent less required airlift, and a 50 percent reduction in operational support.
- The MEWSS-PIP acquisition provides a significantly accelerated procurement schedule and a leap-ahead in operational capability.
- Specialized operational ELINT/EW mission vehicles are eliminated and the standard LAV platform used by several other USMC battlefield systems permits common support and maintenance.
- The Army has agreed to provide (at no cost to the USMC) depot support to the MEWSS-PIP as another IEWCS system platform, thereby providing continuing operations and maintenance cost savings to the MEWSS-PIP deployment throughout the system life-cycle, although also serving to establish a long-term operational support dependency.
- Elimination of USMC-unique operator and maintenance personnel training facilities and associated manpower resources.

At the current time, the MEWSS-PIP development has passed acquisition Milestone II, and is proceeding towards a Milestone III production decision. The MEWSS-PIP is currently seeking a Milestone II-A low rate initial production decision for the implementation of two systems. It is understood that the initial production goal is twelve MEWSS-PIP systems, sufficient to satisfy the Marines' current tactical SIGINT/EW requirements for each of two Radio Battalions. It is believed that there will be some modest operations and support cost avoidance due to use of the LAV platform which is common to several other USMC systems. In addition, the original operational requirement for the development and fielding of 12 unique ESS platforms has been eliminated, thereby avoiding relatively substantial additional procurement and O&S costs.

Additional Intra- and Inter-Service Transfer of IEWCS Technology

Various subsystems and component modules of the IEWCS system have been incorporated within the programs of other Army organizations as well as those of other services and agencies within the DoD. Specific data as to use and adaptability of the IEWCS system technology in these applications is not readily available, nor is specific cost data necessary for an analysis of additional potential cost avoidance. DoD programs that have currently made use of or plan to make use of IEWCS technology include:

[Note: The CHALS-X(M) is the CHALS-X Modular, a man-portable single channel system to be used by the Air Force, Navy, and Special Operational Forces]

Army	Airborne Reconnaissance Low (ARL) System and Guard Rail Common Sensor (GR/CS) System
Air Force	Various airborne and fixed-site systems using CMES (current) and CHALS-X(M) (future)
Navy	Various airborne systems using CMES
	Future surface system using CHALS-X(M)
	SSN-21 Seawolf submarine using TACJAM-A electronic support measures
Other DoD	Special Operations Forces in support of Navy SEALs
	National Security Agency.

CHAPTER 7

LESSONS LEARNED AND THEIR IMPLICATIONS FOR AN OPEN SYSTEMS APPROACH

Introduction

It is the intent of this Case Study of the IEWCS system that the Army's experience in successfully achieving an OSA-based system acquisition can serve to provide helpful insights and lessons learned concerning this process. The following material is adapted from a presentation at a recent OS-JTF Workshop given by COL Tom Vollrath, U.S. Army (retired), a former IEWCS Program Manager and acting PEO IEW. This presentation, as well as other Workshop presentations, is available on the OS-JTF home page on the World Wide Web at http://www.acq.osd.mil/osjtf/
agenda.htm/.

IEWCS Has Achieved a Significant Cost Avoidance

As one of the ongoing acquisition reform initiatives within the DoD, the open systems initiative is oriented towards improving the efficiency and effectiveness of the weapons system acquisition process. Among the most compelling reasons to adopt and pursue an OSA-based systems acquisition are system procurement cost reduction and life-cycle cost avoidance. The IEWCS system acquisition can be shown to provide a cost avoidance to the Army PEO IEW of approximately $1,009 million. When coupled with the associated MEWSS-PIP acquisition cost avoidance to the USMC of approximately $149 million to $481 million, depending on the specific cost avoidance baseline assumptions used, the overall cost avoidance to the Government that has been achieved by the IEWCS program for just these two organizations alone is on the order of $1,158 million to $1,490 million. Additional cost avoidance benefits are expected to accrue to the Government as IEWCS technology is transferred to other Army and DoD systems development programs.

Important Technical Lessons Learned

The IEWCS systems development experience provides many substantive technical lessons learned. Nearly all of these lessons provide direct opportunities for cost avoidance. Among the most important of these technical lessons learned are:

- ❺ OSA is an enabler: Open systems designs for hardware and software enable successful horizontal technology insertion. The ready insertion of appropriate non-developmental items is significantly facilitated. This can permit the incorporation of new technology providing increased system performance at a greatly reduced cost. For example, the 8-channel direction finding subsystem developed by the U.S. Air Force directly inserted into the IEWCS acquisition/access controller chassis since it conformed to the IEEE VME hardware standard.

