

**A Life-cycle Analysis
of the
Advanced Program Management System
(APMS)
Prototype**

by

James H. Simmons III

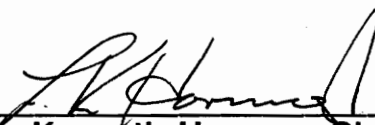
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Committee Chairman: L. Kenneth. Harmon
Systems Engineering

(ABSTRACT)

This life-cycle analysis defines system operational requirements, the maintenance concept, and required program planning information so that the system configuration and system design of the Advanced Program Management System Prototype can be determined.

The Advanced Program Management system will provide a network which will be used by a government agency to conduct softcopy Configuration Management functions.

In this project, a description of the investigation, a cost breakdown structure of subsystem components and a calculation of the total system cost is included.

ACKNOWLEDGEMENTS

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I. PROJECT OBJECTIVE

The objective of this project and report is to provide a life-cycle analysis of the Advanced Program Management System Prototype using sound Systems Engineering and Computer Science tools. The project utilizes Systems Engineering Methodologies, computer program design, and Structured Analysis Practices.

The ultimate goal of this project is to provide the customer with a vehicle to assess the feasibility, operational requirements, system design and life-cycle costs of the APMS Prototype. This baseline may then be used as the basis for the detailed design, development, and implementation of the Advanced Program Management System.

II. BACKGROUND

The Advanced Program Management System Prototype is designed to be a significant element in the highly complex and dynamic environment associated with the a large government agency's configuration management activities as associated with the program management function. The prototype is a critical national program involving multiple, highly complex hardware and software systems.

The APMS will be used by a user community with diverse demographics and requires that APMS be designed in concert with the user community from the start. The users require a user-friendly, automated solution to the currently complex and time consuming configuration managemet process in a near real-time environment. In the analysis and implementation of APMS, it is evident that integration of powerful computing and communication platform and commercially available and custom software is needed.

III. PROJECT METHODOLOGY

The methodology of this project follows the System Engineering process. The methodology is a process employed in the evolution of APMS from the point when a need is identified through design and/or development and ultimate deployment of that system for customer use. This process involved a series of steps accomplished in a logical manner and directed toward the development of an effective and efficient product or system. Specifically, Figure 3.1 details the APMS Prototype development process. Following this structured methodology helped ensure that all elements of a system were considered in a proper and timely manner. The system engineering process was continuous, iterative, and incorporated the feedback actions necessary to ensure convergence.

METHODOLOGY OVERVIEW

The APMS system life-cycle began with an identified need and a completed feasibility study for the purposes of establishing a set of requirements, constraints, and design criteria. After I established the need for a system, an evaluation of various technical approaches was conducted. This evaluation led to a direct application of some existing technology and identified an area where some further research is required. Once these feasible applications were discovered, they were integrated into the requirements definition process.

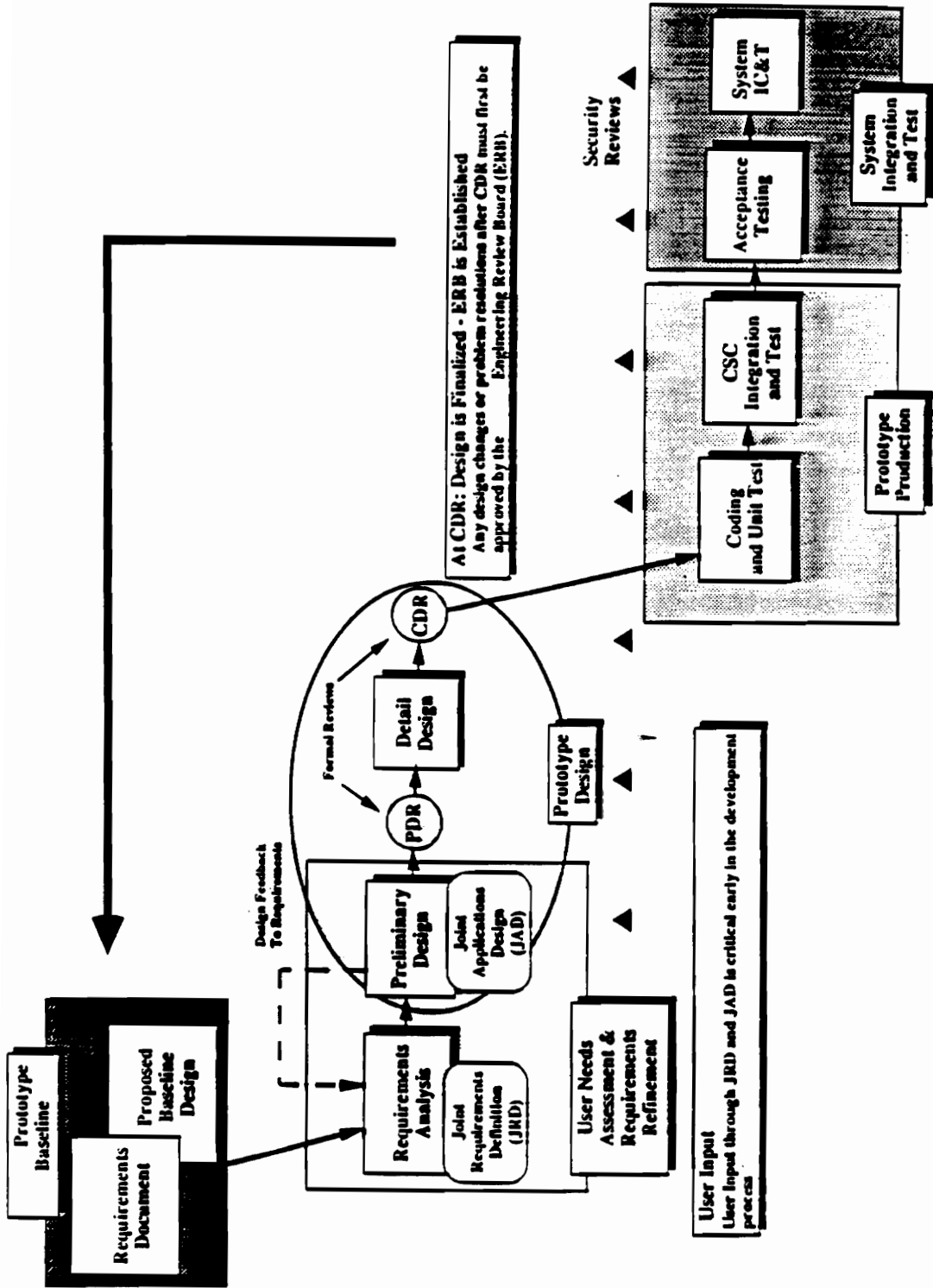


Figure 3.1 APMS Prototype Development Process

The Requirements Analysis Phase focused on defining the system requirements based on the APMS derived requirements and the Joint Requirements Definition (JRD) sessions. The interpretation of the requirements for APMS was a major activity during the requirements analysis phase. The process used in the development of APMS began with definition of need and led to conceptual design reviews.

The forum for the analysis of requirement issues were the Joint Requirements Definition Sessions. The identification and resolution of open requirement areas required the coordinated support of the entire APMS organization through the JRDs. The requirements definition process for APMS involved extensive user community interaction. At each JRD session, an agenda of specific topics was discussed. An initial understanding of the requirements was presented and through interaction with the user community, these requirements were clarified and further defined.

Figure 3.2 shows that in development with JRD/JAD, the effort and hence the costs are lower than that with traditional development cycles. With Joint Requirements Definition, changes were made earlier in the development cycle with less time lost to engineering changes and reworks. With the users better informed and taking an active role in the development and requirements definition phase, project success probability is increased and the total cost is lowered. Additionally, the JRD sessions caused an examination of the goals,

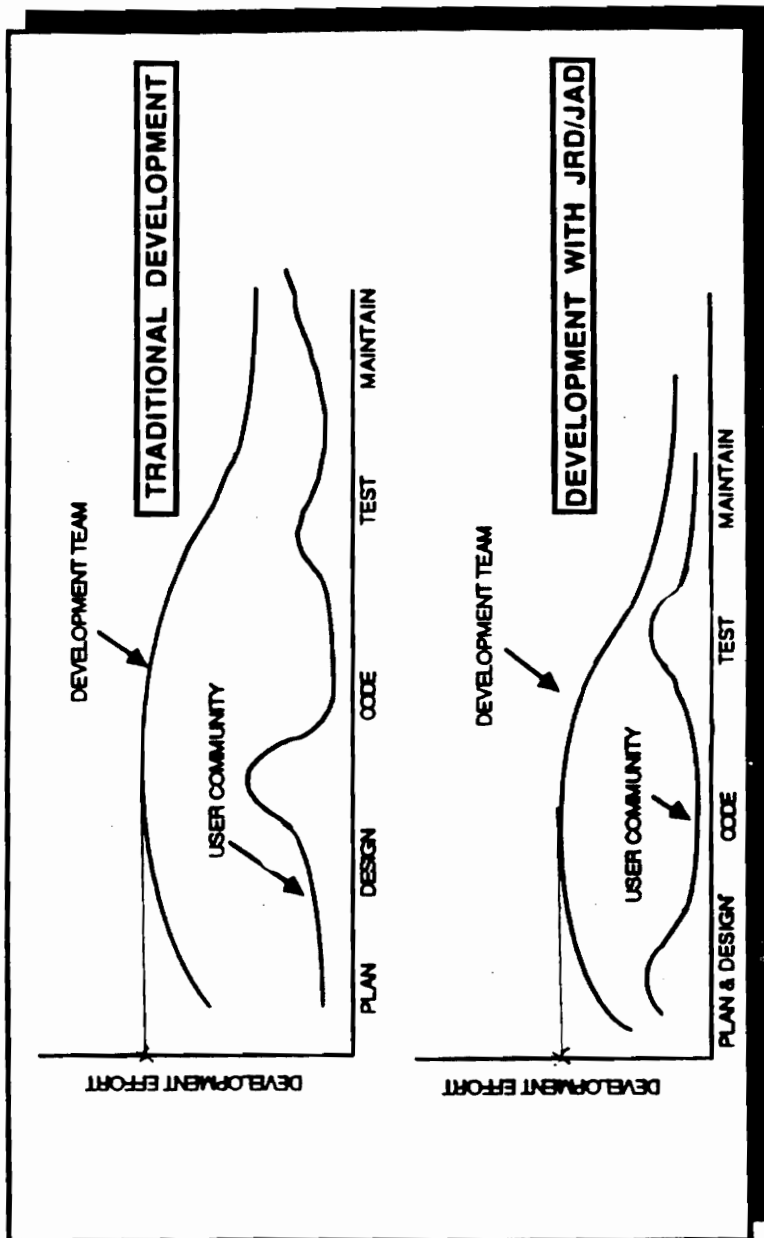


Figure 3.2 JAD/JRD Development Effort & Cost Benefits

problems, and critical success factors. Figure 3.3 details the benefits of the JRD process.

Preliminary & Detailed Design

During the Preliminary Design Phase, the system requirements, as defined in the Requirements Analysis Phase, were allocated to system components; hardware, software, database, communications, and operations. Functional Analysis was an integral part of this activity as system operational and support requirements were translated into specific qualitative and quantitative design requirements. Functional flow diagrams were generated to illustrate the operational flow of the system components.

The detailed design phase translated the requirements baselined in the requirements analysis phase and the implementation concepts developed in the preliminary design phase into detailed process specification (P-specs).

System developers often have difficulty understanding the subtleties of the user requirements. The traditional methods of interviewing users and writing text specifications have been inadequate for this purpose. The answer was to have a joint application design (JAD) session in which the users were guided through a series of structured steps which caused them to think about and describe the procedures they require. A JAD session, conducted with integrated computer

BENEFITS OF JOINT REQUIREMENTS DEFINITION (JRD)

- The JRD Session Focuses The User On The Functional Requirements; Examining The Goals, Problems, Critical Success Factors And The Interfaces Of The Processes That Are Being Automated.
- The JRD Process Identifies Unspecified 'Real' Requirements, Priorities And Desires.
- The JRD Process Provides The System Developer With A Clearer Understanding Of The Users Needs As Well As A 'Validated' Set Of Requirements.

BENEFITS OF JOINT APPLICATION DESIGN (JAD)

- JAD Integrates The User Into The Design Process And Helps To Avoid Dissatisfied Users
- With JAD Sessions The Specification And Design Of DPMS Will Take A Shorter Elapsed Time.
- JAD Reduces Costs By Avoiding The Need To Reprogram Inadequate Designs.
- JAD Improves The Productivity of The Development Process.

Figure 3.3 Benefits of JAD/JRD Process

aided system engineering (CASE) tools, produces a high-quality design much faster than did the techniques of traditional structured analysis. Figures 3.2 and 3.3 demonstrate the benefits of joint application design.

System Design

Here the final draft of the APMS System Design Specification is delivered. The culmination of this exercise is the Critical Design Review. At this review, the customer is presented with the results of the detailed design, as well as the required documents. The APMS document flow and their relationship to other documents is found in Figure 3.4

In the Software Development and Unit Test Phase, the customized software is developed and tested at the Computer Software Unit (CSU) level. Walk-throughs for the code under development are held to ensure requirements verification. In this phase the APMS Engineering Review Board (ERB) and formal configuration management processes are established to control development.

Structured Analysis, as the APMS software design tool, uses graphic documentation tools to produce a structured specification that limits its complexity and promotes user and developer understandability. This model consists of Data Flow Diagrams, Data Dictionaries, and Process Specifications.

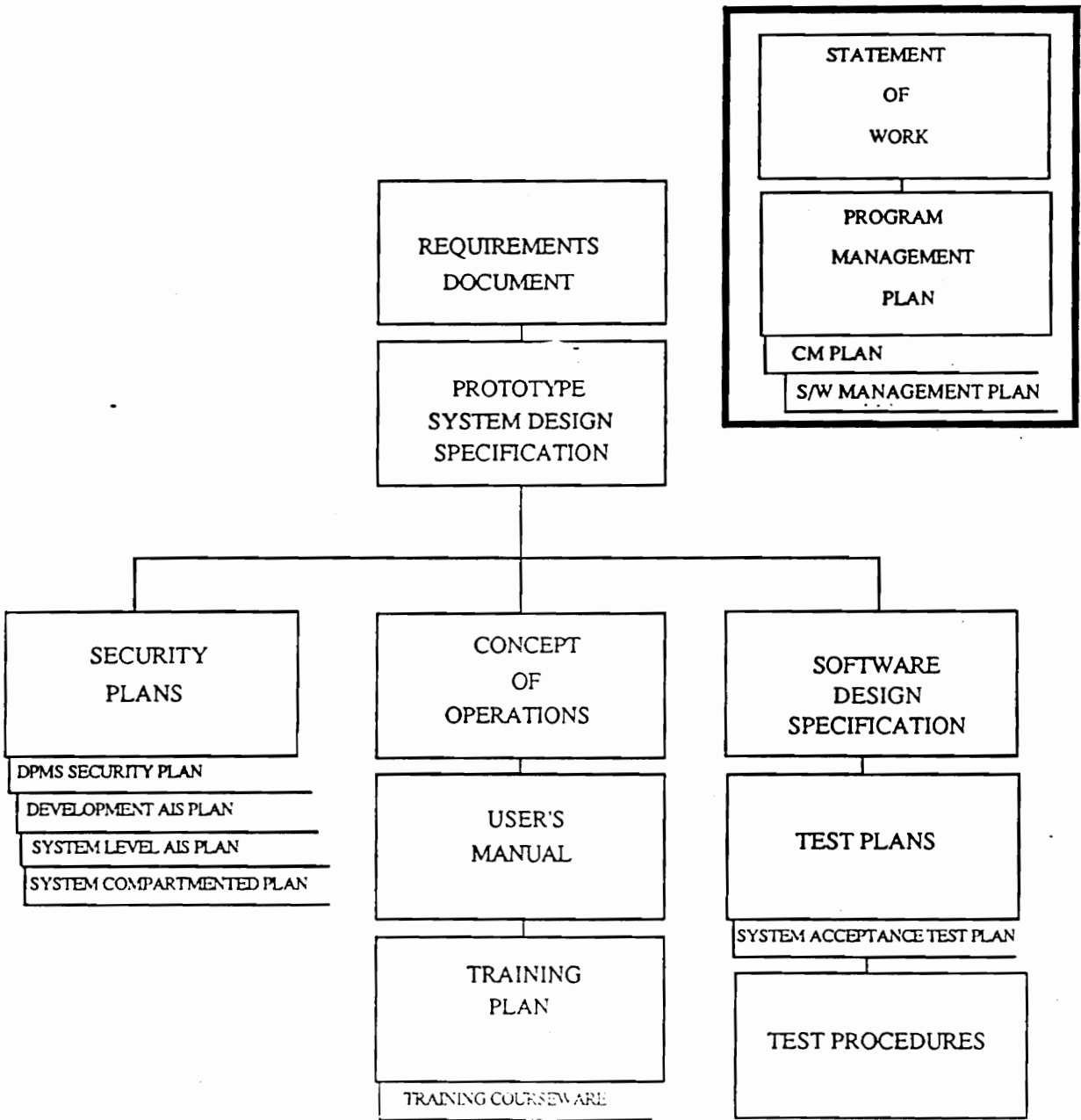


Figure 3.4 APMS Document Flow

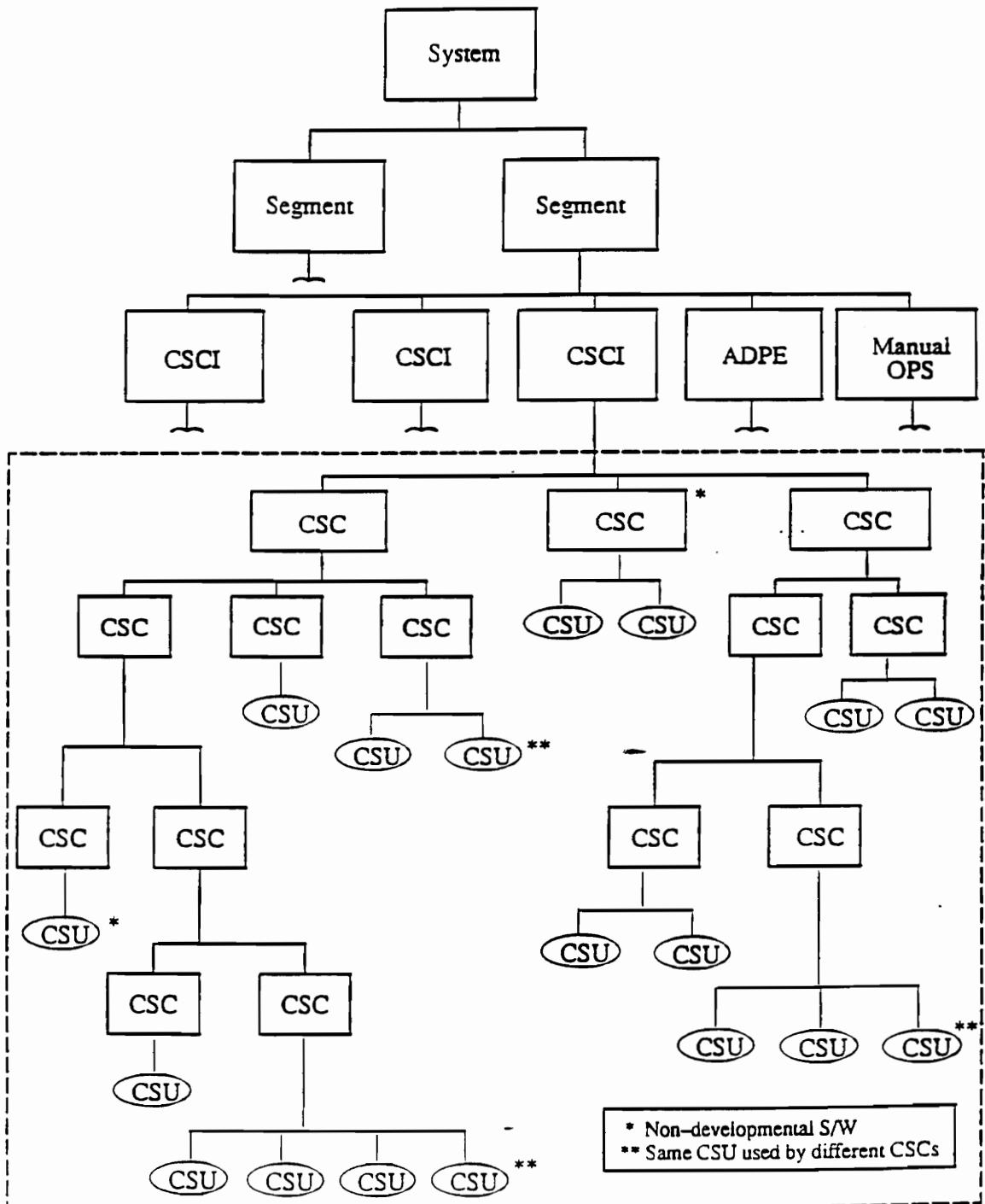


Figure 3.5 System Component Hierarchy

Representations of the APMS functions using the structured analysis model were generated using the Software Through Pictures CASE Tool.

The APMS was decomposed into a hierarchy of components. A CSCI is a subdivision of the System. Every software requirement on the system was levied on at least one CSCI. The CSCI is represented by a collection of one or more CSCs. Thus, the set of all CSCs is a subdivision of the system to a finer granularity. Every software requirement on each CSCI was levied on at least one CSC, which may or may not be executable, and is informally tested in the intra-CSCI test activity. The system component hierarchy which demonstrates the relationship between CSCIs, CSCs and CSUs is shown in Figure 3.5. Appendix II defines the conventions and standards used in structured analysis software design.

For this report, I felt that the CSC level of detail was sufficient for decomposition of system functions. This granularity is precise enough to proceed with detailed design, yet allows the flexibility to allow process allocation at the next level - CSU. The CSCI level is too high a level to get a full understanding of system software components. The data flow diagrams included in the report are at the CSC level.

Integration, Checkout & Test

APMS Integration, Checkout and Test begins following the deployment of the system to the operational locations. At this point, all elements of the system: hardware, software, communications, facilities, etc. are integrated and tested in accordance with the Acceptance Test Plan. Any discrepancies identified during the testing will be documented, through the APMS Internal Discrepancy Report (DR) system and processed through the ERB for disposition. Once the system IC&T is successfully accomplished and the initial operations database is loaded, the system is declared to be at its Initial Operating Capability (IOC), and transitions into an operational mode. This is the final review before system delivery. As opposed to previous reviews and baselines, this last review is a 'make or break' decision.

System Utilization & Support

During system utilization and support, the system is assessed, analyzed and evaluated. The users determine if modifications for corrective action are needed. If changes are needed, support personnel are utilized to implement the necessary corrections. The primary support will be accomplished by the consumer with supplemental support of the producer in certain areas.

Phase-Out & Disposal

No significant costs or effort is anticipated for the phase-out and disposal after the ten (10) year useful life of the system is completed. At the end of the 10 year life-span, the equipment for which this project was developed on will be obsolete. Hence, it is unreasonable to believe that any salvage value will be obtainable. The nominal parts value of the equipment or other suitable use will assumably cover the removal costs. One aspect which should be addressed in the removal plan is the security concerns with classified media. Current disk scrubbing procedures are in place and could be performed on the magnetic media. The removable properties of the disk drives make them ideal for easy scrubbing and if necessary, disposal.

IV. DEFINITION OF NEED

A large government agency has a need to acquire a program management system performing primarily configuration management functions to link three distant locations: a system integrator (SI) node, a customer node and a contractor node. The network will be used to conduct these functions with no time or expense lost to travel.

The customer requires an automated softcopy program management system which is designed to improve the efficiency, effectiveness and accuracy of the configuration management processes. The delivered prototype will serve as an operational proof of concept for and the basis of a larger future system which will build on this functionality. The prototype should provide for a robust software architecture, which integrates selected commercial off-the-shelf (COTS) software products, with custom software, all in a trusted computer environment.

The hardware configuration should provide for a wide area network (WAN) with two remote nodes, the System Integrator node and the West Coast Contractor node, connected to the Advanced Program Office via secure, encrypted, point-to-point communications lines. Figure 4.1 illustrates the network as is defined on a national scale. The current system is inadequate in that three separate configuration systems are maintained with separate data and separate policies. Much time and money is lost from travel, lengthy phone conversations, costly meetings, and classified courier runs.. Computing time is wasted with a significant amount of time devoted to database synchronization.

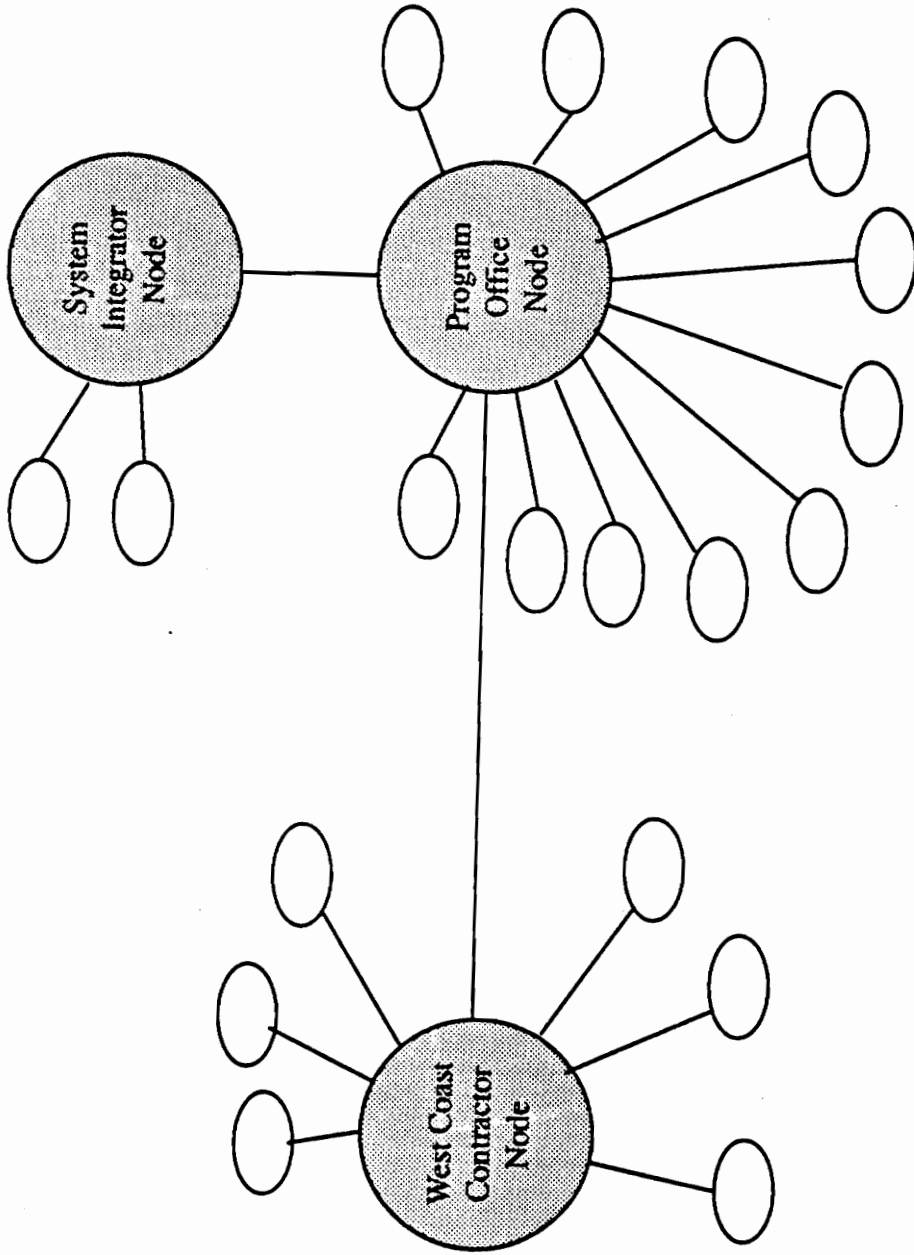


Figure 4.1 APMS Desired System Diagram

The prototype security architecture must provide the compartmented mode level of trust (B1+).

V. FEASIBILITY ANALYSIS/TRADE OFF STUDY

A sound understanding of the environmental, functional, and operational requirements provides the key to APMS success. The diverse user profile requires that APMS be designed in concert with the user community from the start. APMS, developed from joint customer/developer requirements definition, and based on the latest proven technology, will provide the operational softcopy environment to perform all configuration management and program management activities on-line.

FEASIBILITY ANALYSIS

To convince the customer of the feasibility of developing and delivering a system, it must be proven that:

- The benefits of the new system exceed the cost of developing and operating it.
- The benefits of the new system outweigh those of the existing system.
- The project is manageable.
- The schedule is reasonable.

The existing system is based on a hardcopy output and documents which relies on the US Mail service, Faxed documents, telephone conversations and personnel travel (classified courier). Also involved in the process are three largely data redundant yet process separate softcopy PM and CM systems. The

coordination of activities, document control and related projects between three distant sites has become a logistical nightmare. Documents have been lost, deadlines have been missed and as the complexity of the CM and PM processes have increased, so too have the costs of controlling these functions.

The customer has deemed it necessary to implement a system to better handle configuration and program management activities. A system which is cost-effective reduces hardcopy output and eliminates the reliance on classified courier.

Even if there were no cost benefits, the benefits in terms of increased functionality and paper reduction would justify the new system. The proposed system will not only reduce the time and cost of controlling the CM and PM processes, but will increase program control and enhance its usefulness. In addition, the three sites would be in concert with each other in terms of the standardization across the three nodes. In addition, the computing and data storage costs of maintaining 3 separate systems with corresponding databases would be eliminated.

Operationally, the new system will be much more responsive to users' needs. First, all three node database are to be combined into one distributed database, eliminating the creation and maintenance of what are, in effect, three redundant databases. This not only eliminates the need to maintain three sets of data, but also the discrepancies that always occur when duplicate data is accessed. Second, the user interface will be much friendlier enhancing productivity and

thus reducing the total number of persons dedicated to the CM and PM functions..

The recommendation is that the customer should allocate the funds necessary to being work on the new Advanced Program Management System.

TRADE OFF STUDY

The functional requirements of APMS require the development of a powerful information management system capable of automating the current CM and PM tasks.

Full implementation of an effective user interface, a robust text processor with integrated graphics, a high-performance database engine, and an efficient, distributed processing network is needed.

The interface between the automated system and the targeted user community must be intuitive and effectively parallel the manual configuration management and program management processes currently in place. It must be user friendly and logical in its implementation. The use of a Graphical User Interface (GUI) provides the best approach for speed of input and efficiency of navigation through APMS. A network of intelligent workstations, which are both easy to use and responsive, is required for a full APMS implementation.

The extensive data processing and data management tasks of APMS require the use of a high performance database system which provides a high degree of flexibility, substantial capacity and efficient performance. As this database system is the hub of all APMS document control and data integration, it must meet performance functionality.

The text and document processing functionality of the APMS can be accomplished with the use of a robust document processor. This document processor must provide extensive Application Program Interfaces (APIs) to allow for the effective customization and integration required by the system. It must also provide for the integration of graphics into the text files.

The security requirements specified for APMS will factor in the hardware selection, networking configuration, and the software design of the APMS. The individual elements needed to implement a system with a compartmented mode requirement are either currently available or will be available within the proposed development time-frame. The integration of these trusted components is a significant challenge for the developer.

The performance requirements have a significant impact on the design of APMS. The required responsiveness of the system necessitates high-performance hardware, efficient software and fast database processing. The availability requirements drive the need for highly reliable and fault tolerant hardware and software, as well as an effective maintenance plan.

The collective security, performance, and functional requirements, coupled with a desired 10-year useful life, demand a sophisticated, technically advanced design.

To determine the APMS candidate architecture and baseline design, a detailed requirements analysis, market study and trade-off analysis is needed. The compartmented mode security requirement is a significant factor. Fortunately, APMS is not alone in its desire to operate in compartmented mode and several products have been developed to provide this capability.

The "trusted computing base", consisting of a trusted operating system and its hardware platform, is the basis for the prototype design. Once the operating system and platform have been chosen, the analysis of the available COTS database and document processor is conducted. The following sections describe the APMS trade-off analysis for the trusted computing base; the database management system and the document processor.

Trusted Computing Base

The APMS prototype requires the use of 'intelligent' networked workstations that provide multi-tasking operations and a windowing user interface. In the networked workstation environment, UNIX is the operating system of choice, offering both multi-tasking and a windowing user interface. UNIX provides a non-proprietary, open architecture assuring APMS' future growth and connectivity. A non-proprietary system is desired to preclude the system from

being limited by a single vendor's products and capabilities such as the case with Wang. Different vendors provided UNIX-based operating systems that have been enhanced to provide B1 or B2 level of trust and are National Committee of Security Certification (NCSC) evaluated or in the evaluation process. Figure 5.1 provides a comparison of these UNIX products with respect to the stated requirements and the derived design factors for the APMS prototype. Figure 5.2 shows the weighted requirements and the totals associated with the decision.

