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A comparison of the Joint Maritime Command Information System (JMCIS) capabilities with the U.S. Marine Corps (U.S.M.C.) Advanced Tactical Air Command Center (ATACC) data link requirements

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THESIS

A COMPARISON OF THE JOINT MARITIME COMMAND INFORMATION SYSTEM (JMCIS) CAPABILITIES WITH THE UNITED STATES MARINE CORPS (USMC) ADVANCED TACTICAL AIR COMMAND CENTER (ATACC) DATA LINK REQUIREMENTS

by

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September, 1994

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This thesis is a comparison of the capabilities currently available in the Joint Maritime Command Information System (JMCIS) to the data link requirements of the United States Marine Corps (USMC) Advanced Tactical Air command Center (ATACC). The evolution of the JMCIS system and its underlying software design philosophy is discussed as well as the operational and financial advantages of this philosophy The comparison of the ATACC requirements and the JMCIS capabilities is done using the Simple Multi-Attribute Rating technique (SMART). The SMART technique assigns weight values to the ATACC requirements and calculates an overall comparison figure for JMCIS. The weight values were calculated from survey data. Survey subjects provided their perception to the relative mission criticality of the ATACC requirements. The subjects for the evaluation were U.S. Marine Corps Officers with air command and control experience, and the evaluations were elicited using the Criterion DecisionPlus™ software package. The comparison figure for JMCIS averaged across the survey subjects was 68%. The weighting factors and the model of the requirements revealed the shortfalls of the JMCIS system in the area of data link maintenance functionality.

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A Comparison of the Joint Maritime Command Information System (JMCIS) Capabilities with United States Marine Corps (USMC) Advanced Tactical Air Command Center (ATACC) Data Link Requirements

by

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ABSTRACT

This thesis is a comparison of the capabilities currently available in the Joint Maritime Command Information System (JMCIS) to the data link requirements of the United States Marine Corps (USMC) Advanced Tactical Air Command Center (ATACC). The evolution of JMCIS and its underlying software design philosophy is discussed as well as the operational and financial advantages of this philosophy. The comparison of the ATACC requirements and the JMCIS capabilities is done using the Simple Multi-Attribute Rating Technique (SMART). The SMART technique assigns weight values to the ATACC requirements and calculates an overall comparison figure for JMCIS. The weight values were calculated from survey data. Survey subjects provided their perception to the relative mission criticality of the ATACC requirements. The subjects for the evaluation were U.S. Marine Corps Officers with air command and control experience, and the evaluations were elicited using the Criterion DecisionPlus™ software package. The comparison figure for JMCIS averaged across the survey subjects was 68%. The weighting factors and the model of the requirements revealed the shortfalls of the JMCIS system in the area of data link maintenance functionality.

TABLE OF CONTENTS

I. INTRODUCTION

The system design philosophy behind the Joint Maritime Command Information system (JMCIS) is a revolutionary advancement in the development of command and control systems. JMCIS provides the opportunity for significant improvements in operational capability, data interoperability, and human engineering with a substantial cost reduction. All these good things can come about through designing systems with the JMCIS philosophy and migrating current systems to this architecture. Yet it takes knowledge of JMCIS and the proposed migration system to bring these improvements to fruition. The information presented in this thesis can be used as a part of that knowledge to unlock the benefits of JMCIS.

This thesis conducts a comparison between the capabilities currently available in the JMCIS system and the data link requirements of the Advanced Tactical Air Command Center (ATACC). The comparison method yields a numerical correlation figure representing the extent to which JMCIS meets the ATACC requirements and identifies the marginal returns that would be gained by adding further functionality to JMCIS.

A. SCOPE OF THESIS

This thesis is a comparison of the capabilities currently available in the JMCIS to the data link requirements of the United States Marine Corps (USMC) Advanced Tactical Air Command Center (ATACC). The comparison is done using the Simple Multi-Attribute Rating Technique (SMART) as it is implemented in the software package Criterion

DecisionPlus™. The comparison of requirements to capabilities is weighted for relative importance of the requirements. This relative importance is derived from survey data collected from subjects that evaluated the importance of the requirements. The subjects for the importance evaluation were U. S. Marine Corps Officers with air command and control experience, and the evaluations were elicited using Criterion DecisionPlus™ software package.

The origins of the JMCIS system and the Department of Defense policies that have shaped this software architecture are discussed to give the reader an appreciation for the development of JMCIS. Discussions of the benefits and current uses for the system are included in the thesis.

B. THESIS ORGANIZATION

1. Chapter II Introduction to ATACC

In order to understand the structure of the comparison a knowledge of the Marine Corps Tactical Air Command Center's mission and organization is required. Chapter II defines the TACC's mission and gives the reader enough information about the staffing and functioning of the TACC in order to gain an appreciation for the use of the data link systems. The chapter explains the current configuration of the TACC with the AN/TYQ-1 equipment and also details the changes and improvements coming with the fielding of the Advanced Tactical Air Command Center (ATACC) with the AN/TYQ-51 equipment. For readers familiar with the TACC and the Marine Air Command and Control System (MACCS) this is review material.

a. Appendix (A) Tactical Digital Information Links

Appendix A is supplemental data of definitions and technical characteristics of the different types of Tactical Digital Information Links available to the TACC. This data provides further clarification to the Tactical Digital Information Links introduced in Chapter II.

2. Chapter III JMCIS

JMCIS provides the alternative data link capabilities that are evaluated in this thesis. Chapter III describes both the fielded JMCIS command and control system as well as the JMCIS philosophy. This chapter details the development of JMCIS and provides an explanation of the underlying software design philosophy for the readers unfamiliar with JMCIS. The evolution of the philosophy, and the command and control system, are traced through the developments and changes in Department of Defense policy. The lineage of the JMCIS system is traced back through the command and control systems from which it evolved and a projection of the evolution of JMCIS in the future is given.[1]

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1 Chapter III is the product of a collaborative effort between researchers working on related JMCIS projects. Primary contributors include Lt. B. F. Loveless, USN., Lt. M. T. Weatherford, USN., and the author.

3. Chapter IV the ATACC Requirements

The first step in comparing the ATACC data link requirements to the JMCIS capabilities is to have a full understanding of the specified ATACC requirements. The system requirements for the ATACC were found in ELEX-T-620A dated 27 July 1990, and the contract modification to that document, P00068, dated 19 November 1992. This document became the source of the specific requirements that comprised the evaluation criteria for the JMCIS system. Chapter IV discusses the meaning of the specific requirements as well as the structuring of the requirements in the decision tree. The chapter identifies the meaning of the different requirement categories and the different levels within the decision tree.

4. Chapter V the Comparison Method

Chapter V provides an explanation for the selection of the Simple Multi-Attribute Rating Technique (SMART) as the method for rating the system and details how that technique is implemented in the software package Criterium DecisionPlus™. The required steps in using SMART are discussed as well as their manifestation in DecisionPlus™. These described steps illustrate to the reader the method used in building the decision tree as well as its use in capturing survey data from the subjects. The chapter covers the organization of the decision tree, and the importance ranking procedures used to elicit data from the subjects.

a. Appendix (B) Simple Multi-Attribute Rating Technique (SMART)

Appendix B provides supplemental data for the background and the development of the SMART. This background information provides an understanding of SMART and illustrates why it was the appropriate technique for this comparison.

b. Appendix (C) Criterium DecisionPlus™

Appendix C provides details on how SMART is implemented in Criterium DecisionPlus™ and the operating characteristics of the program. This section also provides insight to the different user interfaces available in the software as well as other system capabilities.

5. Chapter VI Alternative Evaluation and Comparison Results

Chapter VI discusses the researcher's evaluation of the JMCIS system for implementation of low level functional requirements as well as the evaluation results. The chapter also clarifies calculations performed to arrive at a numerical score for the comparison of the JMCIS to the ATACC requirements. The methods and the tools used to perform the analysis are discussed, as well as problems encountered using DecisionPlus™.

a. Appendix (D) Supporting Data

Appendix D is supporting numerical data that was used in the calculation of the comparison figures. The data includes the initial rating data, calculated intermediate steps, and other calculations.

6. Chapter VII Conclusion

Chapter VII summarizes the findings of the analysis of the data and reveals the areas where JMCIS did and did not meet the requirements. Related issues not covered in this thesis and other developing questions are discussed as potential research topics.

II. INTRODUCTION TO TACC AND ATACC

The command center from where Marine Corps aviation assets are led and implemented is the Tactical Air Command Center (TACC). This chapter discusses the organization, mission, and equipment of the TACC. The capabilities of the current AN/TYQ-1 equipment is discussed as well as the improvements gained with the new AN/TYQ-51, or Advanced TACC (ATACC) equipment.2

A. THE TACTICAL AIR COMMAND CENTER (TACC)

1. Definition

The TACC is the senior Marine Air Command and Control System (MACCS) agency. The TACC is the one MACCS agency which exercises command and it serves as the operational command post (CP) for the Aviation Combat Element (ACE) commander. The TACC provides the facility from which the ACE commander and his battlestaff plan, supervise, coordinate and execute all current and future Marine Air Ground Taskforce (MAGTF) air operations. The TACC is operated and maintained by the ACE staff, personnel from the Marine Tactical Air Command Squadron (MTACS), and the staff of the Marine Air Control Group (MACG). Liaison personnel from other Services may be required in the TACC for coordination of joint and combined operations. The Marine

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2 Major portions of this chapter are paraphrased from FMFM 5-60 (Control of Aircraft and Missiles), FMFM 5-5 (AntiAir Warfare) and selected Marine Corps Tactical Systems Support Activity (MCTSSA) information packages.

Corps Tactical Air Command Center (TACC) is sometimes called the Marine TACC to avoid confusion with the Navy Tactical Air Control Center (TACC). [Ref. 1:p.3-1]

2. TACC Organization

The ACE commander directs and controls current and future operations from the TACC. Organic agencies of the MACG, support groups, and aircraft groups assist and implement the guidance of the TACC as well as non-organic agencies. Some of these agencies are :

- The Tactical Air Operations Center (TAOC) from the Marine Air Control Squadron (MACS)
- The Direct Air Support Center (DASC) from the Marine Air Support Squadron (MASS)
- Marine Air Traffic Control Squadron (MATCS) detachments
- Stinger firing units from Low Altitude Air Defense (LAAD) Battalion
- Hawk firing units from Light Anti-Aircraft Missile (LAAM) Battalion
- Liaison officers from other Services or nations.
- Liaison officers from aircraft and support groups.
- The Tactical Air Control Parties (TACP) organic to the Ground Combat Element (GCE).
- Airborne controllers / coordinators , Airborne Supporting Arms Coordinator (SAC[A]), Airborne Tactical Air Coordinator (TAC[A]), Forward Air Controller Airborne (FAC[A]) [Ref. 1:p. 3-1]

To facilitate this implementation of the ACE commander's direction and control of air operations the TACC is divided into two sections, Future Operations and Current Operations.

a. Future Operations

The term Future Operations refers to those activities directed against an enemy for which detailed planning must be accomplished and resources allocated. The

Future Operations Section (FOS) of the TACC accomplishes this detailed planning and allocation. Personnel in the FOS build the next Air Tasking Order (ATO) using preplanned requests and planing and coordination information coordinated with, and received from, the ACE HQ staff. The ATO is the document that apportions and allocates the MAGTF aviation assets to specific missions. Future Operations personnel focus on detailed planning and resource allocation for ACE support of the MAGTF for future deep, close and rear operations. [Ref. 1:p. 3-2]

b. Current Operations

The term Current Operations refers to those activities directed against an enemy for which planning has been previously completed and resources committed. This is normally considered from the present time through the next 24 hours. These Current Operations include on-going operations such as deep, close and rear operations by the ACE in support of the MAGTF. Current Operations personnel execute the current Air Tasking Order (ATO). The ATO is a document that allocates the aviation resources to specific missions to be conducted. To accomplish this, the Current Operations Section (COS) communicates with the Future Operations Section (FOS) and other agencies to enable the direction and control of current operations. [Ref. 1:p. 3-1]

3. TACC Tasks

The role of the TACC is to function as the senior MAGTF air command and control agency, and to serve as the operational CP for the ACE commander. From the TACC, the battlestaff can supervise, direct, control, and coordinate the ACE's support of the MAGTF's Current Operations and develop detailed plans for Future Operations. From the TACC, the ACE commander can plan and prosecute air operations to support the MAGTF commander 's deep operations to isolate and prepare the battlefield. Also from the TACC, the ACE commander can plan and prosecute air operations as the MAGTF's main effort or to support close and rear operations. [Ref. 1:p. 3-2]

The tasks necessary to accomplish the role described above are many but can generally be described as maintaining situation awareness and providing tasking to subordinate agencies. While command is centralized for planning within the ACE HQ and the TACC, control is decentralized to subordinate MACCS agencies for specific aviation functions. Examples of this decentralization include the DASC's control of OAS (Offensive Air Support) and the TAOC's control of AAW (Anti Air Warfare) activities.

4. Equipment Capabilities

In order to accomplish the necessary tasks to fulfill the TACC's roles, the Future Operations Section and the Current Operations Section require certain equipment. These equipment requirements can be categorized as either communication or display equipment.

a. Communications

(1) Voice

The TACC has multiple voice communication circuits. A typical TACC configuration to support a Marine Expeditionary Force (MEF) might include (18) ultra high frequency (UHF), (6) very high frequency (VHF), (18) high frequency (HF), and (20) multi-channel radio (MUX) circuits.

(2) Data

The TACC has the capability of communications over several Tactical ʔ Information Link (TADIL) formats. These formats include TADIL-A, TADIL-B, anʟ ɔrth Atlantic Treaty Organization (NATO) Link-1. Joint Tactical Information Distribution System (JTIDS) or TADIL-J will be part of the system in the future. [Ref. 1:p. 3-5]

A TADIL provides the means for the electronic transmission of specifically coded messages or commands from one agency to another and enables agencies to see information being provided by another's sensor. Tactical data exchange with other services is established on a mission or situation dictated basis. [Ref. 1:p. 10-5]

Technical details and specifications of the different types of digital data links is contained in Appendix A. The TACC and the MACCS are normally connected with other services and agencies in the following manor:

- TADIL-A with NATO and the Air Force Airborne Warning and Control Squadron (AWACS) or Tactical Air Control Squadron (TACS).
- TADIL-A with the Navy ,Navy Tactical Data Systems / Airborne Tactical Data Systems (NTDS/ATDS).
- TADIL-B with the Air Force (TACS).
- TADIL-B with the Army , Army Air Defense Command Post (AADCP).
- TADIL-C with appropriately equipped USMC/U.S. Navy (USN) aircraft (TAOC only).
- NATO LINK-1 with NATO air control agencies.
- ATDL-1 (Army Tactical Data Link) with Hawk units (TAOC only).

Figure 2-1 is an example of the typical data link connectivity emanating from a TACC. [Ref. 1:p. 10-6, Figure 10-2] With the capability to operate on different types of links and multiple data links at the same time, this figure represents only one possible connectivity diagram. The different types of links all have different strong points and weak points, thus units that can operate on a variety of links are more robustness and offer different options for connectivity or connectivity reconfiguration.

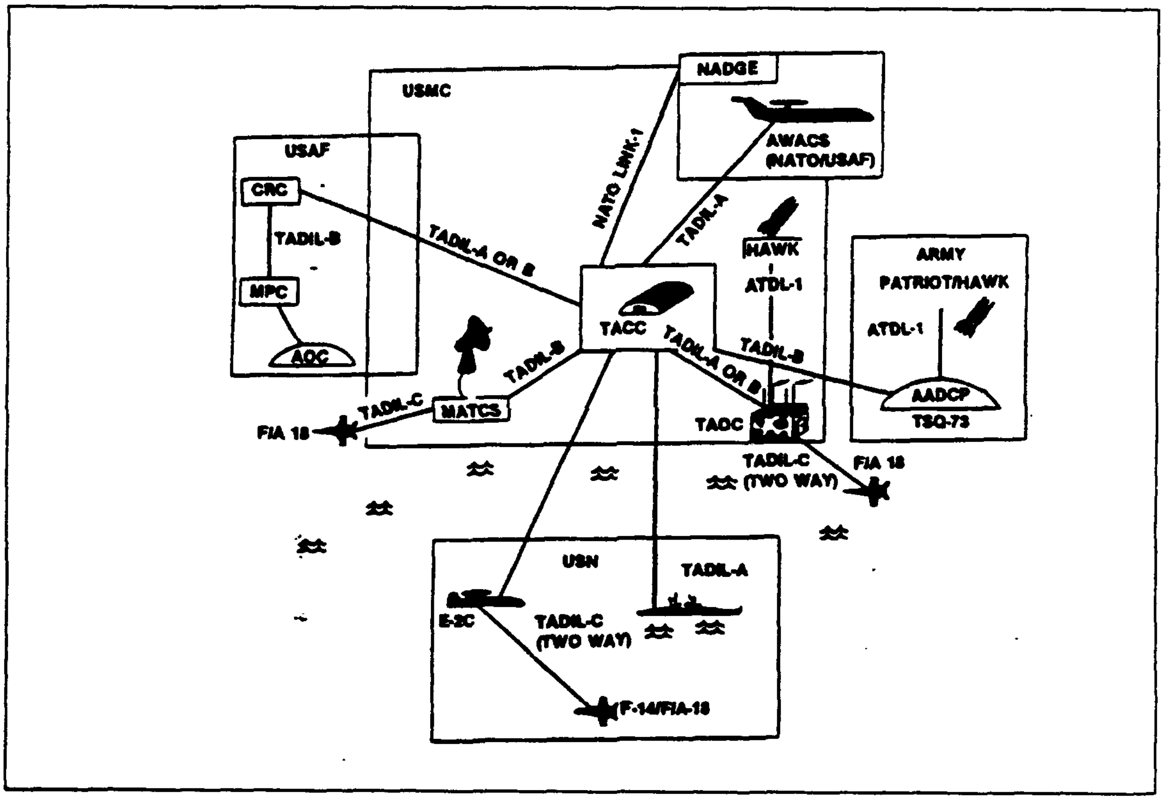

Figure 2-1 Typical TACC Data Link Configuration

b. Displays

The TACC displays selected information necessary for coordination and supervision of MAGTF air activity. To provide this display capability the TACC uses manual status boards and electronic displays. [Ref. 1:p. 3-5]

Manual status boards are used to display data of a stable nature such as weather, communication status, aircraft availability, and ATO flight information.