- ❺ OSA must be the rule—not the exception: Managers must ensure that OSA is utilized in all cases and only documented exceptions are permitted. The maximum appropriate use of OSA-based system design must be enforced for all system material hardware and software development. This can lead to significant cost avoidance as new technology becomes available to replace custom developed components. For example, while the CMES and TACJAM-A subsystems within the IEWCS totally utilize VME-standard circuit boards in their design, their use of custom-developed VME boards has drastically decreased from the E&MD design to the production design:

Circuit Board Design	Used in E&MD	Used in Production
Standard VME Modules	23	80
Modified VME Modules	13	2
Custom VME Modules	51	2
Total VME Modules in Design	87	84

- An OSA must be inherent at every level: There are open systems design opportunities available for both hardware and software development at every tier within the system architecture, from subcomponent level (e.g., electronic, mechanical) to the component, subsystem (e.g., sensor, prime mover), and system levels. In this sense, the overall IEWCS design strongly illustrates the technical and cost advantages of selecting and rigorously adhering to a common VME-based module hardware modules and common reusable software modules. These common modules underlie the three major subsystems which in turn were configured into the three platform implementations of IEWCS, as well as the MEWSS-PIP implementation. The investments in these common modules have also leveraged into various applications within other Army and DoD systems programs.

- Hardware and software can be reused: Hardware and software reuse presents a tremendous system developmental cost avoidance opportunity for the OSA-based design. The reuse of common modules is a cornerstone of the IEWCS systems architecture. It is estimated that approximately 67 percent of the IEWCS component and system software was reused, and was obtained as a non-developmental item to the program office from the legacy systems or other Army programs. It is anticipated that the standards-based OSA design will also permit near total reuse of current IEWCS software in subsequent generations of IEWCS hardware modules.

Important Management Lessons Learned

The IEWCS systems development experience also provides many substantive lessons learned. Among the most important are:

- OSA requires a culture change: The traditional “stovepipe” system development can no longer endure in light of rapid technological change and constrained acquisition budgets. A substantial cultural change must occur in order to effectively implement the structural change in development organizations necessary to meet this future acquisition environment. While the OSA-based design methodology is a proven solution to overcome many of these problems, its effective use requires a corresponding mindset paradigm shift at all levels of system development management. System developers within an applications domain must be organized and charter responsibilities must be aligned to foster the OSA potential. For example, joint technology development and technology transfer among all programs within a PEO must be encouraged and all barriers to such cooperative efforts must be eliminated. This mandate, of course, also applies at higher levels of the system development hierarchy, including across domains and Services. The success the USMC has achieved in spinning the MEWSS-PIP development directly from the IEWCS system investment directly illustrates this potential. Cultural barriers, such as not-invented-here attitudes, must be changed for this potential to be fully realized in other applications domains.

- OSA requires active involvement in standards activities: OSA-based system developers inherently become stakeholders in the commercial standards they select for their systems. Even though DoD systems developers are not the dominant users of most hardware and software standards, they must maintain an active awareness of the standards development and evolution process. Where appropriate, system developers may find they must maintain a direct involvement in standards establishment, maintenance, and modification activities. As a rule, support for these activities are not currently provided for in system development budgets, but represent a new responsibility which must be accommodated by OSA-based system developers. In selecting the VME and other accredited commercial hardware and software standards that are growing in influence and popularity, the IEWCS developers were able to initially avoid any direct involvement in related standards activities. However, the program office must continue a long-term monitoring of each selected standard to maintain a necessary awareness of current status and potential change that could impact any component of the IEWCS system.

- Strong and consistent project management, and most importantly, strong and consistent Project Managers, are the key to successful OSA-based implementation: The IEWCS system development experience clearly highlights the importance of strong and visionary leadership at the PM level. The successful OSA-based implementation also requires a strong and consistent leadership at the Project Manager level who equally considers both the near-term system development goals and the life-cycle implications of critical near-term decisions. The PEO must strive to remove the walls between the several development projects within his domain in order to provide opportunities for technology transfer and common development, but it is each of the individual Project Managers who must exploit and pursue these opportunities to the fullest.

- OSA requires an evolutionary vs. a revolutionary focus on acquisition strategy: The maximum advantage of the OSA is realized by an evolutionary acquisition strategy that can realistically support a 3-year technology and operational upgrade cycle as opposed to a traditional revolutionary acquisition strategy that may struggle to achieve a 10–20 year upgrade cycle. This evolutionary strategy permits a necessary short-term reaction to changing threats and operational requirements, as well as enabling the focus on newer technology developments to be on highest payoff approaches. The pace of technological development will continue to increase over the foreseeable future, and will provide continuing opportunities for system performance improvement and cost reduction. The technical evolution of CHAALS subsystem to CHALS-X and currently to the CHALS-X(M), as is illustrated in Figure 7.1, shows how such rapid technological change has been accommodated and exploited in the IEWCS system design. It may be argued that the initial step to adopt an OSA-based development effort will often be in fact revolutionary, however, the OSA-based IEWCS development clearly illustrates the value of an evolutionary approach to facilitate technology insertion for performance improvement and long-term life-cycle sustainability.