SUN has two UNIX-based products in the evaluation process by NCSC for a B1 rating: the Multi-level secure operating system (SunOS MLS) and the SUN Compartmented Mode Workstation (CMW). Digital Equipment Corporation (DEC) also has two products in the NCSC evaluation process. However, one is a proprietary non-UNIX operating system (SEVMS). The other DEC product being evaluated is the DEC Compartmented Mode Workstation (DEC CMW) based on DEC's ULTRIX (variant of UNIX). International Business Machines (IBM) has only a mainframe product, MVS/ESA, being evaluated. IBM does have a UNIX-based compartmented mode workstation product, however, it is in the early stages of development. It is not yet ready for submission to the NCSC for evaluation.

There are two other CMW products being evaluated by the NCSC: one for Secure-Ware and the other from the Harris Corporation. These products are considered high risk and therefore not viable options for implementation of APMS. Both companies are unproven in this arena with this being their initial

MAJOR OPERATING SYSTEM AND HARDWARE REQUIREMENTS	Sun CMW	SunOS MLS	DEC CMW	AT&T 3B2 Unix	Trust Xenix	IBM CMW	PC 386 CMW	Apple Mac II CMW
3.1.1 SYSTEM NODAL REQUIREMENTS								
3.1.1.1 Communications Support secure point-to-point communications between nodes	✓	✓	✓	✓	✓			
3.1.1.3 Workstations/Node Serve a network of a Min of 16/max of 48 workstations/node w/ CPU.	✓	✓	✓	✓	✓			
3.1.2 SYSTEM HARDWARE REQUIREMENTS								
3.1.2.1 Peripheral Resources Sharing 16 Total devices/node - Printer, OCR, Scanner, Tape, Overhead Proj.	✓	✓			✓	✓	✓	✓
3.1.2.2 Graphics Hardware 19" video displays - mono/color -1024 x 768 resolution.	✓	✓	✓		✓	✓	✓	✓
3.1.2.3 Hardcopy Output Banners, screen dumps, 300 x 300 dpi, listed fonts, sizes, orientations.	✓	✓		✓	✓	✓	✓	✓
3.1.4 MAINTAINABILITY								
3.1.4.1 -3.1.4.4 Maintainability/Availability Requirements Meets stated maintainability, availability and recovery requirements	✓	✓	✓	✓	✓	✓	✓	✓
3.1.5 GENERAL SYSTEM REQUIREMENTS								
3.1.5.1 System to User Intra-Nodal Response Time Meets stated response times for user and administrator actions.	✓	✓	✓	✓		✓		
3.1.5.2-3.1.5.4 Data I/O and Archive Capabilities Support listed I/O devices and archive/retrieve data and files to tape or disk.	✓	✓			✓	✓	✓	✓
3.1.5.5 Useful Life 10 years useful life with normal maintenance	✓	✓	✓			✓		
3.1.6 Mass Storage Requirements Growth estimates to 3 Gigabytes	✓	✓	✓	✓		✓		
3.1.7 SECURITY AND TEMPEST								
3.1.7.1 Trusted Computer System Minimum B1 rating w/ B2 Compartmentalization Features	✓		✓	✓		✓	✓	✓
3.1.7.3 Audit Trail Audit capability of all accesses and system activities	✓	✓	✓	✓	✓	✓	✓	✓
3.1.7.4 TEMPEST All hardware meets TEMPEST requirements	✓	✓	✓		✓		✓	✓
3.2.3 OPERATING SYSTEM								
3.2.3.1 Operating System Architecture Multiple window/multitasking - file, peripheral, read/edit access control.	✓	✓	✓			✓	✓	✓
3.2.3.2 User Access Define/Manage User Access Privileges	✓	✓	✓	✓	✓	✓	✓	✓
3.2.3.2.1 Multiple Access Allow Multiple Data Read Access - Preclude Multiple Write Access	✓	✓	✓	✓	✓	✓	✓	✓
IMPORTANT DESIGN FACTORS								
COTS Availability Availability of COTS Software	✓	✓	✓				✓	✓
Vendor Market Strength and Reliability Relative Position of Vendor	✓	✓	✓			✓		
Product Availability/NCSC Certification Process Availability of a product in certification	✓	✓	✓	✓	✓		✓	✓
Technology Product based on latest proven technology	✓							
UNIX OS/HARDWARE PLATFORM	✓							

✓ - Meets Requirement or Design Factor.
[blank] - Falls to meet Requirement or Factor.

Figure 5.1 Secure Unix Operating System & H/W Platform Comparison

Requirements	Weight	SUN CMW	SUN MLS	DEC	ATT	XENIX	IBM	PC	MAC II
Communication	5	5	5	5	5	5			
Workstation/Node	5	5	5	5	5	5			
Peripheral Resource Sharing	5	5	5			5	5	5	5
Graphic Hardware	7	7	7	7		7	7	7	7
Hardcopy Output	8	8	8		8	8	8	8	8
Maintinability/Availability	10	10	10	10	10	10	10	10	10
Response Time	5	5	5	5	5		5		
Data I/O & Archive	2	2	2			2	2	2	2
Useful Life	2	2	2	2			2		
Mass Storage	3	3	3	3	3		3		
Trusted Computer System	9	9		9	9		9	9	9
Audit Trail	2	2	2	2	2	2	2	2	2
Tempest	8	8	8	8		8		8	8
OS Architecture	2	2	2	2			2	2	2
User Access	5	5	5	5	5	5	5	5	5
Multiple Access	6	6	6	6	6	6	6	6	6
COTS Availability	5	5	5	5				5	5
Vendor Market Strength/Reliabil	4	4	4	4			4		
Product Availability	5	5	5	5	5	5		5	5
Technology	2	2							
Total	100	100	89	83	63	68	70	74	74

Figure 5.2 Weighted H/W Requirements

forays into the UNIX arena. In addition they have an operating system developed separately from the hardware system, and both are based on older technology which will hasten the obsolescence of the system.

The compartmented mode workstation products are being developed based on a specification released by the Defense Intelligence Agency (DIA). The CMW products provide a complete B1 workstation environment with B2 compartmentalization features including the operating system and a windowing user interface. CMW is based on the UNIX operating system and the X.11 standard workstation windowing system.

The combination of the secure operating system and a trusted window manager provide a convenient and cost effective solution to several fundamental APMS requirements. I have concluded that the CMW technology is the most viable solution to the APMS performance, security and schedule requirements.

The CMW is based on trusted computer windowing system. Windows on the workstation display can exist at different security levels determined by: user access privileges, the access rights of the application software and the level of files being accessed. The user can perform tasks in one window while a program is executing in another. This intuitive and easy to use environment allows maximum productivity in a controlled menu driven windowing system. The windowing system provided is compliant with the X.11 'X-Windows' industry standard. This assures compatibility with an extensive suite of application software.

A brief discussion of each of the CMW products is provided here.

1. *SUN Microsystems SPARC CMW*

Sun Microsystems - the world's leading workstation vendor based on market share has committed to provide the CMW operating system on the latest computer technology, the Reduced Instruction Set Computer (RISC). Sun's implementation of RISC, the SPARC architecture, is the industry leader in the workstation market. The SUN SPARC is fast becoming an industry standard as other computer companies generate SPARC clones much as they built IBM PC compatible in the 1980s. The advantages of this proven architecture are its tremendous price/performance ratio, its leadership position, and its capability to provide the necessary processing power for the 10 year useful life of APMS.

2. *Digital Equipment Corp (DEC) CMW*

DEC has placed the CMW operating system on its two hardware architectures, the VAX and the DEC RISC systems but DEC has chosen to have the older VAX architecture certified initially by the NCSC.

The submission of the CMW on the RISC platform is questionable and will not occur until the final evaluation of the VAX based CMW (See Figure 5.3). This delay in submission or the potential decision not to have RISC CMW evaluated increases the uncertainty of certification, and thus increases the development risk of a DEC CMW solution.

3. *IBM RISC CMW*

IBM has chosen to develop its CMW on its new RISC-based workstation, the RS6000. The RISC benefits are overshadowed by RS6000's unproven technology with only about 2,000 units shipped. IBM's UNIX operating system, AIX, is also relatively untested. This makes it difficult to develop a secure system until the base system matures. IBM is very early in its CMW development/accreditation cycle with projected completion outside the APMS time-frame (See Figure 5.3). IBM has not had great success in the workstation market, currently holding only a 3 percent market share. The limited availability of COTS software, coupled with an unacceptable development - evaluation schedule, precludes the selection of IBM CMW for APMS.

THE SUN SPARC COMPARTMENTED MODE WORKSTATION WILL BE THE FIRST RISC BASED CMW, PROVIDING THE REQUIRED LEVEL OF TRUST ON AN ADVANCED COMPUTING PLATFORM

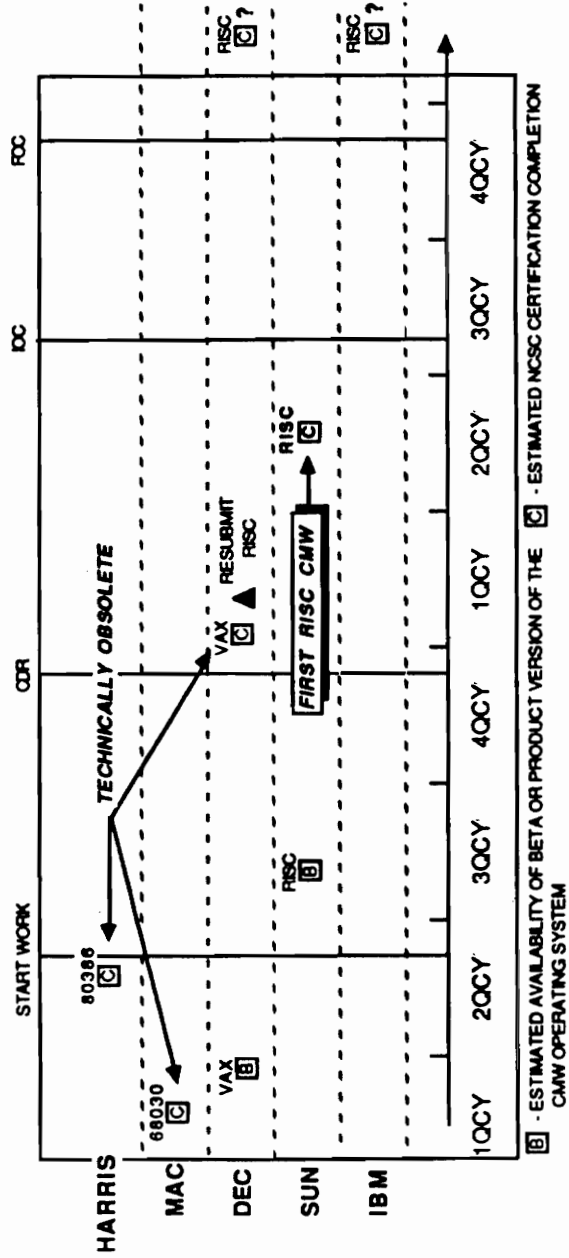


Figure 5.3 Estimated CMW Availability and Certification

4. *Harris Corp. IBM/PC CMW*

An IBM PC/AT based CMW platform is being developed by the Harris Corporation. This computer uses the Intel 80386 microprocessor and runs a UNIX variant modified by Harris Corp. This microprocessor and the PC/AT data bus limit the potential of this CMW. The performance requirements for security mediation and windowing will overload this system. Additionally, multiple vendor development increases the risk associated with the use of this product. When many vendors participate in the development of an unproven proprietary technology, it more often than causes lack of cooperation, schedule slippages and general sub-par performance.

5. *Secure-Ware Inc. Apple Macintosh CMW*

Secure-Ware has developed a CMW operation system that runs on the Apple Macintosh II platform. This CMW, expected to be the first to achieve NCSC certification, uses the Motorola 68030 microprocessor and Apple Computer's UNIX variant (A/UX). Limited COTS software is available for the A/UX operating system.

The Macintosh CMW is to be certified as a stand-alone system which does not meet APMS networking requirements. As with the Harris Corp. CMW, this product is based on aging technology that lacks the performance required for APMS. It is also being developed by an unpredictable multiple vendor effort. These factors preclude the use of this CMW for a compliant APMS.

The Selection

As indicated by the discussion above, the CMW provides that most viable alternative for the APMS trusted computed base. The best CMW product provides the most viable alternative for the APMS trusted computed base. The best CMW product with respect to APMS requirements and design criteria, is the SUN microsystems SPARC CMW. This is a stable product derived for the AT&T UNIX kernel. It is well along in the evaluation process and should achieve B1 and compartmented mode certification within the scheduled APMS development period. The SUN CMW will be available, prior to actual

certification, in August 1992 (See Figure 5.3). Based on the proposed schedule, the August 1992 availability date is 90 days prior to CDR (November 29, 1992). Sun Microsystems has agreed to designate the APMS activity as an official Beta test site. This designation will assure that SUN Corporate management provides the necessary resources and support to the APMS prototype development. As a test site, APMS will have 24 hour phone support and 12 hour technician support to ensure that schedule slippage does not occur. The APMS prototype is crucial to SUN's marketing and product testing activities. In addition, all required peripherals are available in TEMPEST for the SUN architecture.

Database Management System

In the selection of a Database Management System (DBMS) for APMS, consideration of the security assurance features as well as the associated impact on performance is essential. Security features that overly tax the system will ultimately result in degraded performance or require more powerful and therefore more expensive hardware platforms. There are three approaches to providing the security requirements of compartmented database access control.

Integrity Lock

In the integrity lock approach, the database is completely untrusted. A trusted filter and the trusted operating system mediate all communications between the data and the users. The trusted filter provides for data labeling and data

access restrictions based on the user's security clearances. Both the Mandatory Access Controls (MAC) and Discretionary Access Control (DAC), required in a B1 system, are provided by this filter. The integrity lock approach degrades system and database performance. Labeling is only provided at the table level and multiple tables may only be accessed on a single query.

Balanced Assurance

The balanced assurance approach places assurance and most of the security functionality in the trusted operating system. The operating system mediated all access to named objects based on the MAC. The database provides only DAC. The balanced assurance approach provides the ability to build a multi-level database through reliance on the trusted operating system. As the operating system handles all mandatory access security mediation, some performance degradation will result from multi-level queries using this option.

Uniform Assurance

With uniform assurance, the DBMS is built with complete security assurances and mediates all access to the database. The DBMS contains both mandatory and discretionary access controls. Uniform assurance places all database access control in the database management system itself. This allows the DBMS to manage its own resources. This capability does not tax the operating system, and, thus, does not degrade system performance.

The best combination of security assurance and system performance in a multi-level environment is achieved by the uniform assurance approach. Only certain Database Management Systems utilizing the uniform assurance approach are pending NCSC evaluation. The Sybase Secure SQL Server is the industry leading product using the uniform assurance approach.

Document Processor

The document processor must provide complete text manipulation, integrated graphics, and APIs to allow the specific customization required for APMS. The text processor is envisioned to be a WYSIWYG (what you see is what you get) interface. The leading COTS document processors available for the SUN Sparcstation are compared in the trade-off study presented in Figure 5.4. Figure 5.5 shows the weighted requirements and the totals associated with the decision.

These products are Interleaf 5.0, FrameMaker, WordPerfect for UNIX and ALIS. As indicated in the figure, the Interleaf 5 product provides the best correlation with the APMS requirements, as well as having the necessary APIs to allow the integration of the product with the trusted computing base and the secure database management system. It is the best solution for the APMS prototype.

The Interleaf 5 document processing package provides many of the APMS text manipulation requirements and is fully configurable. APMS requires the text processor play a major role in the information management process. APMS

Major Document Processing Requirements	Interleaf	Frame Maker	Word Perfect	ALIS
GENERAL PROCESSING REQUIREMENTS				
IMPORTATION OF DOCUMENTS Import Documents from Wang WP, WP+ and from Mass-11.	✓	✓	✓	
3.1.4.4 RECOVERY Meets requirement of the stated checkpoint - restart recovery capability	✓	✓		
3.3.7.1 BASELINE DOCUMENT PROCESSING				
3.3.7.1.1 BASELINE DOCUMENT MAINTENANCE Import, view, copy, output, and delete baseline documents with text and graphics.	✓	✓	✓	✓
3.3.7.1.2 CHANGE RESTRICTIONS Baseline only updated by approved RFC driven SCN.	✓			
3.3.7.1.3 ACCESS RESTRICTIONS View and copy any portion of a Baseline Document based on system access verification.	✓	✓		
3.3.7.2 RFC PROCESSING				
3.3.7.2.1 RFC LIBRARIES User and controlled libraries are to be provided for RFCs.	✓	✓	✓	✓
3.3.7.2.2 TEXT AND GRAPHICS PROCESSING Create, view, edit, output, and maintain RFC packages of integrated text and graphics.	✓	✓	✓	✓
3.3.7.2.2.1 TEXT PROCESSING Create, edit, delete, replace, copy, move, insert, and merge.	✓	✓	✓	✓
3.3.7.2.2.2 GRAPHICS PROCESSING Create, view, edit, output, and maintain graphics images.	✓	✓	✓	✓
3.3.7.2.3 DOCUMENT REDLINES Extract text/graphics pages from multiple baseline document, able to annotate changes.	✓	✓	✓	
3.3.7.2.3.1 ORIGINAL VERSUS REVISED DATA Original readable and clearly distinguishable from the revised. Multiple revisions.	✓	✓	✓	
3.3.7.2.3.2 CHANGE BARS Automatically add Change-Bars at the right margin which link RFCs to baselines.	✓	✓		
3.3.7.2.3.2.1 CHANGE BAR LABELS The user shall have the capability to label the Change-Bars.	✓			
3.3.7.2.4 RFC COMMENTS Create, view RFC Comments with access control linked to original RFC.	✓	✓		
3.3.7.2.5 RFC PACKAGE REQUIREMENTS Retrieval, Data Merge, RFC Number, Circle Page Number, DIN capabilities.	✓	✓		
3.3.7.2.5.6 CLASSIFICATION Highest classification At Top of Page.	✓	✓		
3.3.7.3 SCN PROCESSING				
3.3.7.3.3 DOCUMENT CHANGE LOG The Change Log shall be maintained and permanently linked to each baseline document.	✓			
3.3.7.3.4 SCN DRIVEN DOCUMENT CHANGES Automated document revisions (text and graphics) on approved changes in the SCN.	✓			
3.3.7.4 CCB AGENDA RESULTS MESSAGE PROCESSING				
3.3.7.4.1 MESSAGE PROCESSING Creation, maintenance, storage, transfer and control of agenda/results messages.	✓	✓	✓	✓
3.3.7.4.2 MESSAGE FORMAT Glossary (templating) capability shall be provided.	✓	✓	✓	✓
3.3.8.2 TBD/TBR MANAGEMENT PROCESSING				
3.3.8.2.3 TBD/TBR DOCUMENT SEARCH Perform automated search of TBDs/TBRs in a document and save locations.	✓	✓		
COTS DOCUMENT PROCESSOR	✓			

✓ - Meets Requirement with COTS or through custom code interface. (API)
[blank] - Fails to meet Requirement.

Figure 5.4 Document Processor Comparison

Requirements	Weight	Interleaf	Frame Maker	Word Perfect	ALIS
Importation of Docs	10	10	10	10	
Recovery	10	10	10		
Baseline Doc Maintenance	2	2	2	2	2
Change Restrictions	7	7			
Access Restrictions	4	4	4		
RFC Libraries	3	3	3	3	3
Text & Graphics	8	8	8	8	8
Text Processing	3	3	3	3	3
Graphics Processing	3	3	3	3	3
Document Redlines	3	3	3	3	
Original Vs. Revised Data	4	4	4	4	
Change Bars	4	4	4		
Change Bar Labels	4	4			
RFC Comments	3	3	3		
RFC Package Requirements	2	2	2		
Classification	10	10	10		
Document Change Log	3	3			
SCN Driven Doc Changes	3	3			
Message Processing	7	7	7	7	7
Message Format	3	3	3	3	3
TBD/TBR Doc Search	4	4	4		
Total	100	100	83	46	29

Figure 5.5 Weighted Document Processor Requirements

users need to be able to trace information through many stages: accessing data, creating revision text and graphics, reviewing, distributing and archiving. Interleaf 5 handles the full information process. Interleaf Active documents automate the workflow with the capability to automatically access, evaluate and act on information anywhere in their computing environment.

Interleaf provides a unique re-programmability capability that allows its products to be customized to meet the APMS demanding text requirements. Interleaf is a full featured package but several factors contribute to making Interleaf a tool easily used by the average APMS user. The adaptability and re-programmability of the Interleaf 5 will allow the APMS development team to customize the product to allow the average trained user to easily perform APMS functions in a mouse-driven menu environment. Templates can easily be created to allow for efficient creation of standard documents, memos, reports or forms. Finally, the professional training and user manuals to be provided with the prototype will ensure that the APMS user is a highly proficient Interleaf user.

VI. OPERATIONAL REQUIREMENTS

The requirements for the system define the technical parameters for system design. These parameters are evolved from the needs analysis and the feasibility of various technological applications. User surveys, current needs, JRD sessions, system uses, and shortcomings, as well as available technology demonstrations were instrumental in the definition of these requirements. The follow-on of the operational requirements leads to the definition of system operating characteristics, the maintenance support concept, and the identification of specific design criteria. Below are a list of the minimum set of operational requirements for the Advanced Program Management System.

HARDWARE REQUIREMENTS

1. *General Node Hardware Requirements*

- 1.a Equipment Size/Arrangement - APMS central computer equipment and related devices shall conform to the floor space allocation of 144 square feet. This allocation is to house common APMS equipment such as servers and disk drives. If no raised floor exists, cables shall be wall mounted.
- 1.b Electrical Power - The APMS shall be designed to operate with the following power sources:
 1. Standard utility power used for lighting and heating.
 2. Technical power, which is isolated from utility power and other power feed, utilized for sensitive APMS electronic equipment.
- 1.c Environment - No special generators, air conditioning, humidity control, or air contamination control shall be required to ensure operability.

2. *APMS Workstation Requirements*

- 2.a Each workstation shall have a CPU, display, keyboard, mouse and shall be capable of processing interactive sessions and batch tasks simultaneously
- 2.b All magnetic media storage shall be removable.
- 2.c High resolution graphics capability shall be provided on all '19 video displays at all locations, with a minimum of 1024 pixels and 768 vertical pixels.
- 2.d A minimum of one (1) color terminal shall be installed at each location, all remaining terminals shall be monochrome.
- 2.e APMS shall provide the capability to input data using a keyboard (Text).
- 2.f APMS shall provide the capability to input data files (Text and Graphics) from floppy disks.

3. *APMS Server Requirements*

- 3.a The system shall have the capability to serve a minimum of 16 workstations per location, with expansion to a maximum of 48 workstations.
- 3.b Mass Storage Requirements - All magnetic media storage shall be removable.
- 3.c Storage Growth Requirements - APMS shall provide the capability to support mass storage with growth estimates to at least 3 gigabytes.

4. *General Peripheral Requirements*

- 4.a A minimum of one (1) of each device listed here will be supported, with expansion to sixteen (16) total devices supported at each location.
- 4.b The peripheral devices support by APMS include but are not limited to the following:
 - 1. Printers/Plotters.
 - 2. Optical Character Recognition Devices.
 - 3. Scanners.
 - 4. Archive Tape Devices.
 - 5. Overhead Projection Devices.
- 4.c APMS will provide nodal specific peripheral resource sharing capability.
- 4.d APMS shall provide the capability to interface to an overhead projection device for boards or conference review of data.

5. *Peripheral Hardware Data Input Requirements*

- 5.a APMS shall provide the capability to input data to AMPS, using any of the following devices:
1. Optical Character Recognition (OCR) Devices. (Text)
 2. Optical Scanner. (Graphics)
 3. Files: Tapes. (Cassette) - (Text and Graphics)
- 5.b APMS shall provide the capability for the APMS System Administrator (SA) to retrieve APMS files and data from magnetic tape and/or disk.

6. *Peripheral Hardware Data Output Requirements.*

- 6.a APMS shall provide the capability to output text and graphics data APMS function, to any of the following compatible devices:
1. Workstation Display Terminal.
 2. Hardcopy Printer/Plotter.
 3. Electronic Overhead Projector.
 4. Files: Disks, Tapes (Reel and/or Cassette)
- 6.b Archive Hardware Requirements.
1. APMS shall provide the capability for the APMS System Administrator to archive APMS files and data to magnetic tape and/or disk.
 2. APMS shall provide the capability to have read/display access to the on-line archive index including title, author, date archived.

7. *Hardcopy Output Hardware Requirements.*

- 7.a Hardcopy output shall have the capability of 300 x 300 dots per inch resolution.
- 7.b The text output shall consist of, but not be limited to, the following fonts and symbol sets:
1. Times (Bold, Italic, and bold Italic)
 2. Helvetica (Bold, Italic, and bold Italic)
 3. Courier (Bold, Italic, and bold Italic)
 4. Avant Garde Gothic (Book, Book-Oblique, Demi)
 5. Palatino (Bold, Italic, and bold Italic)
 6. Symbols Set
- 7.c Hardcopy printers shall be capable of supporting 'postscript'.

- 7.d All text output in typographic fonts shall have a minimum of 30 point sizes ranging from 6-36. All text output in typewriter fonts shall support standard pitch (10, 12, or 15).
- 7.e Portrait and landscape orientation shall be provided. Output sizes of 8 1/2 x 11, 8 1/2 x 14 paper, transparencies, label stock, and envelopes shall be provided.

8. Local Area Network Hardware Requirements

- 8.a The requirement to connect the server to the workstations is implicit.

9. Wide Area Network Requirements

- 9.a A secure point-to-point communication line will be provided between locations, as well as all encryption equipment and red/black interface equipment.
- 9.b Digital data up to 19.2 kbps, synchronous, full-duplex, serial, 24 hours/day, 7 days/week.
- 9.c The Bit Error Rate (BER) shall be less than one error in 10⁶ bits 98% of the time as a measure over any 24-hour period. A BER of less than one error in 10⁵ bits 99.5 of the time shall be provided.
- 9.d The system shall support 3 initial nodes and shall have expansion capability to a maximum of 22 total nodes.

SOFTWARE REQUIREMENTS

10. Baseline Document Requirements

- 10.a APMS will provide softcopy read-only baseline documents to authorized users at APMS workstations.
- 10.b APMS will provide add, edit, and delete access to softcopy baseline documents to authorized custodians at a APMS workstation.
- 10.c APMS will provide softcopy screen formats to authorized document custodians to enter, modify and delete baseline document data.
- 10.d The Baseline Document Database will, at a minimum, consist of the data fields such as date-time stamps which will be utilized by RDBMS to help control the application processing.

- 10.e APMS will provide the capability to view and copy and baseline documents consisting of integrated text and graphics to authorized users.
- 10.f APMS will provide the capability to add, update, and deleted baseline documents consisting of integrated text and graphics to authorized custodians.
- 10.g APMS shall provide the capability to copy baseline documents or portions of baseline documents for purposes other than RFC processing.

11. Recommendation For Change (RFC) Requirements

- 11.a APMS will provide softcopy read-only RFC documents to authorized users at APMS workstations.
- 11.b APMS will provide add, edit, and delete access to softcopy RFC data to authorized originators and/or administrators at a APMS workstation.
- 11.c APMS will provide softcopy screen formats to authorized document custodians to enter, modify and delete RFC data.
- 11.d APMS shall provide the capability to designate the status for standard boards, such as DCCB, or for user-specific boards or approval names. The capability to track RFCs through multiple boards is required.
- 11.e The capability to maintain the history of multiple designators per RFC shall be provided. Each designator shall identify the responsible individual and the date of the status change.
- 11.f RFC Text and Graphic Processing - APMS shall provide the capability to create, view, edit, output and maintain RFC packages consisting of integrated text and graphics.
- 11.g Text Processing - Standard word or text processing capability shall be provided to include, at a minimum, create, edit, delete, replace, copy, move, insert and merge.
- 11.h RFC Submit Function
 - 1. APMS shall provide the capability for submission of RFCs to the RFC administrator queue, while maintaining the draft copy in the user's file.
 - 2. RFCs in the administrator queue shall be locked from further unauthorized changes.

12. Specification Change Notice (SCN) Requirements

- 12.a. An SCN shall be manually activated following the electronic or manual receipt of a formal result message.
- 12.b. The system shall use the RFC with final recommendation and the results message to build the SCN as specified by the administrator.
- 12.c. SCN processing shall identify which baseline documents were impacted, by the RFC package as approved.
- 12.d. A separate SCN package shall be generated for each document impacted.
- 12.e. Each SCN shall contain all the approved RFC and modification information; however, it will carry only changes related to its specific document.
- 12.f. Authorized users shall be capable of preparing and assembling SCN packages consisting of the following items.

13. Requirements Traceability Requirements

- 13.a. A means of identifying each requirement in a document for upward and downward traceability shall be provided.
- 13.b. Requirements shall be identified using the following format:
3 alpha numerics for prefix, 6 numerics for sequential number and 4 for the suffix with a dash before the suffix. with a dash before the suffix. (Example: XXX00001-XXXX).
- 13.c. The capability to reserve/allocate a block of numbers to a specific document being created shall be provided.
- 13.d. The capability to trace a single requirement that expands into multiple requirements in a lower level document shall be provided.
- 13.e. The traceability process shall have the capability to perform requirements tracing the following options:
 - 1. Begin requirements tracing the highest level document (i.e., JRD System Specification) down through the lowest level document within the document hierarchy.
 - 2. Perform traceability starting from a document that falls within the center of the document hierarchy and optionally traces upward, downward.

3. Perform traceability on one or more specified requirements or all requirements in conjunction with the above options.

14. Action Item (AI) Requirements

- 14.a. APMS will assign a unique Action Item number based on predefined AI categories.
- 14.b. APMS will provide the capability to restrict access to AIs.
- 14.c. Each Action Item shall require approval prior to being moved into the formal AI database.
- 14.d. SI, Customer and Contractor Action Items shall be separately distinguishable.
- 14.e. APMS resident AI responses shall be linked to the AI in the database.

15. Discrepancy Report (DR) Requirements

- 15.a. APMS will assign unique DR identifiers for each report by reporting node.
- 15.b. APMS will provide the capability to restrict access to DRs.
- 15.c. Each DR will require DERB approval prior to being moved into the formal DR database.
- 15.d. The DR shall have priority categories.
- 15.e. The capability shall be provided to route a DR to another user for review (user queue).
- 15.f. Administrator override/update capability shall exist.
- 15.g. User modification capability shall exist, subject to the control limitations imposed by configurations management.
- 15.h. DR closure shall be agreed upon by the DR administrator and DR reporting activity, then tagged as closed.
- 15.i. APMS resident DR responses shall be linked to the DR in the DR database.
- 15.j. All reports shall have softcopy display and hardcopy output capability.
- 15.k. The following report types will be provided at a minimum:
 1. Past Due.

2. All Active Discrepancy Reports.
3. Organization Specific.

15.j. Ad hoc query and report capability will be provided in the APMS Utilities function in the DCO CSCI.

16. Registry Requirements

16.a. The Registry Database shall consist of the following:

- Received or Sent
- Segment Received/Sent
- Date Sent/Received
- Person Sent to/Received
- Time Sent/Received
- Package Name
- Date/Time Reviewed

16.b. A capability for inter-nodal sending and receiving of controlled documents shall be provided.

16.b. Document Copy Number assignment and processing for transmitted documents shall conform to approved procedures.

16.c. All appropriate security checks shall be part of the system.

16.d. All reports shall have softcopy display and hardcopy output capability.

17. Engineering Change Proposal (ECP) Requirements

17.a. APMS will provide add, delete, and modify ECP tracking records to the APMS ECP administrator.

17.b. APMS will provide view, query and report capability to authorized users.

17.c. Cost data will be restricted to Program Office Personnel only.

17.d. APMS will provide the capability to generate ECP reports for softcopy display and hardcopy output.

17.e. The capability shall exist to generate reports based on user selected fields defined in the ECP data requirements.

18. To Be Determined/To Be Resolved (TBD/TBR) Requirements

18.a. The capability shall exist to create a current database of TBD/TBR information retrieved from initial issue of baseline documents of RFCs

- 18.b. The capability shall be provided to perform an automated search of TBDs and TBRs in a particular document and save their locations (i.e., section/paragraph).
- 18.c. The TBD/TBR search capability shall return the following items for editing by the user:
 - 1. Document ID.
 - 2. List of all TBD/TBRs with assigned sequential IDs.
 - 3. Paragraph location for each TBD/TBR.
 - 4. A blank description field for user input.

19. Configuration Control Board (CCB) Agenda/Results Requirements

- 19.a. APMS will provide softcopy read-only Agendas and Results Messages to authorized users at a APMS workstation.
- 19.b. APMS will provide softcopy templates to input Agenda and Results Message data to authorized administrators at a APMS workstation.
- 19.c. APMS will provide create, edit and delete access to softcopy Agendas and Results Messages to authorized administrator at a APMS workstation.
- 19.d. APMS will provide for the creation, maintenance, storage and control of agendas.
- 19.e. APMS will provide for the creation, maintenance, storage and control of result messages.
- 19.f. The stored results message will be identified by message ID (TWX NO.), RFC number and Board Approval Date).
- 19.g. Controlled delete capability will exist and will be restricted to the administrator.