The electronic displays of the TACC have the capability to display selected air operations on a near-real-time basis in both graphical and tabular form. Data displayed includes air track information, weapon status, and map information.. Symbols representing aircraft, agencies, and geographic subdivisions are displayed to present a general picture of the air situation in the area of responsibility (AOR). These symbols or tracks are received from external radar surveillance agencies and command, control , communication, and intelligence (C3I) facilities for near-real-time information. [Ref. 1:p 3-5]

5. Relationships

There is a coordinated relationship between the Navy TACC and the Marine TACC in order to conduct joint force operations. This relationship and the importance of information relayed via the Tactical Digital Information Links is described in FMFM 5-5, AntiAir Warfare as follows:

> The (Navy) tactical air control center is the primary air control agency for the Commander Amphibious Task Force (CATF) from which all AAW (AntiAir Warfare) means are controlled during the task force's movement to, and arrival at, the AOA (Amphibious Objective Area). Command relationships during the phasing of air control ashore AAW vary with the tactical situation. When the MACCS (Marine Air Command and Control System) is established ashore, a tactical digital information link (TADIL A)/Link 11 data link is established between MACCS AAW agencies and the tactical air control center afloat. Then, at a time mutually established by CATF and Commander Landing Force (CLF), control of AAW function is passed ashore. The CLF exercises overall control through his tactical command center. At this time, the Tactical Air Control Center (afloat) reverts to a Tactical Air Direction Center and functions in a monitoring capacity ready to resume control if required. [Ref. 2: CD version]

B. ADVANCED TACTICAL AIR COMMAND CENTER (ATACC)

1. Definition

The Advanced Tactical Air Command Central (ATACC)(AN/TYQ-51) is designed to replace the current Tactical Air Command Central Suite of equipment (AN/TYQ-1 and AN/TYQ-3A). The ATACC will provide a facility from which the Tactical Air Commander (TAC) and the Aviation Combat Element (ACE) battlestaff can supervise, coordinate and execute current and future tactical air operations over the Marine Air Ground Task Force's (MAGTF) airspace. Like the currently fielded AN/TYQ-1, the ATACC will be operated by the TAC, his staff, and designated personnel from the Marine Air Control Group (MACG). The ATACC is designed to support both the functions of the TACC's Current Operations Section and the Future Operations Section. The personnel within the Current Operations Section focus on the current battle and deal particularly with a situation display, communications to other Marine and joint command and control agencies, and electronic status boards. The Future Operations Section is focused on planning for the future battle in 48-72 hours and produces the Air Tasking Order (ATO). These are the same functions done with the AN/TYQ-1 equipment however the ATACC was designed to provide the planner with automated planning tools and the ability to electronically generate, disseminate and receive the Air Tasking Order (ATO). [Ref. 3: p. 1]

2. Status

The ATACC provides significant operational and logistic enhancements over the AN/TYQ-1 equipment. It consists of two identical suites of equipment housed in shelters that measure 8 feet by 8 feet by 20 feet. Each suite is equipped with operator workstations, desktop communication units, a large screen display, radios, and other equipment necessary to perform aviation battle staff functions. This reduced logistical footprint enhances the capability to tactically reposition the equipment to meet changing missions and improve survivability. The importance of this maneuverability is echoed in FMFM 5-60, Control of Aircraft and Missiles, and in the Marine Corps Master Plan (MCMP) dated 21 July 1993. In these documents the requirement was identified for automated command and control (C2) systems with joint interoperability and connectivity to be of modular design and to be transportable by tactical vehicles. The most recent version of the Operational Requirements Document (ORD) specifies many of the desired improvements over the previous system. The improvements generally fall into the categories of logistical improvements, increased communication ability, and automation to support the generation and dissemination of the Air Tasking Order (ATO). The ORD document identifies phases of development where the ATACC will evolve with increased capability over the different phases. [Ref. 4:p. 1-34]

Phase one of the ATACC is scheduled for delivery in 1996 and it will consist of a Grumman Data System module for the Current Operations Section and a suite of

CTAPS (Contingency Tactical Air Control System Automatic Planning System)3 terminals for the Future Operations Section. Phase two of the ATACC fielding plan is scheduled for the year 2000, and will involve fielding a system that integrates both of the functionalities into one console. [Ref. 5]

3 CTAPS is a United States Air Force command and control system that has become the default format for processing and disseminating Air Tasking Orders in joint operations.

III. JOINT MARITIME COMMAND INFORMATION SYSTEM (JMCIS)

To understand the concept and the philosophy of JMCIS, the external evolutionary and developmental factors must first be examined. Changes in government and Department of Defense (DoD) information management policy and the complexion of the command and control systems absorbed under the JMCIS umbrella are the two defining elements in the evolution of JMCIS. 4

A. POLICY

The policies that have had the most significant impact in shaping the evolution of JMCIS are DoD's Corporate Information Management (CIM), The Joint Staff's "C4I for the Warrior", and the Navy's Copernicus architecture programs. These policies have contributed to the development of JMCIS by directing the evolution of the command and control environment from which it evolved.

1. DoD's Corporate Information Management (CIM)

Defense Management Review Decision (DMRD) 918 provided the initial direction of the Corporate Information Management (CIM) initiative administered by the Defense Information Systems Agency (DISA). CIM is a strategic management initiative intended to guide the evolution of the DoD enterprise by capturing the benefits of the information revolution. It emphasizes both a functional and technical management focus

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4 Chapter III is the product of a collaborative effort between researchers working on related JMCIS projects. Primary contributors include Lt. B. F. Loveless, USN., Lt. M. T. Weatherford, USN., and the author.

to achieve a combination of improved business processes and effective application of information technology across the functional areas of DoD. It is embodied in policies and programs, implementation guidance, and supporting resources, to help functional managers guide and implement changes to processes, data, and systems across the DoD. [Ref. 6:p. 1]

The management structure of CIM has four "pillars" that support improved Defense capabilities: common information systems; shared, standard data; re-engineered processes; and a computer and communications infrastructure. The overarching goal of CIM is to enable commanders of military forces and managers of support activities to achieve the highest degree of capability in their operations through the effective use of information applied in improved functional processes. The vision of this initiative provides for global end-to-end information connectivity among U.S. and allied forces. In this context, information is considered a critical mission capability and force multiplier for worldwide readiness, mobility, responsiveness, and operations. Joint interoperability and information integration on the battlefield is emphasized to result in significantly improved joint service and multinational operations. [Ref. 6:p. 3]

2. The Joint Staff's "C4I for the Warrior"

C4I for the Warrior is a concept for DoD information management first published by The Joint Staff in 1992. It is clearly targeted at solving the C4I interoperability issues among the services. The intent is to provide an unifying C4I concept that will support the requirements of the joint force Warrior at the battlefield level, while remaining consistent with DoD policy and national security objectives. This focus is expressed by former Chairman, General Colin L. Powell, in the following statement:

> The C4I for the Warrior concept will give the battlefield commander access to all information needed to win in war and will provide the information when, where, and how the commander wants it. The C4I for the Warrior concept starts with the Warrior's requirements and provides a roadmap to reach the objective of a seamless, secure, interoperable global C4I network for the Warrior. [Ref. 7:p. 13]

C4I for the Warrior is considered a seminal doctrine that is intended to guide the evolution of individual service C4I architectures into a broad Global Command and Control System (GCCS). [Ref. 8:p. 49] The concept principles have been incorporated in the Joint Staff's GCCS program.

At the center of the C4I for the Warrior concept is the establishment of a global C4I capability that allows the Warrior to define the battlespace and to "plug in" and "pull" timely, relevant information anytime, anyplace in the performance of any mission. The Warrior, by defining the battlespace, determines the information to "pull" rather than have information "pushed" from various sources. The Warriors neither want nor need the cumulative knowledge of multiple sources dumped into their battlespace information systems. They want only the specific information they need to win the fight; and they want it when they need it, where they need it, and in the form in which it will do them the most good. This demand pull concept provides the capability for the Warrior to poll the global C4I network for any desired information from any location, at any point in time.

This is a key principle of the C4I for the Warrior concept and a guiding concept for future DoD and Navy C4I architecture development.

3. The Navy's Copernicus Architecture

The Copernicus Architecture is the current architectural guidance designed to restructure all Navy C4I systems. The Copernicus Architecture, Phase 1: Requirements Definition, published in 1991, provides both a new C4I architecture to replace the current Navy system and a programmatic investment strategy to construct it over the next decade. [Ref. 9:p. 3-2] It is intended to establish a vision of an overall C4I architecture for the Navy.

The Copernicus Architecture is primarily a telecommunications system designed around a series of global information exchange systems ashore and tactical information exchange systems afloat. The architecture concept is based on four pillars: first, virtual global networks called Global Information Exchange Systems (GLOBIXS); second, metropolitan area networks called CINC Command Centers (CCC); third, tactical virtual nets called Tactical Data Information Exchange Systems (TADIXS); and fourth, interconnecting the previous systems to support the Tactical Command Center (TCC) afloat. In this concept, data can be forwarded from the shore based sensor-to-sensor infrastructure to the tactical commander's C2 infrastructure afloat. Just as Copernicus brought about a revolutionary paradigm shift in astronomy, the Copernicus Architecture was so named because it represents a revolutionary paradigm shift in command and control systems by being centered on the tactical needs of the operator afloat. [Ref. 10:p 10-12]

A key operational concept of the Copernicus Architecture is the recognition of the Space and Electronic Warfare Commander (SEWC) as part of the Composite Warfare Commander (CWC) doctrine afloat. This action follows the establishment of SEW as a designated warfare area within the Navy by the CNO in 1989, which doctrinally assigned command and control (C2) functions to the SEW mission. In many ways, this early recognition of the importance of information management for the operational commander served as a building block for further DoD architecture development. The Copernicus goal of establishing a "common operating environment" now is considered part of the Defense Department's "C4I for the Warrior" initiative, which requires the Army, Navy, and Air Force to develop, through a phased process, approaches to making their C4I data-transfer systems fully compatible for joint operations. [Ref. 8:p. 52]

B. SYSTEMS

JMCIS is an umbrella system that has incorporated various functionalities and attributes of previous command and control systems. The philosophy of incorporating other systems capabilities and functionality is not unique to JMCIS, rather it is a trait inherited from previous systems. The Joint Operational Tactical System (JOTS), Navy Tactical Command System - Afloat (NTCS-A), and Operations Support System (OSS) are examples of systems that applied this same evolutionary methodology and directly influenced the development of JMCIS.

1. Joint Operational Tactical System (JOTS)

JOTS began as a prototyping effort that was first deployed aboard ship in the early 1980s. This system provided the operational commander with the first integrated display of data for decision support purposes. System functionality eventually included track management, track analysis, environment prediction, and a variety of tactical overlays and Tactical Decision Aids (TDAs). JOTS was capable of receiving various data and message input such as Link 11, Link 14, Tactical Data Information Exchange System-A (TADIXS A), Officer in Tactical Command Information Exchange System (OTCIXS), High Interest Track (HIT) Broadcasts, and U.S. Message Text Format (USMTF) messages. JOTS allowed the Fleet Command Centers to interface with command ships and other shore installations. Through the use of a tactical data base manager (TDBM), JOTS provided a consistent tactical battlespace picture for all supporting warfare commanders afloat and ashore. [Ref. 10:p. 60]

The original prototyping effort of JOTS lead to the development of the JOTS Command and Control System by the late 1980s. The primary goal of the JOTS was to integrate information systems onto common hardware and software platforms to provide for the sharing of data bases as well as maximize limited shipboard area. JOTS-derived systems have since been installed onboard over 200 Navy ships, at several U.S. Navy shore intelligence centers, onboard U.S. Coast Guard vessels, onboard allied ships, and a various allied sites. [Ref. 11:p. 1-1] As JOTS matured further and as other C3I systems were developed and deployed, it became apparent that there was much duplication of software and functionality across systems. This duplication led to increased development, maintenance, and training costs and the stated goal of interoperability across systems was virtually non-existent. This led to low interoperability and most importantly, led to conflicting information from multiple sources being provide to the operators. [Ref. 11:p. 1-1]

2. Navy Tactical Command System - Afloat (NTCS-A)

NTCS-A evolved from JOTS in the early 1990s, from the consolidation of a number of prototypes of individual "stovepipe" shipboard command and control software programs, including the Flag Data Display System (FDDS), the Joint Operations Tactical System (JOTS), the electronic Warfare Coordination Module (EWCM), and the Afloat Correlation System (ACS). [Ref. 8:p. 52] Additional NTCS-A functionality was incorporated from other stand-alone or prototype C4I systems such as the Prototype Ocean Surveillance Terminal (POST) and the Naval Intelligence Processing System (NIPS). Central to this consolidation effort was the abstraction of the afloat software into a common "core" set of software that could be used throughout the afloat community as the basis for their systems. This led to a set of common software originally called Government Off The Shelf (GOTS) version 1.1.

The common core software concept was extended to the shore community to reduce development costs and ensure interoperability. This effort resulted in a collection of software commonly referred to as the Unified Build (UB) version 2.0 or GOTS 2.0. This software is now deployed both afloat, in NTCS-A, and ashore, in Operations Support

System (OSS) or Navy Command and Control System-Ashore (NCCS-A). The strength of these two systems is that they are built on top of a common set of functions so that advancements and improvements in one area are immediately translatable to advancements in the other area. [Ref. 11:p. 1-1]

3. Operations Support System (OSS)

OSS is a system that evolved from the functionalities of the Navy World-Wide Military Command and Control System (WWMCCS) Standard Software, Operations Support Group Prototype, Fleet Command Center Battle Management Program, and JOTS. This system is considered the shore installation variant of NTCS-A and is often referred to as Navy Command and Control System-Ashore (NCCS-A). By migrating the OSS into the JMCIS architecture, the Navy is seeking management economies of scale and performance enhancements in OSS.

C. JMCIS

JMCIS represents the next logical step in the evolution of Navy C4I systems. The addition of functions to NTCS-A has led to the creation of a new version of that system, which has been designated the Joint Maritime Command Information System. [Ref. 8:p. 56] JMCIS is described as a "overarching architecture" that is still evolving as fleet operators refine C4I requirements and the functionality of other systems is migrated to the JMCIS architecture. The JMCIS approach to adding new functionality instead of building new systems allows the Navy to benefit from a single-configuration management approach. The system software provides the basic function, such as display control, message traffic control, and specific applications for various classes of ship equipped. [Ref. 8:p. 52] Programmatically, JMCIS has consolidated the functions of NTCS-A and its complimentary ashore program, the OSS. The two systems are expected to form a significant core of the ongoing development of DoD-wide C4I architectures, referred to as Global Command and Control System (GCCS), that will continue to consolidate the C4I initiatives of the individual services. [Ref. 8:p. 52]

1. Genesis and History

JMCIS is the current state of C4I technology initially envisioned in 1981 by Vice Admiral (Ret.) Jerry O. Tuttle as the future of command and control. The JMCIS idea was cultivated from efforts to evolve interoperable C3I systems that began in the mid 1980's with the development of the Joint Operational Tactical System (JOTS) Command and Control System. The system was also designed to operate on the Tactical Advanced Computing (TAC) family of computers, as non-proprietary, open architecture that could be easily transported to subsequent improved versions of the TAC. [Ref. 11:p. 1-3]

Under the direction of SPAWAR (PD-60), the core software GOTS 1.1 was compiled for use throughout the afloat community as the basis for all C3I systems. GOTS 2.0 was called the Unified Build (UB) 2.0 and was developed to include the ashore community to further increase C3I system interoperability. The Unified Build is confirmation of Vice Admiral (Ret.) Tuttle's recent statement :

The future of C4I ... will be built on a foundation of interoperability, open systems, and a common operating environment. 'Standardization' will be our battle cry. [Ref. 12]

2. System Migration

On 1 November 1993, Assistant Secretary of Defense (ASD) for C4I, Mr. Emmitt Paige, issued a memorandum requiring all DoD services to develop a detailed plan for migration of individual systems into a common C4I framework. All systems nominated for migration to a common framework were to be completed within three years. Those systems not designated by the respective service as a candidate for migration were to either cease to exist or apply for exception status. [Ref. 13] Rear Admiral John Gauss of SPAWAR PD-60 stated that obsolete systems must be retired as soon as possible even if some functions have not been replaced due to the significant decreases in DoD funding. [Ref. 14] The ASD memorandum brought the issue of a common C4I framework espoused in the C4I For the Warrior plan to the front. A form of this common C4I framework was in existence prior to the issuance of the memorandum and JMCIS is that architecture selected for the U.S Navy and Marine Corps. Secretary Paige's memorandum accelerated existing Navy and Marine Corps migration planning and established JMCIS as a practical alternative for the other services. The legacy systems that were migrated into JOTS and eventually into JMCIS are depicted in Figure 3-1 [Ref. 15]. The systems that were initially migrated into JMCIS were operationally oriented and eventually this migration philosophy was extended to logistical and intelligence related systems. Table 3-1 provides a listing of the full names for the migrated systems.

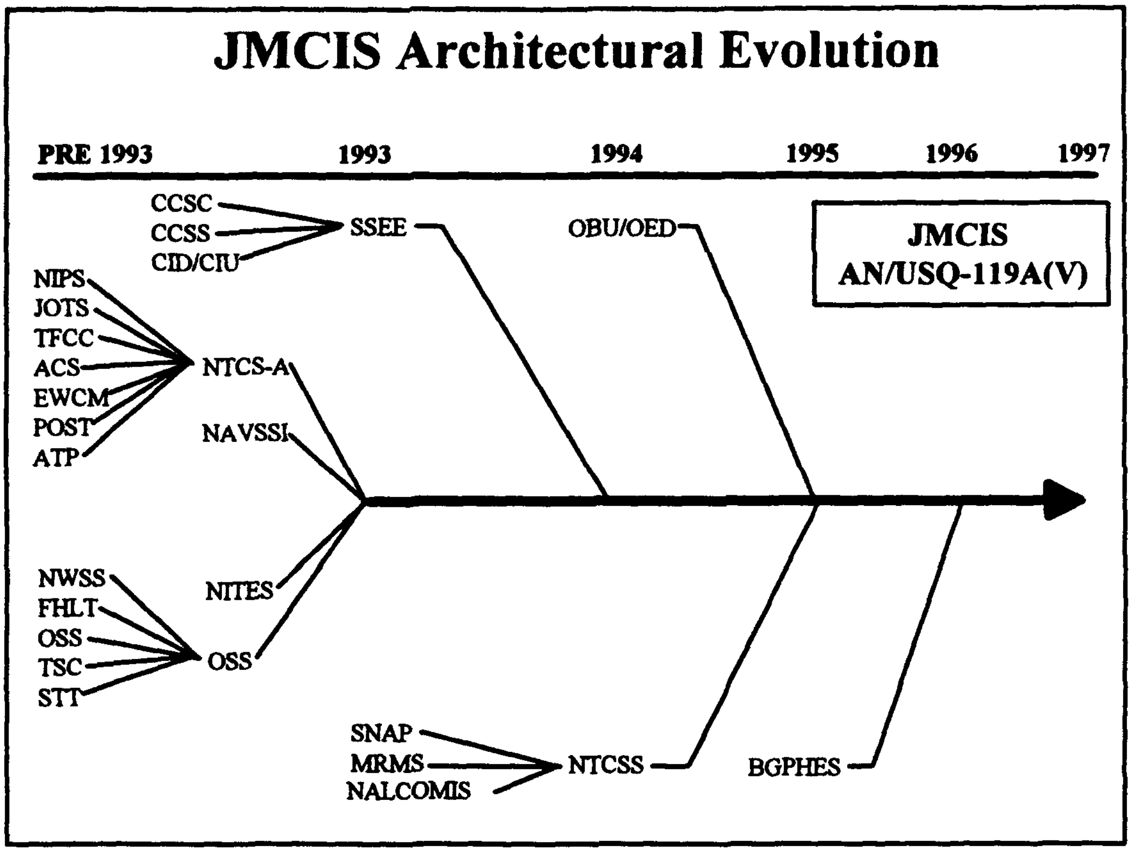


Figure 3-1 Migration of Legacy Systems

3. What is JMCIS?

JMCIS is a system built as an architectural framework to meet specific Navy and DoD command and control capabilities. Just like Microsoft Windows™, JMCIS provides an environment for applications that consolidates common functions. In Windows™, multiple applications can share common utilities such as printing and file management, rather than duplicating those functions for each application. For command and control systems, JMCIS provides various common utilities including mapping, tactical database display, and cartographic functions among others. This collection of utilities comprises the JMCIS core and is graphically depicted as a part of the COE in

Table 3-1 MIGRATION SYSTEMS

Abbreviation	Full System Name
NIPS	NTCS-A Intelligence Processing Services
JOTS	Joint Operational Tactical System
TFCC	Tactical Flag Command Center
ACS	Afloat Correlation System
EWCM	Electronic Warfare Coordination Module
POST	Prototype Ocean Surveillance Terminal
ATP	Advanced Tracking Prototype
NWESS	Navy WMCCS Software Standardization
FHLT	Force High Level System
OSS	Operations Support System
TSC	Tactical Support Center
STT	Shore Targeting System
CCSC	Cryptologic Combat Support Console
CCSS	Cryptologic Combat Support System
CID/CIU	Cryptologic Interface Device/Unit
NTCS-A	Navy Tactical Command System - Afloat
NAVSSI	Navigation Sensor System Interface
NITES	NTCS-A Integrated Tactical Environmental Subsystem
SSEE	Ships Signal Exploitation Equipment
SNAP	Shipboard Non-tactical ADP Program
MRMS	Maintenance Resource Management System
NALCOMIS	Navy Aviation Logistics Command Management Information System
NTCSS	Navy Tactical Command Support System
BGPHES	Battle Group Passive Horizon Extension System
OBU/OED	Ocean Surveillance Information System (OSIS) Baseline Upgrade

Figure 3-2. [Ref. 11:p. 2-2] The core is maintained and expanded based upon the migration of legacy systems and improvements to existing JMCIS applications. The consolidation of common functions allows all applications to access the most efficient utility and provides the opportunity to easily update the core utilities with improved versions. In traditional client/server style, JMCIS servers provide core services to the rest