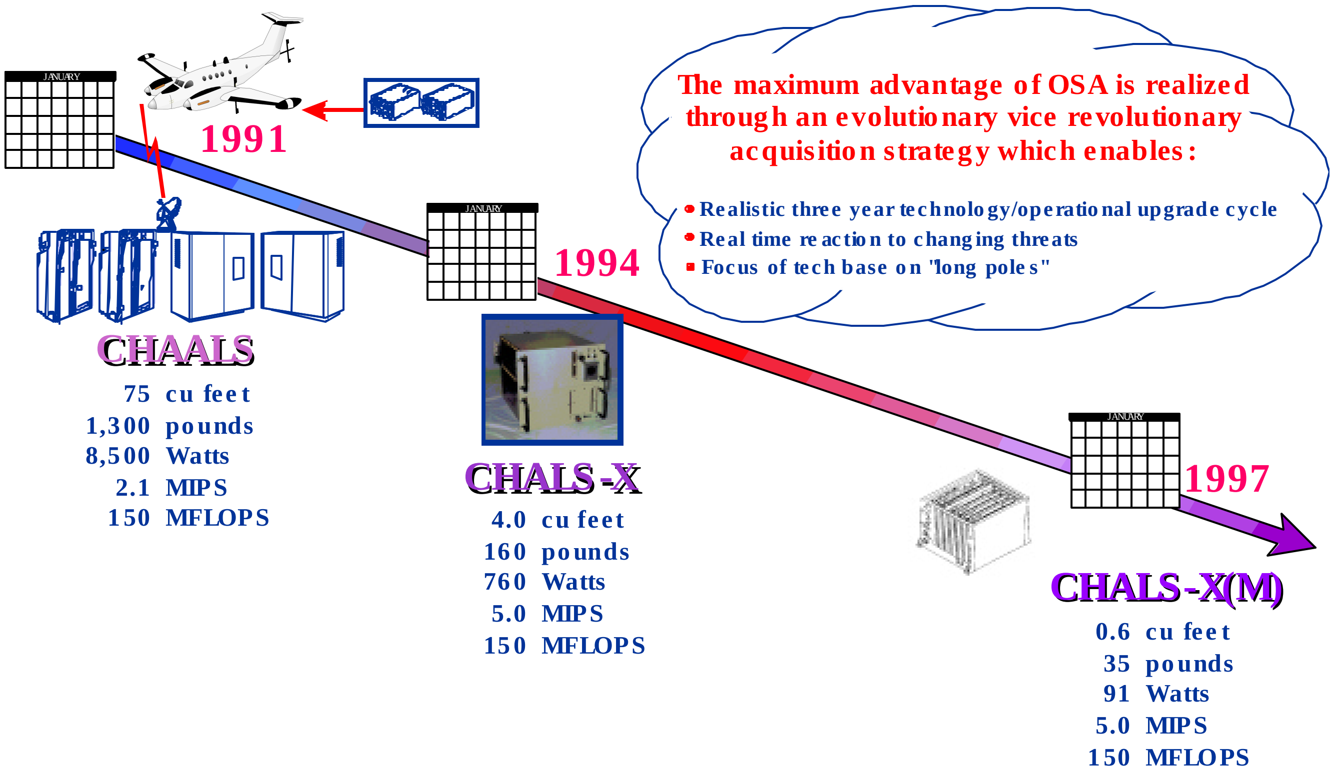


Figure 7.1. Evolution of CHAALS through CHALS-X to CHALS-X(M)

The Biggest Payoff from an OSA

The IEWCS system development experience suggests that the biggest payoff from an OSA-based implementation may lie in opportunities for technology insertion into other system development projects across application domains and Service boundaries. It is arguable that successful pursuit of this process may well be the most difficult task that might be undertaken by the PEO and his Project Managers. In the case of IEWCS, there has been considerable success in the direct transfer of all or part of the technology development to the USMC's MEWSS-PIP and to the Army's ARL program, as well as to other DoD organizations and programs. The IEWCS has experienced several tangible benefits from this transfer, including:

- Lowered costs of individual components, circuit boards, and subsystems due to increased procurement volume.
- Increased number of stakeholders in the hardware and software standards selected for IEWCS implementation.
- An inherent improvement in interoperability among the heretofore disparate units deployed in the field.
- An increase in number of potential vendors and continuing vendor interest in supplying the needs of this segment of the VME-based product market.
- Leverage in higher-level support of IEWCS program budgets and production quantities due to explicit linkages of IEWCS technology to other DoD programs.

Although fortunately not directly experienced by the PEO IEW and the IEWCS system development managers, there are also several "killer" disincentives to technology transfer among DoD acquisition programs, especially among those residing in disparate systems applications and mission domains. These disincentives, which serve to stifle the creative exploitation of technology transfer opportunities, are often due to a "what's in it for me" or a not-invented-here mindset. Other disincentives include:

- Loss of absolute control—managers must rely upon other organizations for critical components and accept the risks associated with that reliance.
- Little or no budget resources allocated to support technology transfer and/or receipt.
- Limited knowledge within the systems development staff of technology developments, needs, and/or opportunities across disparate programs and Service domains.
- Limited or no reward or recognition to the program office for the conduct of technology transfer activities.