20. Document Distribution List (DDL) Requirements

- 20.a. APMS will provide softcopy read-only DDL data to authorized users at a APMS workstation.
- 20.b. APMS will provide softcopy templates to input DDL data to an authorized administrator at a APMS workstation.
- 20.c. APMS will provide, create, edit and delete access to softcopy DDL data to an authorized administrator at a APMS workstation.

- 20.d. Creation and maintenance of distribution document copy numbers for softcopy shall be provided as follows:
- 1) Administrative edit capability of copy number accounting.
 - 2) System generated copy numbers.
- 20.e. Document Distribution List processing shall provide the following:
- 1) Create, view, edit, output and maintain capability of DDLs.
 - 2) Access to DDLs for review and approval.
 - 3) The capability will exist to attach distribution lists to all associated documents including:
 - a) Baseline Documents
 - b) RFCs
 - c) Agendas
 - d) SCNs
 - e) Standard Memos
 - f) Result Messages
- 20.f. The distribution list shall indicate hardcopy (non-APMS user) or softcopy output is to be generated.

PROCESSING REQUIREMENTS

21. Inter-Nodal Response Time Requirements

- 21.a Response time for interactive editing sessions, menu navigation, and other processes requiring continuous user input to proceed shall not exceed two seconds from user request to system response during peak load times.
- 21.b Average response time for file and database storage and retrieval shall not exceed four seconds in interactive mode.
- 21.c Average response time for reports, queries, searches, sorts and other I/O intensive processes shall not exceed thirty minutes.
- 21.d Average time for backup and archival processed shall not exceed 4 hours.

22. Reliability

- 22.a The mean corrective maintenance time for each unit as a result of failure in all system electronics and parts will not exceed 24 hours.

- 22.b The mean time between failure (MTBF) for any node must be 720 hours.
- 22.c The mean time between failure (MTBF) for the entire system must be 8,640 hours.
- 22.d The system shall be available to users 95% of the time seven days a week, 24 hours a day except for scheduled outages and major maintenance.

23 Maintenance

- 23.a The time required to perform and complete any sequence for preventative maintenance routines shall not exceed 80 minutes.
- 23.b The mean time to repair (MTTR) for the APMS shall be less than 4 hours for all components. The MTTR includes fault isolation, disassembly, replacement, reassembly and checkout.

VII. MAINTENANCE CONCEPT

The maintenance concept for the Automated Program Management System provides guidelines for aiding in the design process. Key areas of support are

- levels of maintenance support, and responsibilities,
- operational and maintenance environment, and
- quality factor assessment.

LEVELS OF MAINTENANCE

There will be three levels of maintenance for the new system. These are user level, organizational level and vendor support level.

User Level

Ideally, the user should not be impacted by the existence of software or hardware problems. At the user level of maintenance support, the user is responsible for ensuring that the equipment is properly used and maintained. The user must be capable of recognizing when the equipment is not functioning properly and report the problem to the appropriate support personnel.

Organizational Level

The customer's support center provides the next level of maintenance support, the organization level, for the APMS environment. The user is provided with a technical support function to be staffed by the support center for problem resolution. If the problem can not be resolved telephonically, it is logged into the trouble ticket system where the hardware, software, and administrative personnel begin to investigate the problem. The maintenance system should be able to provide enough hardware spares to provide a direct exchange of any faulty device. Minor software problems should be resolved by the fully trained support center staff.

Vendor Level

When hardware problems cannot be repaired on site, it will be sent to the vendor for repair. Likewise, software problems which cannot be fixed by on-site programmers will be referred to the responsible software developer technician for resolution at the appropriate level of priority. This is the third level of maintenance support, the vendor support level. The hardware supplier is also responsible for maintaining a supply of electrical components for repair and replacement. Figure 7.1 illustrates the system maintenance concept and the delegation of responsibilities for APMS.

ORGANIZATIONAL MAINTENANCE	INTERMEDIATE MAINTENANCE		DEPOT PRODUCER MAINTENANCE
At the system operating site or wherever the prime equipment is located	Mobile or semimobile units	Fixed units	Depot or producer facility
	Truck, van, portable shop, or equivalent	Fixed field shop	Specialized repair activity, or producer's manufacturing plant
System equipment operating personnel (low maintenance skills)	Personnel assigned to mobile, semimobile, or fixed units (intermediate maintenance skills)		Depot facility personnel or producer's production personnel (mix of intermediate fabrication skills and high maintenance skills)
Using organization's equipment	Equipment owned by using organization		
Visual inspection Operational checkout Minor servicing External adjustments Removal and replacement of some components	Detailed inspection and system checkout Major servicing Major equipment repair and modifications Complicated adjustments Limited calibration Overload from organizational level of maintenance		Complicated factory adjustments Complex equipment repairs and modifications Overhaul and rebuild Detailed calibration Supply support Overload from intermediate level of maintenance

Figure 7.1 Maintenance Responsibilities

The system must maintain the user's hardware and software interface to include:

1. Direct exchange of faulty hardware.
2. Installation of all required hardware/software with the required connectivity (workstation, LAN, file server or mainframe).
3. Installation of upgrades/changes on a non-interference basis.
4. Provide administrative control over all user files which are controlled at the division level or higher.
5. Maintaining software at the division level or higher.
6. Testing all new versions of software to preclude impacts to the user community.
7. Establishing a periodic schedule for transition of the new software versions into the operational environment.
8. Establishing and maintaining a trouble ticket system to track problems with hardware and software.

All supplier hardware and COTS software maintenance actions will be handled through supplier factory sites located in the Washington, D.C. metropolitan area. Specialists at the supplier sites are responsible for providing service actions to failed electrical components, answering any complex technical questions, and providing technical training to the customer technical support team. Telephone support will be provided from 7 AM to 5 PM EST. Vendor maintenance contracts for the proposed hardware and software have been purchased and are listed in the life-cycle cost analysis (section XII) of this report.

In the case of catastrophic failure, supplier technicians will be dispatched from the supplier factory location nearest to the customer site.¹ When phone support will suffice, the appropriate replacement parts will be shipped overnight from the supplier factory to the customer to ensure that the mean corrective maintenance time remains under 24 hours.

In accordance with past experiences of the reliability of systems similar in nature, it is assumed that the overwhelming majority of system maintenance will occur at the customer site and be relatively simple.

The maintenance functional flow is detailed for corrective maintenance, support maintenance personnel, etc. This functional flow diagram is shown in the Functional Analysis Section (Figure 8.2).

OPERATING CONDITIONS

Operating conditions detail the conditions under which the system must operate on a day-to-day basis. These conditions include environmental factors, transportation, handling, and storage. It is the responsibility of the customer to provide an environmentally controlled facility so as not to put the network under extreme conditions. The operating specifications of the network include a 10 to 40 degree C operating temperature, relative humidity of less than 80% and an absence of standing water.

¹ A catastrophic failure is defined as a loss of functionality of the total network or of over 30 percent of the workstations.

Each workstation is equipped with cooling fans which will reduce the possibility to overheating due to thermal inductance. Transportation and handling is the responsibility of the suppliers. Additional moving of equipment once on site must be done with extreme care. Damage due to vibration, humidity, shock should be avoided.

QUALITY FACTOR ASSESSMENT

APMS possesses a maintenance design and philosophy in which system down time will be kept to a minimum. For the most part, regular maintenance will be accomplished concurrently while users are working on the system.

System Availability

The flexibility of the prototype configuration will assist in assuring maximum availability. The system is designed so each user workstation can be operated with one or two internal disk drives. The drives will only be used for the application software (no data) and should one or both of the drives fail, the workstation can operate using the server's application software. This reconfiguration is a minimum task for the system administrator. The server is configured with removable drives, that can be replaced quickly if they should fail. These design considerations will allow APMS to meet the maintenance requirements which are identified in the operational requirements section of this report.

System Reliability

Reliability is a major design consideration. The selected hardware components of the system are proven products from industry leaders. These products have been 'battle' tested in the industry in other similar implementations by the corporation. The COTS selected is also industry proven, and both the data base management system (Sybase) and the document processor (Interleaf) provide for the limited fault-tolerance in their design. The maintenance costs for the APMS Prototype suite of equipment is significantly reduced in comparison to that of the similar sized systems.

System Maintainability.

The APMS prototype incorporates several design components which increase system maintainability, such as removable drives which allow for quick replacement should failures occur, and optical mice (no moving parts). Additionally, the system is composed of like components, such as the workstation and servers. These two processors could be inter-changed if required. FiberCom Ethernet Transceivers have a bypass switch that allows the fiber optic signal to pass even when the unit has been damaged or turned off. These actions and precautions will ensure that the time required to perform and complete any sequence for maintenance will not exceed 24 hours.

VII. FUNCTIONAL ANALYSIS

An integral part of preliminary design is the development of a functional approach as a foundation for the identification of design requirements for each level of the system. System functional analysis is a logical and systematic approach to system design and development. It constitutes the process of translating system operational and support requirements into specific qualitative and quantitative design requirements. This process is iterative, and is accomplished through the development of functional flow diagrams.¹

SYSTEM FUNCTIONAL ANALYSIS

A need for a life-cycle analysis has been identified to determine the total system cost. The total system cost is one tool which will be used to determine the most efficient and cost effective method of acquiring the system.

In this analysis, the system is detailed in the planning, design, development, production, deployment, installation, and operation of APMS. Each element of the analysis must be considered during the design and development phase of the system deployment. Lower total system cost, better maintainability, and longer mean time between failure are the long term goals which the system developer is driving toward in the design and development phase.

¹ Blanchard, B. S., and Fabrycky, W. J. *Systems Engineering And Analysis*. Englewood Cliffs, NJ: Prentice Hall, 1990. pg 57.

The functional analysis is based on the definition of system operational requirements and the system maintenance concept, and is subsequently used as the basis for detailed design. Both the operational and maintenance support aspects, as they relate to anticipated system life-cycle use by the customer must be addressed.²

FUNCTIONAL FLOW DIAGRAM

Functional flow diagrams have the primary purpose of structuring system requirements into functional terms. A function constitutes an individual action required to achieve a given objective. Such an action may be accomplished through the use of software, hardware, individuals, data or a combination of the above. They indicate the basic organization of the system and the interfaces of the system.

For the purposes of this study, functional flow diagrams were composed to the third level of detail. The top level diagram shows gross operational functions, with the lower levels detailing expansions on these top level operations. The functional flow diagrams for the operation and maintenance of the Advanced Program Management System are found in Figures 8.1 and 8.2.

² Blanchard, B. S., and Fabrycky, W. J. *Systems Engineering And Analysis*. Englewood Cliffs, NJ: Prentice Hall, 1990. pg 57.

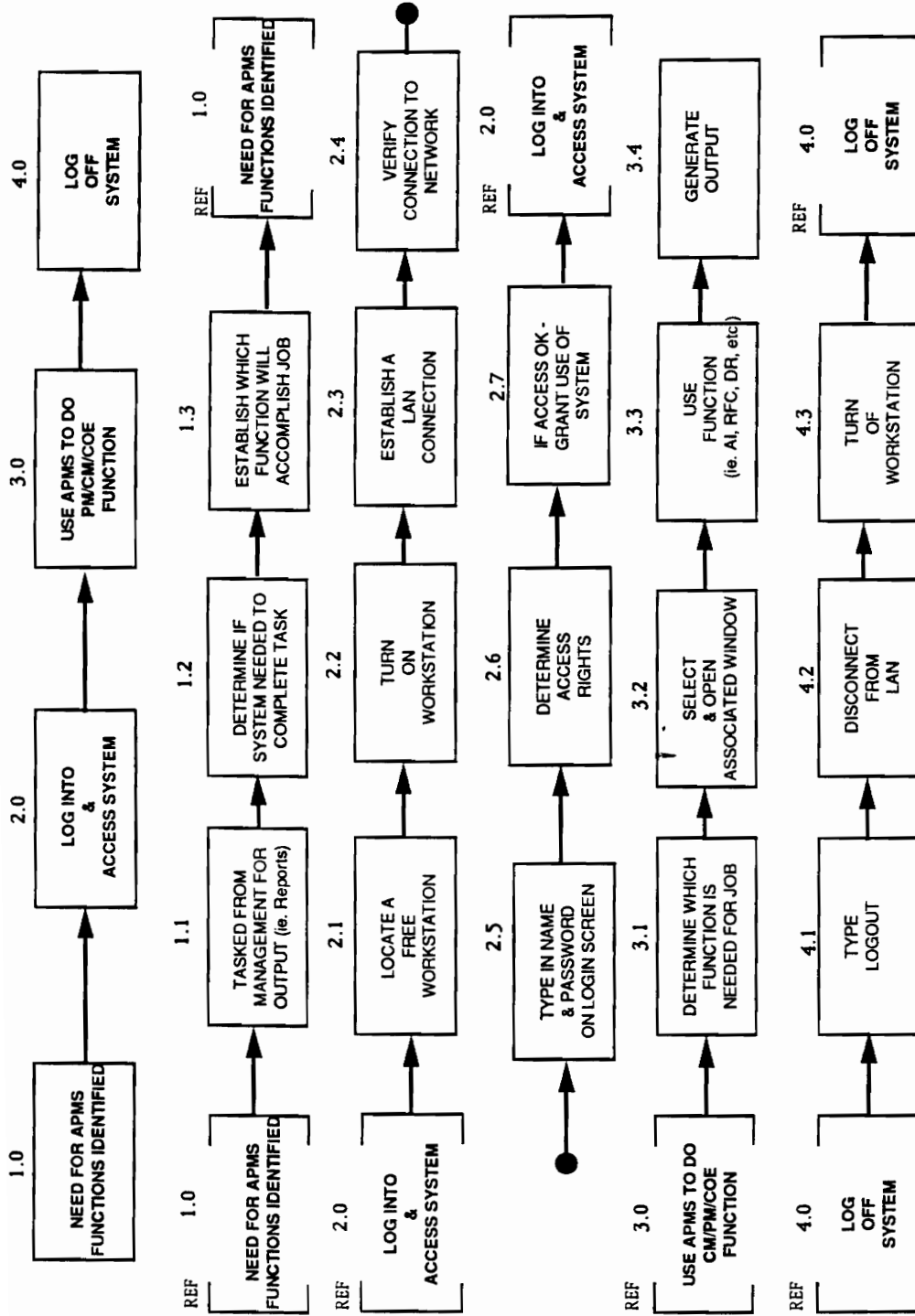


Figure 8.1 Operational Functional Flow Diagram

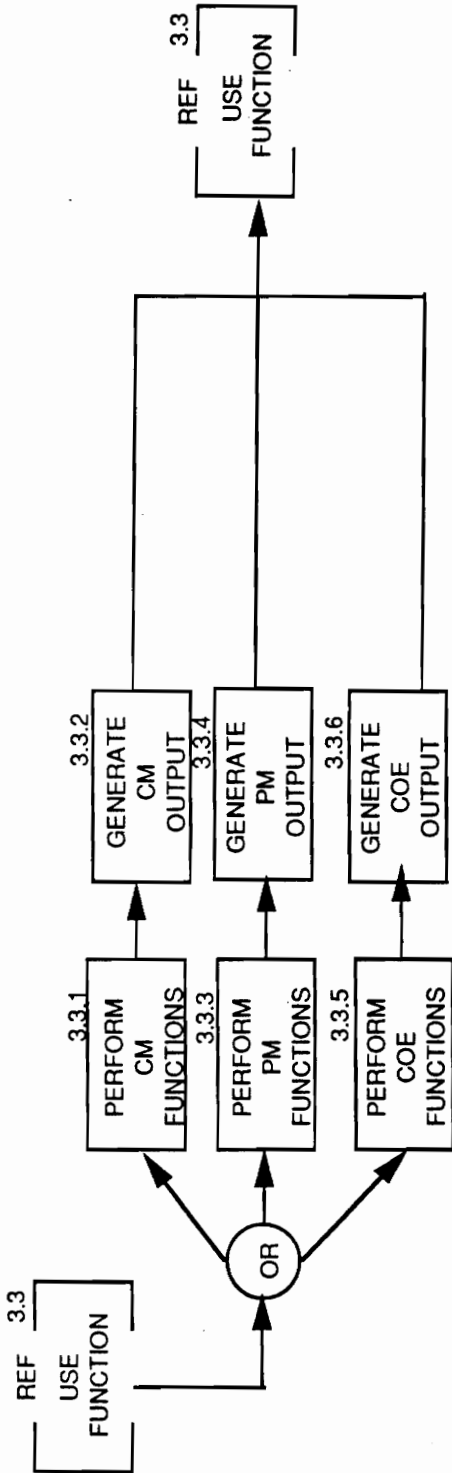


Figure 8.1 Operational Functional Flow Diagram (Cont'd)

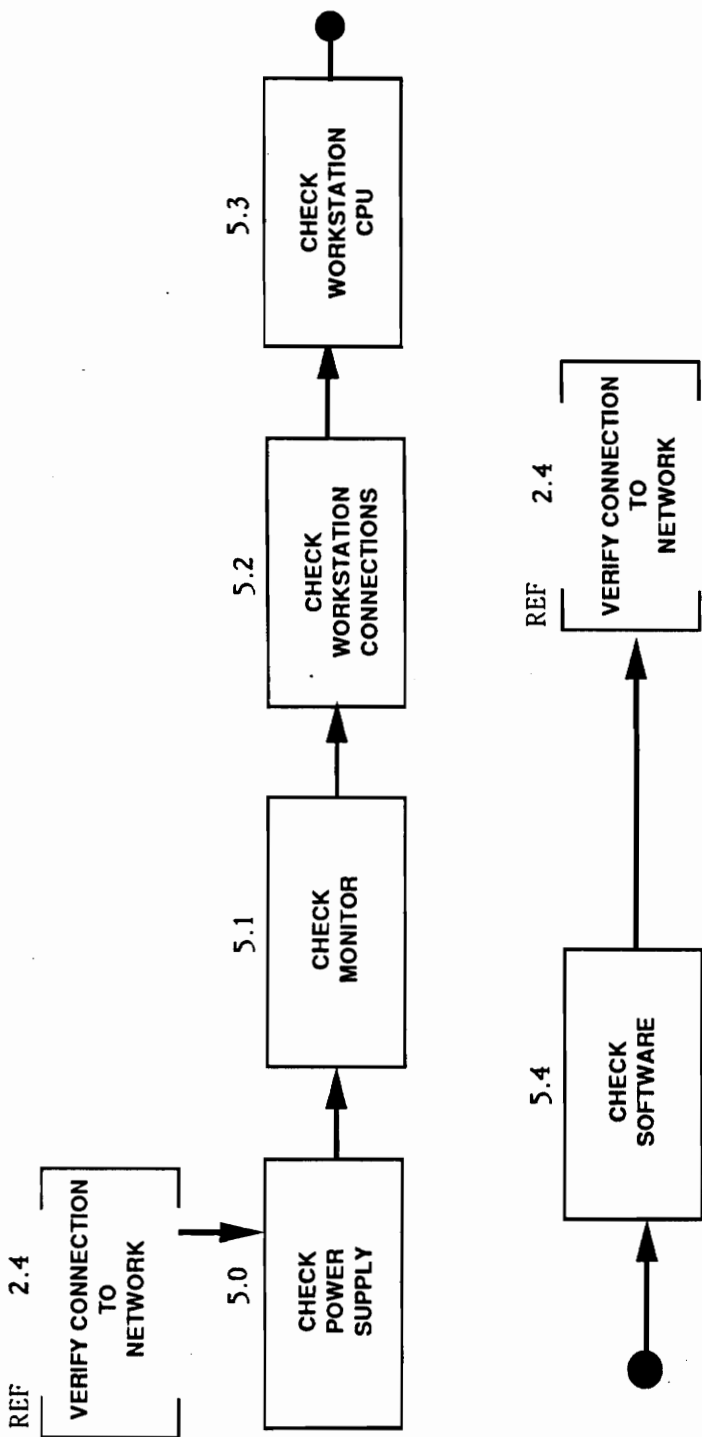


Figure 8.2 Maintenance Functional Flow Diagram

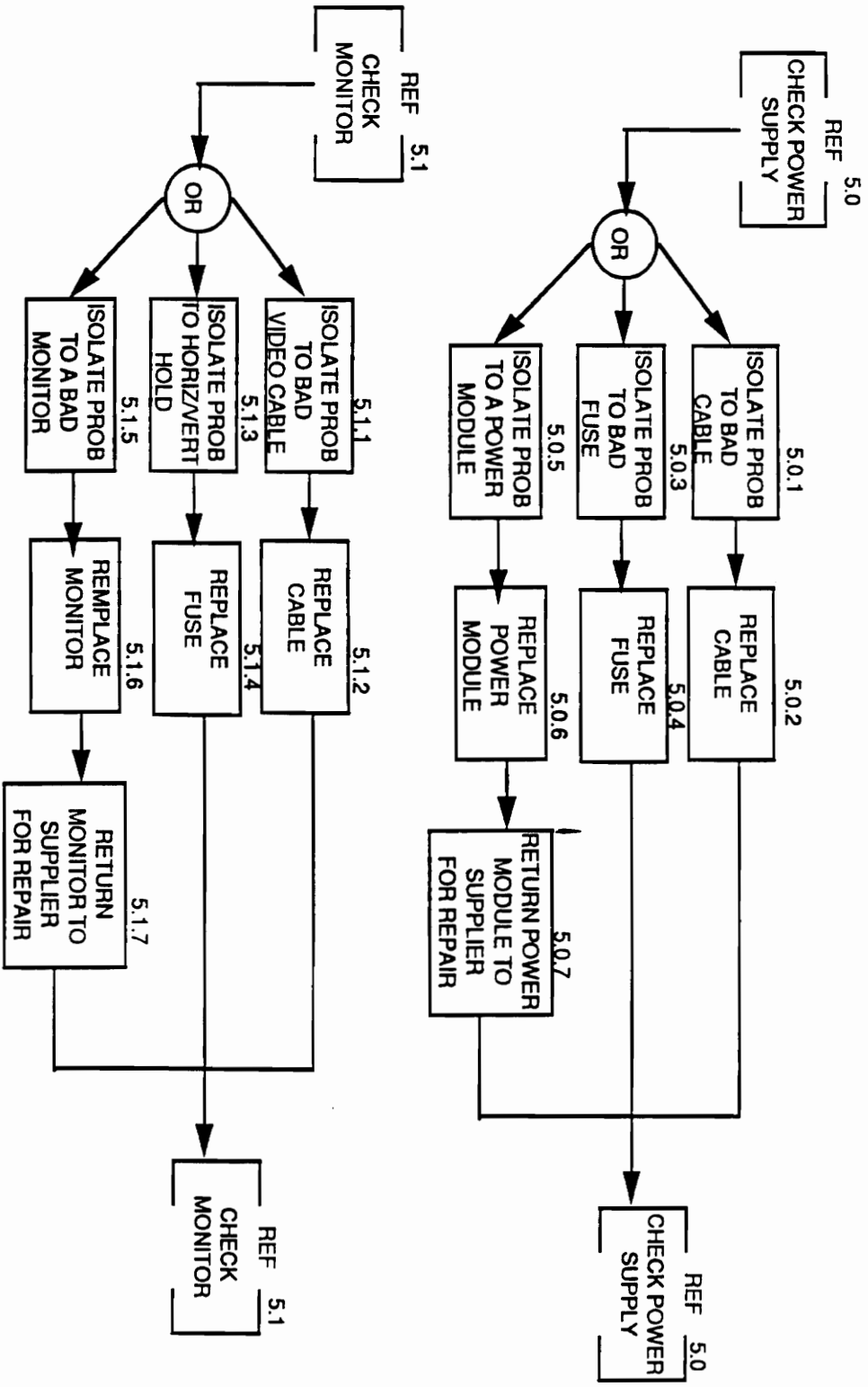


Figure 8.2 Maintenance Functional Flow Diagram (Cont'd)

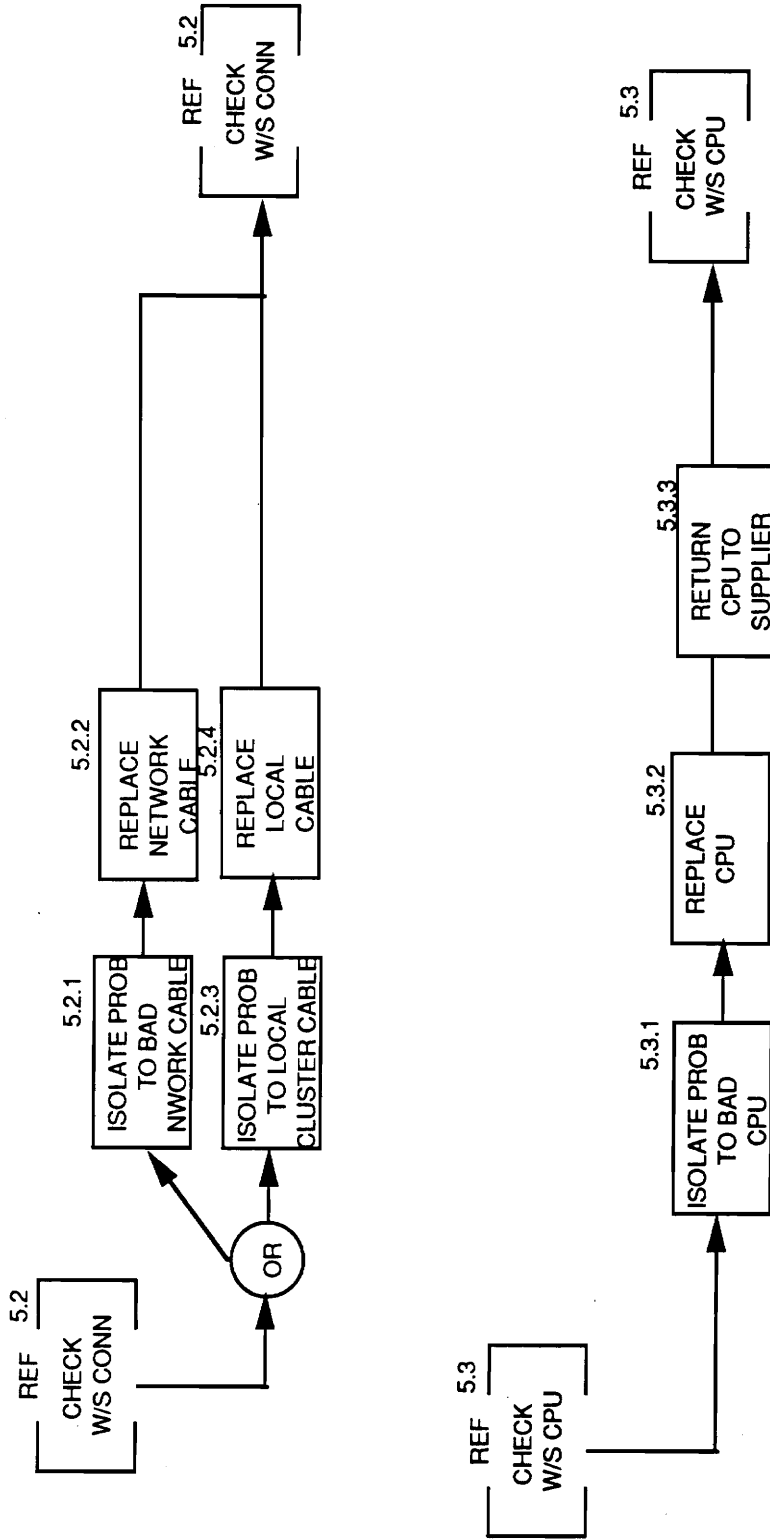


Figure 8.2 Maintenance Functional Flow Diagram (Cont'd)

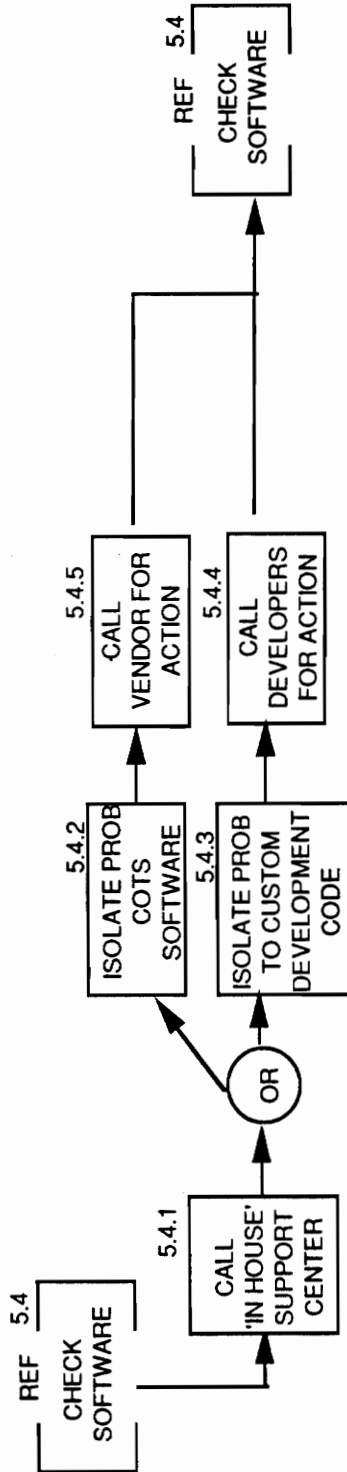


Figure 8.2 Maintenance Functional Flow Diagram (Cont'd)

IX. SYSTEM DESIGN

SYSTEM DESIGN PROCESS

The analysis of the proposed system begins here. The requirements have been collected and are now allocated to operations, software, database and hardware. The proposed system is first described in terms of its logical attributes. The design proceeds from the current logical system rather than the current physical system so that the system design will be driven by the generic representation of the requirements rather than a particular instance of them (the physical system). Figures 9.1 and 9.2 define systems design chronology for the APMS system. The basic software logical flow of data are determined during this process.

SYSTEM OVERVIEW

The APMS application provides automated processing and information management for selected Configuration Management and Program Management functions. The requirements for processing and data management, specific to these functions, as implemented in APMS are detailed in the APMS Operational Requirements Section. The areas of Configuration Management addressed in the APMS design are:

- Baseline Document Processing
- Requests for Change Processing
- Specification Change Notice Management

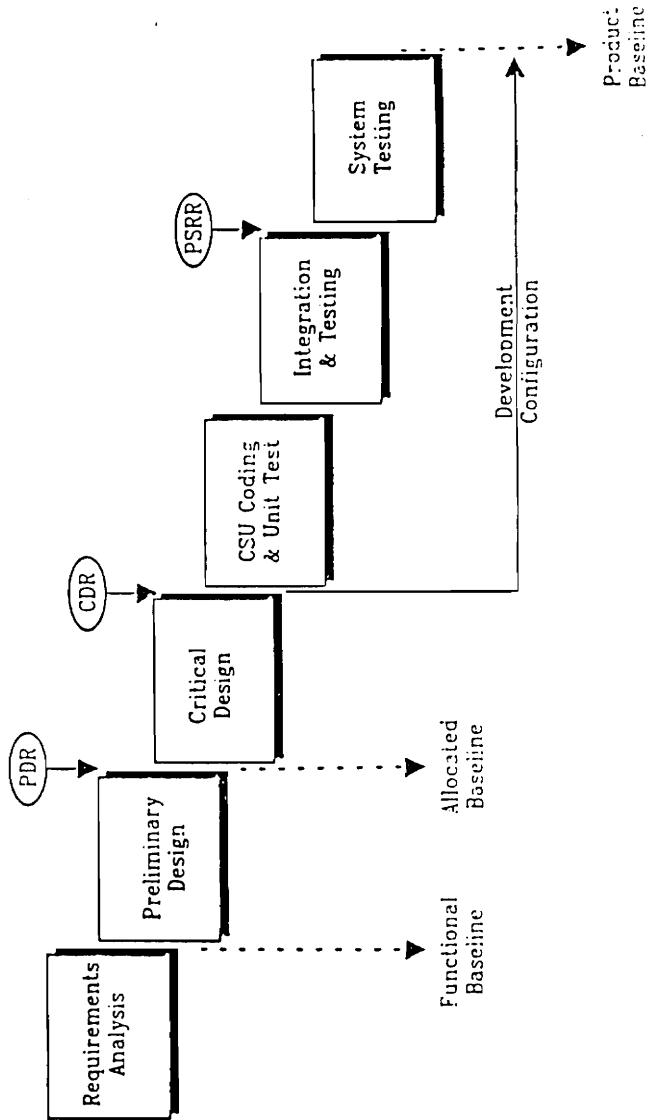


Figure 9.1 System Development Chronology

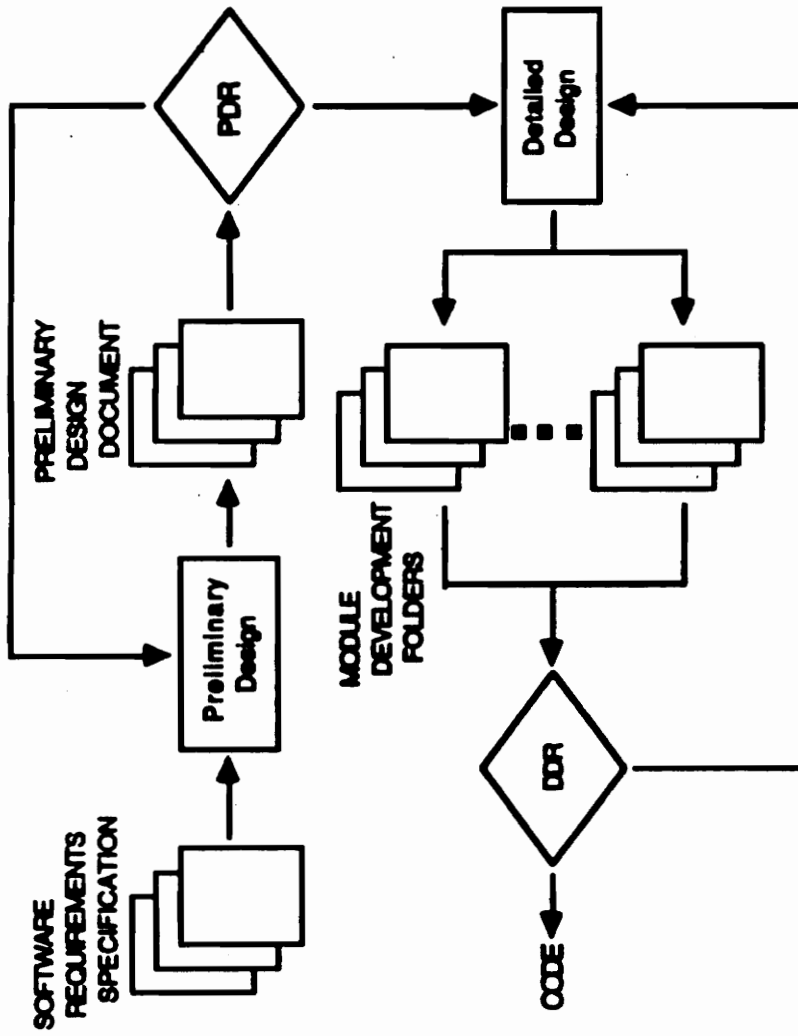


Figure 9.2 Software design chronology.