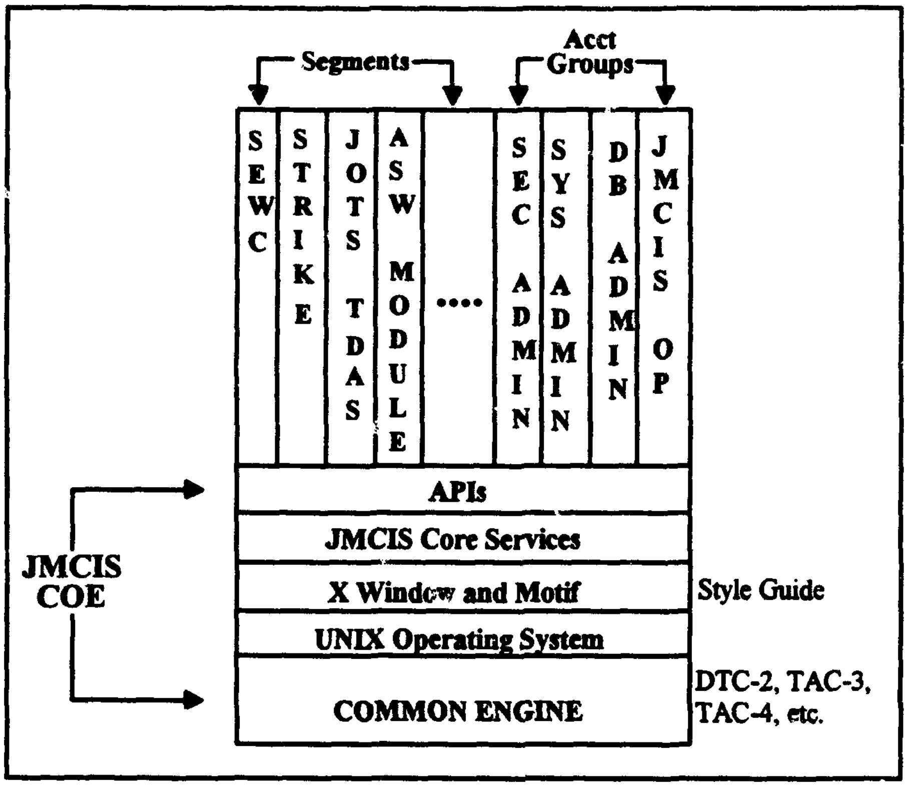


Figure 3-2 JMCIS COE

of the LAN and each workstation may have both the same or different application software running.

a. Components of JMCIS

(1) Applications

Depicted vertically in Figure 3-2, applications access the JMCIS core services via Application Program Interfaces (APIs). In Figure 3-2 the applications annotated as 'Account Groups' are the standard applications that come as a part of JMCIS. These house keeping applications are custom environments for the common activities of System Administration, Security Administration, Database Administration and the standard JMCIS operator environment. The applications annotated as 'Segments' are a sample of some of the unique applications that have been developed or migrated into the JMCIS environment. The specific Segments listed represent:

- SEWC - Space and Electronic Warfare Commander
- STRIKE - Strike Plot
- JOTS TDAS - Joint Operational Tactical System Tactical Decision Aids

(2) Common Operating Environment (COE)

The COE consists of the UNIX Operating System (OS), X Window graphical windowing system, and Motif standard styles, as well as core software for receiving and processing messages, correlation, updating the track database, and software for generating cartographic displays. [Ref. 11:p. 2-1]

(3) Unified Build (UB)

The UB is the foundation for all JMCIS software. The UB is a set of software components that include the Common Operating Environment (COE) and a standard software base for central applications and library functions necessary for basic command, control, and supporting functions.

(4) Segment

A segment is a software application that operates in the JMCIS runtime environment utilizing core functionalities for common operations. Segments access the core functionality through a standard set of Application Program Interfaces (APIs). The standard set of APIs is managed by the core developers and is the access vehicle to core functionality. Unique functionality for individual segments is provided by the individual applications source executable code.

(5) Variant

A variant is a subset of segments, from the JMCIS Superset, installed for a specific mission area such as mission planning or battle group database management. The collection of various JMCIS segments are simply customized modules that define the JMCIS variant.

b. The Three Perspectives of JMCIS

(1) Sailor / Soldier Perspective

To the end user, JMCIS represents a Command Information System which is distributed across a Local Area Network (LAN) of workstations. Operators are able to access all required functionality from any workstation regardless of physical location or the actual location where the processing is taking place. The user is presented with only the functionality needed to meet their mission and other unneeded functionality is hidden to prevent overwhelming the user. An operator with a different set of tasks is presented with a different set of functionality but both operators perceive that the system looks and operates in the same way. JMCIS will appear to the operators as the identical Command Information System in use by military personnel in sister services with completely different mission objectives. This joint commonality is of increasing importance with the expanded role services are performing in the joint arena. [Ref. 11:p. 1-7]

(2) Program Manager Perspective

From the perspective of a military program manager, JMCIS presents the opportunity for an umbrella program which can encompass several programs. Faced with decreased funding, program managers can maintain program viability and achieve considerable savings by constructing their system from the JMCIS building blocks. In these times of budget austerity, this potential savings is sometimes the only feasible option for the programs. [Ref. 11:p. 1-7]

(3) System Developer Perspective

From the perspective of a system developer, JMCIS is an open architecture and a software development environment that offers a collection of services and already-built modules for Command Information Systems. The JMCIS developers provide detailed instructions on how to make applications or systems JMCIS compliant. These instructions include details on standard user interface and the procedures for using core functionality via APIs. This core functionality has been previously developed and tested and therefore the developer need only produce components that are unique to their particular application. [Ref. 11:p. 1-7]

D. WHY JMCIS?

The evolution to JMCIS was an operational and financial necessity in today's world of rapidly changing technology and decreased funding for DoD systems. JMCIS provides DoD with an opportunity to stay ahead of technological growth well into the next century by implementing open systems architectures and ensuring standardization of software and hardware for C4I systems throughout the services.

1. Operational Justification

a. Command, Control, Communications, Computers, and Intelligence (C4I)

Command, control, communications and intelligence are pivotal to the success of any military mission. The addition of computers to the equation increases the fusion capabilities. The concept of computers being a force multiplier is espoused in the 1993 C4I For The Warrior document.

> Fused information is more valuable to the Warrior than information received directly from separate, multiple sources to the degree that it provides the warrior with 'real truth.' [Ref. 7:p. 13]

More importantly, the ability to pull on demand, information from any location at any moment, gives the Warrior both more flexibility and the skill to tailor decisions to his specific needs. [Ref. 7:p. 13]

b. Technology Explosion

Technological leaps are being experienced on an almost exponential scale. Rear Admiral Walter Davis, Head of the Warfare Architecture and Systems Engineering Directorate at the Space and Naval Warfare Systems Command (SPAWAR) summed up the speed of the development of technology by saying that "...the commercial computer industry is introducing new systems and new capabilities approximately every 18 months." [Ref. 8:p. 49-56] With the average DoD major automated information system (AIS) acquisition taking over 24 months from requirements specification to system delivery, DoD is constantly being equipped with obsolete systems. *Open systems architecture is the solution.* The crux of open systems are common development standards from which products can be developed using non-proprietary specifications. The advantages of using open systems architect[illegible] an organization the size of DoD are profound and present the most efficient and practical approach to the use of hardware and software.

One of the objectives of JMCIS is to avoid having command and control systems tied to a specific hardware platform or proprietary system. For this reason the JMCIS system is designed to operate on the family of TAC computers. The system is designed to be easily transported from one version of TAC computer to the next and be capable of exploiting the improved capability of the upgraded system. Rear Admiral Gauss stated that TAC hardware, COTS and GOTS software, and both government and industry standards, were to be used for all current and future JMCIS development. [Ref. 14] With the open architecture and commercial standards used by JMCIS, advances in computing platforms can be easily incorporated by simply changing the host machine for the system. Figure 3-3 presents the dramatic increase in the number of MIPS between successive TAC system procurements and the proposed processing capability of the TAC-4. [Ref. 12, and 16]

c. Shared Access to Common Data

The Track Database is possibly the most important piece of the JMCIS Command Information System. This TDBM, coupled with the extensive communications

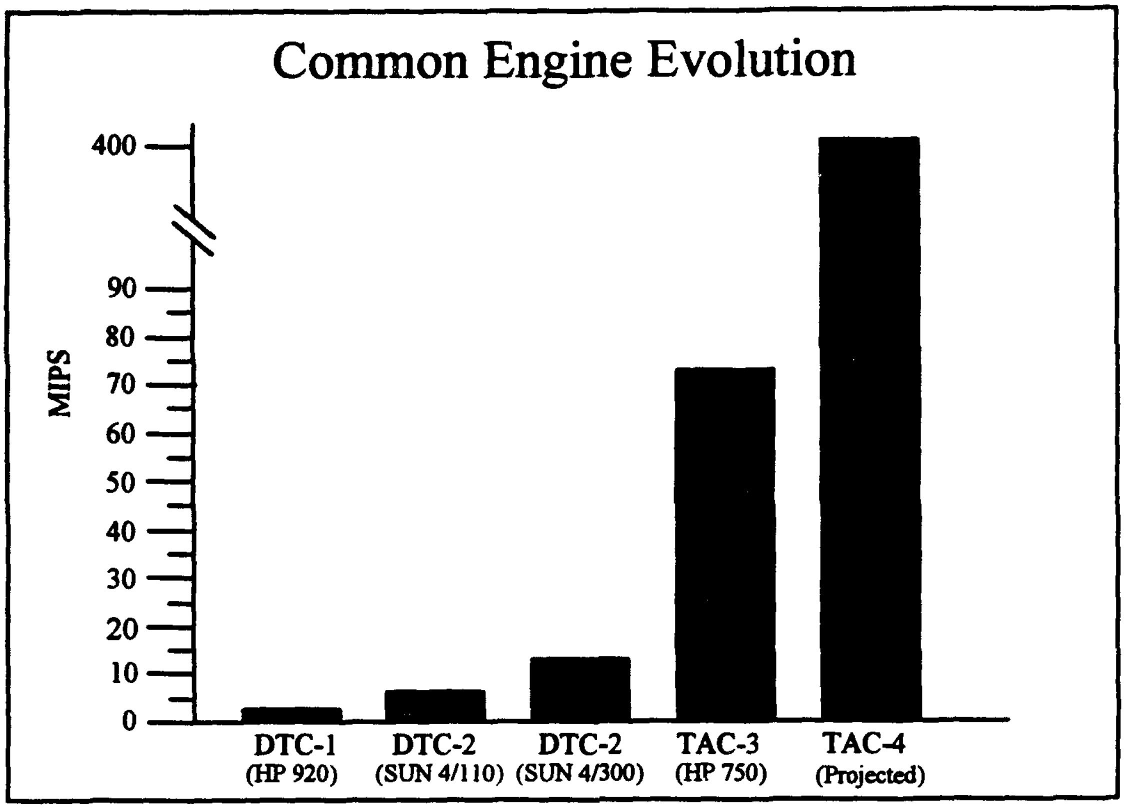


Figure 3-3 Platform Performance Improvements

capabilities of JMCIS, fosters greater interoperability with external sources and databases. The TDBM provides standard procedures and formats to add, delete, modify, and merge basic track data among the various workstations on the local area networks. With the increased capabilities of the TDBM to receive multiple sources of data, fusion of the information gives the warrior more intelligent correlation. [Ref. 11:p. 2-20]

2. Financial Justification

Significant savings can be obtained by supporting a reduced number of lines of code. This reduction in lines of code is accomplished by implementing a common core of software and only producing the unique portions of the segment. Initial analysis of candidate command and control systems eligible for migration to JMCIS revealed significant reductions in post deployment software support.

a. Configuration Management - Hardware/Software

The financial savings of moving toward an open architecture environment cannot afford to be overlooked. While hardware costs have experienced a steady downward trend over the last several years, costs for proprietary software have mushroomed. The use of COTS software products combats the problem of skyrocketing costs by allowing the developer of a product to spread the cost of development among all users of the product. Achieving these economies of scale is the major cost saving characteristic of the JMCIS open architecture environment. Vice Admiral (Ret.) Tuttle noted that "... the expenditures on (software) applications - coding, debugging, and testing - spiral upwards to 90% of the total computer budgets." [Ref. 12]

b. Training

In addition to the costs for hardware and software, the costs related to training are significant. Through the use of open architecture and standardization of human machine interfaces, both operator and maintenance personnel familiarization with one system will translate directly to other systems using TAC hardware and open architecture environments. The Common Operating Environment (COE) of JMCIS includes such standards as X Window and MOTIF style guide as well as the UNIX operating system. By training operators on these standard vendor products, the familiarization time for new personnel is limited to the minimum necessary to understand the new mission and results in more rapid improvement in operator performance.

E. THE JMCIS PHILOSOPHY

1. Don't Reinvent the Wheel

If a component already exists, it should be utilized even if the component is not the optimum, best possible solution. As early as 1987 a GAO report on the issue of interoper[illegible]ity among DoD C3I systems noted that:

> Solving this problem (*of interoperability*) is no easy task. ... It will require a great deal of cooperation among the services and a genuine willingness on the part of each service to accept interoperability even when it conflicts with some traditional service practices. [Ref. 17:p. 18]

Almost any module can be improved but that is rarely the issue. For example, it is usually possible to obtain performance improvements in drawing speeds for cartographic displays by customizing designs to use hardware specific features. However, this may not be cost effective if platform portability is a requirement, or if performance gains are modest relative to perceived performance. [Ref. 11:p.1-11]

2. Existing Standards

The commercial marketplace generally moves at a faster pace than the military marketplace and advancements are usually available at a faster rate. Use of commercial products has the advantage of lowering cost by using already built items, increases the probability of product enhancements because the marketplace is larger, and increases the probability of standardization. [Ref. 11:p.1-12]

3. Interpretability

Interpretation of standards are a major source of problems with interoperability. The way to combat the problem is to use identical software modules to perform common functions. This ensures that the same standards are applied to all users and therefore eliminates the opportunity for inaccurate or varying interpretations. [Ref. 11:p.1-12]

4. Focus Attention

Focus efforts on the development of desired but currently unavailable functionality instead of re-generating existing capabilities. [Ref. 11:p.1-12]

F. THE OBJECTIVES OF JMCIS

Given the philosophy and history of the JMCIS concept, there are a number of objectives which are immediately apparent. The objectives include technical considerations such as software reusability, enforcement of common "look and feel", and standardization of interfaces. These technical objectives in turn result in the potential for significant cost savings and development acceleration.

1. Commonality

Develop a common core of software that will form the foundation for Navy and Joint systems.

2. Reusability

Develop a common core of software that is highly reusable to leverage the investment already made in software development.

3. Standardization

Reduce program development costs through objectives one and two and through adherence to industry standards. This includes the use of commercially available software components whenever possible.

4. Engineering Base

Through standardization and an open JMCIS architecture, establish a large base of trained software/systems engineers.

5. Training

Reduce operator training costs through enforcement of a uniform human-machine interface, commonality of training documentation, and a consistent "look and feel."

6. Interoperability

Solve the interoperability problem (at least partially) through common software and consistent system operation.

7. Certification

Provide a base of certified software so that systems performing identical functions will give identical answers.

8. Testing

Increase the amount of common, reusable software to reduce testing costs because common software can be tested and validated once and then applied to many programs. [Ref. 11:p.1-13]

G. THE FUTURE

The vision provided by strategic planning initiatives is being realized under the JMCIS banner. Systems continue to evolve toward the goal of an interoperable C4I system that focuses on support to the Warrior. The National Military Strategy Document (NMSD) for FY 1994-1999 establishes C4I as the overarching C4 programming objective and states that :

> Consistent with the C4I for the Warrior' plar a' .rvice and Agency programmed systems must be compatible and interoperable to support joint and combined operation across the entire spectrum of conflict. [Ref. 18]

GCCS is a Joint Staff sponsored program envisioned by the C4I for the Warrior concept and represents the next step in the evolution of command and control systems. When fully implemented, GCCS will embody a network of systems providing the Warrior with a full complement of command and control capabilities. As part of the C4I for the Warrior concept, GCCS is evolving into the global, seamless "Infosphere" capable of meeting the Warrior's fused information requirements. [Ref. 7:p.13]

IV. THE ATACC REQUIREMENTS

A. INTRODUCTION

The first step in comparing the ATACC data link requirements to the JMCIS capabilities, is to have a full understanding of the specified ATACC requirements. The system requirements for the ATACC are found in ELEX-T-620A dated 27 July 1990, and the contract modification to that document, P00068, dated 19 November 1992. Only the data link requirements of the ATACC system were evaluated. The requirements for the ATACC were grouped into categories and formed into a decision tree with level zero of the tree being the goal of selecting a data link system that meets the ATAC requirements. The requirements were first divided into the three categories of operational functions, maintenance functions, and performance standards. These three categories of requirements form level one of the decision tree, this section is depicted in Figure 4-1.

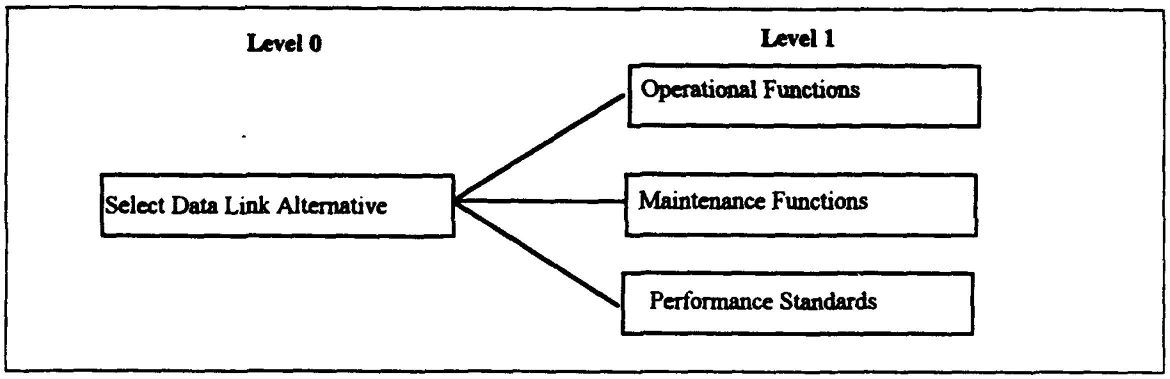


Figure 4-1 Decision Tree Goal Level and Level One

This decision tree was used in determining the relative importance of each requirement and eventually used in the comparison of the JMCIS to the ATACC data link requirements. The broad requirements categories were further broken down into level two categories and finally into level three categories. The level three requirements are the low level functional statements used in the evaluation.

B. OPERATIONAL FUNCTIONS

Operational Requirements are those requirements that specify some operational function be resident within the system or a particular function be performed in a specific manor. The overall analysis of the functional requirements yielded three level two categories of System Interface, Data Readout, and Data Link Capacity under the level one category of Operational Functions. The level two and three branches of the decision tree that fall under the category of Operational Functions is depicted in Figure 4-2.