CHAPTER 8

SUMMARY AND CONCLUSIONS

This Case Study was developed to illustrate the successful use of an integrated technical and business strategy based on an OSA within a current DoD weapon system acquisition. The Army's IEWCS system has been selected for the subject of this Case Study as a representative example of one such system that has achieved its technical performance and manpower/supportability improvement, development schedule acceleration, and cost reduction goals through the use of an OSA-based implementation.

The IEWCS employs an innovative systems design and set of implementation configurations to replace six predecessor SIGINT/EW systems. This OSA-based design and implementation has demonstrated a vastly superior technical and operational performance. The IEWCS can perform across a significantly broader frequency spectral range associated with newer threat emissions and deal with the many newer forms of modulations, such as spread spectrum. Each IEWCS system, regardless of platform installation, can perform all of the specified SIGINT/EW missions. There is full component interchangeability and interoperability among the three major IEWCS subsystems, which in turn are each used to implement the three IEWCS platform configurations, due to extensive use of standards-based interoperable modules. The OSA-based implementation thereby provides a major increase in operational effectiveness and in flexibility of operational deployment.

In addition, there is a significant reduction in required manpower and unit supportability accrued due to a decrease in the number of operators, vehicles, and airlift needed to deploy and operate IEWCS in the field. For example, for an armored/mechanized division, IEWCS requires 46 percent fewer operators, 65 percent fewer vehicles, and 60 percent less airlift compared to the predecessor systems. This decrease in manpower and supportability requirements also provides a significant cost avoidance during the O&S phase of the IEWCS system life-cycle. Moreover, operations and maintenance personnel may be flexibly interchanged among the three IEWCS platform configurations.

The OSA-based IEWCS development provided a significant reduction of development schedule, leading to establishment of a new operational capability in a much shorter period of time. For example, the RDA time was reduced by 64 percent (including an 18-month schedule time required as a result of the initial decision to utilize OSA), and the E&MD time for the three IEWCS platform configurations was reduced by an average of approximately 29 percent, relative to the typical Army program acquisition cycle time.

Moreover, the OSA-based IEWCS acquisition has provided substantial cost avoidance over each phase of its system life-cycle. Given an estimated total R&D and production costs of approximately $845 million, the estimated cost avoidance for these two life-cycle phases alone is approximately $567 million compared to the non-OSA-based development of comparable system having equivalent technical performance. When combined with an estimated cost avoidance for the operations and support phase of approximately $436 million, the OSA-based IEWCS acquisition represents a cost avoidance to the Army of approximately $1,009 million. When further combined with the estimated cost avoidance incurred by the USMC for their MEWSS-PIP development of approximately $149 million to $481 million (depending on the assumptions used), the IEWCS acquisition represents a potential cost avoidance to DoD in the range of approximately $1.2 billion to $1.5 billion. Other IEWCS technology transfer opportunities to other DoD programs have also been realized, providing an even greater potential cost savings to DoD.

These and other relatively impressive IEWCS system development results have been noted by many senior DoD acquisition managers. For example, Major General William H. Campbell, formerly the Army's PEO for IEW and currently the Army's PEO for C3I Systems, has recently stated his strong support of an OSA to systems implementation:

> *"Open systems architectures are the only way to go in designing C3I systems. These architectures enable us to leverage commercial technology, to reduce support costs, and to continuously improve our warfighting systems through product improvement. Only in clearly justified circumstances should we use either proprietary architectures or military only form factors for electronic equipment. I consider proprietary hardware and software to be a garbage game in most circumstances."*

Similar assertions in support of an OSA have also been recently made by Major General Joe W. Rigby (retired), the former Director of the Army's Digitization Office:

> *"Open systems are the underpinnings of the Army Technical Architecture, the hedge to keep up with the commercial marketplace's technology investments, and the key to achieving the Army's vision of seamless interoperability for the warfighter."*

Among the several conclusions which may be drawn from this Case Study are the following:

- The open systems approach to weapons systems design can work and is demonstrably relevant:
  - Commercial technology appropriate to mission requirements is available and can provide desired performance.
  - Appropriate consensus-based publicly-available standards can be successfully used.
  - Seamless insertion of NDI and newly available technology to improve performance is possible.
  - Relatively high levels of hardware and software reuse can be realized to lower system developmental risk.
- Outmoded legacy systems can be replaced by a next-generation rapidly evolvable system that will be supportable into the foreseeable future to provide:
  - A commonality of commercial hardware and software components.

- Interchangeability of component modules and subsystems.
- Flexible system reconfiguration to support special mission needs.

❺ There is exceptional power in a strong system vision at the PEO level when it is well-defined and consistently enforced.

❺ The OSA can provide a tremendous resource multiplier at the system development level, and has even stronger potential at the intra- and inter-Service levels across a multitude of system mission areas and application domains.