- Configuration Control Board (CCB) Agendas/Results Processing
- Document Distribution List Processing

The following areas, specific to the Program Management functions, are addressed in APMS:

- Action Item Management
- APMS Discrepancy Report
- Automated Registry/Document Control Management
- Specification Change Notice Management
- Engineering Change Proposal Management
- TBD/TBR Management

The following Utility Functionality is given by APMS:

- Electronic Mail System
- Electronic Signature

The implementation of the APMS Prototype will provide an effective and efficient tool for the management of the complex processes involved in the control of major programs and the associated configuration management. The APMS Prototype design, as outlined in the following sections, is structured to maximize functionality, ease-of-use and interoperability.

SYSTEM ARCHECTURE

The APMS prototype system architecture, depicted in the diagram shown in Figure 9.3, consists of the following major components:

- The hardware architecture, which includes node hardware, local network connectivity and the wide area network configuration.
- The software architecture, which includes the Computer Software Configuration Items (CSCIs), the operating system and the COTS software.

The interaction between the general users, administrators and other external computer systems is shown in Figure 9.4. This diagram is the high level context diagram for the Advanced Program Management System.

The process bubble labeled "0" represents the entire automated system. The squares represent the externals to APMS. The flow lines represent the high level data transferred between APMS and the externals. These high level flows will be decomposed to show the specific data items provided by the externals to the system, as well as the specific data provided by the system to the externals.

The first external is the general APMS user community. These general users have standard privileges and are not assigned specific responsibilities. Examples of general user input include the information to create an RFC or

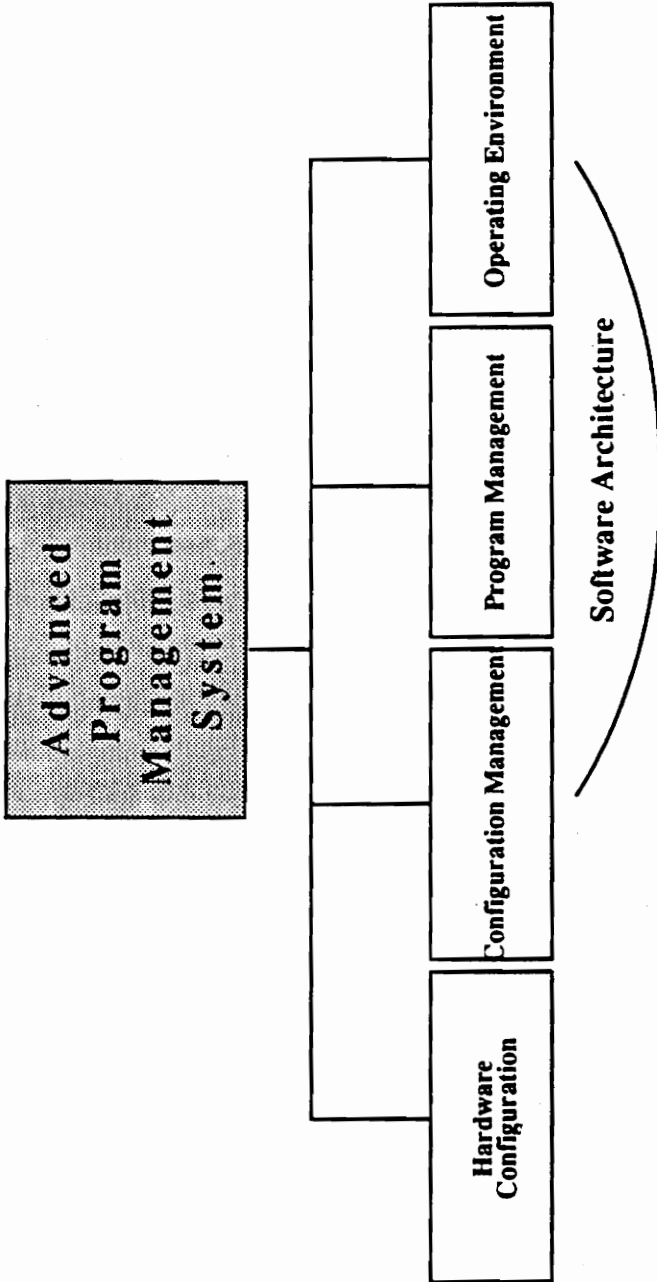


Figure 9.3 Architecture Diagram

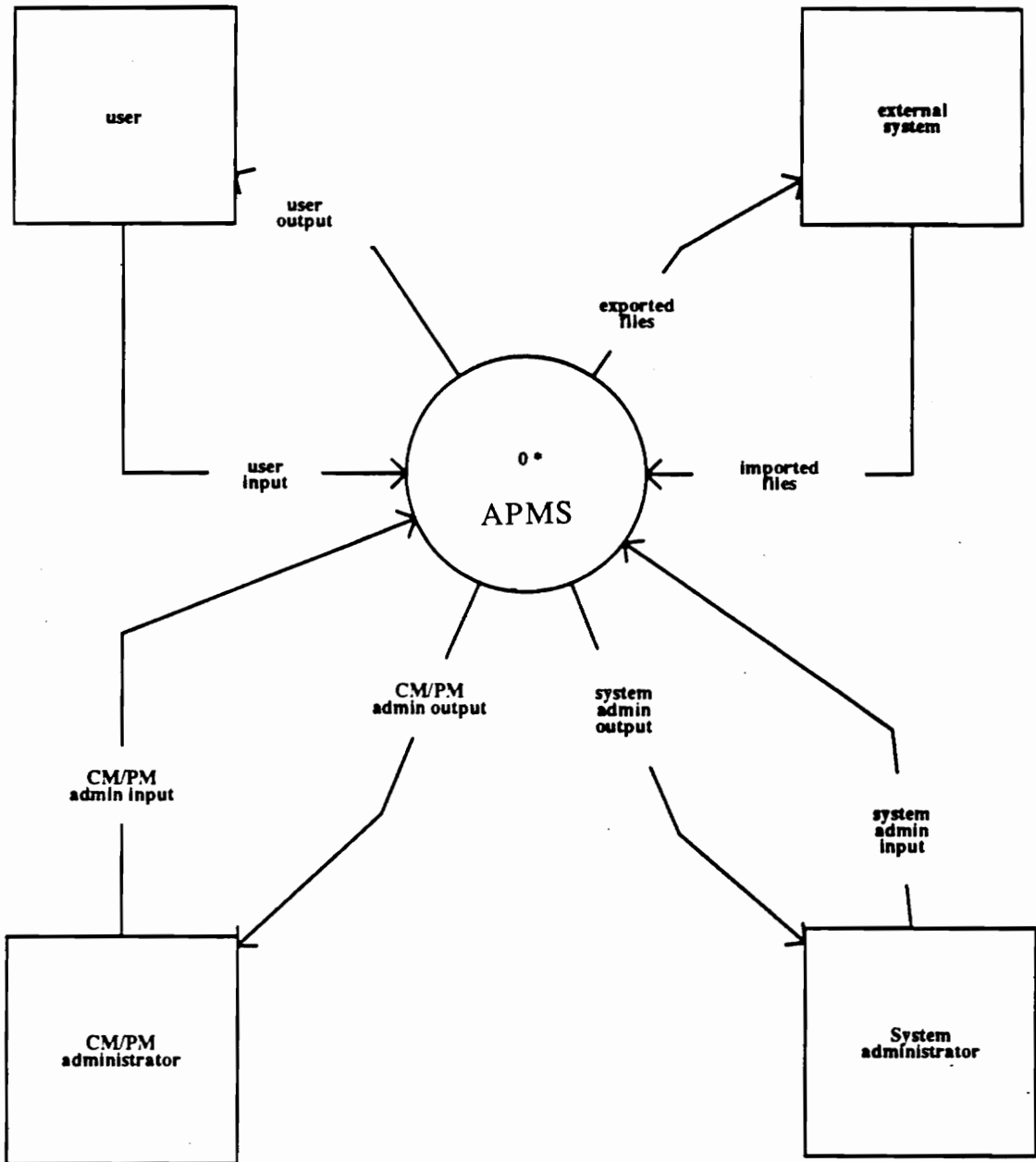


Figure 9.4 Context Level Diagram

action item responses. General user output may include RFCs for review, requirements traceability data or ECP status reports.

The second external is the CM/PM administrator. These individuals are assigned specific responsibilities, such as the RCF administrator or the Action Item administrators, Document Custodians, etc. who process and track APMS items that have been submitted or item that require controlled updates. These CM/PM administrators are given certain privileges, applicable to their specific role. CM/PM administrator input and output examples include tracing information and controlled document updates.

The system administrator external represents individuals who maintain the APMS system at each node, including performing backups and creating new user logins, and other related 'house keeping' tasks. An example of the system administrator inputs and outputs would be the files archived and retrieved by the system administrator, or audit reports retrieved by the administrators.

The final external on the context diagram represents other external systems that APMS will communicate with, such as the existing Macintosh system, Wang system and IBM PCs. The interaction between these external systems and APMS is primarily a file transfer process allowing for the importation of data and the importation of Joint RFCs for transport across the APMS network.

HARDWARE/NETWORK ARCHITECTURE

The APMS prototype hardware architecture consists of a Local Area Network (LAN) at each of the following locations:

- Program Office
- System Integrator Location
- West Coast Contractor Location.

Each APMS Prototype node is comprised of two workstations: one configured as the workstation/data server and the other as a standard workstation. The two workstations are connected via the fiber-optic Ethernet local area network (LAN). The node data server provides the mass storage for the LAN, with a small external enclosure, housing two (2) 1 gigabyte disk drives. Additionally, each node will have a node printer, a 1/4 inch tape drive, a graphic scanner with Optical Character Recognition capability, and a CD-ROM drive. Figure 9.5 depicts a single APMS Prototype Node hardware configuration.

During development, three prototype nodes will be configured as is depicted in Figure 9.6. All six workstations (2 per node) will be connected to the fiber optic wide area network.

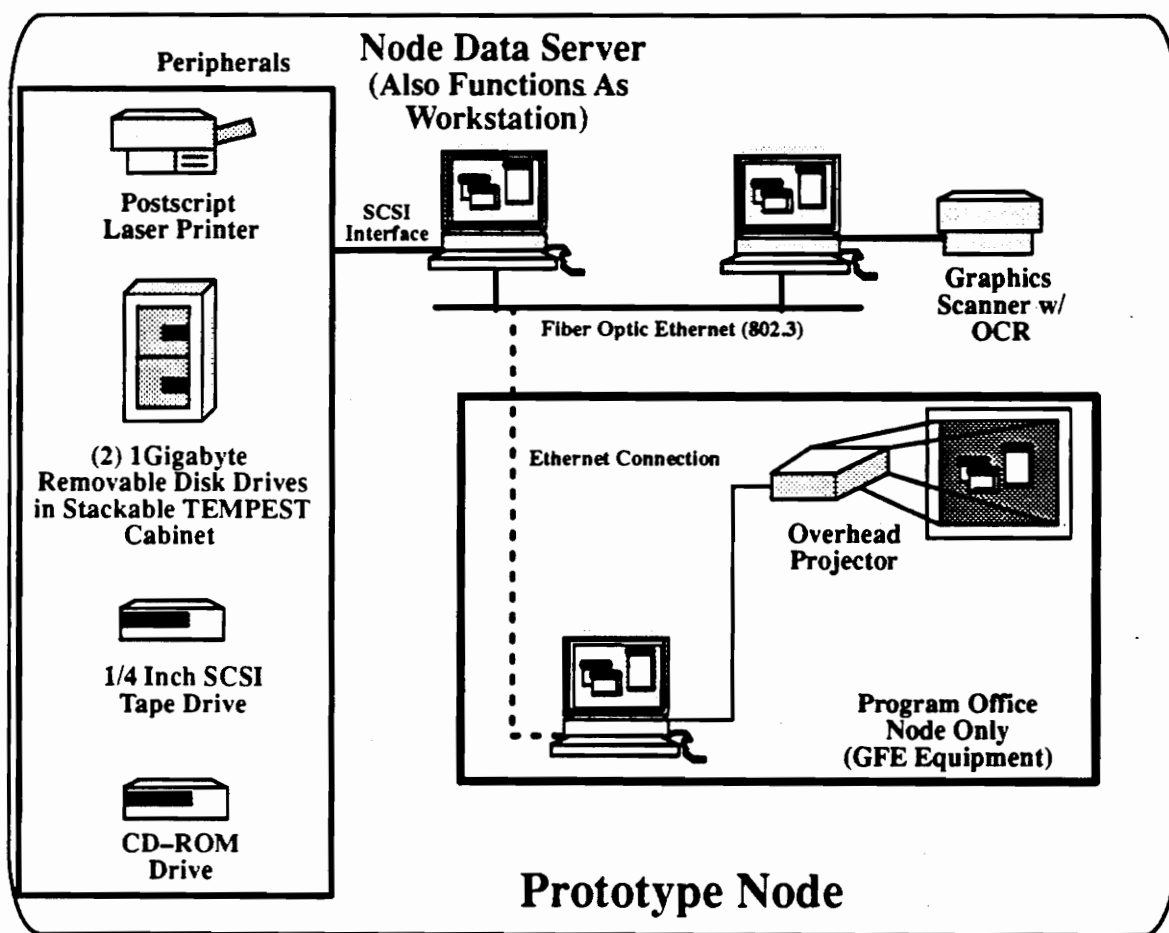


Figure 9.5 Prototype Single Node Hardware Architecture

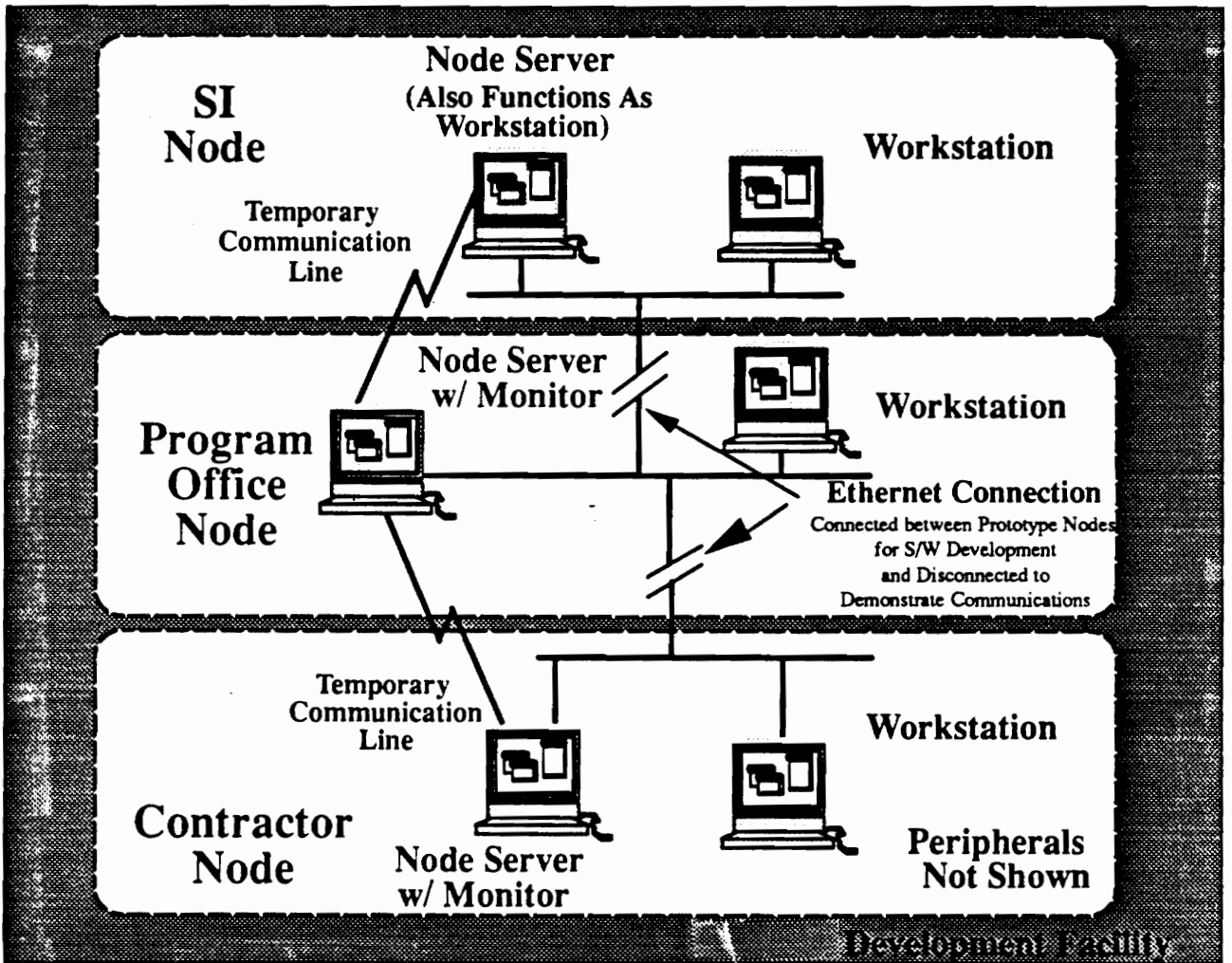


Figure 9.6 Prototype Development and Testing Configuration

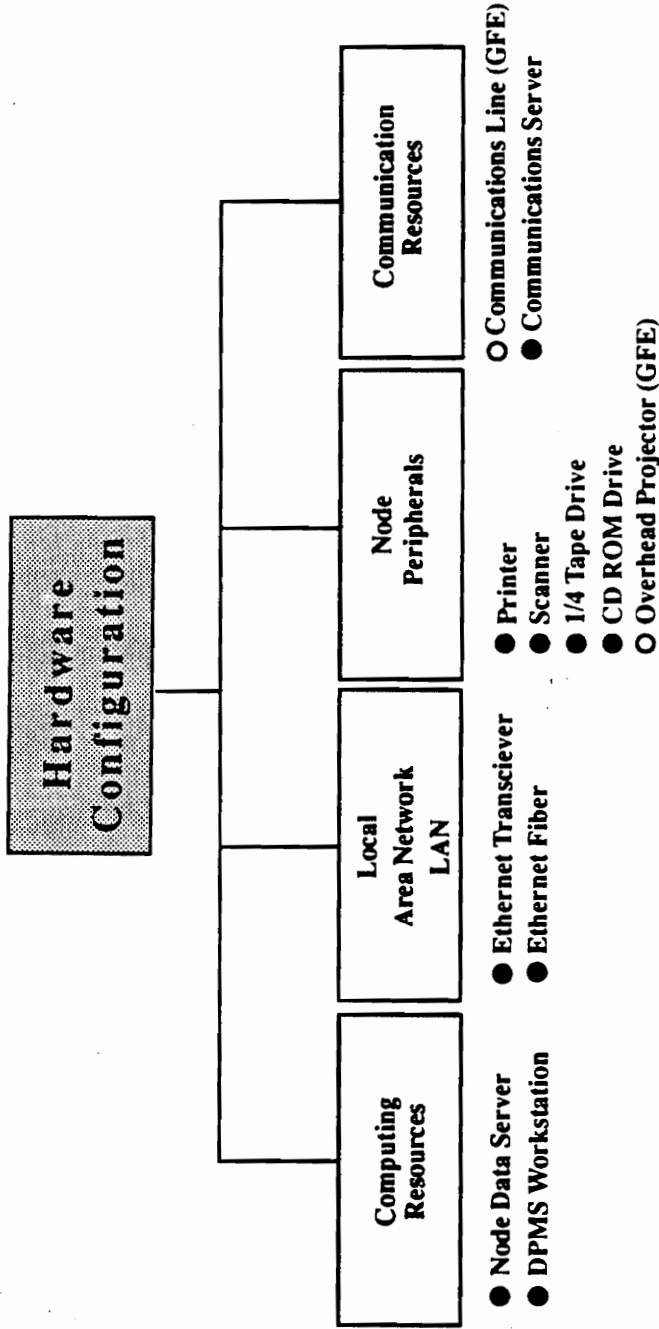
Primary APMS Computer Component - SUN SPARCstation 2

Sun's SPARCstation 2 is to be used for both the APMS workstation and the server. The workstation provides 24.8 million Instructions Per Second (MIPS) of processing performance. The system will be networked using industry standard Ethernet protocols (IEEE 802.3). Sun adheres to the use of government and industry standards, making possible tightly coupled networks that function as a single powerful computer. Figure 9.7 shows the APMS hardware configuration.

The SPARCstation 2 is configured to support a standard 3-1/2 inch, 1.44 MB floppy drive and up to two removable 207 MB disk drives. A 150 MB 1/4 inch tape drive can be attached to the system. Also standard with the workstation are a 19 inch color monitor, the GX graphics accelerated frame buffer, keyboard, and mouse. Figure 9.8 illustrates the detailed prototype single node configuration, a listing of prototype hardware components, and the IOC/FOC prototype configurations.

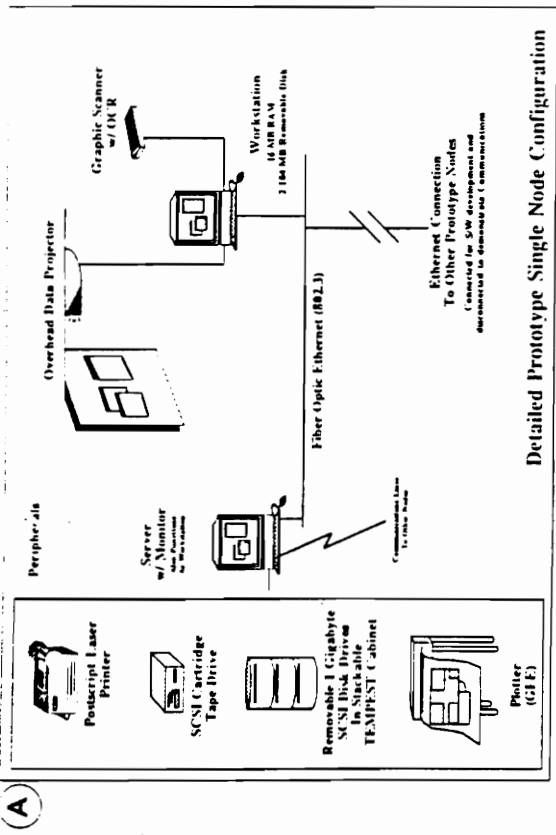
APMS Workstation Configuration

The APMS prototype workstation configuration again uses the SPARCstation with the color monitor and two removable 207 MB disk drives. The local workstation storage will be dataless, only storing the operating system and utilizing the remaining storage for disk swapping functionality.



The APMS prototype hardware configuration, based on the SUN Microsystems SPARC architecture, provides necessary performance to meet APMS requirements and to handle the security audits and processing.

Figure 9.7 APMS Hardware Configuration Hierarchy Diagram



B

NETWORK SERVER	Sun SPARC Station 1+ w/ 32 Megabytes Main Memory 1 - 19" Color Monitor (Sun) 2 - 1 SCSI Gigabyte Disk Drives (Mitek) 2 - 104 Megabyte Removal Disk Drives (Sun) 1 - 150 SCSI Megabyte 1/4 Tape Drive (Sun)
WORKSTATION	Sun SPARC Station 1+ w/ 16 Megabytes Main Memory 1 - 19" Color Monitor (Sun) 2 - 104 Megabyte Removal Disk Drives (Sun)
NETWORK COMPONENTS	Fiber Optic Transceivers (Fiber Com) Fiber Optic Cahlin (Fiber Com)
PERIPHERALS	Printer - Apple Laserwriter II NTX (Amitek) Scanner - Mitek 300 dpi w/OCR

Prototype Hardware Components

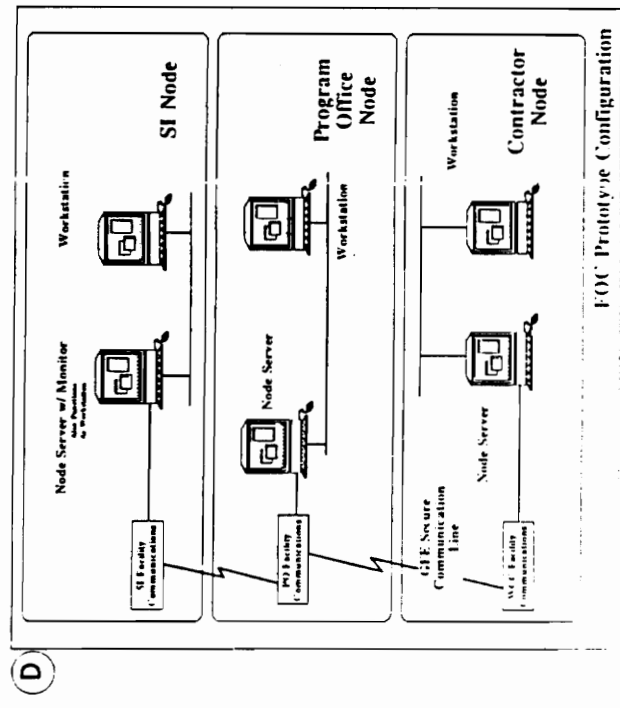
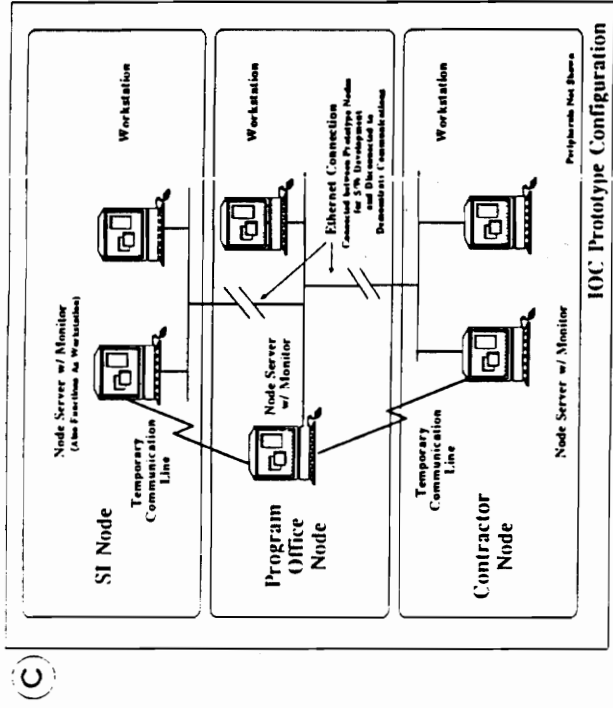


Figure 9.8 APMS Hardware Configurations & Listing

APMS Server Configuration

The SPARCstation 2 server configuration for the APMS prototype is composed of the workstation server with a monitor. This configuration allows the server to be used as a fully functional workstation. The APMS server configured with the following: 32 MB of memory, two 207 MB removable disk drives, the 150 MB 1/4 inch tape drive and 2 Gigabytes of mass storage.

Mass Storage

The Sun SPARCstation server configuration can support up to 7.6 Gigabytes of disk mass storage. The disk drives are in stackable cabinets that allow for easy expansion of the disk storage capability. The initial 2 Gigabytes per node provides cost effective and sufficient storage for the APMS Prototype. Easy storage expansion capability is provided for future APMS deployment requirements.

Peripheral Components Architecture

Tape Drive

Sun Microsystems 150 MByte, 1/4 inch tape drives are included in the APMS Prototype design baseline. Each node server will support one tape drive. The tape drives are provided to allow software loading, data file backups and other activities which require a high capacity, portable medium.

CD ROM

Sun Microsystems CD ROM units are provided for each node server. The CD ROM drives are provided to allow vendor software loading as Sun and other vendors are transferring to this method for software distribution.

Printer

Printing and plotting capabilities are to be handled by Postscript capable Apple Laserwriters. The three printers, one for each prototype node, will meet the APMS font hardcopy output requirements. These printers use the industry standard 200 page capacity tray. The Apple Laserwriter supports a 300 x 300 dots per inch resolution and supports among others, the fonts identified in the operational requirements section. Portrait and landscape orientation, output sizes of 8 1/2 x 11, 8 1/2 x 14 paper, transparencies, label stock, and envelopes are supported by the Laserwriter.

Scanner/OCR

An optical scanner which combines graphics scanning with software optical character recognition capability will be included in each node. The Microtek 300Z scanner, one the highest rated 300 dpi resolution scanners will support this requirement.

Scanner control software, operating in the Sun windowing environment, provides the input of scanned graphics already formatted for easy integration into the APMS document processor. OCR software provides quick transformation of scanned pages into computer recognizable text.

Overhead Data Projector

An overhead projector for the Program Office Node will be utilized to meet this APMS requirement. The projector attaches to the monitor of a workstation and displays the screen of the workstation including text and graphics. APMS will utilize this projector system for presentation via media transfer to a Sun workstation which is permanently connected to the projector system.

Communication Architecture

Local Area Network

The APMS prototype network component is a fiber-optic backbone that complies with the IEEE 802.3 Ethernet standard. Communication on the network is controlled by the networking elements of the operating system. The Sun CMW provides sockets to control communication between users or programs on the network. This networking application identifies the communicating parties and determines the security level of each process. Communication is then performed in a trusted manner. Once the communication is completed, the session is terminated.

Wide Area Network

The APMS Prototype consists of three nodes interconnected by dedicated, secure point to point synchronous communication links. These three nodes, when implemented at IOC, establish the initial APMS wide area network . Additional nodes may be added, following validation and acceptance of the prototype. The design is based on Sun Microsystems Internet Router (IR) software which resides on the data server at each node. The IR software provides the communication drivers to utilize TCP/IP over a serial communication link.

The WAN architecture is shown in Figure 9.9. The lines are 19.2 KB dedicated communications links. The link bandwidth is sized to allow eventual growth and increased traffic loading. The baseline design is a 19.2 Kbps synchronous line between the Program Office and each remote node. This bandwidth is based on the wide area communications analysis provided in Appendix III of this report.

Network Protocol

The communication software utilized for APMS must conform to certain data communications protocols to assure effective, secure communications between workstation within the LAN as well as between nodes across the WAN. APMS

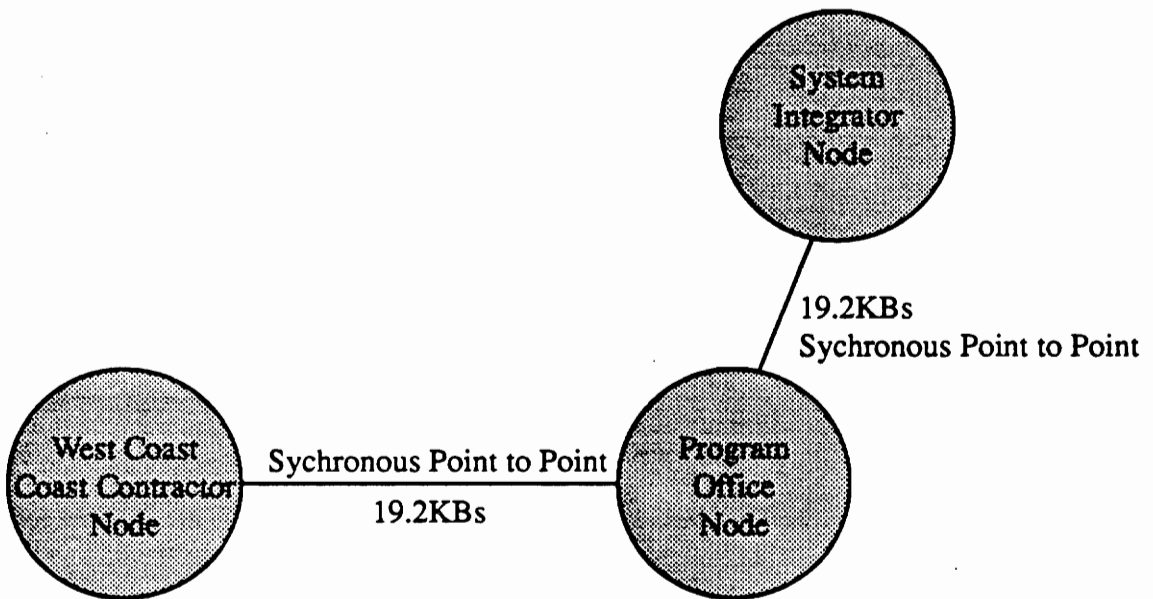


Figure 9.9 Prototype WAN Architecture

will implement the TCP/IP protocol suite, a widely used industry standard as the communications protocol on the APMS prototype network.