1. System Interface

Section 3.1.6.12.1, Software/Operator Interaction, of the ATACC system specification gives the following general requirements:

> All software which interacts with an operator shall utilize menus, icons, prompts, entry feed back, notices, windows, and summaries to guide the operator through the operation of the ATACC. The use of the keyboard for other than text or data entry shall be kept to a minimum. The operator shall be provided a programmable function key capability. Menus, prompts, entry feedback, notices and summaries shall contain sufficient information in English or English abbreviations so that no requirement will exist for the use of hand-held lookup tables. [Ref. 19:p. 62]

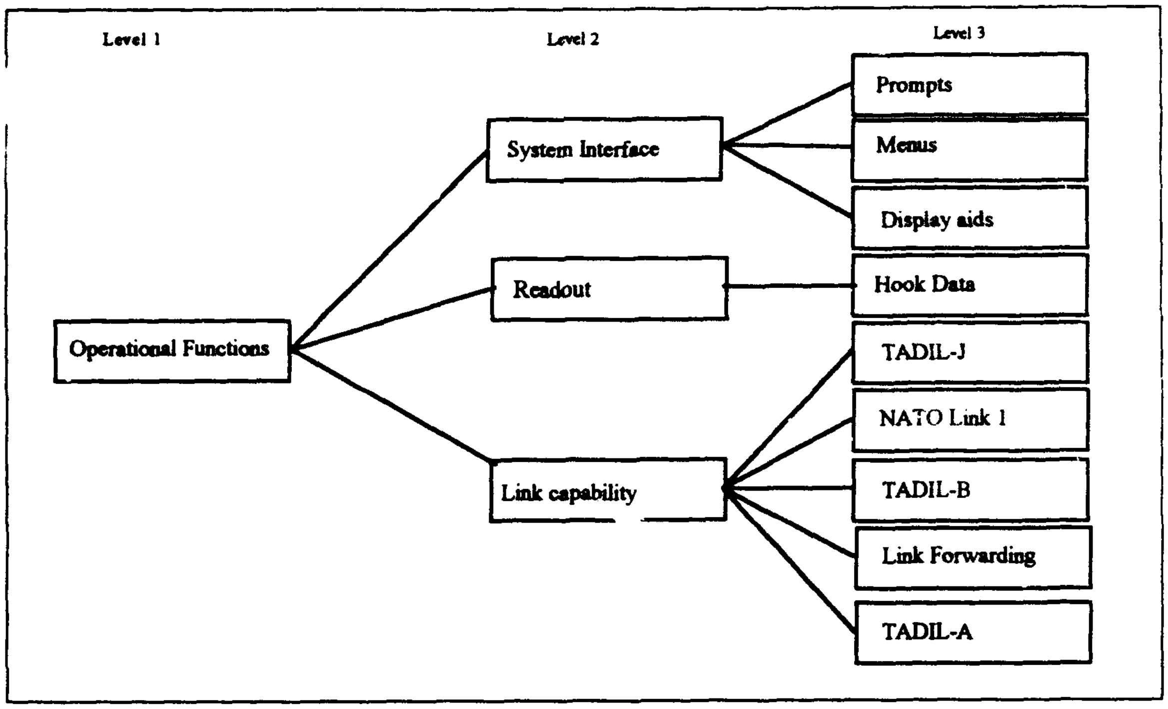


Figure 4-2 Level One Operational Functions

Using this broad requirements statement and the amplifying remarks that followed the level two functional requirements of Prompts, Menus, and Display Aids were created under the level one category of system interface.

a. Prompts

Prompts shall be used when requesting the operator to enter variable data. Entry of valid data shall cause the display of menus, other prompts, entry feedback, or summaries. [Ref. 19:p. 63]

b. Menus

Menus shall be used to provide a collection of items form which an operator may make a single selection. The selection of any valid menu item shall cause the display of other menus, prompts, entry feedback, or summaries. [Ref. 19:p. 62]

c. Display Aids

After system initialization the necessary display aids shall be provided to complete the entry of date and time, data link parameters, and data extraction information. There shall be a provision for magnetic storage and recall of these entries. The data link parameters shall consist of the following:

- Data Link Reference Point (DLRP)
- Unit System Coordinate Center (USCC)
- Unit Position (UPOS)
- Unit Address (UADD) [Ref. 19:p. 97]

2. Data Readout (Hook Data)

Section 3.1.6.2.2.1, Hook Data Readout, specifies that when a track is hooked by an operator at any workstation, information pertaining to the hooked track shall be presented in an area reserved on the face of the workstation. The system is required to display TADIL-A , TADIL-B, TADIL-J and NATO Link-1 tracks in a predetermined format. [Ref. 19:p. 55] This level two requirement was broken down into only one level three functional requirement relating to forwarding of data link information in general.

3. Data Link Capability

Section 3.1.5.1.5, Digital Message Interface, specifies the required types of digital information links the system must be able to communicate on and the standards that must be obeyed. The level two requirement of Data Link Capabilities is broken down into three level three functional requirements. [Ref. 19 :p. 23]

a. TADIL-J

The ATACC will be capable of operating on TADIL-J in accordance with IDH JTIDS TIDP-TE Vol. III (Interface Design Handbook, Joint Tactical Information Distribution System, Technical Interface Design Plan - Technical Edition, Volume III). [Ref. 19 :p. 23]

b. NATO Link-1

The ATACC will be capable of operating on NATO Link-1 in accordance with Standardization Agreement or Standard NATO Agreement 5601 (STANAG). [Ref. 19 :p. 23]

c. TADIL-B

The ATACC shall be capable of operating on TADIL-B in accordance with Joint Chiefs of Staff Publication 6-01.1(C) (JCS PUB 6-01.1(C)). [Ref. 19 :p. 23]

d. Link Forwarding

All links will be capable of forwarding tracks from one link to another as specified in STANAG 5601, JCS PUB 6-01.1(C) and the Interface Design Handbook, Joint Tactical Information Distribution System, Technical Interface Design Plan - Technical Edition, Volume III (IDH JTIDS TIDP-TE Vol. III.) [Ref. 19 :p. 23]

e. TADIL-A

The ATACC shall be capable of operating on TADIL-A in accordance with Joint Chief's of Staff Publication 6-01.1(C) (JCS Pub 6-01.1(C)). [Ref. 19 :p. 23]

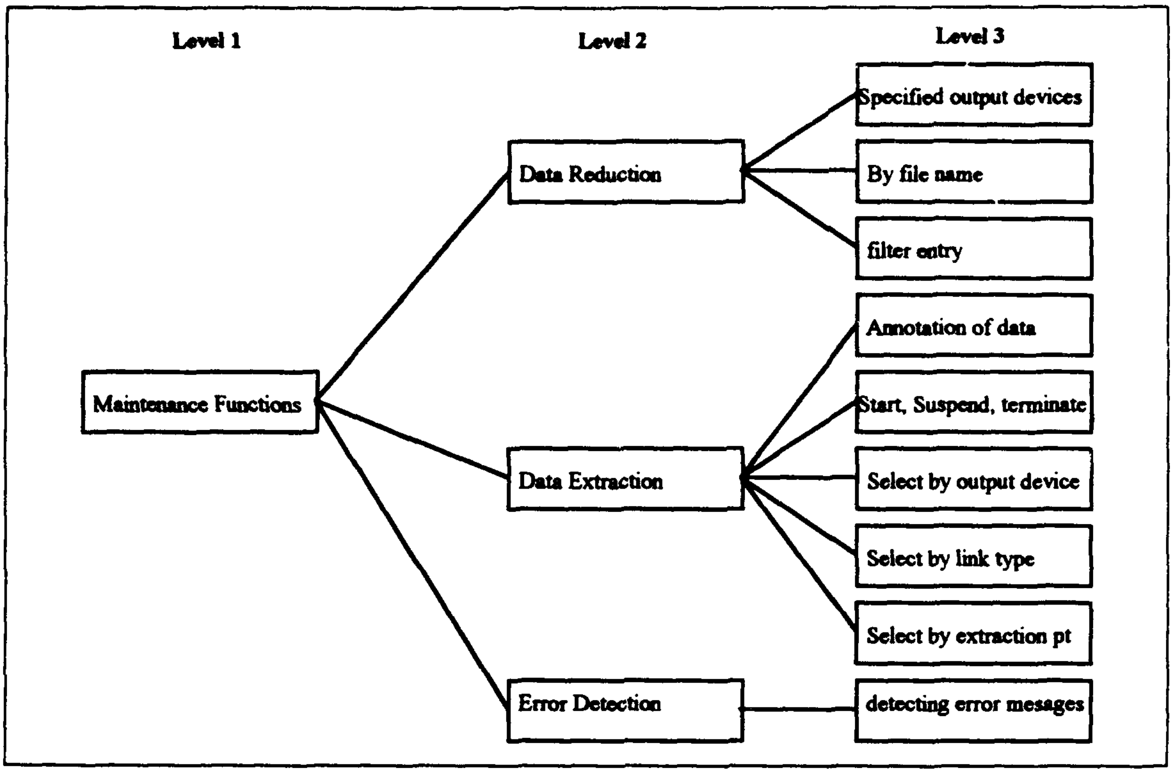
C. MAINTENANCE REQUIREMENTS

The level one requirements category of Maintenance Requirements consists of those items that are generally related to maintenance functions of the system or actions supporting some other operational function. The level one category of Maintenance Requirements was broken down into three level two categories of Data Extraction , Data Reduction, and Error Detection. The data extraction is analogous to taking a sample and the data reduction is analogous to analyzing that sample. That portion of the decision tree below Maintenance Requirements and down to the level three requirements is depicted in Figure 4-3.

1. Data Extraction

Section 3.1.6.12.7 of the ELEX-T-620A details the data management requirements of the system for data extraction. Data extraction is the process of taking samples of data flows or directing a copy of that data to some non-temporary storage medium for further analysis. The capability to extract data for further analysis is of little

Figure 4-3 Level One Maintenance Functions



use, unless the operator has some control over selecting the extraction location, data type, and output devices. After analyzing the stated general requirements and the listed provisions for the level 2 requirement of Data Extraction, five level 3 functional requirements were determined. [Ref. 19:p. 70]

a. Annotation of Data

The system is required to allow the operator to annotate the extracted data with a system time tag, extraction point indicator, link type designator, and channel number. [Ref. 19 :p.70]

b. Start, Stop and Suspend

The operator must have the ability to enter control information to start, stop, suspend, or terminate any particular extraction activity. [Ref. 19:p. 70]

c. Select by Output Device

The operator must have the ability to define the output device, for example magnetic tape or magnetic disc. The operator must also be capable of defining the extraction file name. [Ref. 19:p. 70]

d. Select by Link Type

The operator must be capable of defining the data type by link identifier. Examples of a link identifier are TADIL-A, TADIL-B, TADIL-J, and NATO Link-1. [Ref. 10:p. 70]

e. Select by Point of Extraction

The operator must have the capability to define the extraction point by link type and channel identifier and/or Central Processing Unit (CPU) channel identifier. The operator must also be able to select data as transmitted data or received data. [Ref. 19:p. 70]

2. Data Reduction

Section 3.1.6.12.8 of the ELEX-T-620A specifies the requirements of the system for data reduction. The reduction of extracted data is a maintenance tool used to determine the health of a data link, or a system, by analyzing a sample of the data. After analyzing the stated general requirements for the level two category of Data Reduction, three level three functional requirements were determined. [Ref. 19:p. 70]

a. Specified Output Devices

The operator must have the capability to designate the output device for the data reduction results. [Ref. 19:p. 71]

b. By File Name

The operator must be capable of specifying by file name the source data to be analyzed. [Ref. 19:p. 70]

c. By Specified Filter Type

The operator must be able to define the data to be reduced based upon filter entry. The selectable filters shall be inclusive and additive and only data meeting the combined characteristics of the selected filters shall be reduced and output. These filters shall include link type, channel number and /or CPU channel identifier, time tag (from start reduction, and to stop reduction), track number, message number, track identity, and identity amplifiers such as track type. [Ref. 19:p.71]

3. Error Detection

Section 3.1.6.12.6 of ELEX-T-620A specifies that the system shall manage digital data communications to provide the capabilities necessary to support the exchange of digital data link information. This shall include the processing capability for message building, message interpretation, and error detection. [Ref. 19:p. 69] Analyzing these broad requirements and the accompanying conditions, the level two requirement of Error Detection was broken down into one level three functional requirement that was relevant to the data link requirements.

a. *Error Detection*

The system must provide the capabilities necessary to support the exchange of digital data link information, including error detection of messages for TADIL-A, TADIL-B, TADIL-J, and NATO Link-1. [Ref. 19:p.69]

D. PERFORMANCE REQUIREMENTS

The level one category of Performance Requirements consists of those items in the system specification that dictate a specific level of performance or action. Relating to the data link requirements this section contains not just what types of links the system will communicate on but at what level of reliability, availability, maintainability and the data / track volume the system must maintain. The portion of the decision tree below Performance Requirements and down to the level three requirements is depicted in Figure 4-4.

1. Maintainability

Section 3.2.4 of ELEX-T-620A describes the maintainability requirements and delineates these requirements to the appropriate echelon of maintenance. These levels of maintenance are Organizational level (first and second echelon), Intermediate level (on-equipment, third echelon), and Intermediate level (off-equipment, fourth echelon).

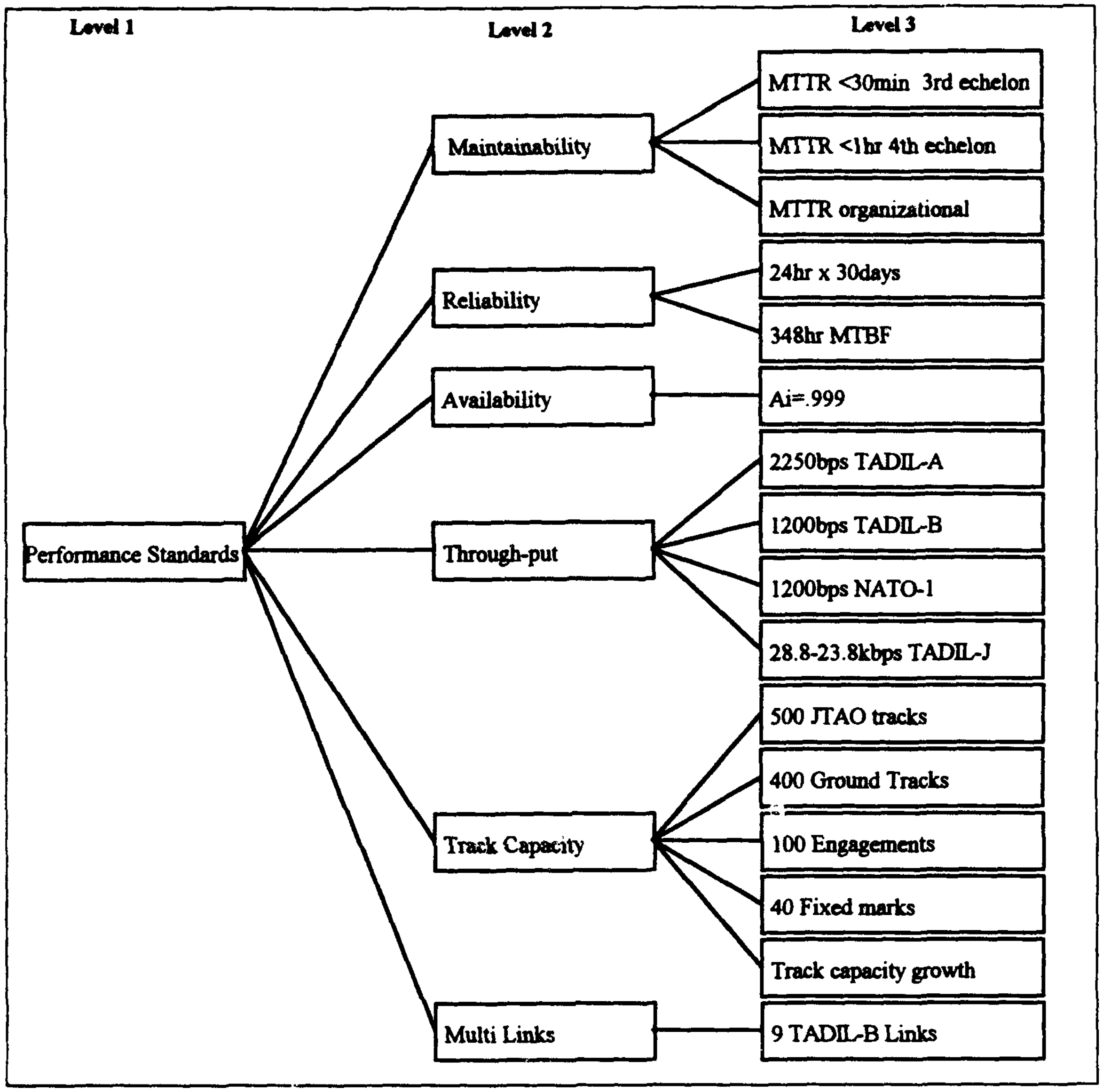


Figure 4-4 Level Two Performance Standards

The measures specified for each level of maintenance is the mean time to repair (MTTR) and the maximum corrective time (Mct). [Ref. 19:p.83] The level two requirements category of Maintainability was broken down into three level three functional requirements.

a. Mean Time To Repair (MTTR) First and Second Echelon (Organizational Level)

Organizational level maintenance (first and second echelon) shall be limited to maintenance tasks that do not require any special tools or test equipment. At this level preventive maintenance tasks including visual inspection, testing, cleaning and minor adjustments shall be done. The system shall be repaired by removal/replacement of faulty lowest replaceable units. A MTTR of no greater than 30 minutes and a Mct of no greater than one hour at the 90th percentile shall be achieved. [Ref. 19:p.83]

b. Mean Time To Repair (MTTR) Third Echelon (Intermediate Level)

At the intermediate level (on-equipment, Third echelon) maintenance shall be performed by diagnostics and by replacement / removal of faulty lowest replaceable units. These lowest replaceable units include black boxes and circuit card assemblies. A MTTR no greater than 30 minutes and a Mct no grater than one hour at the 90th percentile shall be achieved. [Ref. 19:p 83]

c. Mean Time To Repair (MTTR) Fourth Echelon

At the intermediate level (off-equipment, Fourth echelon) maintenance shall have the capability to repair selected lowest replaceable units. These lowest replaceable units include black boxes and circuit card assemblies. A MTTR no greater than one hour and a Mct no greater than two hours at the 90th percentile shall be achieved. [Ref. 19:p. 83]

2. Reliability

In section 3.2.3 of ELEX-T-620A, reliability is defined as the probability that the ATACC shall complete its mission 24 hours a day for a minimum period of 30 days. The system specification prescribes a lower threshold of mean time between failure (MTBF) and the formula for calculating the reliability percentage. The level two requirements category of Reliability was broken down into two level three functional requirements.

a. Mean Time Between Failure (MTBF)

The system shall have a lower threshold of 348 hours MTBF, using the MIL-STD-781D definition of failures. [Ref. 19:p. 82]

b. Reliability Percentage

The system shall operate for 24 hours a day for 30 days with an acceptable reliability percentage. The mathematical equation for calculating the reliability is:

$$R = e^{\frac{-m}{MTBF}}$$

Where R = Reliability %, MTBF (lower) = 348 hours, m=720 hour mission, and "e"=Base of the natural logarithm. [Ref. 19:p.83]

3. Availability

Section 3.2.5 of ELEX-T-620 defines availability as the probability that the ATACC is totally operable at any random point in time. The level two requirements category of Availability was broken down to only one data link relevant functional requirement. [Ref. 19:p. 84]

a. Availability Calculations

The minimum inherent availability (Ai) of each suite shall be 0.999, based on specified reliability and maintainability requirements, expressed as a percentage ratio. The mathematical formula for the availability calculations is :

$$A_i = \frac{MTBF}{MTBF+MTTR} = 0.999$$

Where the MTBF is the Mean Time Between Failure and MTTR is the Mean Time To Repair. [Ref. 19:p. 84]

4. Data Through-put

Section 3.2.1.9.3 of ELEX-T-620A specifies the channel bit rates required of the system for the different digital information links. This level two requirements category is broken down into four level three functional requirements corresponding to the different links. [Ref. 19:p. 82]

a. TADIL-A

The system shall implement TADIL-A and maintain a channel data rate of 2,250 bits per second (bps) half duplex and a message rate of 1800 bps. [Ref. 19:p. 82]

b. TADIL-B

The system shall implement TADIL-B and maintain a channel data rate of 1,200 bps full duplex and a message rate of 800 bps in and 800 bps out. [Ref. 19:p. 82]

c. NATO Link-1

The system shall implement NATO Link-1 and maintain a channel data rate of 1,200 bps full duplex and a message rate of 920 bps in and 920 bps out. [Ref. 19:p. 82]

d. TADIL-J

The system shall implement TADIL-J and maintain a channel data rate of 28,800 - 23,800 bps half duplex and a variable message rate of 1,219 bps (min.) in/out and 2,211 (max.) in/out. [Ref. 19:p. 82]

5. Data Link Track Capacity

Section 3.2.1.1 of ELEX-T-620A describes the minimum track capacity required of the system. This level two requirements category is broken down into five level three functional requirements.

a. JTAO Tracks

The system must process data representing a minimum of 500 JTAO and NATO tracks. [Ref. 19:p. 74]

b. Ground Tracks

The system must process data representing a minimum of 400 ground tracks. [Ref. 19:p. 74]

c. Engagements

The system must display at least 100 engagements and at least 100 pairings. [Ref. 19:p. 74]

d. Fixed Marks

The system must display at least 40 fixed and at least 50 internal communication marks, and 50 external pointers. [Ref. 19:p. 74]

e. Track Growth Capacity

The system must have the growth capacity to grow from 500 JTAO and NATO tracks up to 1000 tracks. Additionally the ground tracks must have a growth potential to go from 400 up to 600 tracks. [Ref. 19:p. 74]

6. Multiple Data Link Capability

Section 3.2.1.9.2 of ELEX-T-620A, specifies the numbers of simultaneous data links that the system must accommodated. The level two requirements category of Multiple Data Link Capability is broken down into only one, data link relevant, level three functional requirement.

a. Multiple TADIL-B Links

The system must be capable of processing nine TADIL-B links simultaneously. [Ref. 19:p. 81]

V. THE COMPARISON

There are several academically accepted methods for performing a comparison of the data link requirements for the ATACC to the capabilities found in JMCIS. Some of these methods are: the Analytical Hierarchy Process (AHP), Multi-Attribute Utility Theory (MAUT), and the Simple Multi-Attribute Ratting Technique (SMART). For this comparison SMART was chosen based upon its simple and straight forward calculations and elicitation methods. The comparison of the requirements was done using a weighting factor for the ATACC requirements based upon their importance to operators. Having the ability to accept weighted assignments was another reasons why SMART was the favored choice.