Although these conclusions are drawn from the specific OSA-based IEWCS system development experience presented in this Case Study, they may be readily generalized as applicable to many similar weapons systems developments. The importance of the OSA process to the DoD has been summarized in a recent presentation by the Under Secretary of Defense for Acquisition and Technology, Dr. Paul G. Kaminski:

> *"… [OSA] is both a <u>technical approach</u> and a <u>preferred business strategy</u> that allows us to field superior combat capability quicker, and at a more affordable cost. … [It] is increasingly necessary for us to ride on the shoulders of the commercial marketplace. [The OSA] helps insure that DoD has access to that marketplace for the components we need. … [Further,] in order for these systems to remain effective over the long term, they need to be supported and sustained. The OSA provides a lower cost path for insertion of new technologies in existing platforms. … The military advantage goes to the nation that has the best cycle time to capture the very best commercially available technologies, incorporate them in weapons systems, and get them fielded first. … Open systems help prevent ourselves from being locked into proprietary technology and outdated systems. … Open systems specifications and standards promote standard interfaces and promote interoperability with our friends and allies, and enable access to the commercial marketplace, and to lower cost, rapid technology insertion. … These are some of the reasons why an OSA makes sense. It is also why the Department's senior leadership is thoroughly committed to the OSA."*

APPENDIX A.1

THE OPEN SYSTEM APPROACH TO WEAPONS SYSTEM DESIGN

Why Open Systems?

An open system approach is designed to facilitate the use of widely accepted, standard products—from multiple suppliers—in DoD weapons systems. In addition, if the architecture is defined by specifications and standards used in the private sector, the DoD can be one of many customers and leverage the benefits of the commercial marketplace, taking advantage of the competitive pressures which motivate commercial companies to reduce prices and introduce new products developed with internal resources. The open system approach can have a profound effect on the life-cycle cost of a system. Program managers can have access to alternative sources for the key subsystems and components to construct DoD systems. DoD investment early in the life-cycle is reduced since at least some of the required subsystems or components are likely to already be available, or being developed without direct DoD investment. Production sources can be competitively selected from multiple competitors. The system design flexibility inherent in the open system approach, and the more widespread availability of conforming commercial products, mitigates potential problems associated with a diminishing defense-dependent manufacturing base. Finally, life-cycle costs are reduced by a long-lived, standards based architecture that facilitates upgrades by incremental technology insertion, rather than by large scale system redesign.

What Is The Open System Approach?

The open system approach is an *integrated* technical and business strategy that defines key interfaces for a system (or piece of equipment) being developed. Interfaces generally are best defined by formal consensus (adopted by recognized industry standards bodies) specifications and standards. However, commonly accepted (de facto) specifications and standards (both company proprietary and non-proprietary) are also acceptable if they facilitate utilization of multiple suppliers. The use of de facto specifications and standards takes advantage of the fact that firms, particularly those in the commercial arena, frequently develop hardware, software and systems standards for the design and fabrication of computing, telecommunications, display, sensing, and signal processing systems. Whether interfaces are described by consensus or de facto standards, the benefits only accrue if products from multiple sources are economically possible. Although the most common emphasis is on electronic systems, the open system approach is widely applicable, from fasteners and light bulbs to jet engines.

An effective open system architecture will rely on physical modularity and functional partitioning of both hardware and software. Physical modularity and functional partitioning should be aligned to facilitate the replacement of specific subsystems and components without impacting others. The subsystems and components described by the system design should be consistent with the system repairable level. Subsystems and components below the repairable level will normally not be under government configuration control. Therefore, repairs below the repairable level, if required, will be by the supplier. If the hardware and software is effectively partitioned, processing hardware can be replaced with new technology without modifying application software. Additionally, application software can be modified without necessitating hardware changes.

Applying the Open System Approach to Weapons Systems Acquisition

The system architecture should be addressed early in a program to maximize the number of potential solutions, and thereby help reduce program cost. By developing the architecture early in a program, the specific technology used in its implementation can then be chosen as late as possible.

Open system interfaces must be managed more rigorously than in previous practice. An interface specification or standard is inherently a performance standard, is used as such by industry, and must be recognized as such in DoD. System partitions must not violate the interface, unilaterally extend it, or define it so that it is no longer compliant with the standard. At the start of production the open system requirements are published, thus identifying the market opportunities for suppliers.

The open system approach facilitates the use of lower cost, high performance weapons system subsystems and components, mostly built to commercial specifications and standards. The open system approach does not imply that only consumer grade products should be used. However, some commercial environments are as demanding as military environments, and commercial products that function in these environments will also function in the military environment. *In any case, all open systems designs still must meet military requirements.*

The application of the open system approach to legacy systems is less obvious but still beneficial. Legacy systems usually have size, space, power, cooling and shape factor constraints. For these systems, the open system approach can provide form-fit-function interface (F3I) solutions within existing packaging, power, and environmental constraints. In such cases the open system solution frequently requires less system resources by using newer, more efficient technologies. The open system approach is similar to F3I except that the open system approach emphasizes choosing interfaces that are broadly accepted in the marketplace to allow for as many suppliers as possible over the long term.