SOFTWARE DESIGN

The APMS Prototype Software Design is structured as a layered implementation. Figure 9.10, depicts how APMS is designed. Two primary layers are defined as the Application Layer and the Service Layer. The Application layer (shown as the columns in the graphic) contains the APMS custom application software that provides the specific APMS functionality. The Service Layer (shown as the steps in the graphic) consists of the Commercial-Off-The-Shelf software utilized in APMS, including the Sun operating system, the Interleaf document processor, the Sybase SQL database server and the communications software.

The APMS Software Design is composed of three Computer Software Configuration Items. The three CSCIs are two Application CSCIs:

1. The APMS Configuration Management (CM) CSCI 1.0
2. The APMS Program Management (PM) CSCI 2.0

and one system software CSCI,

3. The APMS Common Operating Environment (CO) CSCI 3.0

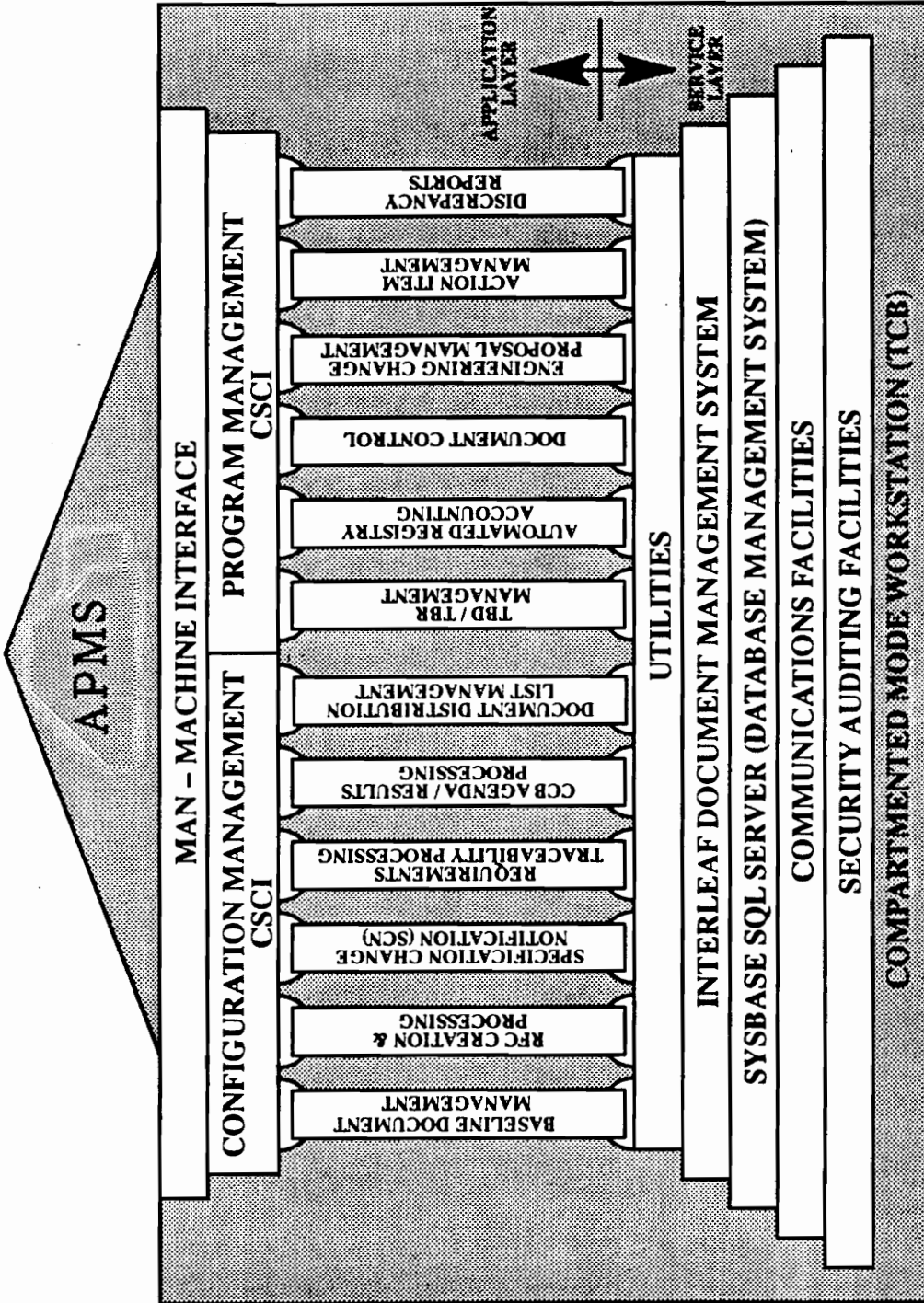


Figure 9.10 Software Architecture

Although, each CSCI is primarily defined in a particular layer, all three CSCIs span both the Application and Service layers of the APMS architecture. The CM and PM CSCIs provide the application functions required and mainly reside in the application layer. The CM CSCI is defined as the common operating environment and mainly resides in the service layer.

Figure 9.11 shows the hierarchical diagram of the APMS software design. Correspondingly, Figure 9.12 depicts a high level data flow diagram (Level 0) showing the data interaction between the CSCIs, the APMS data system and the flows external to APMS.

Configuration Management CSCI

The CM CSCI, depicted as the process bubble 1 in Figure 9.12, represents all the APMS Configuration Management functions. The CM inputs/outputs represent any data that enters/exits the CM process. These data flows are representative of data from users and from CM administrators.

The CM CSCI 1.0 automates selected functions of the CM process. This provides control of the system baseline. The system baseline is controlled through the maintenance of baseline documentation. Changes are implemented utilizing a formal Request For Change process. Changes and document impacts are identified and an RFC package is created. To identify the proper documents impacted, Requirements traceability is utilized which traces a requirement between documents. The RFC is routed through several boards for

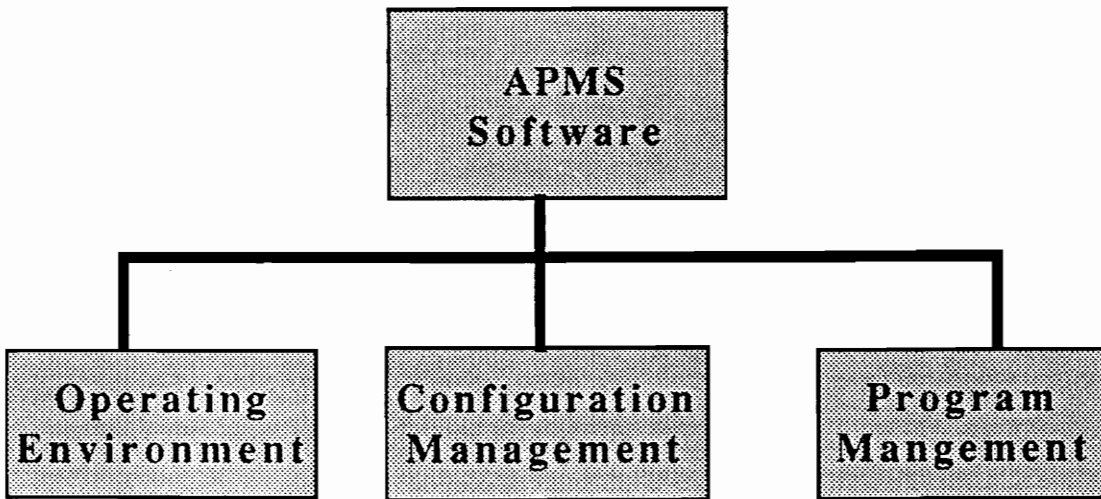


Figure 9.11 APMS Software Architecture

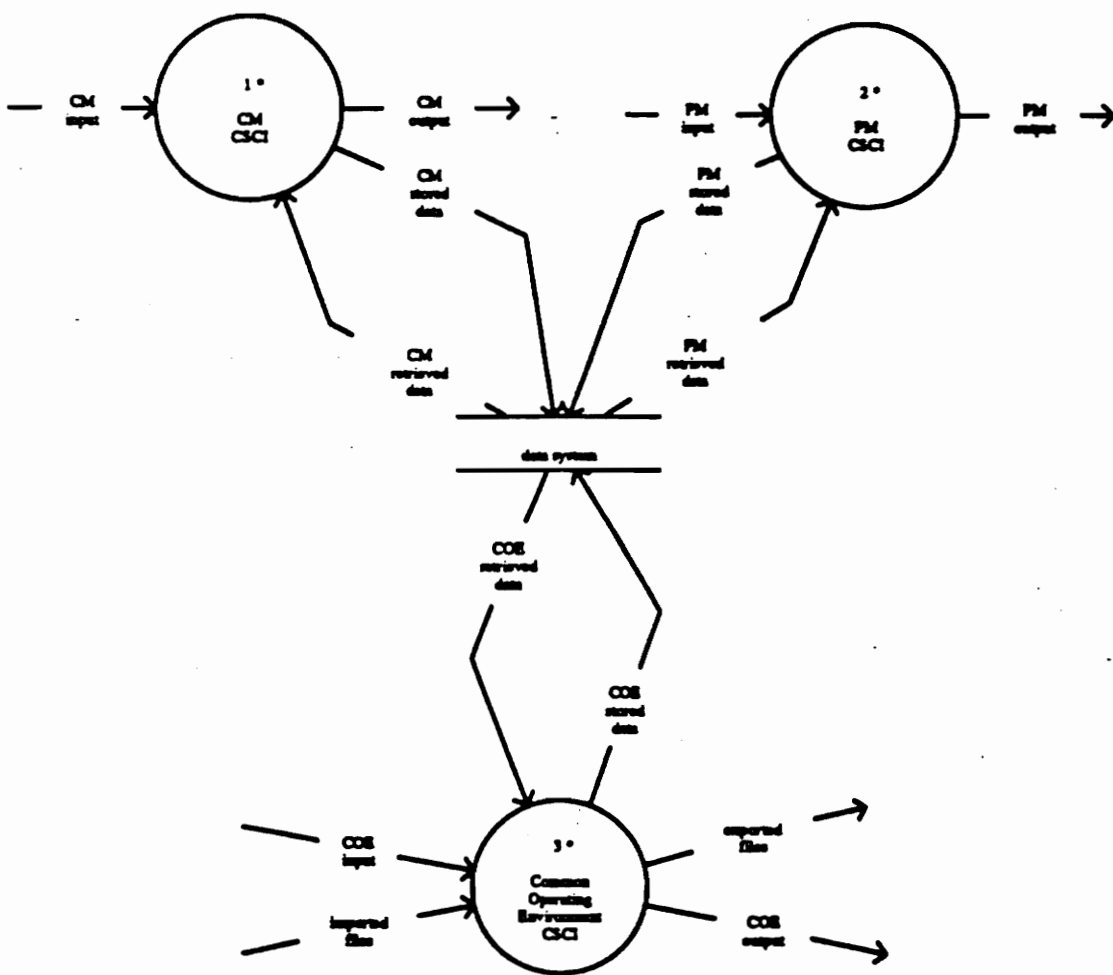


Figure 9.12 Flow Diagram 0

the necessary approvals to reach implementation. Upon final approval, the RFC can be implemented depending on the cost impact. If the cost impact exceeds a specified level, and Engineering Change Proposal (ECP) must be submitted and approved to determine more details of the technical and cost impact of the change. These updates are distributed to recipients identified on a document distribution list (DDL) via a Specification Change Notification (SCN). The SCN contains the approved change pages to the controlled baseline document. The hierarchy diagram and DFD for the CM CSCI is found in Figures 9.13 and 9.14 respectively.

Request for Change Processing

Request for Change is the method by which changes are identified, coordinated, approved and issued to the baseline document database. The DFD for this process is found in Figure 9.15.

Design Concept

The RFC Processing design, based on the selected document processor, Interleaf, and the database allows for efficient RFC creation, control and approval. The RFC will be a package that is stored and maintained utilizing Interleaf. The user selecting "RFC creation" from the RFC processing menu will be presented with options such as: "create RFC face plate", "view baselines", searching for specific requirements or querying the document for words or phrases. The user will be able to extract pages of text and graphics from

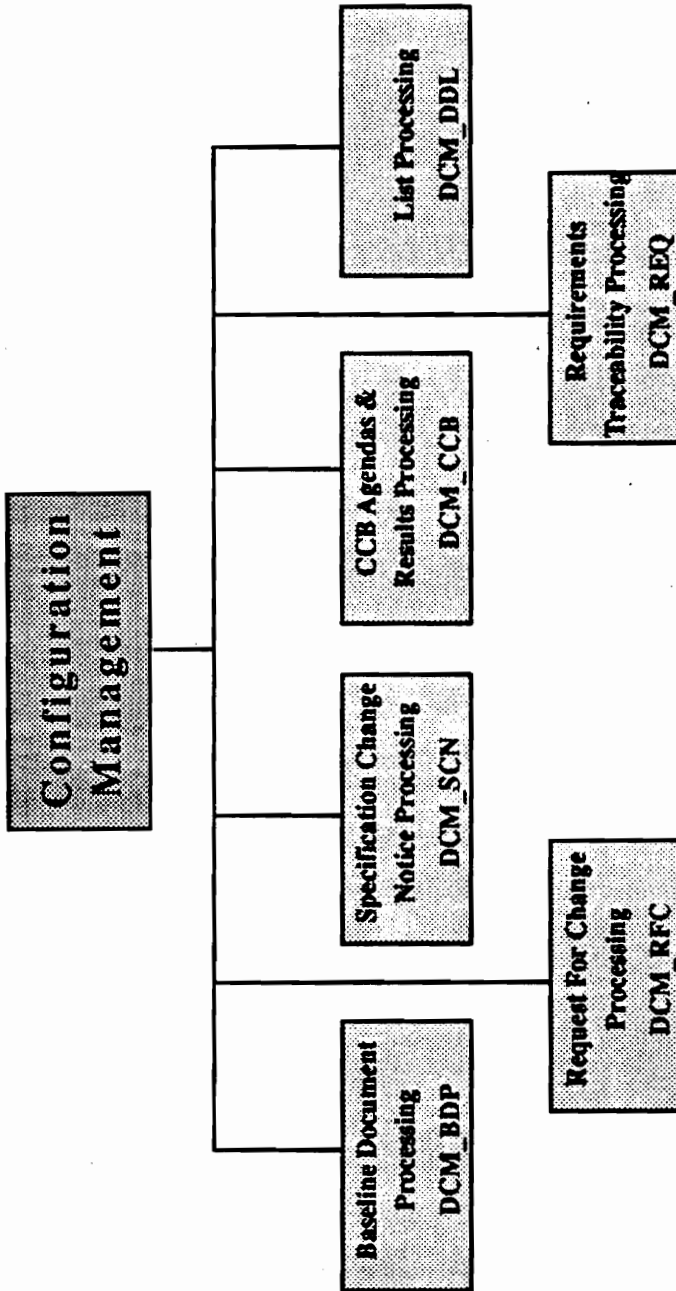


Figure 9.13 APMS Configuration Management (DCM) Hierarchy Diagram

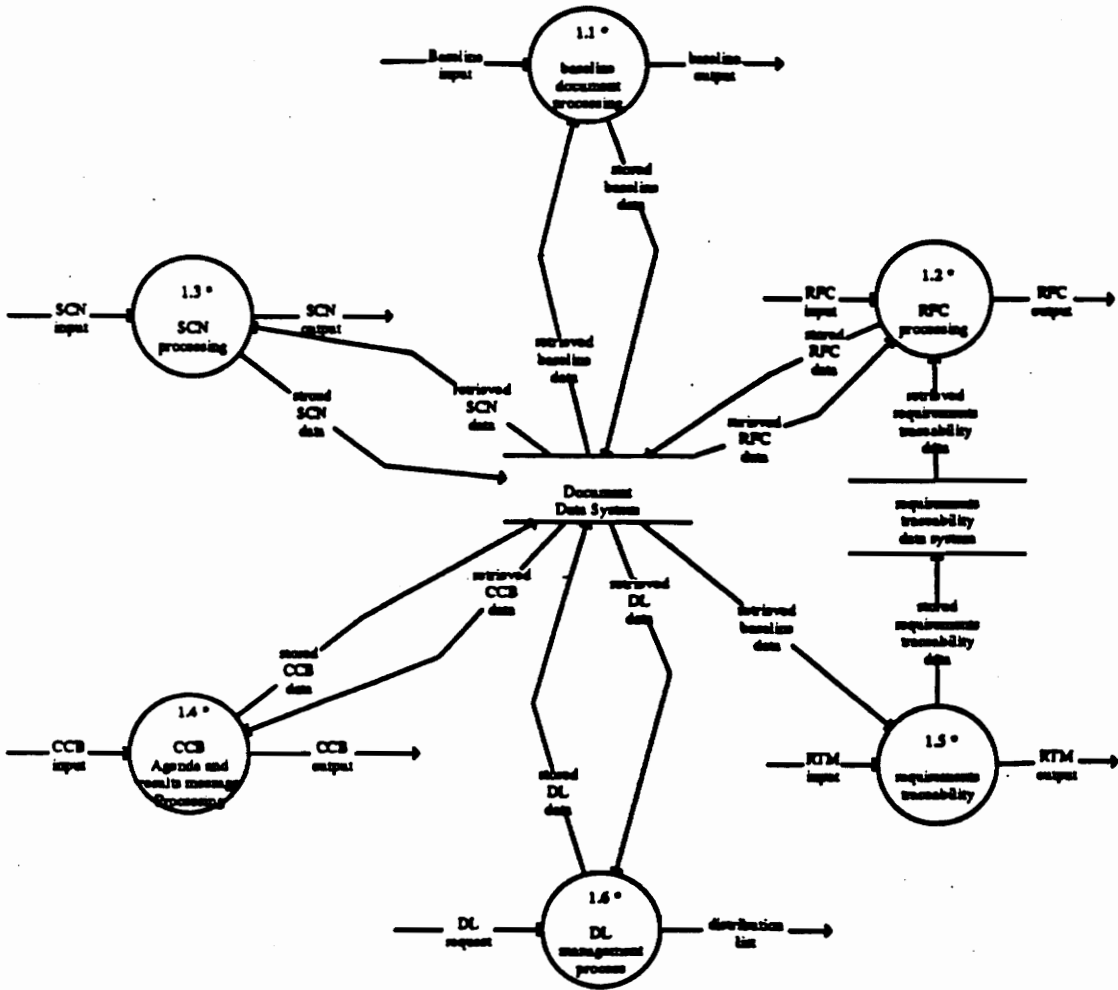


Figure 9.14 Flow Diagram 1 (DCM)

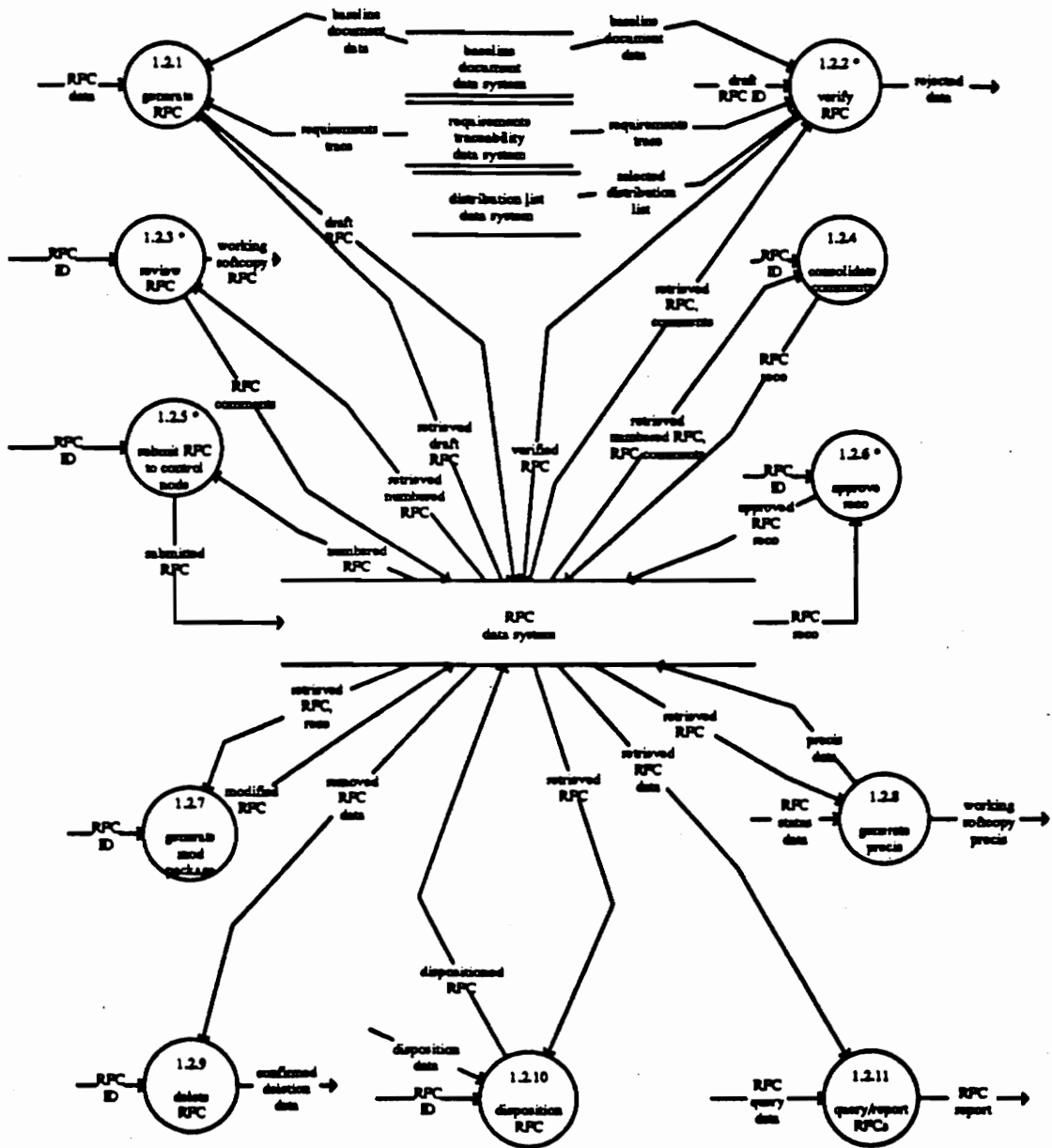


Figure 9.15 Flow Diagram 1.2 (DCM_RPC)

multiple documents. A requirement traceability database will be provided and can be utilized to obtain a list of linked requirements across the baseline documentation. The pages, then can be extracted from the baselines and added to the RFC package. APMS will provide the capability to delete pages out of RFC package prior to submission. Redlining, change bars and circle [circling] page numbers will be supported to annotate change pages. The capability of adding the mandatory RFC face plate will be provided. The user will be able to store, view and update RFC in a personal library. Once submitted, the RFC administrator at local node will control the RFCs in a controlled access library. The RFC can be reviewed and tracked at the local node. Once approved at the local node, the RFC administrator can submit the RFC to the RFC control node, the SI for CCB RFCs and the PO for higher level RFCs. At the control node, the RFC can be reviewed on-line and tracked through appropriate boards. Once approved at the control node, the RFC is distributed electronically to the nodes on APMS and in hardcopy to other recipients. Authorized users on APMS will be allowed to view the RFC on-line and add comments and recommendations utilizing a softcopy template which will be provided (See Appendix I for RFC softcopy template). RFC administrators at nodes will be able to combine comments on-line and create recommendations for submission to the control node. The review and comment capability can be utilized during different phases of the RFC process, e.g. for local node approval prior to submission to the control node, at the control node to facilitate ERBs , and once the RFC has been distributed prior to final board. Electronic Signature capability will be provided to facilitate approval process. The RFC tracking database design concept is defined in Appendix I.

As an example of full decomposition of a function, RFC processing has been detailed to the next level in Appendix I. This is the only process that is detailed to the fourth level with all consequent CM and PM processes only defined at the third level (Levels as defined by Structured Analysis Methodology).

Baseline Document Processing

Baseline Documents consist of system level specifications, segment specifications, Interface Control Documents (ICDs), Joint Requirements Documents, and selected level documents. The DFD for this process is found in Figure 9.16.

Design Concept

The control, maintenance and update of the Baseline Documents will be controlled by APMS utilizing the document processor. Documents will be stored in Interleaf format. Document status information will be controlled by the data management system.

The Baseline Documents will be controlled in master libraries at the baseline document controlling node. For CCB level documents, the master copy will reside at the SI, and for higher level controlled documents, the master copy will reside at the west coast contractor (WCC). Access structures will be implemented to allow baseline custodians the privileges necessary to control libraries and update documents. Baseline documents for view and copy access

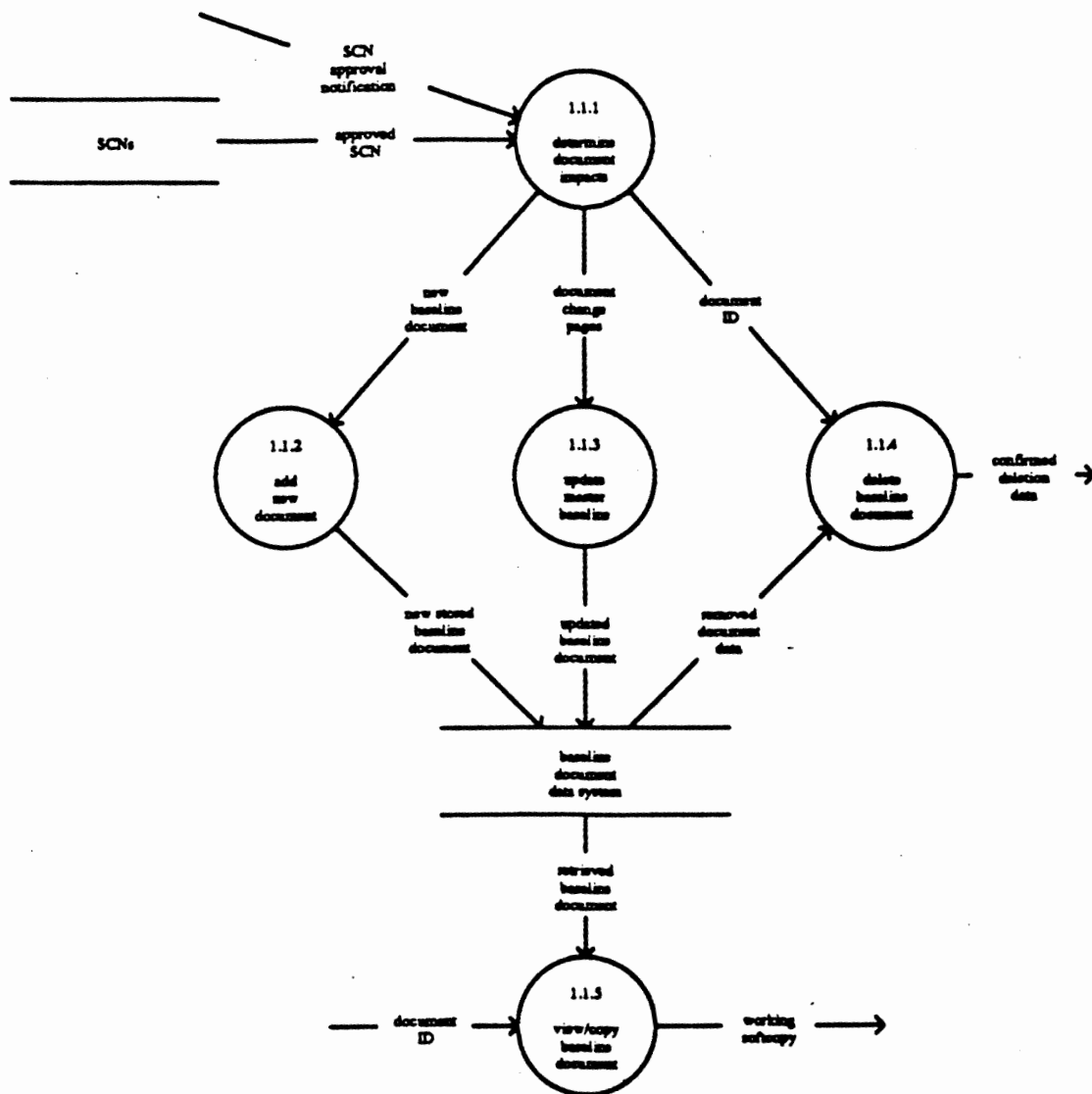


Figure 9.16 Flow Diagram 1.1 (DCM_BDP)

will be distributed to the other nodes. Documents that are distributed will be documents that have an identified recipient at the receiving node. Read-only documents not resident at a node may be obtained based on the appropriate approval for addition to the distribution list. Read-only libraries will be available to users at each node for reviewing, copying and RFC creation.

Approved RFC-generated SCNs will update Baseline Documents under the ultimate control of the baseline administrator. Database synchronization as described in the following section will be provided to ensure baselines accessible at each node are up-to-date.

Specification Change Notice Management

The Specification Change Notice is the method of issuing and controlling changes to baseline documentation. The DFD for this process is found in Figure 9.17.

Design Concept

The generation and management of SCNs will be provided as a part of the APMS change control process. A menu-driven SCN creation capability will allow an administrator to utilize Interleaf to easily assemble SCN packages, including the required change letter, based on approved RFCs. APMS will provide the capability for review and approval of an SCN prior to releasing it to document recipients. The SCNs will be distributed with an attached distribution

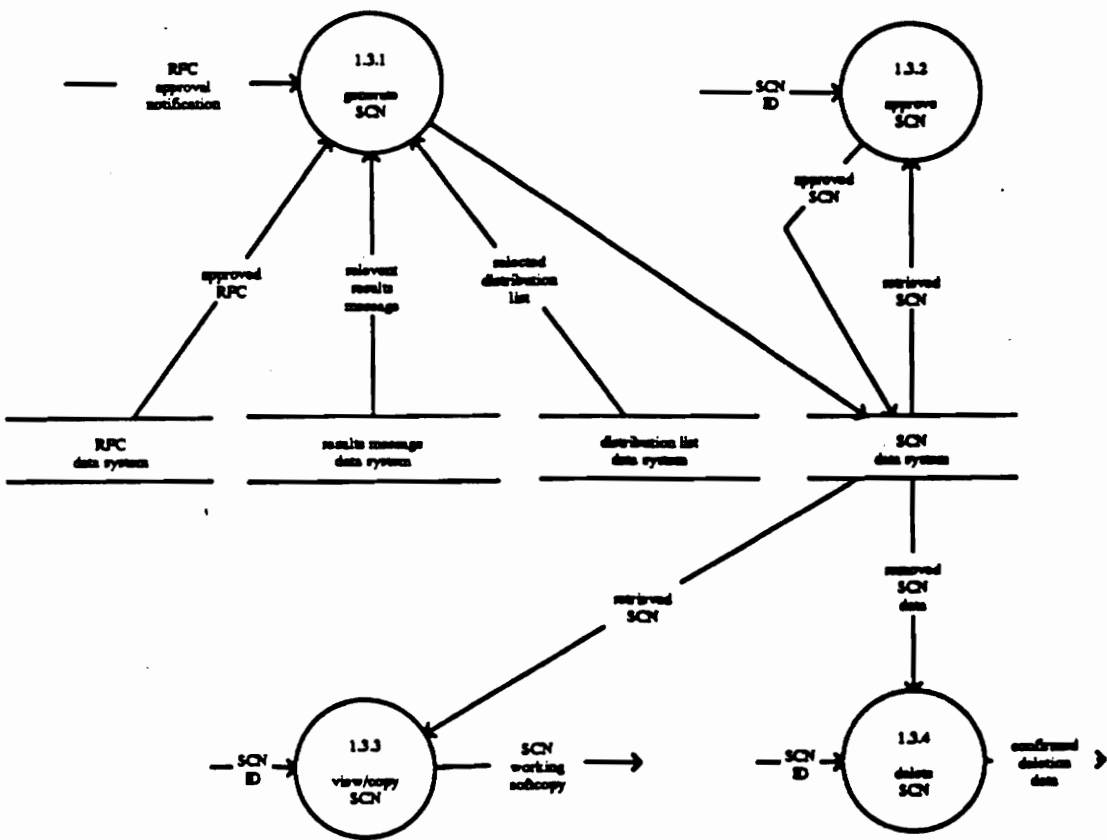


Figure 9.17 Flow Diagram 1.3 (DCM_SCN)

list to all recipients of the document. Recipients on-line on APMS will receive a softcopy at their local node to review. Recipients not on-line will receive hardcopy output. APMS will provide approved SCN-driven updates of baseline documents in an automated manner. New or revised documents that require distribution will be distributed as an SCN with a change letter and a distribution list attached.