Using the Simple Multi-Attribute Rating Technique (SMART) and its implementation in the software package Criterium DecisionPlus™, a model of the decision was made. The model was used to make a comparison between the ATACC requirements and the JMCIS capabilities. In order to use Criterium DecisionPlus™, software the task had to be reduced to a decision between at least two alternatives based upon multiple attributes. In this instance the multiple attributes were the ATACC requirements, and the alternatives were the JMCIS System and an ideal system. This ideal system was assumed to be a system that meets all of the ATACC requirements at the stated level and nothing more. The ideal system will obviously meet the ATACC requirements and got the maximum score from the model because it was built precisely to meet the requirements.

However, the distance between the score for JMCIS and the score for the ideal system will give an indication of how closely the JMCIS capabilities meet the ATACC's data link requirements.

A. SIMPLE MULTI-ATTRIBUTE RATING TECHNIQUE (SMART)

The Simple Multi-Attribute Rating Technique (SMART) was developed by Dr. Ward Edwards in 1977. It can be considered a derivative of the Multi-Attribute Utility Theory (MAUT) of which versions can be traced back as far as 1959. SMART is simplified in that it uses easier more straight forward measurement and elicitation techniques than MAUT. SMART ignores measurement theory and nonadditives and instead relies on simple additive models, numerical estimation techniques for eliciting single-attribute values and ratio estimation of weights. There are several different versions of SMART but all have in common the reliance upon direct numerical estimation methods. [Ref. 20:p. 278]

Appendix (B) provides a more detailed discussion of the development and details of SMART, including the list of the ten steps associated with SMART.

B. CRITERIUM DECISIONPLUS™ SOFTWARE

Criterium DecisionPlus™ is a Microsoft Windows™ based program designed to be an analysis tool to aid in complex decision making tasks. This software is designed to support individual decisions, group decisions, and research findings. The software implements both the Analytical Hierarchy Process (AHP) and the Simple Multi-Attribute

Rating Technique (SMART) as selectable rating techniques. The user friendly mouse driven environment provides simplified elicitation of subjects rating opinions, performs numerical aggregation, weighting calculations, and generates selectable reports and graphs.

The software supports a brainstorming feature where the user can enter a goal, and alternatives to achieve that goal, on a blank canvas. The user then can connect the goal to attributes relevant to that goal and relationships are established. The finished brainstorm session can be used to automatically generate a value tree or hierarchy tree which represents the decision scenario.

DecisionPlus™ provides a criterion rating environment where the user is given one of several selectable rating views to enter their evaluation to assign weights to the attributes entered in the brainstorming session. The weighted criterion are aggregated and used in determining the desired alternative . The data from the evaluation is finally used in several reports, graphs and tables. A more detailed discussion on the capabilities and the steps for using DecisionPlus™ is contained in Appendix (C).

C. ANALYSIS METHODOLOGY

Using the DecisionPlus™ software a decision scenario was constructed using the brainstorming feature. During the brainstorming process four steps need to be completed. These four steps are :

- Define a goal.
- Define alternatives.
- Identify relevant criteria.
- Establish the relationships between criteria, subcriteria and the goal.

These four steps were the key decisions in designing the scenario in the brainstorming function. The researcher defined the goal and alternatives in order to meet the research objectives. The relevant criteria were selected from the ATACC system specification based upon their relevance to data link operations. The relationships between the criteria was established by the researcher according to functionality and the detail of the criteria. Completing the four steps, the brainstorming se[illegible]as then used to automatically generate a decision hierarchy.

1. Defining a Goal

Using the brainstorming feature of DecisionPlus™ the first step was to establish a goal for the decision. The goal for this decision scenario was to choose an alternative data link system for the Marine Corps ATACC.

2. Define Alternatives

With the goal of the decision scenario established, the alternatives to meet that goal must be defined. The alternatives for this decision scenario were defined as:

- A JMCIS system with its included data link capabilities
- An ideal system that was assumed to have met all of the requirements specified in the ATACC system specification.

3. Identify Relevant Criteria

The relevant criteria relating to the decision goal of selecting an alternative data link system for the Marine Corps ATACC were the data link related requirements from the ATACC system specification. These data link related requirements are detailed in Chapter IV.

4. Establish Relationships Between Criteria, Subcriteria and Goal

To establish relationships between the criteria and the goal, the criteria were grouped into major functional categories and separated into three levels. The decision tree generated with the different levels, alternatives and the goal is depicted in Figure 5-1.

5. Evaluating the Importance of Categories and Criteria

Having established the goal, alternatives, criteria, and relationships the decision model was completed. At this point the model depicts relationships but the relationships are not evaluated. Referring again to Figure 5-1, when evaluating the level one and level two criteria the evaluation is on categories of functional capabilities rather than the capabilities themselves. In evaluating these two levels the subjects evaluate one criteria at a time and score the relative importance of that criteria against the other criteria at that level. When evaluating the level three functional criteria, subjects repeat the process and rank each criteria for its relative importance among the other level three criteria. After evaluating the relative importance, DecisionPlus™ facilitates the evaluation of each of the level three criteria for their level of implementation in the alternatives. More succinctly put, all criteria and categories are scored for how important they are compared to others at their level, and then the alternatives are scored on how well they implement the level three criteria.

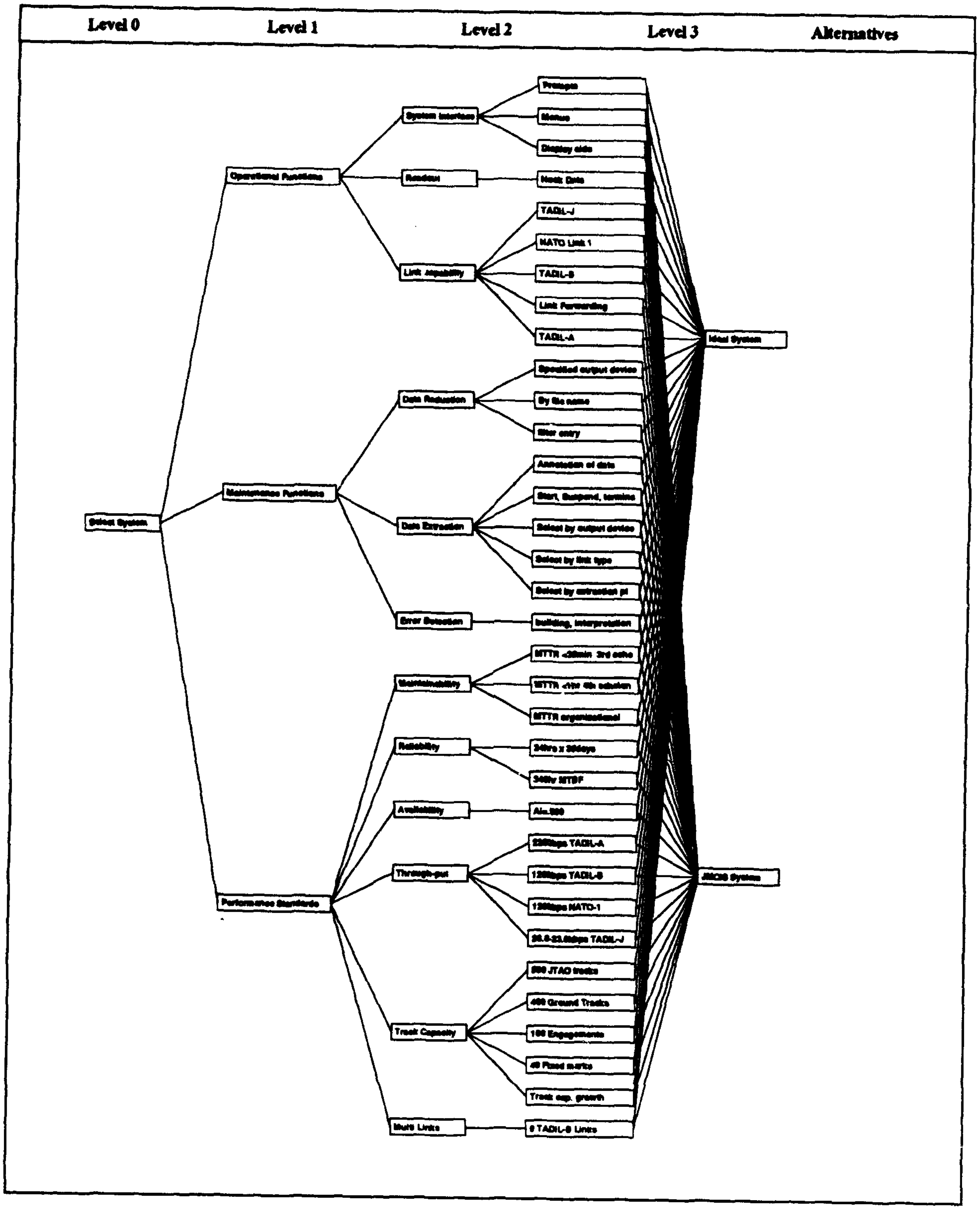


Figure 5-1 Decision Tree

The evaluation of the relative importance of the three levels of criteria was conducted using the Criterion Rating environment in DecisionPlus™ The subjects for the evaluation were Marine Corps Officers with recent Marine Air Command and Control experience. All of the subjects had been assigned to a Marine Air Control Group and have had experience with digital information links in the Marine Corps.4 The subjects only rated the relative importance of the level one, two, and three criteria and did not rate the alternatives for the level three criteria. The alternatives were scored by the researcher following an in-depth study of the JMCIS system.

a. Evaluation View

DecisionPlus™ provides the options of presenting the subject with three different views of the Criterion Rating environment. The researcher has the choice between a graphical view, numerical view, verbal view, or a combination of the three. The graphical view presents a sliding bar to the user that can move by mouse input. The numerical view presents the user with an entry window to enter a number and it informs the user of the acceptable range of numbers. The verbal view presents the subject with five rating level categories. DecisionPlus™ provides six, default groups of categories for the researcher to choose from, or a custom scale can be created. The view used to evaluate the importance of the ATACC criteria was the verbal view with a scale of Critical, Very Important, Important, Unimportant, and Trivial. The verbal view was

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4 All Marine Officers within the Marine Air Control Group with the military occupational specialty of 7202, 7204, 7208, 7210, and 7323 are eligible for assignment to the Marine TACC and are familiar with data link operations. All subjects came from the 72XX communities.

selected based upon several reasons. In addition to the categories the verbal view provides a descriptive sentence that seems to serve as a continuous reinforcement to the user as to the purpose and the context of the current evaluation. An example of the evaluation window used is provided in Figure C-2 of Appendix C.

The five categories of the verbal view are more limited than the possible inputs from the graphical view or the numerical view, however based upon the findings of Elmore & Beggs (1975), the increase from 5 to 7 or 9 points on a Likert type scale does not statistically improve the reliability of the ratings. [Ref. 21 :p.134] Therefore the increased numbers of possible inputs was sacrificed in order to facilitate easier solicitation of responses from the subjects.

6. Evaluation of the Alternatives

The decision hierarchy generated by the brainstorming session was presented to the subjects for the evaluation of the importance of the categories and criteria. The evaluation of the functional criteria for the alternatives was already completed by the researcher. The ideal system (or perfect system) had been given a maximum score for implementing all level three criteria. The JMCIS system was scored by the researcher based upon evaluations done in coordination with the JMCIS developers at Naval Research and Development (NRAD) and hands on experience. This section of the model was pre-scored based upon the subjects not having been exposed to JMCIS and not having a full understanding of its capabilities. This also added consistency to the interpretation of the functional requirements and the JMCIS capabilities.

VI. ALTERNATIVE EVALUATION AND COMPARISON RESULTS

This chapter discusses the evaluation of the level three requirements in the JMCIS system as well as the logic used to determine the scoring. The steps used in processing the survey data and the calculation methods used to reach the JMCIS correlation figure are presented.

A. SCORING THE JMCIS SYSTEM

The capabilities of the JMCIS system were evaluated and compared to the level three functional requirements. The level three requirements were individually evaluated and scored as a "yes" or a "no" in the DecisionPlus™ software. Yes, the system has a capability that meets the stated requirement, or, No the system does not have a capability that meets the stated requirement. The methods used for determining the scores ranged from literature reviews, interviews with system developers, and hands on experience. In instances where the JMCIS capabilities were defined by different methods than the standards specified in the ATACC requirements document, attempts were made to normalize the comparison. In cases where the comparison could not be normalized the researcher's judgment was the deciding factor.

B. SCORING OPERATIONAL FUNCTIONS

Under the level one category of Operational Functions there were three level two functional categories. These level two categories were System Interface, Data Readout, and Data Link Capability. Table 6-1 is a summary of the Score of the Operational Functions.

Table 6-1 OPERATIONAL FUNCTIONS SCORE

System Interface	Prompts	Yes
	Menus	Yes
	Display aids	Yes
Readout	Hook Data	Yes
Link capability	TADIL-J	Yes
	NATO Link 1	No
	TADIL-B	No
	Link Forwarding	No
	TADIL-A	Yes

1. System Interface

The functional capabilities grouped under System Interface were, Menus, Prompts, and Display Aids. These items generally describe a set of user friendly operator to machine interaction conventions. The JMCIS system was designed to conform with version 3.0 of the DoD Human Computer Interface Style Guide. The specific implementation of this style guide in the JMCIS system is specified in the User Interface Specifications For the Joint Maritime Command Information System version 1.3, November 1993. [Ref. 22:p. 1-4] After reviewing this document and considering hands on evaluation of a stand alone system, the JMCIS system was evaluated as "yes" to all the functional requirements under System Interface.

2. Data Readout (Hook Data)

The system specification for Data Readout relates to the display of track data from the different data links in the specified format. The JMCIS system displays data from multiple sources to include some data links. Accordingly, the JMCIS system was scored "yes" for the requirements under Data Readout.

3. Data Link Capability

The system specifications grouped under Data Link Capability list the specific types of data links the system must be capable of performing. As discussed in Chapter III, the origins of the JMCIS system show that it had its beginnings with the U.S.. Navy shipboard community. For this reason the system incorporates TADIL-A and the newly developed TADIL-J. Additionally, since the JMCIS predecessor JOTS was run in parallel with the older NTDS systems (Naval Tactical Data Systems) the systems were only used in a receive mode and did not transmit track information.

For TADIL-A the JMCIS system is capable of receiving and displaying data from a link terminating device. There are three devices fielded today in the Navy. The Passive Link Tap (PLT), the Link Eleven Display System (LEDS) and the EDO box produced by EDO of Chesapeake, Virginia. [Ref. 23] These three link terminating devices provide the JMCIS system with a one way, or receive only capability for TADIL-A. An upgrade to the JMCIS system has been developed and is being fielded in the Navy's Tactical Support Centers (TSC) to give the system a two way, receive and transmit, capability on TADIL-A. [Ref. 23] The link terminating device for TADIL-J is the Joint Tactical Information Distribution System (JTIDS) terminal. Currently the Navy's Advanced Combat Direction System (ACDS) ships equipped with block zero software have the capability for one way, or receive only TADIL-J. Ships equipped with ACDS and block one software have the capability for two way or, receive and transmit, capability on TADIL-J. [Ref. 23]

Accordingly the JMCIS system was scored "yes" for TADIL-A and TADIL-J, and scored a "no" for NATO Link-1, TADIL-B, and Data Link Forwarding.

C. SCORING MAINTENANCE REQUIREMENTS

Under the category of Maintenance Requirements the three level two categories were Data Extraction, Data Reduction, and Error Detection. Table 6-2 is a summary of the score of the Maintenance Requirements.

Table 6-2 MAINTENANCE FUNCTIONS SCORE

Data Reduction	Specified output devices	No
	By file name	No
	filter entry	No
Data Extraction	Annotation of data	No
	Start, Suspend, terminate	No
	Select by output device	No
	Select by link type	No
	Select by extraction pt	No
Error Detection	building, interpretation and error detection of me	Yes

1. Data Extraction

The requirements under Data Extraction in the ATACC specifications generally deal with the capability to extract a sample of data for future analysis. The specific requirements in this section deal with capabilities regarding the control of taking that sample data and the storage, marking and maintaining that data.

The JMCIS system was not designed with a data extraction capability specifically intended for data link communications. The JMCIS system was designed to communicate and share data over a variety of links and communication paths. The system does have the capability to view incoming data and route that data from an incoming port to another out going port. It is conceivable that a form of data extraction could be done by routing an incoming data stream to an external port and capturing that data with some other recording device. [Ref. 23] A data extraction of this method would not provide for the specified control and annotation capability detailed in the ATACC requirements. Accordingly the JMCIS system was scored a "no" for all of the functional requirements under data extraction.

2. Data Reduction

The data reduction capability is normally considered the processing of the data collected or sampled during the data extraction process. The JMCIS system was scored as "no" for all of the requirements under Data Reduction since the system has neither the capability to take samples nor analyze them. [Ref. 23]

3. Error Detection

The function of error detection for data links is not contained in the JMCIS system. However, considering the combination of the JMCIS system and the appropriate link terminating equipment there is considerable error checking . For TADIL-A the error detection is done in either the PLT, ELDS, or EDO Box and for TADIL-J the error detection is done at the JTIDS terminal. [Ref. 23] Therefore the JMCIS system was scored as a "yes" for the requirements under Error Detection.

D. SCORING THE PERFORMANCE REQUIREMENTS

Under the level one category of Performance Requirements there were six level two requirements categories of Maintainability, Reliability, Availability, Data Through-put, Data Link Track Capacity, and Multiple Data Link Capability. Table 6-3 is a summary of the Performance Requirements Score.

1. Maintainability

The ATACC system specification describes the maintainability requirements and delineates these requirements for the appropriate echelon of maintenance. These levels of maintenance are Organizational level (first and second echelon), Intermediate level (on-equipment, third echelon), and Intermediate level (off-equipment, fourth echelon). The JMCIS system does not delineate maintainability by echelon of maintenance but rather by MTTR for hardware and MTTR for software. The JMCIS criteria for these MTTR is $\leq$ 1.00 hour for hardware and $\leq$ 20 minutes for software. [Ref. 16:p. 12] These times can be roughly considered equivalent to the ATACC requirements and therefore the JMCIS system was scored "yes" for the maintainability requirements.

Table 6-3 PERFORMANCE STANDARDS SCORE

Maintainability	MTTR <30min 3rd echelon	Yes
	MTTR <1hr 4th echelon	Yes
	MTTR organizational	Yes
Reliability	24hrs x 30days	Yes
	348hr MTBF	Yes
Availability	Ai=.999	Yes
Through-put	2250bps TADIL-A	No
	1200bps TADIL-B	No
	1200bps NATO-1	Yes
	28.8-23.8kbps TADIL-J	Yes
Track Capacity	500 JTAO tracks	Yes
	400 Ground Tracks	No
	100 Engagements	No
	40 Fixed marks	No
	Track cap. growth	No
Multi Links	9 TADIL-B Links	Yes

2. Reliability

The ATACC system specification for reliability details a lower threshold of mean time between failure (MTBF) of 348 hours, and the formula for calculating the reliability percentage. The JMCIS system criterion specifies a separate MTBF for hardware ($\geq$ 800 hours) and MTBF software ($\geq$200 hours). [Ref. 24:p. 11] After evaluating the differences between the two system requirements the JMCIS system was scored "yes" for the reliability requirements.

3. Availability

The ATACC system specification defines availability as the probability that the ATACC is totally operable at any random point in time. The minimum inherent availability (Ai) of each ATACC suite shall be 0.999, based on specified reliability and maintainability requirements, expressed as a percentage ratio. The criterion availability for the JMCIS system is $\geq .96$. In an operational evaluation of NTCS-A version 2.0, the version that preceded JMCIS, the demonstrated operational availability was 0.89 aboard USS KITTY HAWK and 0.99 aboard USS COWPENS. [Ref. 24:p. 12] After considering the differences in the availability rates and the different calculation methods, the JMCIS was scored as a "yes" for the requirements under Availability.