Conclusion

On November 29, 1994, Under Secretary of Defense Kaminski directed that the open system approach be used for the acquisition of the electronics in weapons systems. DoD Directives 5000.1 and 5000.2-R establish a consistent policy for all DoD systems acquisitions, including the mandate for open system approaches integrated with the other activities essential to the reformed acquisition process.

The open system approach is a new way of doing business, and an important part of Acquisition Reform. Beyond all that, however, *the open system approach is a smart way to do business*. Hard pressed to maintain the superiority of U.S. military systems within severe budget constraints, DoD program managers need the flexibility of open system to leverage the creativity and competitive pressures of the commercial marketplace. Program managers should ask this question of any proposed design solution: "*What provisions have been made to ensure that the widest range of suppliers will have the opportunity to offer their products throughout the program life cycle?*"

Additional information is available from the Internet World Wide Web at the Open Systems Joint Task Force home page (http://www.acq.osd.mil/osjtf/).

APPENDIX A.2

DETAILED IEWCS LIFE CYCLE COST ANALYSIS

Establishment of a System Development Basis

The estimation of an overall cost avoidance that could be realized in the IEWCS acquisition due to use of an OSA requires the establishment of a hypothetical alternative system to the IEWCS which did not utilize an OSA-based implementation but that provided equivalent technical performance. With the considerable assistance of the PEO IEW staff, such a comparable IEWCS-like SIGINT/EW system is hypothesized in the following analysis. This system would incorporate a straightforward contemporary technological extension of each of the six predecessor legacy systems to the IEWCS that in deployment would continue to utilize the same number of operator personnel and platform vehicles as the legacy systems. It is assumed that this IEWCS-like system would utilize an upgraded TACJAM system rather than the common module TACJAM-A subsystem of the IEWCS and an upgraded Communications High-Accuracy Advanced Location System (CHAALS) rather the common module CHALS-X subsystem of the IEWCS. This IEWCS-like SIGINT/EW system would also use a non-common module variation of the IEWCS's CMES.

It is further assumed that the existing platform configurations as used in legacy ground and air vehicles would be utilized and operationally deployed to field this IEWCS-like system as follows:

	Hypothetical SIGINT/EW System	Actual IEWCS System
Platform Configurations:	QUICKFIX	Advanced QUICKFIX
	TEAMMATE	GBCS-Light
	TEAMPACK	GBCS-Heavy
	TRAILBLAZER	
	TRAFFICJAM	
	TACJAM	
Production Units:	150 CMES	150 CMES
	138 CHAALS	138 CHALS-X
	198 TACJAM	138 TACJAM-A
Airborne Division Deployment:	54 operators	40 operators
	18 vehicles	8 vehicles
	3 airlift aircraft	4 airlift aircraft
Heavy Division Deployment:	96 operators	52 operators
	34 vehicles	12 vehicles
	3 airlift aircraft	4 airlift aircraft

Light Division Deployment:	30 operators	40 operators
	6 vehicles	8 vehicles
	3 airlift aircraft	4 airlift aircraft

This acquisition costs of this hypothetical IEWCS-like system and its assumed deployment are then used to develop a comparison with actual or anticipated IEWCS system costs to establish a potential cost avoidance during the research and development (R&D), production, and operations and support (O&S) phases of the system life cycle.

IEWCS R&D Cost Comparison

Component R&D Cost	Estimate for Hypothetical System	Actual IEWCS Experience
CHAALS/CHALS-X	$ 66.0 M	$ 66.0 M
CMES	54.3 M	7.0 M
TACJAM/TACJAM-A	195.0 M	165.0 M
Subsystems Integration (IEWCS only)	-	75.0 M
Platform Integration	81.7 M	49.0 M
Total R&D Costs:	$ 397.0 M	$ 362.0 M

Estimated R&D Cost Avoidance: $ 35.0 M

IEWCS Production Cost Comparison

Major System/Subsystem Production Component	Hypothetical System Unit Cost	Hypothetical System Total Cost	IEWCS System Unit Cost	IEWCS System Total Cost
CHAALS/CHALS-X	$ 1.30 M	$ 179.4 M	$ 0.60 M	$ 82.8 M
(+ Platform Integration)		12.5 M		16.3 M
CMES	2.32 M	347.4 M	0.90 M	135.0 M
TACJAM/TACJAM-A	2.40 M	475.2 M	1.80 M	248.4 M
Total Production Costs:		$ 1014.5 M		$ 482.5 M

Estimated Production Cost Avoidance: $ 532.0 M

IEWCS O&S Cost Avoidance

An estimate of the overall O&S cost avoidance can be obtained by differencing the annual O&S costs that would be incurred in mission deployment of the hypothetical IEWCS-like system and those anticipated IEWCS O&S costs as developed by the PEO IEW. These costs are based on standard SIGINT/EW mission platform deployments by Army field operational organizations. A 20 year system operational life is assumed for either system deployment in any organization.