CCB Agendas/Results Message Processing

CCB agendas are the schedule of RFCs and ECPs that are to be addressed by a specific meeting of the Configuration Control Board (CCB). Results Messages are the CCB decision results for each RFC and ECP dispositioned at the Board. The DFD for this process is found in Figure 9.18.

Design Concept

The Agendas/Results Message Processing component will implement a templating capability to allow users to easily create consistent CCB Agendas and Results messages. The initial generation of agendas and results messages will be from the RFC and ECP databases into an Interleaf softcopy format, where an authorized administrator can modify it. Agendas and results messages have an approval capability prior to final release. These agendas and results messages will be distributed to the appropriate users at multiple sites according to the distribution list attached to the message.

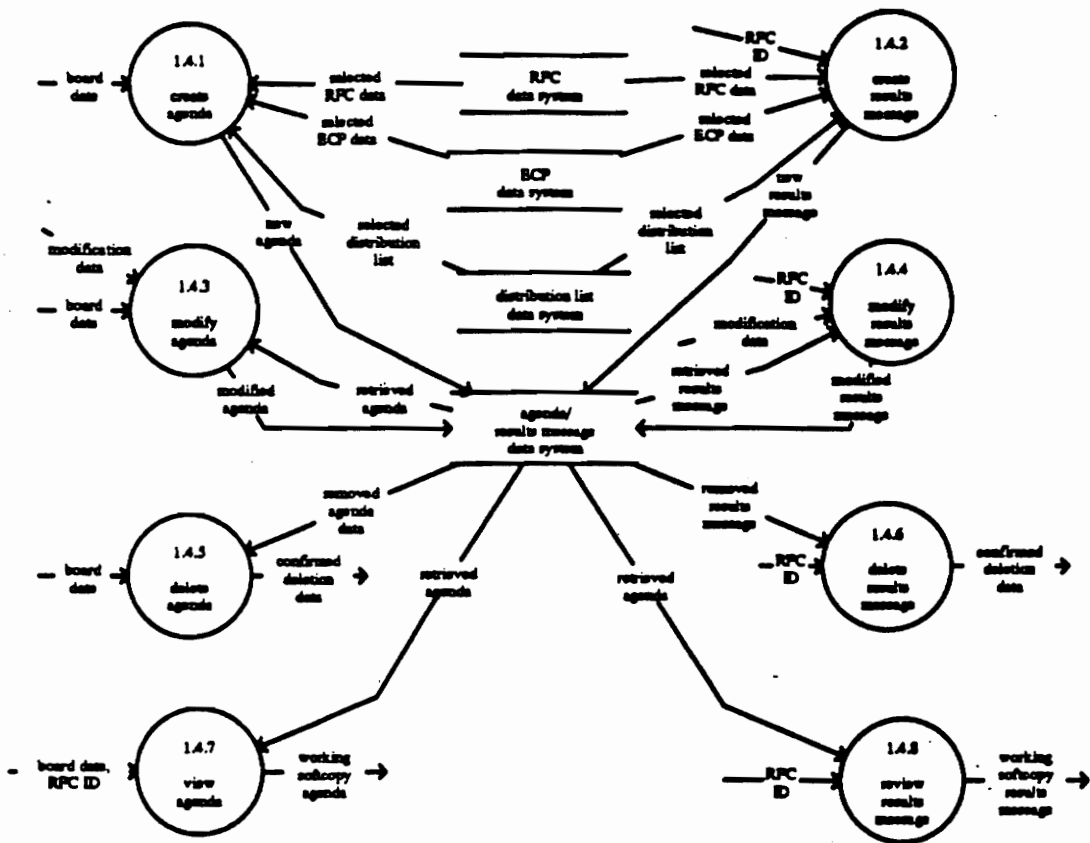


Figure 9.18 Flow Diagram 1.4 (DCM_CBP)

Requirement Traceability Processing

Requirements traceability is a process that links requirements and derivatives of requirements between the various documents within a document hierarchy. The DFD for this process is found in Figure 9.19.

Design Concept

The Requirement Traceability Processing will provide for the establishment and tracing of requirement links through a database implementation. APMS will provide the capability to store requirement identifications in the database management system. APMS will also provide the capability to extract a properly annotated requirement ID from a document for storage in the database. These requirement IDs will provide links between requirements in separate documents. These links will enhance the tracing of high level requirements to very detailed specifications. The requirements traceability database will be accessible to users to perform traces to determine the impacts of changing a particular requirement. The capability to access the Requirements Traceability function will be provided from RFC processing to assist the determination of all impacted documents.

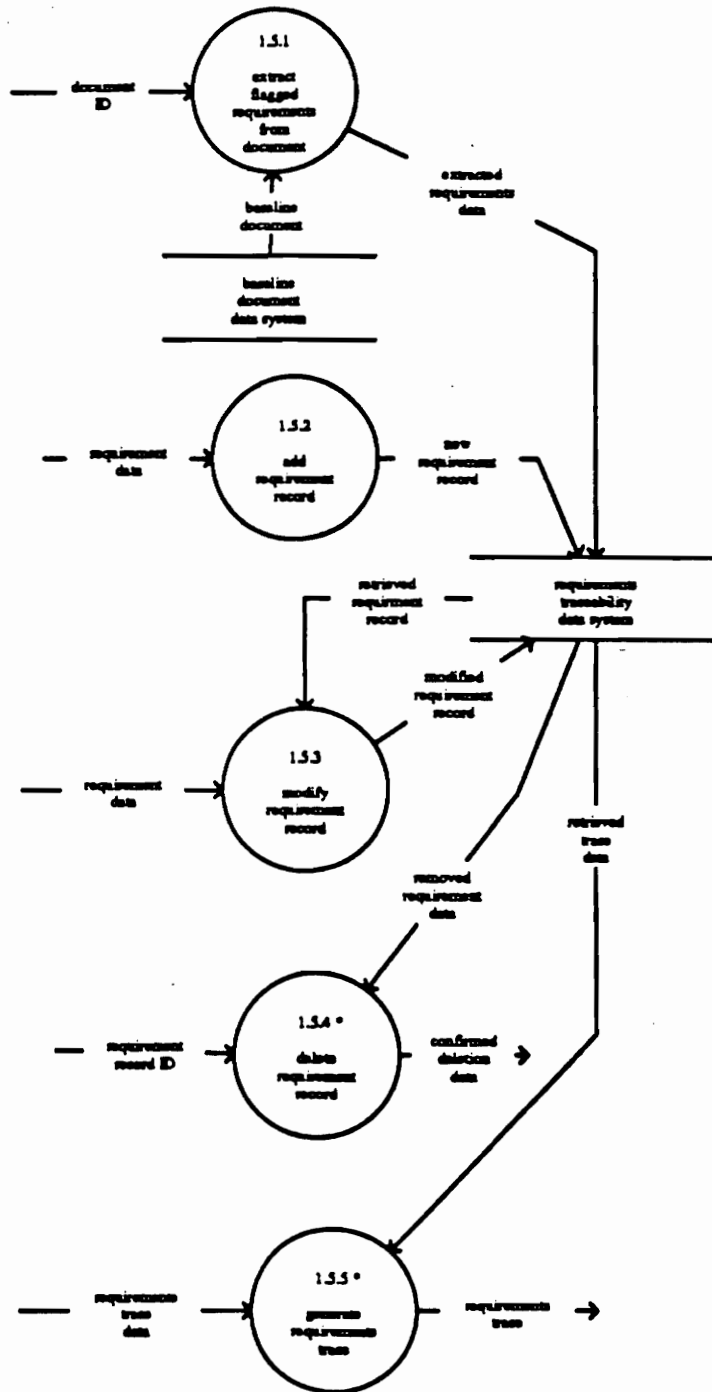


Figure 9.19 Flow Diagram 1.5 (DCM_REQ)

Documentation Distribution List Processing

Document Distribution Lists are utilized to identify recipients of baseline documents, RFCs, SCNs, etc., when these documents are distributed. The DFD for this process is found in Figure 9.20.

Design Concept

The Design of Distribution List Processing component will implement the capability to create permanent and ad hoc distribution lists to distribute documents to users at multiple sites. Users will be able to attach a distribution list to a document and distribute it to the recipients identified. Distribution lists for controlled documents and RFCs will be controlled in the database. A security compliant distribution system integrated with an E-mail package is provided to meet the security and the functional distribution requirements.

Program Management CSCI

The Program Management CSCI includes all of the processes which help to achieve project and program control. These include Action Item management, automated registry control, APMS discrepancy reporting, TBD/TBR management, and engineering change proposal management. The hierarchy diagram and DFD for the PM CSCI is found in Figures 9.21 and 9.22 respectively.

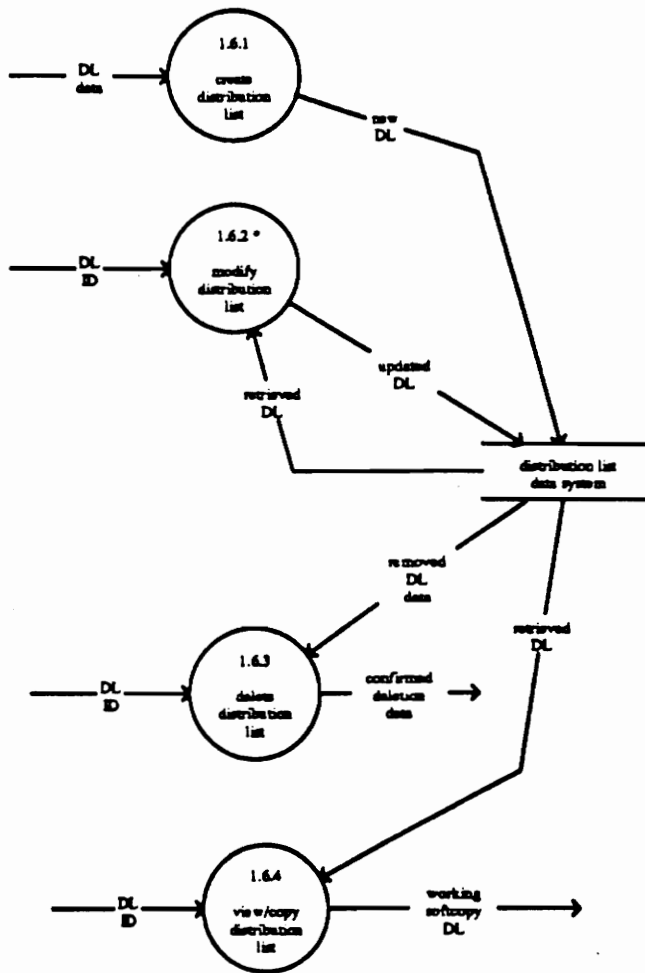


Figure 9.20 Flow Diagram 1.6 (DCM_DDL)

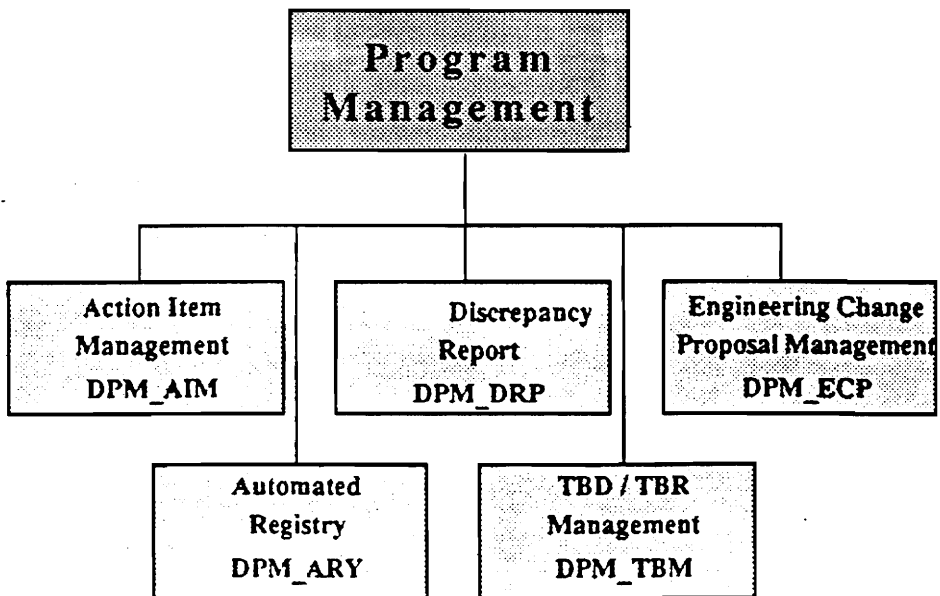


Figure 9.21 Program Management (DPM) Hierarchy Diagram

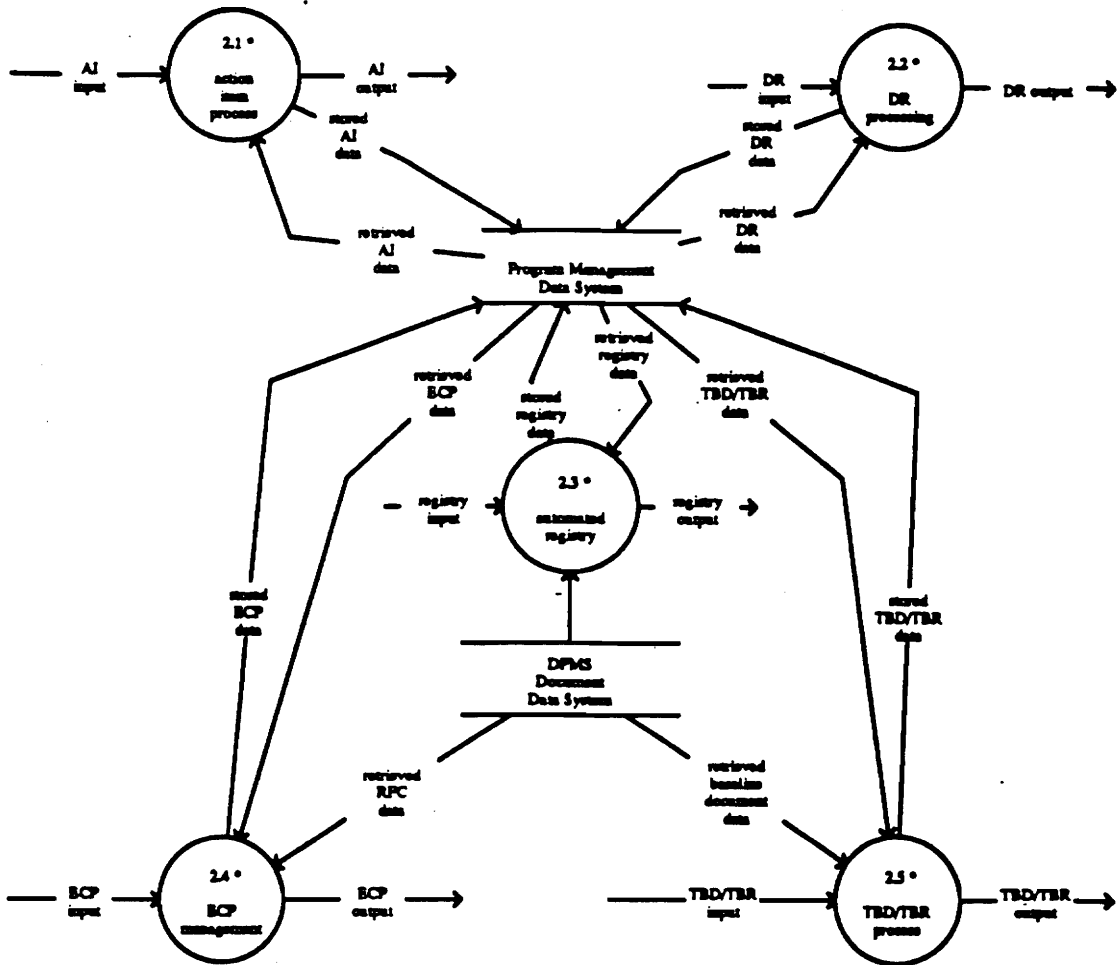


Figure 9.22 Flow Diagram 2 (DPM)

Action Item Management

The Action Item (AI) process is the method of identifying, statusing, and reporting actions assigned at technical meetings. APMS automates the statusing and reporting of Action Items. The DFD for this process is found in Figure 9.23.

Design Concept

The Action Item Management component will provide the capability to create, update and control Action Items and to generate Action Item Status reports. This capability, built on the database, is designed to allow the Action Item administrator to have menu-driven control to query, sort, update and generate reports efficiently. All nodes will be able to query the database to review action item status.

Discrepancy Report Processing

Discrepancy Reports shall be used for reporting APMS problems. APMS automates the entering, statusing and reporting of Discrepancy Reports. The DFD for this process is found in Figure 9.24.

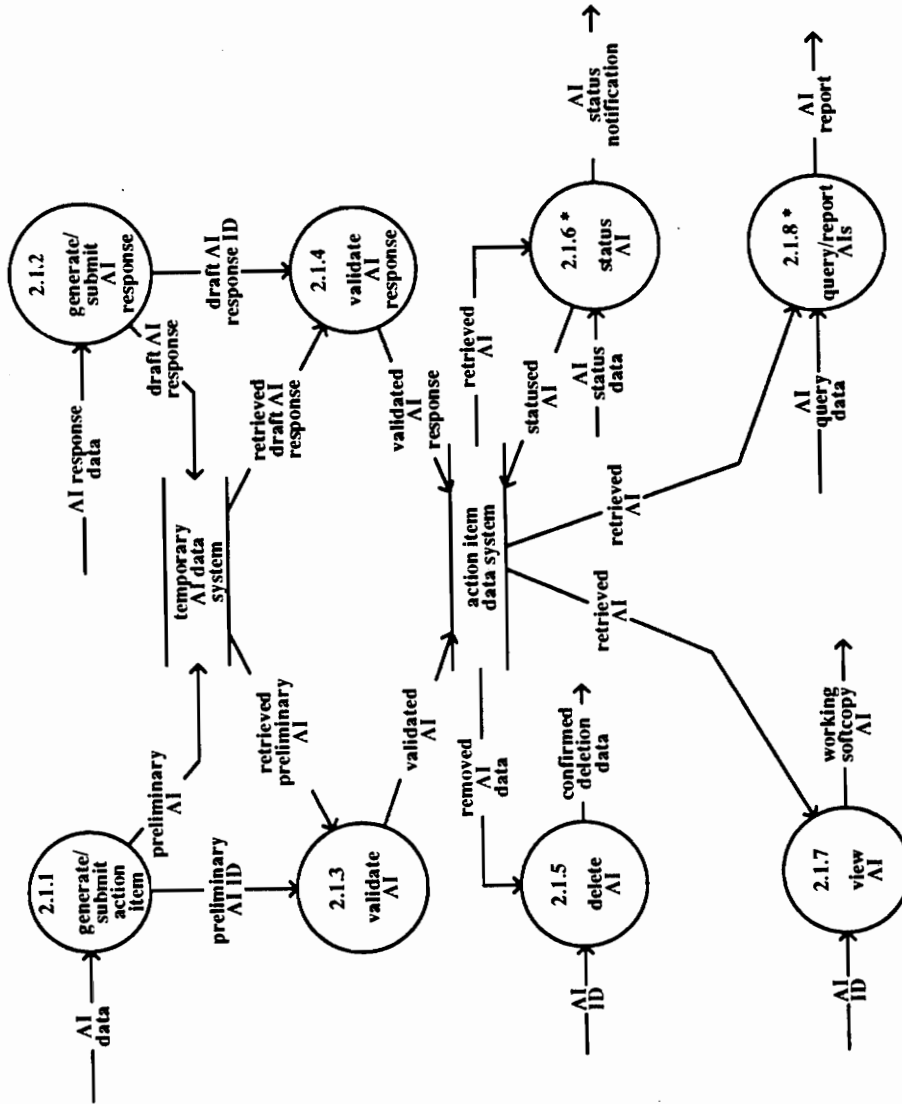


Figure 9.23 Flow Diagram 2.1 (DPM_AIM)

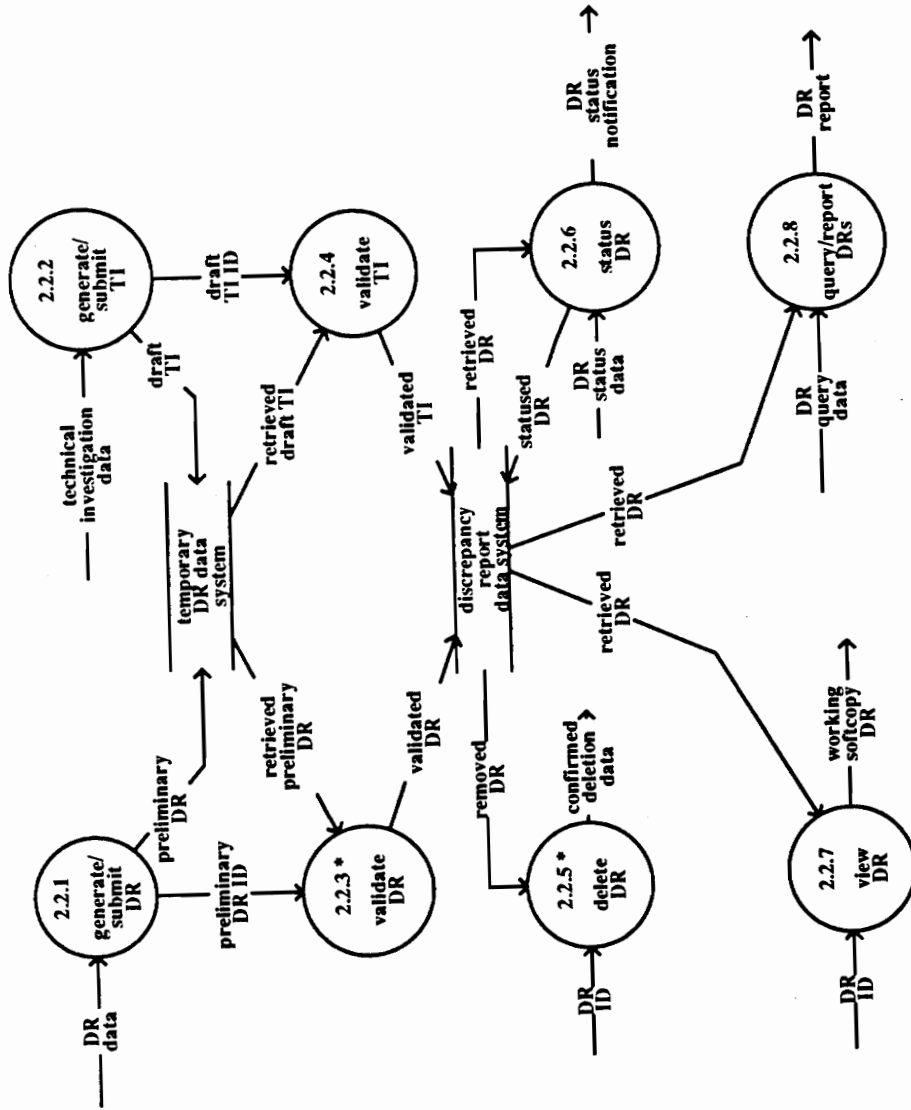


Figure 9.24 Flow Diagram 2.2 (DPM_DRP)

Design Concept

APMS provides the capability for users to enter discrepancy reports and submit these reports to the discrepancy report administrator. The DR administrator validates the DR and enters it into the controlled DR database. APMS provides for the approval, update and control of the Discrepancy Reports by the administrator and view of the reports by users. This component is provided as a function of the database.

Engineering Change Proposal Management

The Engineering Change Proposal process is the method of changing a contract with a significant cost impact. APMS automates the statusing and reporting of Engineering Change Proposals. The DFD for this process is found in Figure 9.25.

Design Concept

The ECP Management component provides for the tracking and reporting of Engineering Change Proposal information in the APMS environment. APMS will provide an ECP tracking database, in which status information regarding the ECP process will be maintained. ECP administrators will be able to add, modify and delete records tracking the ECP through the approval process. APMS will support querying and report generation from the ECP management database.

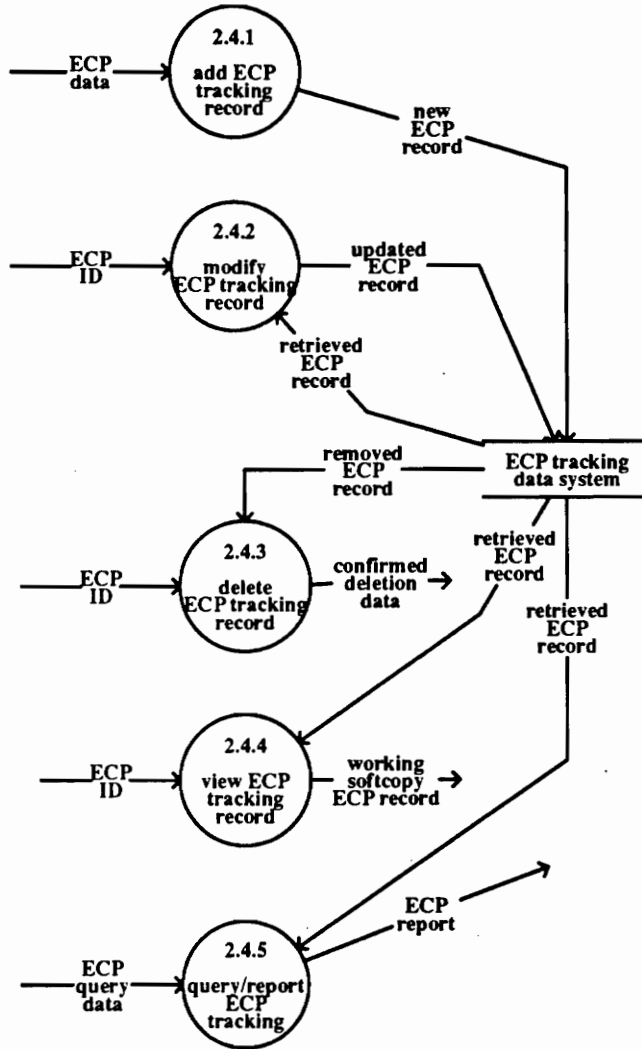


Figure 9.25 Flow Diagram 2.3 (DPM_ECP)

TBD/TBR Management

The high level design concept for TBD/TBR Management is provided in this section. The system level requirement is identified and the system and database concepts are described for TBD/TBR Management. User and Administration capabilities for TBD/TBR Management are identified. Finally, the software requirements, defined in and derived from APMS Requirements Document and determined through the Joint requirements Definition sessions, are allocated to the TBD/TBR Management CSC. The DFD for this process is found in Figure 9.26.

Design Concept

The TBD/TBR Management component provides the following functionality to meet this requirement: 1) A TBD/TBR database which provides for the creation, update, maintenance and control of TBD/TBRs; 2) A document search capability to return and store TBD/TBR locations; 3) The generation of TBD/TBR reports. The design to meet this functionality is based on the database, the document processor and a customized interface between the two. The database provides the search capability, and the interface communicates the search information to the database.

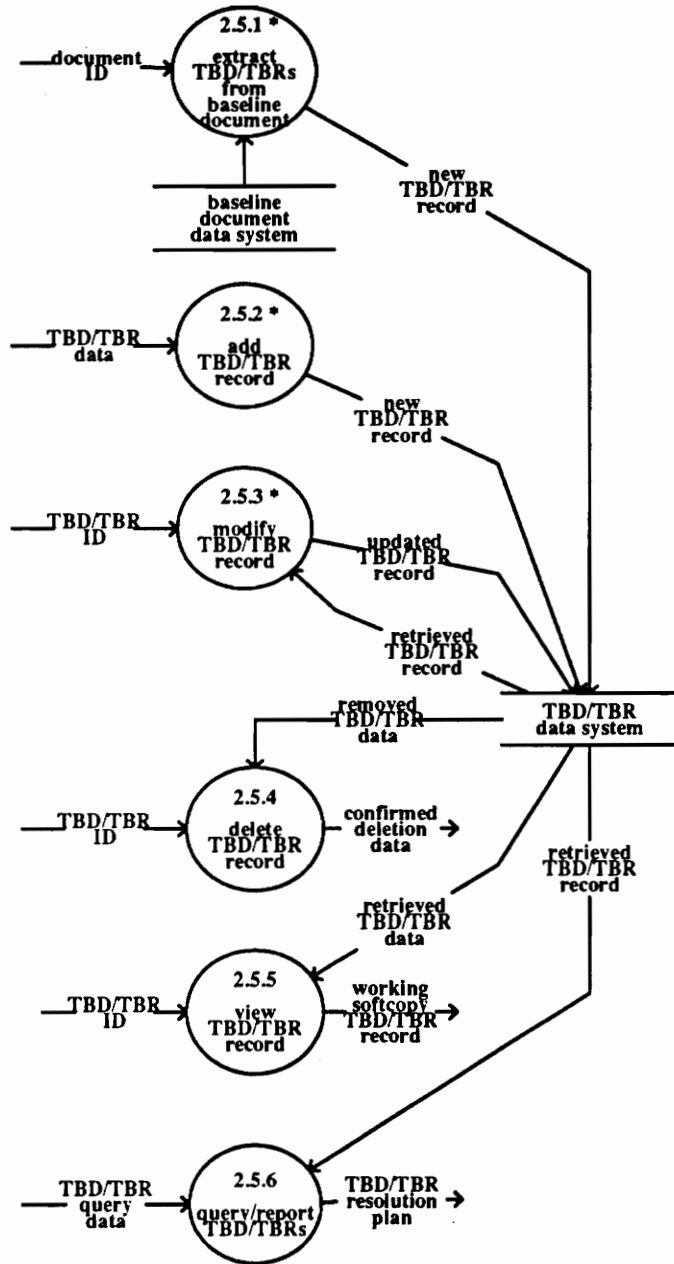


Figure 9.26 Flow Diagram 2.4 (DPM_TBM)

Automated Registry

The Automated Registry process controls all documents for APMS. The DFD for this process is found in Figure 9.27.

Design Concept

The Automated Registry/Document Control component will document control functionality at each node, assuring proper logging and security administrative accounting functionality. This component will also provide a document control database in which registry administrators can easily maintain control of APMS maintained documents. All printing of controlled documents will be performed by this CSC. The Automated Registry component will also maintain a database of control documents that are transferred between APMS nodes.

Common Operating Environment CSCI

This CSCI incorporates all aspects of the operating system. Of these functions only electronic mail and electronic signature are detailed below. The Secure Operating System, COTS S/W Library, Developer Tools, and Source Code Libraries are self-explanatory and do not require further definition here. The hierarchy diagram for the CO CSCI is found in Figure 9.28.

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The Automated Registry DFD is TBD
pending Vendor Specificatons on
SunCMW OS

Figure 9.27 Automated Registry DFD (DPM_ARY)

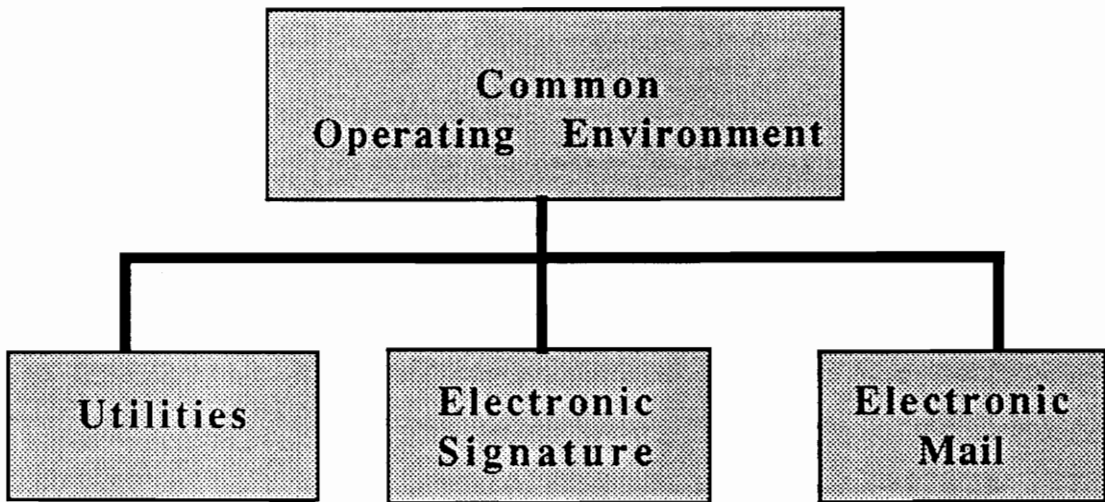


Figure 9.28 Common Operating Environment Hierarchy

Electronic Mail/Package Creation

An office mail function will be included in APMS that conforms to B1/B2 security requirements and is capable of handling message traffic among APMS users within and between nodes. It will distribute messages and notes, as well as formatted document attachments containing graphics, line art, spreadsheets, etc. The mail system will provide acknowledgement to the originator once the message transfer system delivers the message to the recipient.