4. Data Through-put

The system requirements grouped under Data Through-put specify the speed at which the different data links must pass data. The JMCIS system was scored "yes" for TADIL-A and TADIL-J and for all others was scored "no". [Ref. 23]

5. Data Link Track Capacity

The requirements grouped under Data Link Track Capacity generally deal with the minimum numbers of the different types of tracks the system must be able to display. The different categories of tracks are: JTAO Tracks, Ground Tracks, Engagements, and Fixed Marks. The specifications also list the desired Track Growth Capacity. The JMCIS system is capable of displaying 2000 OTH Gold tracks and any combination of 500 data link tracks. Considering the system capability the JMCIS system was scored a "yes" for JTAO Tracks, and Ground Tracks, and was scored as "no" for Engagements, Fixed Marks and Track Capacity Growth. [Ref. 23]

6. Multiple Data Link Capability

The functional category of Multiple Data Link Capacity refers to the section of the system specification where the specific numbers of data links the system must be capable of performing at the same time. The requirement specifies that the system be capable of operating on nine different TADIL-B links at the same time. Recognizing that the JMCIS system cannot operate on any TADIL-B data links, the system was scored as "no" for this requirement. [Ref. 23]

E. SURVEY RESULTS

The elicitation methods described in Chapter V were used to gain data from the survey subjects. U.S. Marine Corps Officers with previous command and control experience comprised the survey sample. The subjects all previously had spent time working in a Marine Tactical Air Command Center (TACC) or Tactical Air Operations Center (TAOC), and were familiar with the Tactical Digital Information Links used by the Marine Corps. The survey elicited opinion data from six subjects. The results derived from a sample of this size were not intended to be statistically significant, rather they are intended to *illustrate* the comparison methodology rather than the results.

The software package DecisionPlus™ gathered the individual rating factors from the subjects and also calculated the overall weighting functions for the scoring of the alternatives. The software provided a list of weights by criteria and an overall score for both the JMCIS System and the Ideal System for each subject.

1. Score Calculation Process

The scores were calculated by DecisionPlus™ in a method that weighed the presence of a functional criteria based upon the subjects impression of the criteria's importance.

a. Ratings to Weighed Criteria

DecisionPlus™ recorded the subjects rating of each of the level one, two and three criteria. The ratings for the individual criteria were converted to the level three weighted criteria by multiplying the level three rating by the parent level two ratting and the level one parent ratting. The resulting set of level three weights all sum to one. This normalized list of weights was considered as the weighted importance of the level three functional requirements.

b. Alternative Scoring

The scoring of the JMCIS system and the Ideal system was also done in DecisionPlus™. This scoring was conducted by the researcher and the scale was a dichotomous yes or no decision. The yes or no score indicated whether the alternative system could, or could not meet the specified requirement. This scoring on the dichotomous scale yielded a ratting value of zero for a no response, and one for a yes response. The requirement scores as a group represent the by requirement evaluation of the alternative systems.

c. Individual Overall Score of the System

The score of the alternative systems on each criteria was determined by multiplying the weighted importance of the level three functional requirements by the appropriate requirement score. This operation yielded the score of the system for that criteria and the sum of all the criteria is the overall score of the system. The ideal system was scored as yes on all of the criteria and therefore the sum of the criteria scores was one. The overall score of the system was calculated by DecisionPlus™ for the individual sets of data.

d. Average Ratings Set

DecisionPlus™ has the capability to link several individual rating models into an aggregated result. This method of linking was attempted and a calculation error in DecisionPlus™ was detected. [Ref. 25] The logic of the data aggregation model was recreated in a Lotus 123™ spread sheet and the individual rating data was exported from DecisionPlus™. The individual responses to each rating were averaged to come up with an average set of ratings for the group.

e. Average Weighted Importance of Level three Requirements

The average ratings were multiplied in the same manor as the individual ratings (Level three rating *Parent Level two ratting *Parent Level one ratting) to come up with the average weighted importance of the level three functional requirements.

f. Average Overall Score of the System

The average overall score of the system was calculated in the same method as the individual score of the system with the exception of using the average weighted importance of level three requirements vice the individual weights. The data and the steps used while generating the average overall system score for JMCIS is provided in Table 6-4. The table consists of four columns of data labeled and calculated as follows:

- **JMCIS Score:** represents the researchers dichotomous evaluation of JMCIS for the level three requirements.
- **Avg Rating:** represents the Average Rating which is the average of each of the subjects rating value given for that requirement.
- **Std. Dev:** represents the Standard Deviation of the rating values for a specific requirement.
- **Avg. Weight:** represents the average weighting factor for that requirement. It is calculated by multiplying the average level three rating by its parent level two and one average rating value.

Appendix D provides a complete listing of the individual and average data.

F. ANALYSIS OF DATA

Table 6-4 depicted the average ratings of the criteria, the score of the level three criteria, and the overall score of the JMCIS system. There are a total of 34 level three functional requirements. Of these 34 functional requirements the JMCIS was evaluated as meeting 17 and not meeting 17. The 17 requirements that JMCIS did fulfill accounted for a score of .67 out of a possible perfect score of 1.00. Let us now turn our attention to not

Table 6-4 AVERAGE OVERALL SYSTEM SCORE CALCULATIONS

	JMCIS Score	Avg. Rating	Std. Dev	Avg. Weight	Avg. Score
Operational Functions		0.3717	0.0271		
System Interface		0.3533	0.0807		
Prompts	1	0.3433	0.0952	0.045	0.0451
Menus	1	0.365	0.0653	0.048	0.0479
Display aids	1	0.295	0.1299	0.039	0.0387
Readout		0.3217	0.0445		
Hook Data	1	1	0	0.12	0.1196
Link capability		0.32	0.0972		
TADIL-J	1	0.22	0.0245	0.024	0.0242
NATO Link 1	0	0.17	0.0548	0.014	0
TADIL-B	0	0.2	0.011	0.01	0
Link Forwarding	0	0.2117	0.0306	0.014	0
TADIL-A	1	0.2	0.0395	0.042	0.0423
Maintenance Functions		0.2667	0.0579		
Data Reduction		0.2867	0.0814		
Specified output dev	0	0.375	0.0981	0.029	0
By file name	0	0.2817	0.0935	0.022	0
filter entry	0	0.3417	0.0449	0.026	0
Data Extraction		0.3133	0.0585		
Annotation of data	0	0.1867	0.0186	0.016	0
Start, Stop, Suspend	0	0.22	0.0268	0.018	0
Select by output dev	0	0.1867	0.0186	0.016	0
Select by link type	0	0.2067	0.0383	0.017	0
Select by extraction	0	0.2033	0.0585	0.017	0
Error Detection		0.3967	0.1031		
building, interpretat	1	1	0	0.106	0.1058
Performance Standards		0.3583	0.0634		
Maintainability		0.1983	0.0248		
MMTR <30min 3rd	1	0.3283	0.0293	0.023	0.0233
MMTR <1hr 4th ecl	1	0.28	0.0369	0.02	0.0199
MTTR organization	1	0.3867	0.0437	0.027	0.0275
Reliability		0.1983	0.0319		
24hrs x 30days	1	0.535	0.0586	0.038	0.038
348hr MTBF	1	0.465	0.0586	0.033	0.033
Availability		0.1617	0.0248		
Ai=.999	1	1	0	0.058	0.0579
Through-put		0.175	0.0558		
2250bps TADIL-A	1	0.2517	0.0299	0.016	0.0158
1200bps TADIL-B	0	0.2383	0.0271	0.015	0
1200bps NATO-1	0	0.23	0.046	0.014	0
28.8-23.8kbps TAD	1	0.2817	0.0313	0.018	0.0177
Track Capacity		0.1417	0.0337		
500 JTAO tracks	1	0.255	0.0489	0.013	0.0129
400 Ground Tracks	1	0.175	0.0543	0.009	0.0089
100 Engagements	0	0.155	0.0418	0.008	0
40 Fixed marks	0	0.175	0.0753	0.009	0
Track cap. growth	0	0.2417	0.0204	0.012	0
Multi Links		0.1333	0.0489		
9 TADIL-B Links	0	1	0	0.048	0
Average Overall JMCIS Score					**0.6786**

what the system does but what it does not do. The 17 requirements that were not fulfilled are distributed among the level one functional categories as follows:

- three (3) from Operational Functions
- eight (8) from Maintenance Functions
- six (6) from Performance Standards

Rather than look at the unfulfilled requirements as they relate to the level one functional categories, a more meaningful measure is to group the requirements by similarities from within the group of 17. Categorizing the requirements based upon similarities the 17 unfulfilled requirements can be assembled into seven groups. Table 6-5 depicts the consolidation of these requirements into the seven groups with the individual contribution and the group total contribution. The groups are listed in the order of highest group total to lowest group total. Rather than dealing with the 17 unfulfilled requirements individually, this table depicts the major categorical shortcomings of the JMCIS system. Additionally it depicts where the largest improvement in score could be gained when deciding to add new functionality to JMCIS.

The seven groups of unfulfilled requirements are:

- Data Extraction Group
- Data Reduction Group
- Multiple Links
- Forwarding
- NATO Link Group

Table 6-5 RANKING OF MISSING FUNCTIONALITY

	Avg. Weight	Total By Group	Group % of Total
Data Extraction Group			
Annotation of data	0.0156		
Start, Stop, Suspend	0.0184		
Select by output device	0.0156		
Select by link type	0.0173		
Select by extraction pt	0.017	0.083834	**27.612**
Data Reduction Group			
Specified output devices	0.0287		
By file name	0.0215		
filter entry	0.0261	0.076317	**25.136**
Multiple Links			
9 TADIL-B Links	0.0478	0.047778	**15.736**
Track Capacity Group			
100 Engagements	0.0079		
40 Fixed marks	0.0089		
Track cap. growth	0.0123	0.02902	**9.5581**
NATO Link Group			
NATO Link 1	0.0137		
1200bps NATO-1	0.0144	0.028074	9.2465
TADIL-B Group			
TADIL-B	0.01		
1200bps TADIL-B	0.0149	0.024975	**8.226**
Forwarding			
Link Forwarding	0.0136	0.013617	**4.485**
Total Points for Unfulfilled Requirements		**0.303616**	

- TADIL-B Group
- TADIL-B
- 1200 bps TADIL-B
- Track Capacity

The grouping of the unfulfilled requirements in this manor illuminates the fact that the major shortcomings of the JMCIS system came under the level two category of maintenance functions. The missing maintenance functions alone account for over 50% of the missing points. If the system were to implement the maintenance functions of data extraction, data reduction, and the required control features, the overall system score would go from 0.68 to 0.85.

VII. CONCLUSIONS

A. THE FINDINGS

By using the Simple Multi-Attribute Rating Technique to conduct a comparison of the capabilities found in JMCIS with the ATACC data link requirements, a numerical score was calculated. This figure represents the percentage of functionality required by the ATACC specifications that is found in the JMCIS system. The score is weighted to represent a higher percentage value for the requirements evaluated as more mission critical by a survey of subject area experts. Combining the authors evaluation of the JMCIS functionality and interpretation of the ATACC specifications with the subject experts evaluations, the comparison method revealed a 68% correlation.

The requirements that were evaluated as not being met by the JMCIS system compromise the remaining 32%. Closer evaluation of these unfulfilled requirements reveals that over half of them are maintenance related requirements in the areas of Data Extraction and Data Reduction capabilities.

B. FURTHER RESEARCH

This comparison has attempted to measure the commonalty between a set of requirements and the capabilities within JMCIS. The methodology used in this comparison represents an alternative method for assessing the potential systems to be migrated to the JMCIS environment. The evolutionary process of command and control systems migrating to the JMCIS environment normally begins with an analysis of the required functionality. This functionality analysis in the past has been focused on what functionality will reside in the common core, and what system unique functionality will be maintained in an application segment to JMCIS. The modeling approach taken in this thesis could be used on a larger scale to determine trends in the unfulfilled requirements across several systems. The scores from candidate systems could be compared by conducting an analysis similar to this thesis before and after functions common to the systems were added to the core. This would represent the value of adding those functions to the core.

The author presents the JMCIS philosophy toward system engineering which revealed several key questions that routinely arise during system migration. Currently, there is much work underway involving system migration and analysis of what systems would make good migration candidates. These questions and the search for better ways to answer them will be at the forefront of system engineering for some time to come. The benefits achieved by the system design philosophy that gave birth to JMCIS are key to the elusive improvements sought on numerous fronts. For this reason, any other research efforts that attempt to provide better or alternative methods for comparing systems or system functionality will be of benefit to the community.

APPENDIX (A): TACTICAL DIGITAL INFORMATION LINKS

The definitions of the different types of data links as listed in Joint Publication 1 (DOD Dictionary of Military and Associated Terms, JP 1-02) and in FMFM 3-30 Communications, 3 April 1989, are provided as follows:

A. TADIL

A Tactical Digital Information Link is a Joint Staff approved, standardized communication link suitable for transmission of digital information. The current practice is to characterize a tactical digital information link (TADIL) by its standardized message formats and transmission characteristics. TADILs interface two or more command and control or weapons systems via a single or multiple network architecture. Multiple communication media can be used for the exchange of this tactical information. [Ref. 26:CD version]

B. TADIL-A

TADIL-A is a secure, half-duplex, netted digital data link utilizing parallel transmission frame characteristics and standard message formats at either 1364 or 2250 bits per second. It is normally operated in a roll-call mode under control of a net control station to exchange digital information among airborne, land-based, and shipboard systems. Data from sensors such as radar is processed, then time multiplexed on either HF or UHF for transmission to all participants in the net. TADIL-A utilizes the M-series message standard described in JCS Pub 6-01.1(C) and its NATO equivalent is Link 11. [Ref. 26:CD version]

C. TADIL-B

TADIL-B is a secure, full-duplex, point-to-point digital data link utilizing serial transmission frame characteristics and standard message formats at either 2400, 1200, or 600 bits per second. It interconnects tactical air defense and air control units. TADIL-B utilizes the M-series messages standard described in JCS Pub 6-01.1 (C). [Ref. 26:CD version]

D. TADIL-J

TADIL-J is a secure, high capacity, jam-resistant, node-less data link which uses the Joint Tactical Information Distribution System (JTIDS) transmission characteristics. The JTIDS protocols, conventions, and fixed-length message formats defined by the JTIDS Technical Interface Design Plan (TIDP) are also used. The spread spectrum (Frequency Hopping) system uses the JTIDS Class 2 Time Division Multiple Access (TDMA) terminal to broadcast J-series messages to all / specific participants. [Ref. 26:CD version]

E. NATO LINK 1

NATO Link 1 (North Atlantic Treaty Organization Link 1) or NADGE Link 1 (NATO Air Defense in the Ground Environment Link 1) is a NATO point-to-point digital data link. This link utilizes serial transmission frame characteristics and standard message formats at a speed of 600, 750, 1200, or 1500 bits per second. [Ref. 27p. 44]

APPENDIX (B): SIMPLE MULTI-ATTRIBUTE RATING TECHNIQUE

The Simple Multi-attribute Rating Technique (SMART) can be considered a derivative of the Multi-attribute Utility Theory (MAUT) of which versions can be traced back as far as 1959. In 1971 Dr. Ward Edwards knew of the theory behind MAUT but was frustrated with its complicated measurement and elicitation techniques it seemed to require. Dr. Edwards thought that some set of simple and robust procedures would be better than the theoretical soundness and elegance of MAUT. His answer was SMART. SMART ignores measurement theory and non-additives and instead relies on simple additive models, numerical estimation techniques for eliciting single-attribute values and ratio estimation of weights. There are now several different versions of SMART but all have in common the reliance upon direct numerical estimation methods. [Ref. 20:p. 278]

In Dr. Edwards article "How to Use Multi-attribute Utility Measurement for Social Decisionmaking", IEEE Transactions on Systems, Man, and Cybernetics, Vol. SMC-7, No 5, May 1977, the following ten steps to SMART were identified:

1. Identify the person or organization whose utilities are to maximized
2. Identify the issue or issues to which the utilities needed are relevant.
3. Identify the entities to be evaluated.
4. Identify the relevant dimensions of value for evaluation of the entities.
5. Rank the dimensions in order of importance.
6. Make ratio estimates of the relative importance of each attribute relative to the one ranked lowest in importance.
7. Sum the importance weights: divide each by the sum.
8. Measure the relative value of each entity (alternative, object) on each dimension on a scale of 0 to 100.
9. Calculate the overall values using a weighted additive model.
10. Choose the alternative that maximizes the overall value. [Ref. 28:p. 328]

In recent versions of SMART the structuring of steps 1-4 have been emphasized. Recognizing the hierarchical nature of structures of objects and attributes frequently leads to versions of SMART that make use of value trees and hierarchical weighting procedures. [Ref. 20:p. 279]

APPENDIX (C): CRITERIUM DECISIONPLUS™

A. CAPABILITIES

DecisionPlus™ implements two primary decision making methodologies, the Analytical Hierarchy Process (AHP) and a Multi-Attribute Utility Theory as implemented in the Simple Multi-Attribute Rating Technique (SMART). In this software package the primary differences between AHP and SMART lies in the different rating techniques used.

When using SMART for decision making the problem is broken down into attributes, and single attribute evaluations are constructed by means of value measurements . A value tree structure is created to assist in defining the problem. The values are determined for each attribute and the software does aggregation of the model to provide results of the compared alternatives. [Ref. 29:p. 33] The value tree starts with a goal and then branches out into criteria relating to that goal, and finally ending in alternatives for that goal. DecisionPlus™ is limited to seven levels including the goal level and the alternatives. The software will support a maximum of 255 blocks in the model and a maximum of 100 blocks on any level not including the alternative level. There can be a maximum of 50 alternatives and these also count against the total of 255 blocks. [Ref. 29:p. 33]

SMART provides a simplified method of employing MAUT techniques and allows the user to use a direct rating procedure for assessing single attribute values, and use additive aggregation in calculating the preferred alternative. DecisionPlus™ also supports nonlinear functions in assigning values to the attributes. [Ref. 29:p. 33]

1. Brainstorming

The first step in the decision process is to define the problem. DecisionPlus™'s brainstorming capability assists the user in identifying the issues. The brainstorming session starts with a blank canvas ... des the user into defining a goal, important criteria, and alternatives. The goal and the criteria are grouped and connected by the user based upon the users perception of the relationships. Figure C-1 is an example of a completed brainstorm session. [Ref. 29:p. 44]

2. Build the Hierarchy

After using the brainstorming function the saved session automatically generates the hierarchy or structure. If the brainstorming function was not used the structure can be created and edited through a user friendly mouse driven interface. Figure 5-1 is an example of a completed hierarchy created by DecisionPlus™. [Ref. 29:p. 44]

3. Weight the Criteria

Once the hierarchy is constructed the individual criteria must be assigned weights. The assignment of weights is a separate task but is done in DecisionPlus™'s Hierarchy session. By double clicking on a criteria or selecting rate sub-criteria from the main menu, the Criterion Rating window appears. In this window the subject is presented with a customizable view to elicited the rating information. Figure C-2 is an example of the Criterium Rating Window.