Army Field Organization	Number of Field Organizations	Annual O&S Cost Avoidance per Org.	Estimated Annual O&S Cost Avoidance
Airborne/Air Assault Division	2	$ 1.04 M	$ 2.1 M
Armored/Mechanized Infantry Division	5	4.30 M	21.5 M
Heavy Armored Cavalry Regiment	2	(0.80 M)	(1.6 M)
Light Army Cavalry Regiment	1	(0.80 M)	(0.8 M)
Light Division	3	0.26 M	0.8 M
Separate Brigade	1	(0.2 M)	(0.2 M)

Estimated Overall Annual O&S Cost Avoidance: $ 21.8 M

Estimated Overall O&S Cost Avoidance Over a 20-Year System Life: $ 436.0 M

It is also noted that this O&S cost avoidance estimate does not take into account the corresponding cost reductions due to elimination of a variety of unique training, vehicles, maintenance facilities, etc., associated with overall O&S activities of the six predecessor legacy systems.

MEWSS-PIP Acquisition Cost Avoidance

As a "fourth mission configuration" of the IEWCS system and its three major subsystems, the MEWSS-PIP acquisition also provides an important component to the overall cost avoidance that can be associated with the OSA-based implementation of the IEWCS. As discussed in Chapter 6, there are two possible MEWSS-PIP acquisition scenarios that may be considered in development of a potential cost avoidance estimate. These hypothetical acquisition scenarios are for illustrative purposes only and do not represent actual USMC plans:

Scenario I: The USMC elects to pursue a new SIGINT/EW system development totally independent from the Army's IEWCS system using a traditional non-OSA technical architecture. A "bare-bones" development effort is undertaken using predecessor system technology wherever possible. An electronic support capability equivalent to the stated ESS requirements is also developed and incorporated within this system, thereby eliminating the need for separate ESS production and deployment. The resultant system is integrated into a legacy platform vehicle as opposed to a LAV platform. This overall system development will provide a technical and operational performance in the communications SIGINT/EW mission consistent with the USMC's stated requirements, but significantly less than that of the IEWCS.

Scenario II: As in the previous scenario, the USMC elects to develop a new SIGINT/EW system capability, but using the technical system development rationale followed by the Army's independent development of an OSA-based technical architecture. This approach is a distinct departure from predecessor USMC system acquisitions and will require an R&D investment comparable to that of the IEWCS. This system will also be integrated into a legacy platform vehicle. The resultant system's technical capability and operational performance is exactly comparable to that of the IEWCS, and will have a comparable production cost. Again, this system's overall capability and operational performance eliminates the need for any ESS.

It is assumed that the acquisition cost difference between the two scenarios occurs only in the R&D phase wherein significantly different system development costs are incurred. In both the production and O&S phases under either scenario, it is assumed that the overall costs for the hypothetical system will be the same as those anticipated for the actual MEWSS-PIP, without any cost avoidance. However, due to the elimination of the ESS, there will be a production cost avoidance of $7.6 M per each of the 12 ESS platforms and an associated annual O&S cost avoidance.

It is further assumed that under either scenario 12 MEWSS-PIP platform units will be acquired, and that the acquisition of 12 ESS units was avoided. Again, a 20 year system operational life is assumed. The following cost avoidance estimates were developed with the assistance of the MEWSS Program Office staff at the USMC Systems Command, Quantico, VA:

System Life Cycle Phase		Estimated Cost Avoidance: Scenario I	Estimated Cost Avoidance: Scenario II
R&D Phase:	SIGINT/EW System Development	$ 15.0 M	$ 362.0 M
	ESS Development	15.0 M	-
	Actual MEWSS Platform Integration	(12.5 M)	(12.5 M)
	Total Cost Avoidance:	$ 17.5 M	$ 349.5 M
Production Phase:	$7.6 M per ESS X 12 ESS units	$ 91.2 M	$ 91.2 M
	Total Cost Avoidance:	$ 91.2 M	$ 91.2 M
O&S Phase:	$35K annual per ESS vehicle X 12 ESS vehicles X 20 years	$ 8.4 M	$ 8.4 M
	$33K annual per operator X 4 operators per ESS vehicle X 12 vehicles X 20 year	31.7 M	31.7 M
	Total Cost Avoidance:	$ 40.1 M	$ 40.1 M
Overall Estimated Life Cycle Cost Avoidance:		$ 148.8 M	$ 480.8 M

APPENDIX A.3

POINTS OF CONTACT FOR FURTHER INFORMATION

The following points of contact concerning the IEWCS system and open systems acquisition processes are provided to the reader desiring to pursue additional information concerning this Case Study:

- Open Systems Joint Task Force, 2001 N. Beauregard Street, Arlington, VA 22311
  Mr. H. Leonard Burke, Director, (703) 578-6568
  COL Mick Hanratty, Deputy Director, (703) 578-6590
  http://www.acq.osd.mil/osjtf
- Project Manager Signals Warfare, Vint Hill Farms Station, Warrenton, VA 22186
  Mr. William Hayden, IEWCS Project Manager, (540) 349-7068
- Program Executive Office, Intelligence and Electronic Warfare, Fort Monmouth, NJ 07703-5301
  Mr. Eddie Bair, Deputy PEO IEW, (908) 532-0179
  Mr. Mike Ryan, (908) 532-6859
- Program Executive Office, Command, Control, Communications and Intelligence Systems, Fort Monmouth, NJ 07703-5301
  MG William H. Campbell, PEO C3 Systems, (908) 427-4937
- Marine Corps Systems Command, Signals Intelligence and Electronic Warfare Program Office, Quantico, VA 22134-5010
  MAJ Mike Groen, USMC, MEWSS Project Manager, (703) 784-2044, x7223.

APPENDIX A.4

REFERENCES

The following reports, briefings, and related material are suggested to the reader desiring further information concerning the IEWCS system and open systems acquisition processes:

- Allan R. Olson, "Intelligence and Electronic Warfare Common Sensor (IEWCS): A Case Study in Open Systems Acquisition," Project Manager Signals Warfare, Vint Hill Farms Station, Warrenton, VA 22186, 27 January 1996.
- COL Thomas L. Vollrath (ret.), "Open Systems Case Study: IEWCS," presented at the OSD Open Systems Workshop, Defense Systems Management College, Fort Belvoir, VA, 12 June 1996 [available on the OSJTF Home Page on the World Wide Web at http://www.acq.osd.mil/osjtf/agenda.html/.]
- COL Melvin Heritage, "Open Architecture at Work," Project Manager Signals Warfare, Vint Hill Farms Station, Warrenton, VA, undated briefing.
- J. M. Browne, M.C. Johnson, R.C. Masline, and J.C. Van Nada, "IEW 1989 Software and Hardware Standard Module Studies Revisited," Technical Report JPL D-8980, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 30 September 1991.
- "Milestone IV Documentation Package for the TRAILBLAZER, TEAMMATE, QUICKFIX, TEAMPACK, TACJAM, and TRAFFICJAM Systems," Project Manager Signals Warfare, Vint Hill Farms Station, Warrenton, VA, in two Volumes with Appendices, 7 April 1993.
- Under Secretary of Defense (Acquisition and Technology), "Acquisition of Weapons Systems Electronics Using Open Systems Specifications and Standards," Department of Defense, Washington, DC, memorandum dated 29 November 1994.

APPENDIX A.5

LIST OF ACRONYMS

API	Applications Program Interface
AQF	Advanced QUICKFIX
ARL	Airborne Reconnaissance Low
C2V	Command and Control Vehicle
C3I	Command, Control, Communications, and Intelligence
CEWI	Communications, Electronic Warfare, and Intelligence
CHAALS	Communications High-Accuracy Advanced Location System
CHALS-X	Communications High-Accuracy Location System Exploitable
CHALS-X(M)	CHALS-X Modular
CI	Commercial Item
CMES	Common Modular Electronic Intelligence System
COMINT	Communications Intelligence
DF	Direction Finding
DoD	Department of Defense
ECM	Electronic Counter-Measures
EDM	Engineering Development Module
EFVS	Electronic Fighting Vehicle System
ELINT	Electronics Intelligence
E&MD	Engineering and Manufacturing Development
ESM	Electronic Support Measures
ESS	Electronic Support System
EW	Electronic Warfare
F3I	Form-Fit-Function Interface
GBCS	Ground Based Common Sensor
GBCS-H	GBCS Heavy
GBCS-L	GBCS Light
GR/CS	Guard Rail Common Sensor
HF	High Frequency
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HTI	Horizontal Technology Integration
IEW	Intelligence and Electronic Warfare
IEWCS	IEW Common Sensor
JPL	Jet Propulsion Laboratory
LAV	Light Armored Vehicle
MAGTF	Marine Air Ground Task Force
MEWSS	Mobile Electronic Warfare Support System
MEWSS-PIP	MEWSS Product Improvement Program
NDI	Non-Developmental Item
ONS	Operational Needs Statement

O&S	Operations and Support
OS	Open Systems
OSA	Open Systems Approach
OSI	Open Systems Interconnect
OS-JTF	Open Systems Joint Task Force
PEO	Program Executive Office
PM	Program Manager
POSIX	Portable Operating System Interface
R&D	Research and Development
SEM-E	Standard Electronic Module - Enhanced
SHF	Super High Frequency
SIGINT	Signals Intelligence
TACJAM	Tactical Jammer
TACJAM-A	TACJAM Advanced System
TT/UT	Technical Testing/User Testing
UHF	Ultra High Frequency
USA	United States Army
USAF	United States Air Force
USMC	United States Marine Corps
VHF	Very High Frequency
VME	Versa Module Eurocard