Electronic Signature Approval

The electronic signature utility will be accomplished via a password that is entered along with the user's ID into fields of a custom GUI panel. Each APMS user will be asked to choose a unique signature password in addition to the logon password. When this password is entered, it will be verified, then the ID of the password's owner will be stored in the database, along with the date and time, and the ID of the user who actually entered the signature password. This signature information will be write protected against everyone. The only way that it may be modified in the database will be through the electronic signature capability.

DATABASE DESIGN

The APMS Database architecture is designed using a distributed relational database framework. The relational database model is used because it offers

substantial productivity benefits due to its inherent ability to use and exploit data that already exists within the system. The databases will be distributed in the fact that updates to data at one node will, depending on the circumstances, cause updates at other nodes. The Sybase relational database management system (RDBMS) employs an advanced Client/Server architecture. This architecture facilitates the separation of data management and transaction functions from the client applications and user interfaces. As a result, database reliability is greatly increased because data integrity is maintained independently from application programs. Also application development cost are significantly reduced, because server-enforced data rules and transactions can be shared across all applications. Due to the security requirements of APMS the prototype database architecture will utilize two variants of the Sybase product, the Standard Sybase SQL Server and the Secure SQL Server. The Standard Server will be utilized during the 'dedicated' and 'system high' modes of operation, and the Secure SQL Server will be utilized for the 'compartmented' mode of operation. The database applications being developed for APMS will be designed to function on either Sybase product.

Local Autonomy

Each node that connects into the APMS Wide Area Network will have its own database framework. This framework will include a semi-autonomous Sybase server, HMI's and a security filter. The servers are described as semi-autonomous in the sense that each Sybase server at an individual node will manage the data entered at that node as well as manage the data that is

transferred from other nodes for querying purposes (e.g. Action Item status, RFC "system level" status). These data transfers from the other nodes will be done in a manner that is transparent to the users. Also, users at each node will remain locally-autonomous until such time as the control of the data is transferred to another node for tracking purposes. Local autonomy means that the data entered at a node is owned and managed by that node for increased responsiveness and to insure invulnerability to events at the other nodes. RFC tracking offers a good example of this concept. When an RFC is generated, the data entry and tracking will be the sole responsibility of the generating node. However, when the RFC is submitted to the SI, the responsibility to track the progress of the data now rests on the SI RFC management personnel.

Local Autonomy also allows the database to be administered locally at each node. Because APMS has a significant data handling requirement, database maintenance is crucial to maintaining the integrity and functional capabilities of the system. APMS database administration will be provided under the APMS utility CSC function, System Administration. A local system administrator will function as the database administrator for APMS at each node.

Database Structure

Each node will have an almost identical database structure. The structures will differ in that certain tables of data will be read-only at certain nodes and that some nodes, such as the program office, will have tables that only exist at that

node. For an example and more detailed discussion of an APMS database structure see Appendix I for the data structure for RFCs.

Database Queries

All queries to the database will be constructed using the ANSI standard Structured Query Language (SQL). Queries will be divided into two types, standard and ad hoc. A standard query is a predetermined query built into the system by the APMS development team. Operationally, the standard queries will be initiated by simply picking the desired query from a menu list of existing queries. An ad hoc query is one that must be designed interactively by the individual who is seeking a specific set of information from the database. Ad hoc queries will be implemented using the Sun Simplify SQL software package. Using the Simplify SQL software, users will have the capability to generate any kind of query to the database they desire, although it is the responsibility of the user to construct a meaningful query. Once an ad hoc query is completed, the APMS user will have the capability to save the query definition for future needs. Regardless of the type of query to the database, the SQL request will pass through the security filter which will insure that the data is gathered from the proper view of the database. Data that is returned in response to a query will either be placed in a report or shown on the screen in a scrollable window. The users will be able to format the returned data in a number of different ways or they will be able to specify their own unique report format. The users will have the capability to "cut and paste" from scrollable windows into reports if they so desire.

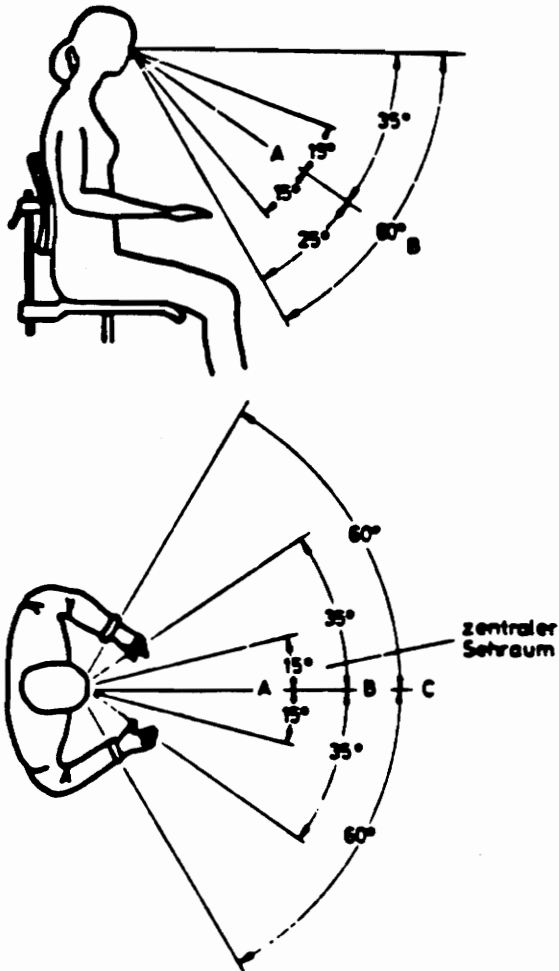
X. HUMAN FACTORS ENGINEERING

The APMS human factors analysis consists of a series of activities which lead to:

- the initial establishment of human factors requirements for system design,
- the evaluation of system design to ensure that the optimum interface exists between human and other elements of the system, and
- the assessment of personnel number and skill level requirements for a given system design configuration.

For APMS, there are a number of human factor workstation requirements. The major consideration that needs to be addressed is the positioning of personnel in relation to the workstation. It is recommended that the users remain at least 20 inches from the monitors to reduce eye strain and to allow for the best possible viewing angle. The optimum eye rotation angle has been found to be 15 degrees off-center. Placing a person 20 inches from the monitor easily allows for the optimum eye rotation angle to be achieved with only the slightest of head rotation. Figures 10.1 to 10.3 illustrate the ergonomics of the APMS workstation configuration design.¹

¹ *Office Systems Ergonomics Report*. Volume 3, Number 3. March/April 1984. pp. 13, 15, 18.



Limits to the field of vision
 A — optimum field of vision
 B — maximum field of vision without head movement
 C — extended field of vision including permissible head movement.

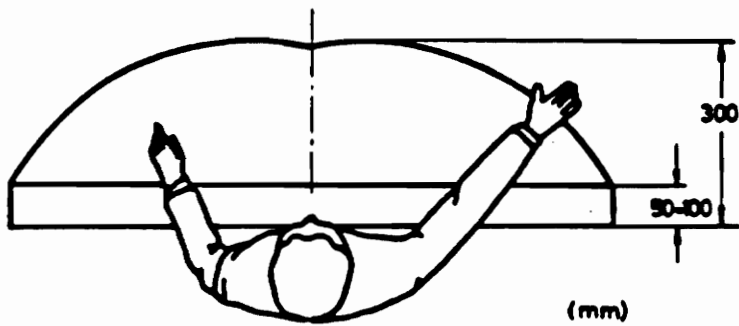
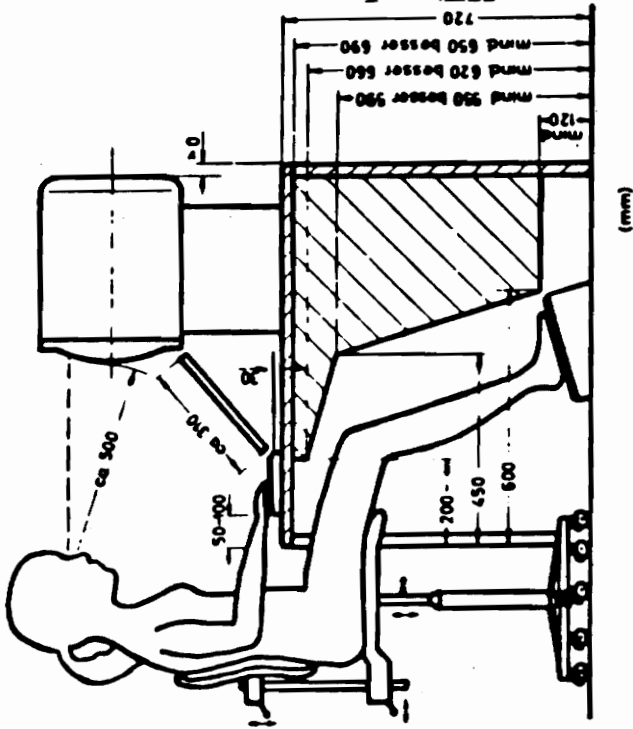
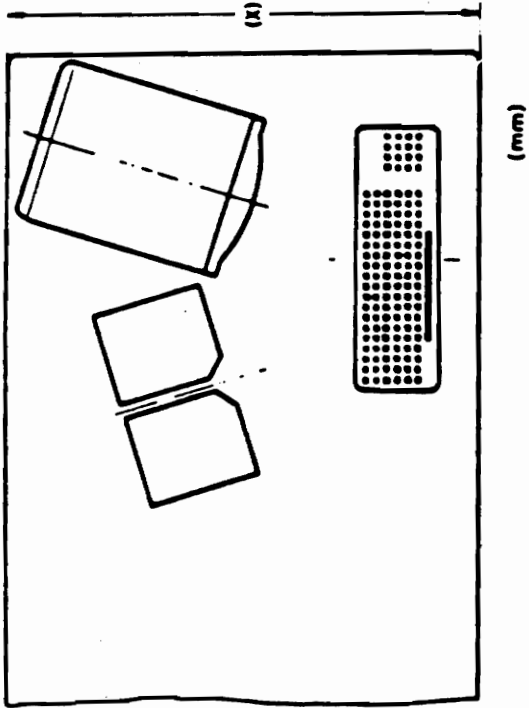


Figure 10.1 Ergonomics of Human Factors Engineering

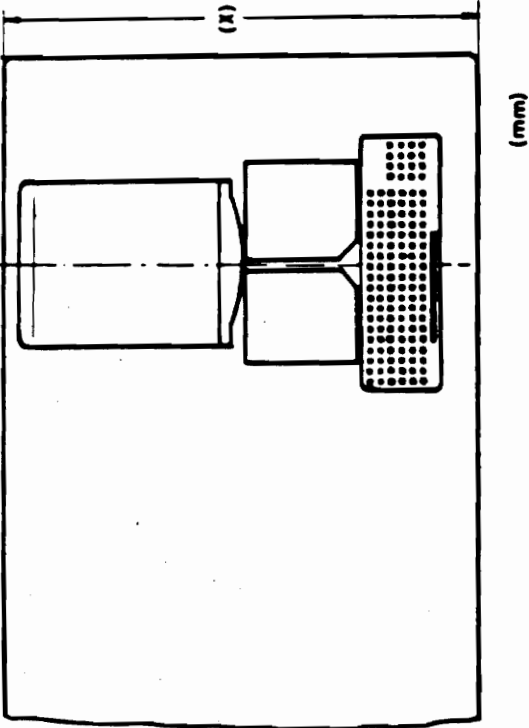


Example of an ergonomically designed work place with a table not adjustable in height, keyboard, document and display arranged one behind the other.

Figure 10.2 Ergonomics of Human Factors Engineering (Continued)



Example of an arrangement of equipment for work with documents.



Example of one-behind-the-other arrangement of keyboard, document, display for word processing.

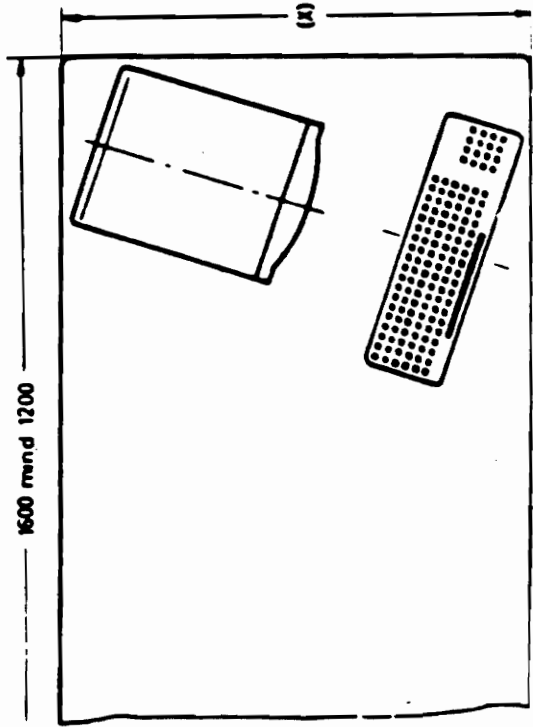


Figure 10.2 Ergonomics of Human Factors Engineering (Cont'd)

The keyboard should have an tactile feel with medium pressure needed for strokes. The normal typewriter layout with numerical key pad will ease operations. Oversized shift keys and a caps lock mechanism is required. An ergonomically designed mouse with a smooth roll and glide is also desirable.

A major objective is to design the system such that it promotes simplicity in operation as well as simplicity in maintenance. This will aid in accomplishing the goal of minimizing personnel training costs.

Any internal circuitry and electronic material should be designed to ensure inaccessibility and protection from the user while remaining easily repairable by trained maintenance personnel. These precautions will reduce the probability of personnel-induced failures and prevent possible injuries.

Figure 10.4 shows the major stages of the system design process.² In the basic design stage, the principal human factors activities are:

- allocation of functions to humans, hardware and software and
- specifications of human performance requirements.

Given that in some instances there are some options as to whether any particular function is best performed by a human being or by a machine, the

² Larkin, L. I., *Computer Systems Engineering*. GE Corporate Management Development, 1988.

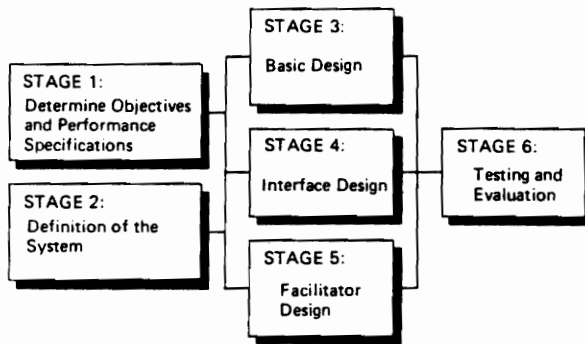


Figure 10.4

Major stages in the system design process. These stages are carried out in iterative fashion as the system develops. Later stages may modify decisions made in earlier stages. For some simple systems, these stages are carried out informally and, in some cases, not at all. (Source: Adapted from Bailey, 1982.)

guidelines of Figure 10.5 are generally followed.³ Once these functions have been allocated, the user interface can be developed. A detailed task analysis which leads from the functional flow diagram to Human Factors Engineering is a tool which could be employed in this project.

DESIGN OF THE USER INTERFACE

After the basic design of the system is defined and the functions and tasks allocated to humans are delineated, attention can be given to the characteristics of the human-machine and human-software interfaces. These include work spaces, displays, controls, consoles, etc. Although the actual design of the physical components is predominantly an engineering chore, this stage represents a time when human factors inputs are of considerable concern. The specific nature of the design decisions made during this phase can forever plague the user and cause decrement in system performance or conversely, facilitate use of the system and bring about better performance.

The data relevant to human factors engineering are

- Sets of quantitative data (such as anthropometric measures of samples of people, and error rates in performing various tasks)

³ Eastman Kodak Co. *Ergonomics Design for People at Work*. Lifetime Learning Publications, 1983.

Humans are generally better in their abilities to

- Sense very low levels of certain kinds of stimuli: visual, auditory, tactual, olfactory, and taste
 - Detect stimuli against high-noise-level background, such as blips on CRT displays with poor reception
 - Recognize patterns of complex stimuli which may vary from situation to situation, such as objects in aerial photographs and speech sounds
 - Sense unusual and unexpected events in the environment
 - Store (remember) large amounts of information over long periods (better for remembering principles and strategies than masses of detailed information)
 - Retrieve pertinent information from storage (recall), frequently retrieving many related items of information (but reliability of recall is low)
 - Draw upon varied experience in making decisions; adapt decisions to situational requirements; act in emergencies (do not require previous "programming" for all situations)
 - Select alternative modes of operation if certain modes fail
 - Reason inductively, generalizing from observations
 - Apply principles to solutions of varied problems
 - Make subjective estimates and evaluations
 - Develop entirely new solutions
 - Concentrate on most important activities when overload conditions require
 - Adapt physical response (within reason) to variations in operational requirements

Machines are generally better in their abilities to

- Sense stimuli outside the normal range of human sensitivity, such as x-rays, radar wavelengths, and ultrasonic vibrations
 - Apply deductive reasoning, such as recognizing stimuli as belonging to a general class (when the characteristics of the class need to be specified)
 - Monitor for prespecified events, especially infrequent ones (but machines cannot improvise in case of unanticipated types of events)
 - Store coded information quickly and in substantial quantity (for example, large sets of numerical values can be stored very quickly)
 - Retrieve coded information quickly and accurately when specifically requested (although specific instructions need to be provided on the type of information to be recalled)
 - Process quantitative information following specified programs
 - Make rapid and consistent responses to input signals
 - Perform repetitive activities reliably
 - Exert considerable physical force in a highly controlled manner
 - Maintain performance over extended periods (machines typically do not "fatigue" as rapidly as humans)
 - Count or measure physical quantities
 - Perform several programmed activities simultaneously

Figure 10.5 Human/Machine Guidelines

- Principles (based on substantial experience and research, which provide guidelines for design, such as the principle of avoiding or minimizing glare when possible)
- Comparative quantitative data (such as relative accuracy in reading two types of displays)
- Design standards or criteria (consisting of specifications for specific areas of application, such as displays, controls, etc.).

AMPS HUMAN MACHINE INTERFACE

The APMS Human Machine Interface (HMI) is a Graphical User Interface (GUI), which provides a multi-windowed, "point-and-click" mouse-based command system. Sun Microsystems' Open-Look GUI complies with the industry standard UNIX windowing interface, X.11 (X-windows). Open-Look is designed to interface with the Sun operating system and has been used to implement the interface for the Sun workstation. The APMS HMI provides a standard view to all applications. This interface will be developed using the Sun Development Guide (interface builder) which provides the capability to quickly develop standardized screens and menus.

The GUI will be designed to maximize the efficiency of the user through the use of on-line menu picks and mouse button selections. It is important to note that menu picks offer the added advantage of improved data consistency in

comparison to manual typing. Thus, wherever possible, the interfaces will attempt to include common inputs, to the particular fields, as menu choices so that the users need only click on the correct response with the mouse. Data entry will in no way be exclusively limited to the choices presented in a menu as there is always the capability to have an 'other' choice which will allow for non-standard responses.

XI. MANAGEMENT PLAN

APPROACH OVERVIEW

The APMS management plan details how the prototype will be implemented, organized, and supervised. The management of the design, installation, test and evaluation of this project is critical to its success. The management structure which will be used is a project staff structure. In any development project, there are four major functions which are business, engineering, support, and operations. In this software design and development project, the emphasis of management is the engineering function. These major headings support the APMS project staff structure.

The project staff structure lends itself to a high degree of synergy and communication across projects as well as sharing information, expertise and resources. Two examples of project structures are show in Figures 11.1 and 11.2.¹ It is felt that this organization will best facilitate the meeting of milestones as is detailed in the program schedule shown in Figure 11.3.

Every effort has been made to assemble a team with the best credentials by selecting an outstanding technical staff, structuring a task-oriented project

¹ Figure 11.1 - Yourdon, Edward., *Managing the System Life Cycle*. New York: Yourdon Press, 1982. pg 45.

Figure 11.2 - Blanchard, B. S., and Fabrycky, W. J. *Systems Engineering And Analysis*. Englewood Cliffs, NJ: Prentice Hall, 1990. pg. 561.

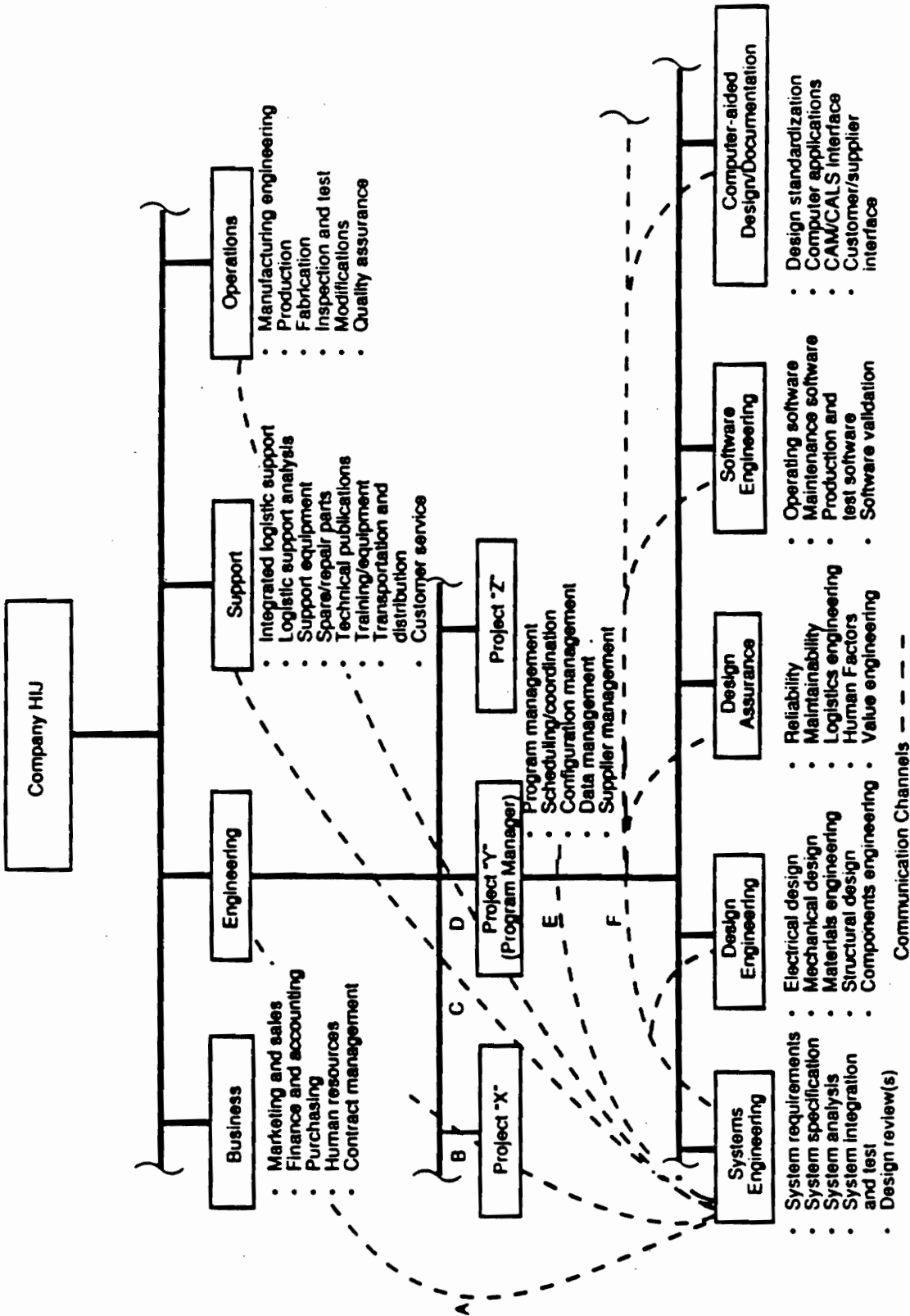


Figure 11.1 Project Staff Organization

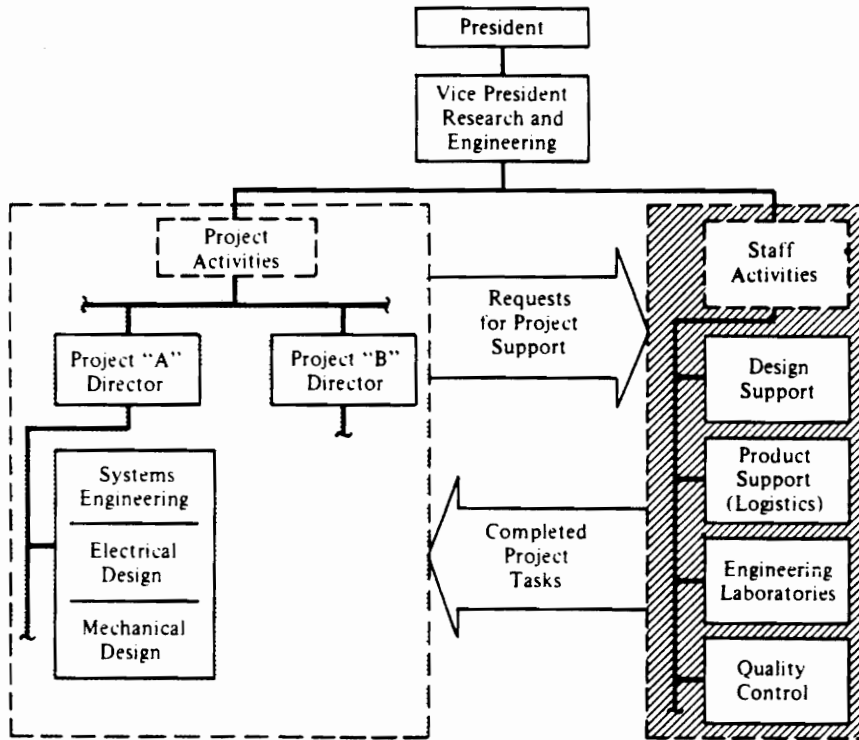


Figure 11.2 Typical project-staff organization.

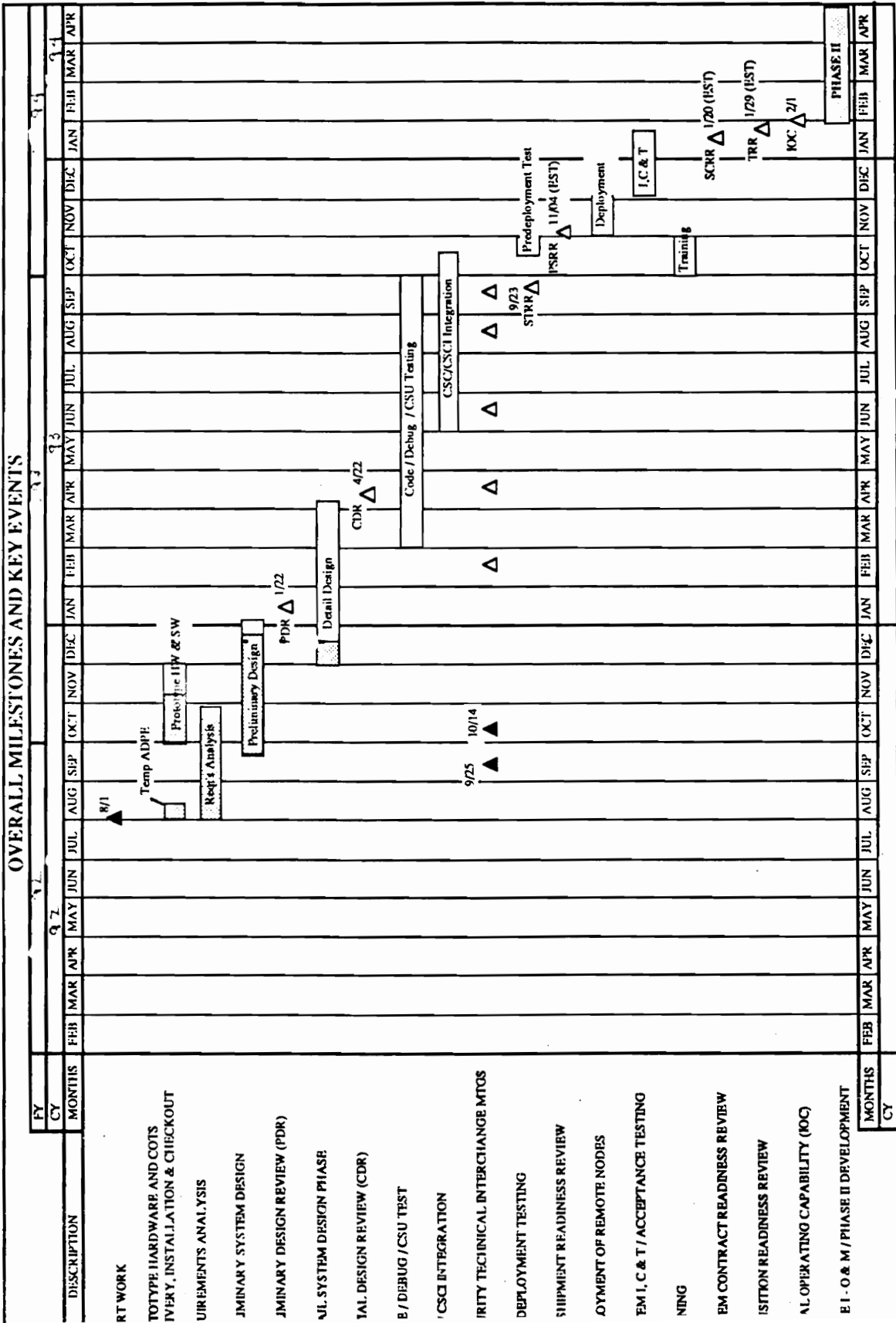


Figure 11.3 Overall Milestones and Key Events

management organization, and by applying a proven management approach in accomplishing the APMS tasks.

PROJECT ORGANIZATION AND PERSONNEL

The APMS development has been organized to respond directly to the schedule. A team of experienced system developers with hands-on knowledge of the environment, configuration management, and program management processes has been selected. These qualified professionals come with the right mix of experience, and have made firm commitments that they will remain with the program from its inception through the completion of the Prototype.

The program organization is structured such that clear lines of communications and responsibility exist. The team development concept is the central theme for the APMS prototype. Systems and software elements work in a coordinated effort to develop APMS and to design, code, and test software deliveries. The organization depicted in Figure 11.4 has the following features:

- A dedicated Program Manager who has full authority to commit assigned resources, responsibility for the team performance, and final approval of project costs and schedules.
- An organizational structure that assures visibility to upper management.
- Interrelationships among tasks and personnel that provide unambiguous responsibilities and clear accountability.

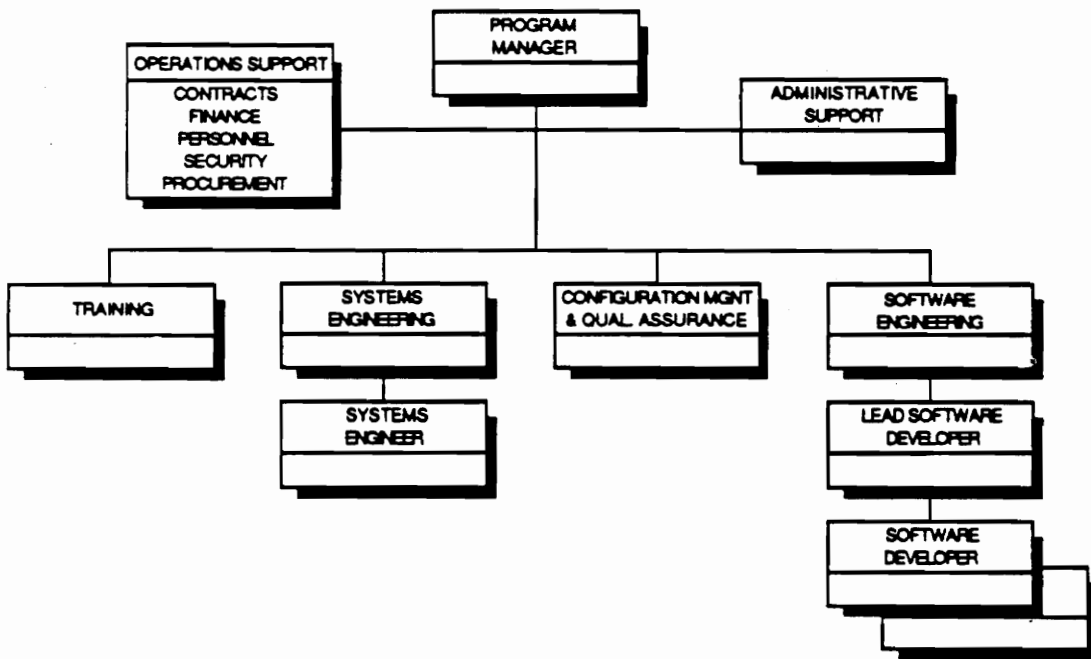


Figure 11.4 Prototype Development Organization

CORPORATE ORGANIZATION

The placement of this program within the corporate structure provides a short, direct management chain to key executives (See Figure 11.5). This visibility provides the APMS Program Manager with access to a wide range of resources that can be applied to the effort. It also furnishes the technical services necessary to support the life cycle of the program.

Key Personnel

A task-oriented team, staffed with the right skill mix has been developed to assure a fully compliant Advanced Program Management System. Specific areas of responsibility for key personnel have been established as is detailed below.