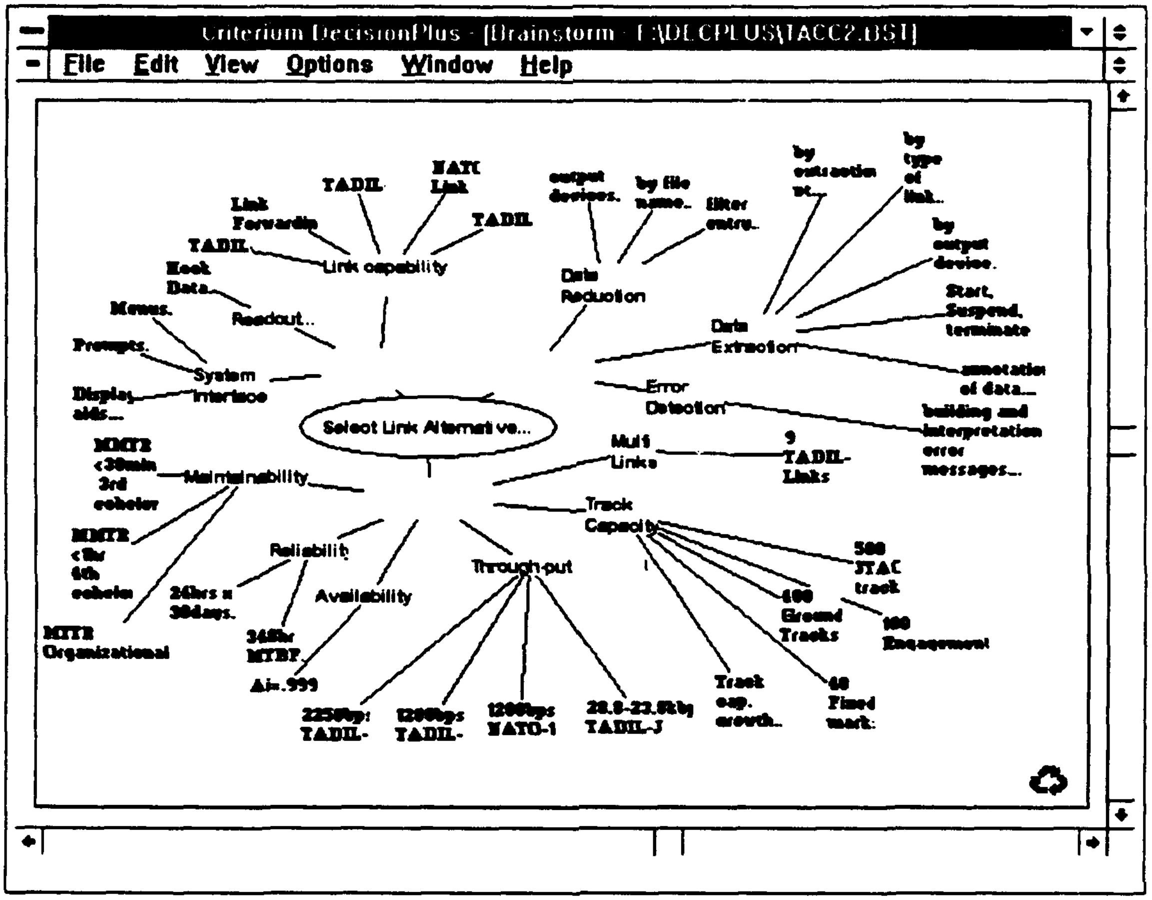

Figure C-1 Brainstorm-Graph

a. The Rating Views

DecisionPlus™ provides the capability to select between three different rating views. These views are selectable and are not mutually exclusive.

(1) Numerical View

In the numerical view the criterion that are being rated appear next to a box where a numerical weighting value can be entered. The numerical range of the box is selectable and unless modified it defaults to a 0.00 to 100.00 scale.

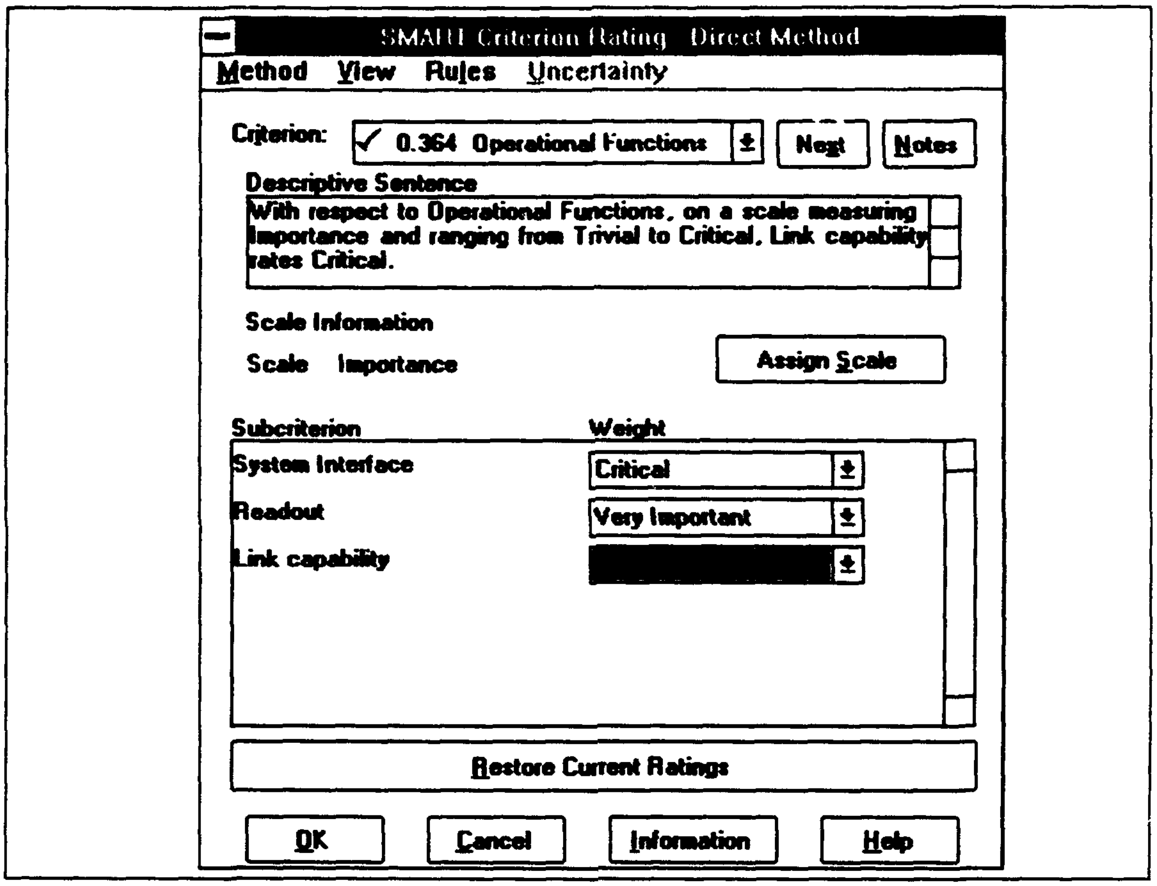

Figure C-2 Criterion Rating Window

(2) Graphical View

In the graphical view the subject is presented with the sub-criterion next to a sliding bar. The evaluation is done by using a mouse to move the position of the bar to indicate the rating.

(3) Verbal View

In the verbal view six different verbal measurements can be assigned, each with its own numerical scale. The subject is presented with the sub-criteria next to a verbal measure in a pull down menu box. Opening the menu bar reveals the other verbal measurements available for that sub-criterion with the currently selected one highlighted. Figure C-2 is an example of the presentation with the verbal view with the optional descriptive sentence.

(4) Descriptive Sentence

The Descriptive sentence is a sentence describing the rating logic as it relates to your goal. It uses the wording of the verbal scale selected to describe how one sub-criterrion is to be rated against another sub-criterion. Upon selecting a different verbal scale, or changing the ratings, the wording in the descriptive sentence changes also. [Ref. 29:p. 128]

4. Review the Results

After the hierarchy has been rated the results can be reviewed in one of several different forms. The results can be viewed as discrete values representing the preferences of the alternatives, or a view of the contributions screen. The contribution screen shows the contribution to each alternative preference based on the criteria at a given level in the hierarchy. [Ref. 29:p. 47]

5. Sensitivity Analysis

DecisionPlus™ supports checking for reasonableness of the decision with its Sensitivity Analysis function. The sensitivity analysis determines how sensitive the decision is to changes in the values assigned to the criteria. Upon selecting Sensitivity Analysis, DecisionPlus™ shows a list of the criteria with a metric that measures the sensitivity of the result when a change to the value of the child criteria is made. The list is prioritized in order of most critical to least critical to focus attention on the criteria that can influence the decision the most. [Ref. 29:p. 48]

6. Document the Decision

DecisionPlus™ provides a complete report generation program to display the results of rating or the generation of the hierarchy chart. Some of the printable graphs and reports are:

- Hierarchy - Graph
- Hierarchy - Data
- Hierarchy - Notes & Rules
- Hierarchy - Results Graph
- Hierarchy - Results Data
- Hierarchy - Sensitivity Graph
- Hierarchy - Uncertainty Inputs
- Hierarchy - Uncertainty Results
- Hierarchy - Uncertainty Data
- Hierarchy - Level Contributions
- Hierarchy - Uncertainty Sensitivity

By selecting the report option instead of the single items listed above a combination of any of the above can be combined into a report. [Ref. 29:p. 21]

APPENDIX (D): DATA

Appendix D provides the data generated in the initial, intermediate and final steps of the calculations. This section displays the responses from the subjects and other statistical data.

	Evaluation of JMCIS	S1 Rt	S1 Wt	S2 Rt	S2 Wt	S3 Rt	S3 Wt	S4 Rt	S4 Wt	S5 Rt	S5 Wt	S6 Rt	S6 Wt	Average Avg Rt	Avg Wt	AvgWt*Score
Operational Functions		0.36		0.38		0.33		0.4		0.36		0.4		0.3716667		
System Interface		0.44		0.4		0.22		0.3		0.36		0.4		0.3633333		
Prompts	1	0.38	0.06019	0.4	0.061	0.17	0.012	0.38	0.046	0.3	0.0389	0.43	0.0688	0.3433333	0.0451	0.0450873
Menus	1	0.38	0.06019	0.4	0.061	0.33	0.024	0.25	0.03	0.4	0.0518	0.43	0.0688	0.365	0.0479	0.04793261
Display aids	1	0.25	0.0396	0.2	0.03	0.5	0.036	0.38	0.046	0.3	0.0389	0.14	0.0224	0.295	0.0367	0.03674006
Readout		0.33		0.3		0.33		0.3		0.27		0.4		0.3216667		
Hook Data	1	1	0.1188	1	0.114	1	0.109	1	0.12	1	0.0972	1	0.16	1	0.1196	0.11966278
Link capability		0.22		0.3		0.44		0.4		0.36		0.2		0.32		
TADIL-J	1	0.2	0.01584	0.25	0.029	0.22	0.032	0.25	0.04	0.2	0.0259	0.2	0.016	0.22	0.0242	0.02417067
NATO Link 1	0	0.2	0.01584	0.13	0.015	0.11	0.016	0.25	0.04	0.2	0.0259	0.13	0.0104	0.17	0.0137	0
TADIL-B	0	0.2	0.01584	0.19	0.022	0.22	0.032	0.19	0.03	0.2	0.0259	0.2	0.016	0.2	0.01	0
Link Forwarding	0	0.2	0.01584	0.19	0.022	0.22	0.032	0.19	0.03	0.2	0.0259	0.27	0.0216	0.2116667	0.0136	0
TADIL-A	1	0.2	0.01584	0.25	0.029	0.22	0.032	0.13	0.021	0.2	0.0259	0.2	0.016	0.2	0.0423	0.04233333
Maintenance Functions		0.36		0.25		0.22		0.3		0.27		0.2		0.2666667		
Data Reduction		0.3		0.22		0.4		0.33		0.3		0.17		0.2866667		
Specified output device	0	0.5	0.054	0.33	0.018	0.5	0.044	0.29	0.029	0.3	0.0243	0.33	0.0112	0.375	0.0287	0
By file name	0	0.17	0.01836	0.33	0.018	0.17	0.015	0.29	0.029	0.4	0.0324	0.33	0.0112	0.2816667	0.0216	0
filter entry	0	0.33	0.03564	0.33	0.018	0.33	0.029	0.43	0.043	0.3	0.0243	0.33	0.0112	0.3416667	0.0261	0
Data Extraction		0.3		0.33		0.4		0.22		0.3		0.33		0.3133333		
Annotation of data	0	0.15	0.0162	0.19	0.016	0.19	0.017	0.2	0.013	0.19	0.0154	0.2	0.0132	0.1866667	0.0156	0
Start, Stop, Suspend	0	0.23	0.02484	0.19	0.016	0.25	0.022	0.2	0.013	0.25	0.0203	0.2	0.0132	0.22	0.0184	0
Select by output device	0	0.15	0.0162	0.19	0.016	0.19	0.017	0.2	0.013	0.19	0.0154	0.2	0.0132	0.1866667	0.0156	0
Select by link type	0	0.15	0.0162	0.25	0.021	0.25	0.022	0.2	0.013	0.19	0.0154	0.2	0.0132	0.2066667	0.0173	0
Select by extraction pt	0	0.31	0.03348	0.19	0.016	0.13	0.011	0.2	0.013	0.19	0.0154	0.2	0.0132	0.2033333	0.017	0
Error Detection		0.4		0.44		0.2		0.44		0.4		0.5		0.3966667		
building, interpretation a	1	1	0.144	1	0.11	1	0.044	1	0.132	1	0.108	1	0.1	1	0.1058	0.10577778
Performance Standards		0.27		0.38		0.44		0.3		0.36		0.4		0.3583333		
Maintainability		0.19		0.2		0.24		0.17		0.21		0.18		0.1983333		
MMTR <30min 3rd ech	1	0.36	0.01847	0.36	0.027	0.29	0.031	0.33	0.017	0.3	0.0227	0.33	0.0238	0.3283333	0.0233	0.02333447
MMTR <1hr 4th echelon	1	0.27	0.01385	0.27	0.021	0.29	0.031	0.33	0.017	0.3	0.0227	0.22	0.0158	0.28	0.0199	0.01989944
MTTR organizational	1	0.36	0.01847	0.36	0.027	0.43	0.045	0.33	0.017	0.4	0.0302	0.44	0.0317	0.3866667	0.0275	0.02748019
Reliability		0.19		0.15		0.18		0.22		0.21		0.24		0.1983333		
24hrs x 30days	1	0.57	0.02924	0.57	0.032	0.57	0.045	0.43	0.028	0.57	0.0431	0.5	0.048	0.535	0.038	0.03802215
348hr MTBF	1	0.43	0.02206	0.43	0.025	0.43	0.034	0.57	0.038	0.43	0.0325	0.5	0.048	0.465	0.033	0.03304729
Availability		0.19		0.15		0.12		0.17		0.16		0.18		0.1616667		
Ao= 999	1	1	0.0513	1	0.057	1	0.053	1	0.051	1	0.0576	1	0.072	1	0.0579	0.05793056
Through-put		0.14		0.1		0.24		0.17		0.16		0.24		0.175		
2250bps TADIL-A	1	0.25	0.00945	0.25	0.01	0.27	0.029	0.2	0.01	0.29	0.0167	0.25	0.024	0.2516667	0.0158	0.0157816
1200bps TADIL-B	0	0.25	0.00945	0.25	0.01	0.27	0.028	0.2	0.01	0.21	0.0121	0.25	0.024	0.2383333	0.0149	0
1200bps NATO-1	0	0.25	0.00945	0.25	0.01	0.2	0.021	0.3	0.015	0.21	0.0121	0.17	0.0163	0.23	0.0144	0
28 8-23 8kbps TADIL-J	1	0.25	0.00945	0.25	0.01	0.27	0.029	0.3	0.015	0.29	0.0167	0.33	0.0317	0.2816667	0.0177	0.01766285
Track Capacity		0.14		0.2		0.12		0.11		0.16		0.12		0.1416667		
500 JTAO tracks	1	0.24	0.00907	0.31	0.024	0.27	0.014	0.17	0.006	0.25	0.0144	0.29	0.0139	0.255	0.0129	0.01294479
400 Ground Tracks	1	0.18	0.0068	0.15	0.011	0.09	0.005	0.17	0.006	0.25	0.0144	0.21	0.0101	0.175	0.0089	0.00888368
100 Engagements	0	0.18	0.0068	0.15	0.011	0.09	0.005	0.17	0.006	0.13	0.0075	0.21	0.0101	0.155	0.0079	0
40 Fixed marks	0	0.18	0.0068	0.15	0.011	0.27	0.014	0.25	0.008	0.13	0.0075	0.07	0.0034	0.175	0.0089	0
Track cap growth	0	0.24	0.00907	0.23	0.017	0.27	0.014	0.25	0.008	0.25	0.0144	0.21	0.0101	0.2416667	0.0123	0
Multi Links		0.14		0.2		0.12		0.17		0.11		0.06		0.1333333		
9 TADIL-B Links	0	1	0.0378	1	0.076	1	0.053	1	0.051	1	0.0396	1	0.024	1	0.0478	0
Individual JMCIS Score		0.643		0.68		0.604		0.64		0.6576		0.771				
Sum of AvgWt* Score = Overall JMCIS Score																0.67858153

Mean JMCIS Score	0.665
Sample Standard Deviation	0.057
Median	0.65
Minimum Value	0.604
Maximum Value	0.771
Variance	0.003

Notes:
- Rt - The rating of the individual attributes
- Wt - The calculated weighted for the attribute Rt(Level1)*Rt(Level2)*Rt*(Level 3)
- Score - The sum of the Wts
- S1...S6 - Subject 1..6
- Avg Rt - Average Ratinvg Value
- Avg Wt. - Average Weight Value

Goal Level	Weights	Priorities	Subcriteria	Level 2	Weights	Priorities	Subcriteria	Level 3	Weights	Priorities	Subcriteria	Lowest Level	Mythical System Rati	Mythical System Prior	JMCIS System Rati	JMCIS System Prior
Brown. Sel	100.00	0.36	Operations	Operatio	100.00	0.44	System int	System I	75.00	0.38	Prompts	Prompts	100.00	1.00	100.00	1.00
	100.00	0.36	Maintenan		75.00	0.33	Readout		75.00	0.38	Menus	Menus	100.00	1.00	100.00	1.00
	75.00	0.27	Performan		50.00	0.22	Link capab		50.00	0.25	Display aid	Display aids	100.00	1.00	100.00	1.00
				Maintena	75.00	0.30	Data Redu	Readout	100.00	1.00	Hook Data	Hook Data	100.00	1.00	100.00	1.00
					75.00	0.30	Data Extra	Link capa	100.00	0.20	TADIL-J	TADIL-J	100.00	1.00	100.00	1.00
					100.00	0.40	Error Dete		100.00	0.20	NATO Link	NATO Link 1	100.00	1.00	0.00	0.00
				Performa	100.00	0.19	Maintainab		100.00	0.20	TADIL-B	TADIL-B	100.00	1.00	0.00	0.00
					100.00	0.19	Reliability		100.00	0.20	Link Forwa	Link Forward	100.00	1.00	0.00	0.00
					100.00	0.19	Availability		100.00	0.20	TADIL-A	TADIL-A	100.00	1.00	100.00	1.00
					75.00	0.14	Through-p	Data Red	75.00	0.50	Specified	Specified out	100.00	1.00	0.00	0.00
					75.00	0.14	Track Cap		25.00	0.17	By file nam	By file name	100.00	1.00	0.00	0.00
					75.00	0.14	Multi Links		50.00	0.33	fi'ter entry	filter entry	100.00	1.00	0.00	0.00
								Data Extr	50.00	0.15	Annotation	Annotation o	100.00	1.00	0.00	0.00
									75.00	0.23	Start, Sue	Start, Suspe	100.00	1.00	0.00	0.00
									50.00	0.15	Select by o	Select by out	100.00	1.00	0.00	0.00
									50.00	0.15	Select by ti	Select by tin	100.00	1.00	0.00	0.00
									100.00	0.31	Select by e	Select by ext	100.00	1.00	0.00	0.00
								Error Det	100.00	1.00	building, I	building, inte	100.00	1.00	100.00	1.00
								Maintaina	100.00	0.36	MMTR <30	MMTR <30mi	100.00	1.00	100.00	1.00
									75.00	0.27	MMTR <1h	MMTR <1hr	100.00	1.00	100.00	1.00
									100.00	0.36	MTTR orga	24hrs x 30da	100.00	1.00	100.00	1.00
								Reliability	100.00	0.57	24hrs x 30	349hr MTBF	100.00	1.00	100.00	1.00
									75.00	0.43	349hr MTB	Ai=.999	100.00	1.00	100.00	1.00
								Availabili	100.00	1.00	Ai=.999	2250bps TA	100.00	1.00	100.00	1.00
								Through-	100.00	0.25	2250bps T	1200bps TA	100.00	1.00	0.00	0.00
									100.00	0.25	1200bps T	1200bps NA	100.00	1.00	0.00	0.00
									100.00	0.25	1200bps N	28.8-23.8kbp	100.00	1.00	100.00	1.00
									100.00	0.25	28.8-23.8k	500 JTAO tra	100.00	1.00	100.00	1.00
								Track Ca	100.00	0.24	500 JTAO t	400 Ground	100.00	1.00	100.00	1.00
									75.00	0.18	400 Groun	100 Engage	100.00	1.00	0.00	0.00
									75.00	0.18	100 Engag	40 Fixed mar	100.00	1.00	0.00	0.00
									75.00	0.18	40 Fixed m	Track cap. gr	100.00	1.00	0.00	0.00
									100.00	0.24	Track cap.	9 TADIL-B Li	100.00	1.00	0.00	0.00
								Multi Lin	100.00	1.00	9 TADIL-B	MTTR organi	100.00	1.00	100.00	1.00

Goal Level	Weights	Priorities	Subcriteria	Level 2	Weights	Priorities	Subcriteria	Level 3	Weights	Priorities	Subcriteria	Lowest Level	Mythical System Rati	Mythical System Prior	JMCIS System Rati	JMCIS System Prior
Buckner, S	75.00	0.38	Operationa	Operatio	100.00	0.40	System Int	System I	50.00	0.40	Prompts	Prompts	100.00	1.00	100.00	1.00
	50.00	0.25	Maintenan		75.00	0.30	Readout		50.00	0.40	Menus	Menus	100.00	1.00	100.00	1.00
	75.00	0.38	Performan		75.00	0.30	Link capab		25.00	0.20	Display aid	Display aids	100.00	1.00	100.00	1.00
				Maintena	50.00	0.22	Data Redu	Readout	50.00	1.00	Hook Data	Hook Data	100.00	1.00	100.00	1.00
					75.00	0.33	Data Extra	Link capa	100.00	0.25	TADIL-J	TADIL-J	100.00	1.00	100.00	1.00
					100.00	0.44	Error Dete		50.00	0.13	NATO Link	NATO Link 1	100.00	1.00	0.00	0.00
				Performa	100.00	0.20	Maintainab		75.00	0.19	TADIL-B	TADIL-B	100.00	1.00	0.00	0.00
					75.00	0.15	Reliability		75.00	0.19	Link Forwa	Link Forward	100.00	1.00	0.00	0.00
					75.00	0.15	Availability		100.00	0.25	TADIL-A	TADIL-A	100.00	1.00	100.00	1.00
					50.00	0.10	Through-p	Data Red	75.00	0.33	Specified	Specified out	100.00	1.00	0.00	0.00
					100.00	0.20	Track Cap		75.00	0.33	By file nam	By file name	100.00	1.00	0.00	0.00
					100.00	0.20	Multi Links		75.00	0.33	filter entry	filter entry	100.00	1.00	0.00	0.00
								Data Extr	75.00	0.19	Annotation	Annotation o	100.00	1.00	0.00	0.00
									75.00	0.19	Start, Sus	Start, Suspe	100.00	1.00	0.00	0.00
									75.00	0.19	Select by o	Select by out	100.00	1.00	0.00	0.00
									100.00	0.25	Select by li	Select by lin	100.00	1.00	0.00	0.00
									75.00	0.19	Select by e	Select by ext	100.00	1.00	0.00	0.00
								Error Det	100.00	1.00	building, i	building, inte	100.00	1.00	100.00	1.00
								Maintaina	100.00	0.36	MMTR <30	MMTR <30mi	100.00	1.00	100.00	1.00
									75.00	0.27	MMTR <1h	MMTR <1hr	100.00	1.00	100.00	1.00
									100.00	0.36	MTTR orga	24hrs x 30ds	100.00	1.00	100.00	1.00
								Reliability	100.00	0.57	24hrs x 30	348hr MTBF	100.00	1.00	100.00	1.00
									75.00	0.43	348hr MTB	Ai=.999	100.00	1.00	100.00	1.00
								Availabili	100.00	1.00	Ai=.999	2250bps TA	100.00	1.00	100.00	1.00
								Through-	100.00	0.25	2250bps T	1200bps TA	100.00	1.00	0.00	0.00
									100.00	0.25	1200bps T	1200bps NA	100.00	1.00	0.00	0.00
									100.00	0.25	1200bps N	28.8-23.6kbp	100.00	1.00	100.00	1.00
									100.00	0.25	28.8-23.6k	500 JTAO tra	100.00	1.00	100.00	1.00
								Track Ca	100.00	0.31	500 JTAO t	400 Ground	100.00	1.00	100.00	1.00
									50.00	0.15	400 Groun	100 Engage	100.00	1.00	0.00	0.00
									50.00	0.15	100 Engag	40 Fixed mar	100.00	1.00	0.00	0.00
									50.00	0.15	40 Fixed m	Track cap. gr	100.00	1.00	0.00	0.00
									75.00	0.23	Track cap.	9 TADIL-B Li	100.00	1.00	0.00	0.00
								Multi Lin	50.00	1.00	9 TADIL-B	MTTR organi	100.00	1.00	100.00	1.00

Goal Level	Weights	Priorities	Subcriteria	Level 2	Weights	Priorities	Subcriteria	Level 3	Weights	Priorities	Subcriteria	Lowest Level	Mythical System Rati	Mythical System Prior	JMCIS System Rati	JMCIS System Prior
Jeff C. Sel	75.00	0.33	Operational	Operatio	50.00	0.22	System Int	System I	25.00	0.17	Prompts	Prompts	100.00	1.00	100.00	1.00
	50.00	0.22	Maintenan		75.00	0.33	Readout		50.00	0.33	Menus	Menus	100.00	1.00	100.00	1.00
	100.00	0.44	Performan		100.00	0.44	Link capab		75.00	0.50	Display aid	Display aids	100.00	1.00	100.00	1.00
				Maintena	100.00	0.40	Data Redu	Readout	50.00	1.00	Hook Data	Hook Data	100.00	1.00	100.00	1.00
					100.00	0.40	Data Extra	Link capa	100.00	0.22	TADIL-J	TADIL-J	100.00	1.00	100.00	1.00
					50.00	0.20	Error Data		50.00	0.11	NATO Link	NATO Link 1	100.00	1.00	0.00	0.00
				Performa	100.00	0.24	Maintainab		100.00	0.22	TADIL-B	TADIL-B	100.00	1.00	0.00	0.00
					75.00	0.18	Reliability		100.00	0.22	Link Forwa	Link Forward	100.00	1.00	0.00	0.00
					50.00	0.12	Availability		100.00	0.22	TADIL-A	TADIL-A	100.00	1.00	0.00	0.00
					100.00	0.24	Through-p	Data Red	75.00	0.50	Specified	Specified out	100.00	1.00	100.00	1.00
					50.00	0.12	Track Cap		25.00	0.17	By file nam	By file name	100.00	1.00	0.00	0.00
					50.00	0.12	Multi Links		50.00	0.33	filter entry	filter entry	100.00	1.00	0.00	0.00
								Data Extr	75.00	0.19	Annotation	Annotation o	100.00	1.00	0.00	0.00
									100.00	0.25	Start, Sus	Start, Suspe	100.00	1.00	0.00	0.00
									75.00	0.19	Select by o	Select by out	100.00	1.00	0.00	0.00
									100.00	0.25	Select by li	Select by lin	100.00	1.00	0.00	0.00
									50.00	0.13	Select by e	Select by ext	100.00	1.00	0.00	0.00
								Error Det	50.00	1.00	building, I	building, inte	100.00	1.00	100.00	1.00
								Maintaina	50.00	0.29	MMTR <30	MMTR <30mi	100.00	1.00	100.00	1.00
									50.00	0.29	MMTR <1h	MMTR <1hr	100.00	1.00	100.00	1.00
									75.00	0.43	MTTR orga	24hrs x 30da	100.00	1.00	100.00	1.00
								Reliability	100.00	0.57	24hrs x 30	348hr MTBF	100.00	1.00	100.00	1.00
									75.00	0.43	348hr MTB	Ai=.999	100.00	1.00	100.00	1.00
								Availabili	75.00	1.00	Ai=.999	2250bps TA	100.00	1.00	100.00	1.00
								Through-	100.00	0.27	2250bps T	1200bps TA	100.00	1.00	0.00	0.00
									100.00	0.27	1200bps T	1200bps NA	100.00	1.00	0.00	0.00
									75.00	0.20	1200bps N	28.8-23.8kbp	100.00	1.00	100.00	1.00
									100.00	0.27	28.8-23.8k	500 JTAO tra	100.00	1.00	100.00	1.00
								Track Ca	75.00	0.27	500 JTAO t	400 Ground	100.00	1.00	100.00	1.00
									25.00	0.08	400 Groun	100 Engage	100.00	1.00	0.00	0.00
									25.00	0.08	100 Engag	40 Fixed mar	100.00	1.00	0.00	0.00
									75.00	0.27	40 Fixed m	Track cap. gr	100.00	1.00	0.00	0.00
									75.00	0.27	Track cap.	9 TADIL-B Li	100.00	1.00	0.00	0.00
								Multi Lin	50.00	1.00	9 TADIL-B	MTTR organi	100.00	1.00	100.00	1.00

Goal Level	Weights	Priorities	Subcriteria	Level 2	Weights	Priorities	Subcriteria	Level 3	Weights	Priorities	Subcriteria	Lowest Level	Mythical System Rati	Mythical System Prior	UJMCIS System Rati	UJMCIS System Prior
King. Sele	100.00	0.40	Operations	Operatio	75.00	0.30	System Int	System I	75.00	0.38	Prompts	Prompts	100.00	1.00	100.00	1.00
	75.00	0.30	Maintenan		75.00	0.30	Readout		50.00	0.25	Menus	Menus	100.00	1.00	100.00	1.00
	75.00	0.30	Performan		100.00	0.40	Link capab		75.00	0.38	Display sid	Display side	100.00	1.00	100.00	1.00
				Maintena	75.00	0.33	Data Redu	Readout	75.00	1.00	Hook Data	Hook Data	100.00	1.00	100.00	1.00
					50.00	0.22	Data Extra	Link capa	100.00	0.25	TADIL-J	TADIL-J	100.00	1.00	100.00	1.00
					100.00	0.44	Error Dete		100.00	0.25	NATO Link	NATO Link 1	100.00	1.00	0.00	0.00
				Performa	75.00	0.17	Maintainab		75.00	0.19	TADIL-B	TADIL-B	100.00	1.00	0.00	0.00
					100.00	0.22	Reliability		75.00	0.19	Link Forwa	Link Forward	100.00	1.00	0.00	0.00
					75.00	0.17	Availability		50.00	0.13	TADIL-A	TADIL-A	100.00	1.00	100.00	1.00
					75.00	0.17	Through-p	Data Red	50.00	0.29	Specified	Specified out	100.00	1.00	0.00	0.00
					50.00	0.11	Track Cap		50.00	0.29	By file nam	By file name	100.00	1.00	0.00	0.00
					75.00	0.17	Multi Links		75.00	0.43	filter entry	filter entry	100.00	1.00	0.00	0.00
								Data Extr	50.00	0.20	Annotation	Annotation o	100.00	1.00	0.00	0.00
									50.00	0.20	Start. Sus	Start. Suspe	100.00	1.00	0.00	0.00
									50.00	0.20	Select by o	Select by out	100.00	1.00	0.00	0.00
									50.00	0.20	Select by li	Select by lin	100.00	1.00	0.00	0.00
									50.00	0.20	Select by e	Select by ext	100.00	1.00	0.00	0.00
								Error Det	100.00	1.00	building. I	building. Inte	100.00	1.00	100.00	1.00
								Maintaina	75.00	0.33	MMTR <30	MMTR <30mi	100.00	1.00	100.00	1.00
									75.00	0.33	MMTR <1h	MMTR <1hr	100.00	1.00	100.00	1.00
									75.00	0.33	MTTR orga	24hrs x 30da	100.00	1.00	100.00	1.00
								Reliability	75.00	0.43	24hrs x 30	348hr MTBF	100.00	1.00	100.00	1.00
									100.00	0.57	348hr MTB	Ai=.999	100.00	1.00	100.00	1.00
								Availabili	100.00	1.00	Ai=.999	2250bps TA	100.00	1.00	100.00	1.00
								Through-	50.00	0.20	2250bps T	1200bps TA	100.00	1.00	0.00	0.00
									50.00	0.20	1200bps T	1200bps NA	100.00	1.00	0.00	0.00
									75.00	0.30	1200bps N	28.8-23.8kbp	100.00	1.00	100.00	1.00
									75.00	0.30	28.8-23.8k	500 JTAO tra	100.00	1.00	100.00	1.00
								Track Ca	50.00	0.17	500 JTAO t	400 Ground	100.00	1.00	100.00	1.00
									50.00	0.17	400 Groun	100 Engage	100.00	1.00	0.00	0.00
									50.00	0.17	100 Engag	40 Fixed mar	100.00	1.00	0.00	0.00
									75.00	0.25	40 Fixed m	Track cap. gr	100.00	1.00	0.00	0.00
									75.00	0.25	Track cap.	9 TADIL-B Li	100.00	1.00	0.00	0.00
								Multi Lin	75.00	1.00	9 TADIL-B	MTTR organi	100.00	1.00	100.00	1.00

Goal Level	Weights	Priorities	Subcriteria	Level 2	Weights	Priorities	Subcriteria	Level 3	Weights	Priorities	Subcriteria	Lowest Level	Mythical System Rati	Mythical System Prior	JMCIS System Rati	JMCIS System Prior
Select Lin	100.00	0.36	Operations	Operatio	100.00	0.36	System Int	System I	75.00	0.30	Prompts	Prompts	100.00	1.00	100.00	1.00
	75.00	0.27	Maintenan		75.00	0.27	Readout		100.00	0.40	Menus	Menus	100.00	1.00	100.00	1.00
	100.00	0.36	Performan		100.00	0.36	Link capab		75.00	0.30	Display aids	Display aids	100.00	1.00	100.00	1.00
				Maintena	75.00	0.30	Data Redu	Readout	100.00	1.00	Hook Data	Hook Data	100.00	1.00	100.00	1.00
					75.00	0.30	Data Extra	Link capa	100.00	0.20	TADIL-J	TADIL-J	100.00	1.00	100.00	1.00
					100.00	0.40	Error Data		100.00	0.20	NATO Link	NATO Link 1	100.00	1.00	0.00	0.00
				Performa	100.00	0.21	Maintainab		100.00	0.20	TADIL-B	TADIL-B	100.00	1.00	0.00	0.00
					100.00	0.21	Reliability		100.00	0.20	Link Forwa	Link Forward	100.00	1.00	0.00	0.00
					75.00	0.16	Availability		100.00	0.20	TADIL-A	TADIL-A	100.00	1.00	100.00	1.00
					75.00	0.16	Through-p	Data Red	75.00	0.30	Specified	Specified out	100.00	1.00	0.00	0.00
					75.00	0.16	Track Cap		100.00	0.40	By file nam	By file name	100.00	1.00	0.00	0.00
					50.00	0.11	Multi Links		75.00	0.30	filter entry	filter entry	100.00	1.00	0.00	0.00
								Data Extr	75.00	0.19	Annotation	Annotation o	100.00	1.00	0.00	0.00
									100.00	0.25	Start. Sus	Start. Suspe	100.00	1.00	0.00	0.00
									75.00	0.19	Select by o	Select by out	100.00	1.00	0.00	0.00
									75.00	0.19	Select by li	Select by lin	100.00	1.00	0.00	0.00
									75.00	0.19	Select by e	Select by ext	100.00	1.00	0.00	0.00
								Error Det	100.00	1.00	building. I	building. inte	100.00	1.00	100.00	1.00
								Maintaina	75.00	0.30	MMTR <30	MMTR <30mi	100.00	1.00	100.00	1.00
									75.00	0.30	MMTR <1h	MMTR <1hr	100.00	1.00	100.00	1.00
									100.00	0.40	MTTR orgs	24hrs x 30ds	100.00	1.00	100.00	1.00
								Reliability	100.00	0.57	24hrs x 30	348hr MTBF	100.00	1.00	100.00	1.00
									75.00	0.43	348hr MTB	Ai.999	100.00	1.00	100.00	1.00
								Availabili	100.00	1.00	Ai.999	2250bps TA	100.00	1.00	100.00	1.00
								Through-	100.00	0.29	2250bps T	1200bps TA	100.00	1.00	0.00	0.00
									75.00	0.21	1200bps T	1200bps NA	100.00	1.00	0.00	0.00
									75.00	0.21	1200bps N	28.8-23.8kbp	100.00	1.00	100.00	1.00
									100.00	0.29	28.8-23.8k	500 JTAO tra	100.00	1.00	100.00	1.00
								Track Ca	100.00	0.25	500 JTAO t	400 Ground	100.00	1.00	100.00	1.00
									100.00	0.25	400 Groun	100 Engage	100.00	1.00	0.00	0.00
									50.00	0.13	100 Engag	40 Fixed mar	100.00	1.00	0.00	0.00
									50.00	0.13	40 Fixed m	Track cap. gr	100.00	1.00	0.00	0.00
									100.00	0.25	Track cap.	9 TADIL-B Li	100.00	1.00	0.00	0.00
								Multi Lin	25.00	1.00	9 TADIL-B	MTTR organi	100.00	1.00	100.00	1.00

Goal Level	Weights	Priorities	Subcriteria	Level 2	Weights	Priorities	Subcriteria	Level 3	Weights	Priorities	Subcriteria	Lowest Level	Mythical System Rati	Mythical System Prior	JMCIS System Rati	JMCIS System Prior
Swett. Sel	100.00	0.40	Operations	Operatio	100.00	0.40	System Int	System I	75.00	0.43	Prompts	Prompts	100.00	1.00	100.00	1.00
	50.00	0.20	Maintenan		100.00	0.40	Readout		75.00	0.43	Menus	Menus	100.00	1.00	100.00	1.00
	100.00	0.40	Performan		50.00	0.20	Link capab		25.00	0.14	Display aid	Display aids	100.00	1.00	100.00	1.00
				Maintena	25.00	0.17	Data Redu	Readout	100.00	1.00	Hook Data	Hook Data	100.00	1.00	100.00	1.00
					50.00	0.33	Data Extra	Link capa	75.00	0.20	TADIL-J	TADIL-J	100.00	1.00	100.00	1.00
					75.00	0.50	Error Dete		50.00	0.13	NATO Link	NATO Link 1	100.00	1.00	0.00	0.00
				Performa	75.00	0.18	Maintainab		75.00	0.20	TADIL-B	TADIL-B	100.00	1.00	0.00	0.00
					100.00	0.24	Reliability		100.00	0.27	Link Forwa	Link Forward	100.00	1.00	0.00	0.00
					75.00	0.18	Availability		75.00	0.20	TADIL-A	TADIL-A	100.00	1.00	100.00	1.00
					100.00	0.24	Through-p	Data Red	50.00	0.33	Specified	Specified out	100.00	1.00	0.00	0.00
					50.00	0.12	Track Cap		50.00	0.33	By file nam	By file name	100.00	1.00	0.00	0.00
					25.00	0.06	Multi Links		50.00	0.33	filter entry	filter entry	100.00	1.00	0.00	0.00
								Data Extr	50.00	0.20	Annotation	Annotation o	100.00	1.00	0.00	0.00
									50.00	0.20	Start. Sus	Start. Suspe	100.00	1.00	0.00	0.00
									50.00	0.20	Select by o	Select by out	100.00	1.00	0.00	0.00
									50.00	0.20	Select by li	Select by lin	100.00	1.00	0.00	0.00
									50.00	0.20	Select by e	Select by ext	100.00	1.00	0.00	0.00
								Error Det	75.00	1.00	building, i	building, inte	100.00	1.00	100.00	1.00
								Maintaina	75.00	0.33	MTTR <30	MTTR <30mi	100.00	1.00	100.00	1.00
									50.00	0.22	MTTR <1hr	MTTR <1hr 4	100.00	1.00	100.00	1.00
									100.00	0.44	MTTR orga	24hrs x 30ds	100.00	1.00	100.00	1.00
								Reliability	75.00	0.50	24hrs x 30	348hr MTBF	100.00	1.00	100.00	1.00
									75.00	0.50	348hr MTBF	Ale.999	100.00	1.00	100.00	1.00
								Availabili	75.00	1.00	Ale.999	2250bps TA	100.00	1.00	100.00	1.00
								Through-	75.00	0.25	2250bps T	1200bps TA	100.00	1.00	0.00	0.00
									75.00	0.25	1200bps T	1200bps NA	100.00	1.00	0.00	0.00
									50.00	0.17	1200bps N	28.8-23.8kbp	100.00	1.00	100.00	1.00
									100.00	0.33	28.8-23.8k	500 JTAO tra	100.00	1.00	100.00	1.00
								Track Ca	100.00	0.29	500 JTAO t	400 Ground	100.00	1.00	100.00	1.00
									75.00	0.21	400 Groun	100 Engage	100.00	1.00	0.00	0.00
									75.00	0.21	100 Engag	40 Fixed mar	100.00	1.00	0.00	0.00
									25.00	0.07	40 Fixed m	Track cap. gr	100.00	1.00	0.00	0.00
									75.00	0.21	Track cap.	9 TADIL-B LI	100.00	1.00	0.00	0.00
								Multi Lin	50.00	1.00	9 TADIL-B	MTTR organi	100.00	1.00	100.00	1.00

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