Program Manager

The Program Manager (PM) is directly responsible to the customer for all facets of program performance and has full authority to commit program resources in response to requirements. The PM is the primary interface between the customer and the development team. The PM provides technical and managerial direction to the personnel, and is fully responsible for staffing, which includes: hiring, dismissal and performance evaluation.

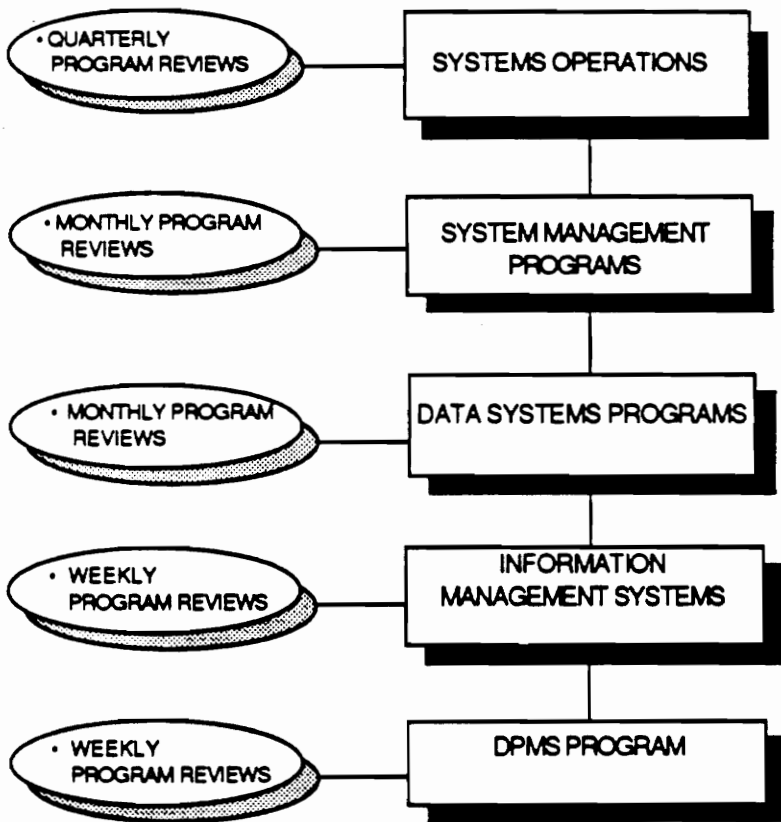


Figure 11.5 Relationship to Corporate Organization

Lead Systems Engineer

The Lead Systems Engineer reports directly to the Program Manager and is responsible for the technical direction of all systems engineering. The Lead Systems Engineer has technical responsibility for overall system design which includes: the system hardware configuration, communications subsystem design, database architecture, the design of the man-machine interface, and evaluation and recommendation of candidate hardware configurations. Additionally, he/she has responsibility for the development and implementation of the system acceptance tests.

Senior Software Engineer

The Senior Software Engineer reports directly to the Program Manager and is responsible for the technical direction of all software engineering and development tasks. The Senior Software Engineer has technical responsibility for the APMS software architecture and for the design and development of the Computer Software Components (CSCs). The Senior S/W Engineer is also responsible for the detailed design, coding and informal testing of the Computer Software Units (CSUs).

Senior Configuration Management Engineer

The Senior CM Engineer reports directly to the Program Manager and is responsible for configuration management, quality control and the design

verification of the prototype. The Senior CM Engineer is the project focal point for cost and schedule control, configuration and data management, and CDRL quality control. The Senior CM Engineer also serves as the team's functional expert in Configuration Management and will work closely with the customer user communities and the APMS development team to facilitate the development of a APMS that fully meets all requirements and acceptance by all users. This person will also serve as the APMS training coordinator. This individual will work with our training specialist, and their staff to assure the provision of quality training and user aids to the user community. Our development team will be onsite in the customer facility, co-located with the program office. One of the primary benefits of locating all project personnel in the customer facility is the maximized communications with the program office. It also allows the systems users to be an integral part of the development team, routinely interfacing with the developers throughout the requirements definition and software development phases.

This team effort will assure that the system is designed to validate requirements and is fully reviewed by the user community during the design phase of the program. The onsite team will be supported by the corporate organization in the areas of contracts, finance, security, procurement and training.

REVIEWS

Executive management encourages candid and open communications among project personnel and between customer and development counterparts

concerning progress and problems. A comprehensive, and structured review process has been designed to facilitate this process which will employ disciplined methods for identifying potential problems and assigning and tracking action plans. This process of reviews has proved to be a very cost effective method of ensuring the appropriate level of visibility and resources are provided for the project. The reviews are shown in Figure 11.6, which indicates planned dates, attendees, and objectives for each review. This hierarchy of reviews is the integrating element of the management approach.

PROGRAM PLANNING PROCESS

The overall program planning process is depicted in Figure 11.7. The data generated by the comprehensive planning process will be captured and reviewed. The planning/monitoring/replanning activities process is an iterative activity carried on throughout the project life cycle and includes the work breakdown structure which is described below.

Work Breakdown Structure

Activities associated with the completion of the project are organized into interrelated work packages. This allows management to evaluate alternatives relative to the allocation of resources for activity accomplishment. The individual packages are combined and integrated with the program work breakdown structure (WBS). The WBS pairs objectives and tasks with resources and is used as a management tool for program planning, budgeting

REVIEW	FREQUENCY	ATTENDEES	OBJECTIVES
PROGRAM MGRS STATUS MEETING	WEEKLY	PROGRAM MANAGER, TECHNICAL LEADS	DETAILED STATUS REVIEW. IDENTIFY AND RESOLVE CRITICAL ISSUES. REVIEW WORKING GROUP SESSION RESULTS/ACTIONS.
PROGRAM COST/ SCHEDULE REVIEW	WEEKLY	PROGRAM MANAGER, TECHNICAL LEADS, PROGRAM CONTROL PERSONNEL	REVIEW COST/SCHEDULE VERSUS PLAN. VARIANCE IDENTIFICATION. ACTION PLAN.
OPERATION REVIEW	MONTHLY	GE/SMP GM, PROGRAM MANAGER, PROGRAM CONTROL PERSONNEL	REVIEW COST, SCHEDULE AND TECHNICAL PERFORMANCE.
PROGRAM ASSESSMENT REVIEW	QUARTERLY	M&DSO GM, SMP GM, PROGRAM MANAGER	PROGRAM PERFORMANCE, TECHNICAL, SCHEDULE AND COST.
DPMS TECHNICAL REVIEWS	DESIGNATED MILESTONES	GOVERNMENT PERSONNEL, PROGRAM MANAGER AND TECHNICAL LEADS	REVIEW PROGRAM STATUS, DECISION/DIRECTION ON CRITICAL DESIGN ISSUES.

Figure 11.6 Program Review Process

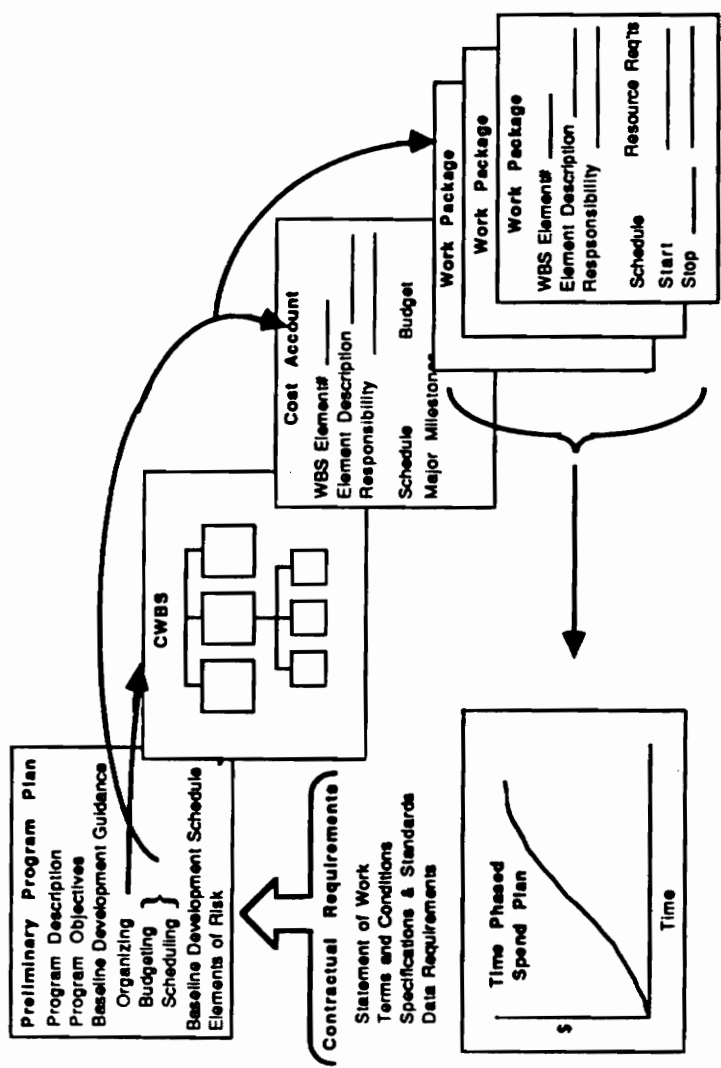


Figure 11.7 Program Planning Process

and task accountability. The APMS development activities are itemized and allocated to appropriate functions in Figure 11.8. These activities are allocated to personnel in Figure 11.9 and 11.10.

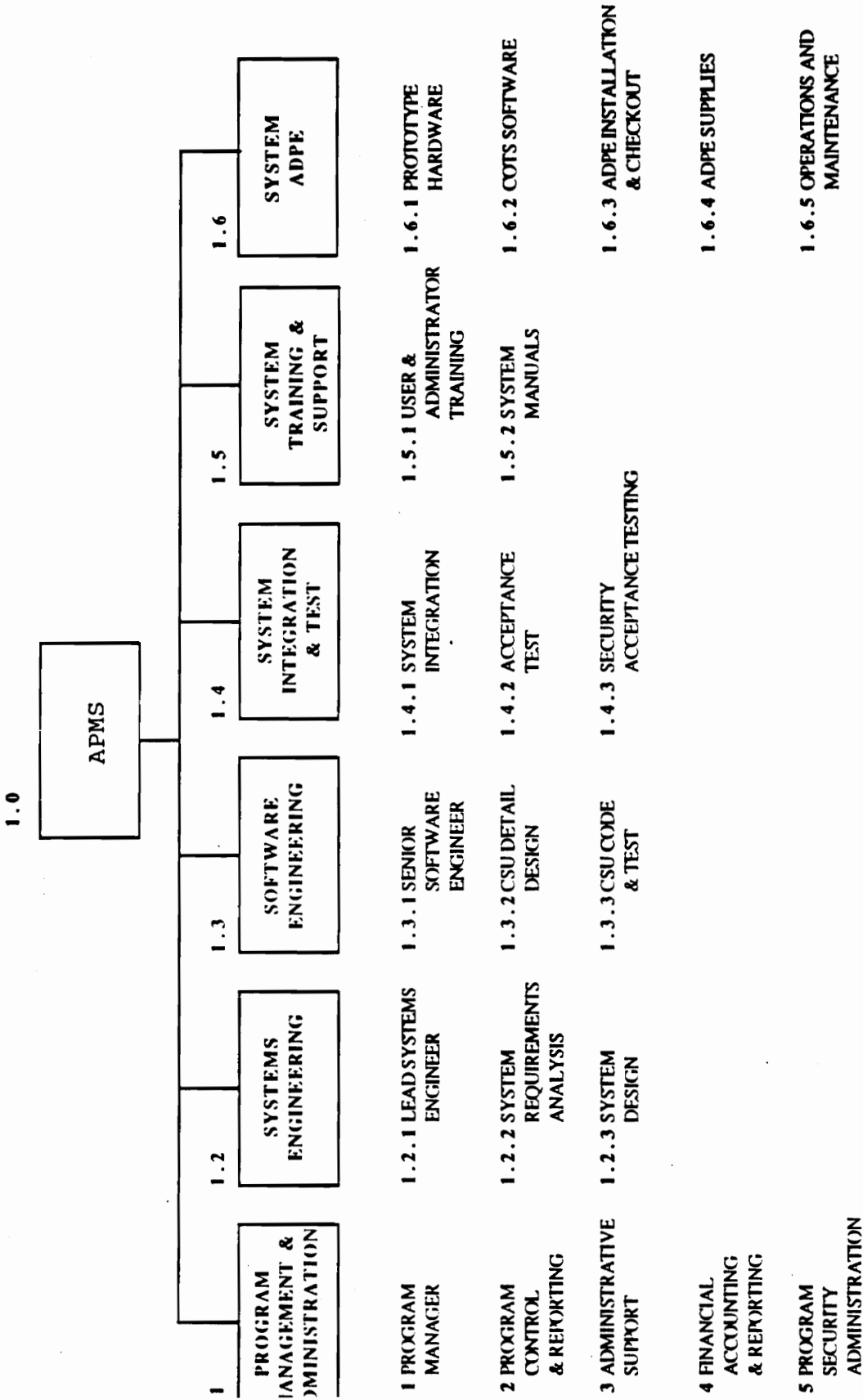


Figure 11.8 Contract Work Breakdown Structure (CWBS)

GROUP	DESCRIPTION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN 92	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
ENGR E11	PERFORM AND SUPERVISE THE INSTALLATION OF HARDWARE FOR COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
ENGR E12	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
ENGR E13	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
ENGR E14	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
ENGR E15	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
	PERFORM AND SUPERVISE THE INSTALLATION OF COMMUNICATIONS EQUIPMENT																		
SPECIALIST	PERSONNEL WITH OVERALL COGNIZANCE FOR PLANNING, ORGANIZING AND DIRECTING TECHNICAL SUPPORT EFFORTS ON MAJOR PROGRAMS OR PROJECTS WHERE DECISIONS DIRECTLY AFFECT ACHIEVEMENT OF MISSION OBJECTIVES																		
	PERSONNEL RESPONSIBLE FOR PLANNING, ORGANIZING AND LEADING TECHNICAL SUPPORT PROGRAMS OF HIGH COMPLEXITY WHERE UNUSUAL PROBLEMS REQUIRE SOLUTION																		
	PERSONNEL WITH SPECIALIZED KNOWLEDGE AND EXTENSIVE EXPERIENCE ENGAGED IN TECHNICAL SUPPORT REQUIRING THE APPLICATION OF PRINCIPLES AND PRACTICES TO THE SOLUTION OF VARIOUS AND COMPLEX PROBLEMS																		
	PERSONNEL RESPONSIBLE FOR SPECIALIZED TECHNICAL SUPPORT REQUIRING THE APPLICATION OF KNOWLEDGE AND SKILL TOWARD THE DEVELOPMENT OF NEW TECHNIQUES, PRACTICES AND PROCEDURES																		
TECHNICIAN	NON-EXEMPT PERSONNEL INVOLVED IN TECHNICAL SUPPORT WORK REQUIRING TWO YEARS OF POST-HIGH SCHOOL TRAINING OR EQUIVALENT SPECIALIZED TRAINING, ABLE TO PERFORM COMPLICATED TESTS OR ANALYSES AND OPERATE OR MAINTAIN COMPLEX MECHANICAL/ELECTRONIC EQUIPMENT																		
	NON-EXEMPT PERSONNEL INVOLVED IN TECHNICAL SUPPORT WORK REQUIRING TWO YEARS OF POST-HIGH SCHOOL TRAINING OR EQUIVALENT SPECIALIZED TRAINING, ABLE TO PERFORM COMPLICATED TESTS OR ANALYSES AND OPERATE OR MAINTAIN COMPLEX MECHANICAL/ELECTRONIC EQUIPMENT																		
	NON-EXEMPT PERSONNEL INVOLVED IN TECHNICAL SUPPORT WORK REQUIRING TWO YEARS OF POST-HIGH SCHOOL TRAINING OR EQUIVALENT SPECIALIZED TRAINING, ABLE TO PERFORM COMPLICATED TESTS OR ANALYSES AND OPERATE OR MAINTAIN COMPLEX MECHANICAL/ELECTRONIC EQUIPMENT																		
	NON-EXEMPT PERSONNEL INVOLVED IN TECHNICAL SUPPORT WORK REQUIRING TWO YEARS OF POST-HIGH SCHOOL TRAINING OR EQUIVALENT SPECIALIZED TRAINING, ABLE TO PERFORM COMPLICATED TESTS OR ANALYSES AND OPERATE OR MAINTAIN COMPLEX MECHANICAL/ELECTRONIC EQUIPMENT																		

Figure 11.9 Manpower Allocation By Task and Schedule

Responsible Element	SOW Paragraph	CWBS Element
Program Manager	7.0 Program Management 8.0 Progress Compliance 6.3.3 User Manual 6.6.4 User Training	1.1 Program Management & Administration 1.1.2 Program Control and Reporting 1.1.3 Admin Support 1.1.4 Financial Acct'g and Reporting 1.1.5 Security Admin 1.5.1 User & Administrator Training 1.5.2 System Manuals
Lead Systems Engineer	6.1 Systems Engineering 6.1.1 Requirements Analysis 6.1.2 System Design 6.3 System Integration 6.3.2.2 Acceptance Testing	1.2 Systems Engineering 1.2.2 Systems Requirements Analysis 1.2.3 System Design 1.4.1 System Integration 1.4.2/3 Acceptance Testing
Senior Software Engineer	6.0 Requirements and Tasks 6.3.2 Software Design 4.0 Scope of Work to be Performed	1.3 Software Engineering 1.3.2 CSU Detailed Design 1.3.3 CSU Code & Test 1.6.3 ADPE Installation & Checkout 1.6.4 Development ADPE Ops & Maintenance

Figure 11.10 Allocation of Responsibilities for Major SOW Paragraph and CWBS Elements.

XI. LIFE CYCLE COST

A major objective in the design and delivery of a system is cost effectiveness. Cost effectiveness is defined in terms of life cycle cost, system effectiveness, and system performance attributes. The goal is to incorporate as many of the elements of cost effectiveness in the design as early as possible. These are found in Figure 12.1.¹ In determining these elements and in an effort to include these in design, an evaluation process is undertaken which is found in Figure 12.2.²

COST ESTIMATES

The Cost Estimating System used provides cost estimates in accordance with all applicable government requirement in a manner that provides accurate, current, and complete proposals for customer review. This section provides discussions of all elements from which costs are calculated. Direct labor is divided into four principal classes: Engineering, Drafting, Production, and Specialist/Technician. A brief overall description for the two classes used in this effort is provided below and is further described in Figure 12.3.

The *Specialist/Technician* ("T") classification includes exempt personnel performing, planning, organizing, and other specialized technical support

¹ Blanchard, B. S., and Fabrycky, W. J. *Systems Engineering And Analysis*. Englewood Cliffs, NJ: Prentice Hall, 1990. pg. 81.

² Blanchard, B. S., and Fabrycky, W. J. *Systems Engineering And Analysis*. Englewood Cliffs, NJ: Prentice Hall, 1990. pg 69.

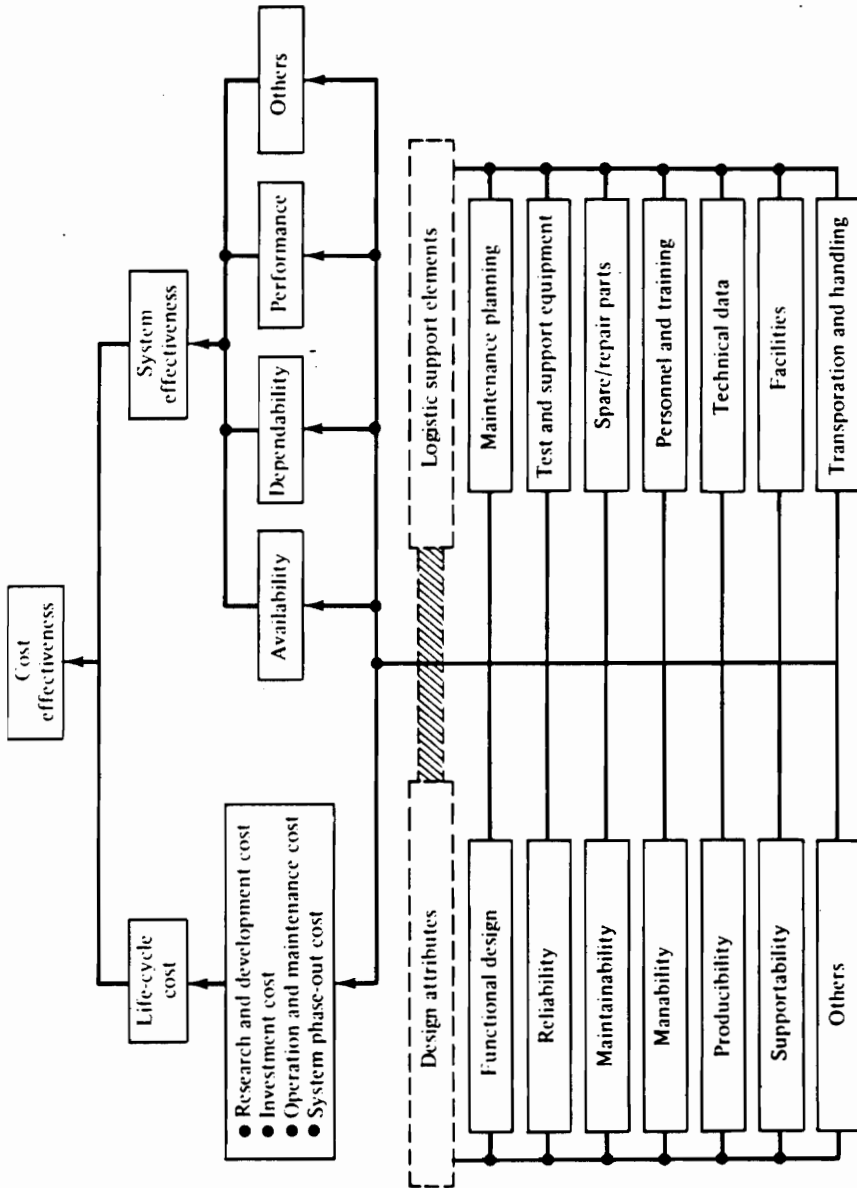


Figure 12.1 The elements of cost-effectiveness.

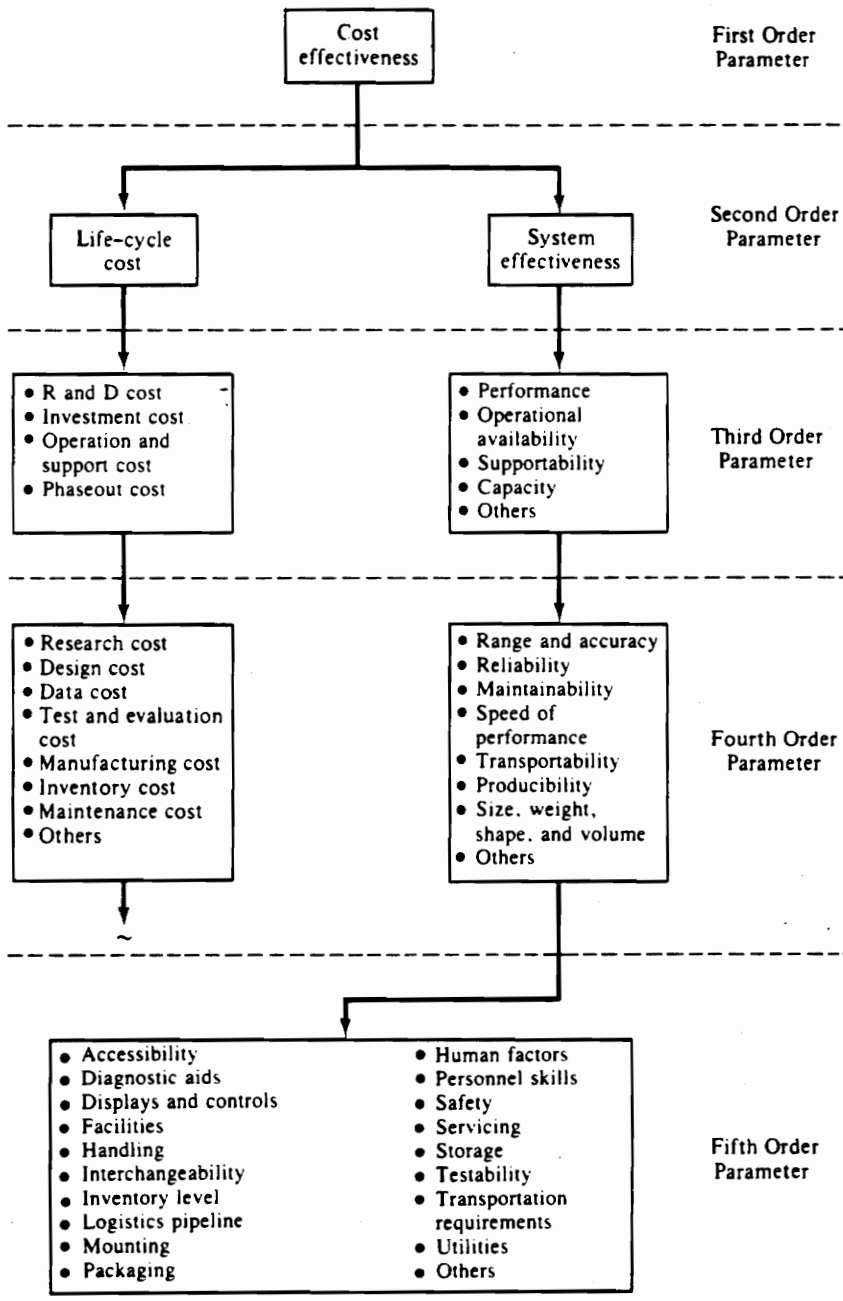


Figure 12.2 Order of evaluation parameters.

CODE	GROUP	DESCRIPTION
E1	ENGINEER	ENGINEERING AND SCIENTIFIC PERSONNEL RESPONSIBLE FOR ACHIEVING OVER-ALL PROGRAMS OR PROJECTS OBJECTIVES: DECISIONS AND TECHNICAL CONTRIBUTIONS ARE CRITICAL TO MISSION SUCCESS.
E2	ENGINEER	ENGINEERS AND SCIENTISTS RESPONSIBLE FOR PLANNING, ORGANIZING, AND LEADING TECHNICAL PROGRAMS OF HIGH COMPLEXITY, OR DIRECTING RESEARCH IN STATE OF THE ART TECHNOLOGY.
E3	ENGINEER	ENGINEERS AND SCIENTISTS WITH EXTENSIVE EXPERIENCE WHOSE KNOWLEDGE AND JUDGEMENT ENABLE THEM TO SOLVE UNUSUAL AND COMPLEX TECHNICAL PROBLEMS AND DEVELOP STANDARDS AND GUIDELINES FOR DIVERSE PROGRAM ACTIVITIES.
E4	ENGINEER	ENGINEERS AND SCIENTISTS WITH THE EXPERIENCE AND KNOWLEDGE TO APPLY ENGINEERING PRINCIPLES AND PRACTICES TO DIVERSE TECHNICAL PROBLEMS AND DEVELOP NEW TECHNIQUES AND SOLUTIONS.
E5	ENGINEER	ENGINEERS AND SCIENTISTS HAVING A FORMAL DEGREE (OR EQUIVALENT) IN A TECHNICAL DISCIPLINE WHOSE ASSIGNMENT REQUIRES A COMPREHENSIVE KNOWLEDGE OF ENGINEERING PRICIPLES TO DEVELOP NEW TECHNIQUES OR PROCEDURES ON RESEARCH OR SCIENTIFIC PROGRAMS.
T1	SPECIALIST	PERSONNEL WITH OVERALL COGNIZANCE FOR PLANNING, ORGANIZING AND DIRECTING TECHNICAL SUPPORT EFFORTS ON MAJOR PROGRAMS OR PROJECTS WHERE DECISIONS DIRECTLY AFFECT ACHIEVEMENT OF MISSION OBJECTIVES.
T2	SPECIALIST	PERSONNEL RESPONSIBLE FOR PLANNING, ORGANIZING AND LEADING TECHNICAL SUPPORT FOR PROGRAMS OF HIGH COMPLEXITY WHERE DIVERSE AND UNUSUAL PROBLEMS REQUIRE SOLUTION.
T3	SPECIALIST	PERSONNEL WITH SPECIALIZED KNOWLEDGE AND EXTENSIVE EXPERIENCE ENGAGED IN TECHNICAL SUPPORT REQUIRING THE APPLICATION OF PRINCIPLES AND PRACTICES TO THE SOLUTION OF VARIED AND COMPLEX PROBLEMS.
T4	SPECIALIST	PERSONNEL RESPONSIBLE FOR SPECIALIZED TECHNICAL SUPPORT REQUIRING THE APPLICATION OF KNOWLEDGE AND SKILL TOWARD THE DEVELOPMENT OF NEW TECHNIQUES, PRACTICES AND PROCEDURES
T5	TECHNICIAN	NON-EXEMPT PERSONNEL INVOLVED IN TECHNICAL SUPPORT WORK REQUIRING TWO YEARS OF POST HIGH SCHOOL TRAINING OR EQUIVALENT SPECIALIZED TRAINING; ABLE TO PERFORM COMPLICATED TESTS OR ANALYSES AND OPERATE OR MAINTAIN COMPLEX MECHANICAL/ELECTRONIC EQUIPMENT.

Figure 12.3 LABOR CLASSIFICATION AND DEFINITION

functions on work which is program or contract related. The category includes holding non-engineering degree such as computer sciences, mathematics and business majors. It also includes non-exempt personnel able to perform complicated tests or analyses and operate or maintain complex mechanical/electronic equipment and applied secretaries. There are five levels in this class (T1 to T5).

The *Engineering* ("E") classification includes Engineers and Scientists having a formal degree or equivalent in a technical discipline. Their assignment requires achieving overall program objectives, directing research in state-of-the-art technologies, developing standards and guidelines for diverse program activities, applying engineering principles and practices to diverse technical problems, and developing new techniques or procedures on research scientific programs.

Estimated Labor Hours

The direct labor hours included have been developed by labor class by the responsible functional organizations. Upon completion, the total estimate is reviewed for reasonableness and completeness by the appropriate functional manager, program manager, and the General Manager.

Labor hours are estimated primarily by using relevant prior experience on similar work as a guide. The number of hours per year is determined by subtracting historical unapplied labor (UPAL), average vacation and holidays

from the total available hours in a year. Historical data for UPAL and vacation were used to derive the hours listed below. These hours were used as the basis for estimating hours per month. See Figure 12.4 for labor hour distributions.

Labor Rates

The forward pricing labor rates utilized in calculating the direct labor dollars are based on the average rate of the personnel in each labor class within the corporate structure. The rates are forward priced on an annual basis in accordance with accepted costing and accounting practices. These forward pricing factors are based upon projected cost of living and merit increases coupled with anticipated hiring objectives and include a labor added that accounts for vacation, holidays and paid absences. The rates applicable to the are included in Figure 12.5.

Direct Labor Costs

Direct labor costs is calculated by multiplying the estimated hours in a labor class by the applicable rate per hour for that time period. Where actual hours/costs have been incurred, they are included at the recorded amounts.

	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>
GFY										169	134	131
GFY	169	132	135	144	138	144	177	134	140	169	134	131
GFY	169	132	150	125								

Figure 12.4 Estimated Labor Hours

<u>LABOR</u>	<u>LABOR CLASS</u>	<u>CY 1991</u>	<u>CY 1992</u>
	E1	\$47.64	\$48.49
	E2	\$38.54	\$39.22
	E3	\$30.57	\$31.11
	E4	\$24.88	\$25.32
	E5	\$20.25	\$20.61
	T1	\$36.76	\$37.41
	T2	\$28.98	\$29.49
	T3	\$23.36	\$23.77
	T4	\$18.80	\$19.13
	T5	\$14.43	\$14.65
	Exempt Escalation	1.80%	1.75%
	Non-Exempt Escal.	1.50%	1.50%

<u>INDIRECT RATES</u>	<u>DESCRIPTION</u>	<u>POOL</u>	<u>CY 1991</u>	<u>CY 1992</u>
	Overhead		101.7%	100.9%
	Washington Area Field		35.1%	34.6%
	SSP Field (On-Site)		33.0%	34.0%
	G & A		11.3%	10.8%
	Material Handling		3.4%	3.6%

Figure 12.5 FORWARD PRICING RATES

Overhead

Labor overhead is a cost that cannot be readily identified within a particular project. Overhead expenses are liquidated based on the direct labor generated by each cost pool. APMS' overhead expenses are divided appropriately into corporate overhead and Field overhead cost pools. The overhead pools are determined by the organization of the personnel performing the work. The rates applicable are detailed below and include in Figure 12.6.

Overtime Premium

As a result of the schedule guidelines and the dedicated staff we are proposing to support this activity, some overtime may be required. This overtime is required primarily in the design and development phases of the project. The price impact for overtime premium is approximately \$4,250. The distribution of this overtime is identified in the cost breakdown structure.

Overtime premium is calculated at \$6.00/hour for employees with annual salaries in excess of \$25,000 and at 1/2 hourly rate for employees with annual salaries of less than \$25,000.

Travel And Living Expenses

Standard practice is to reimburse employees for actual, reasonable, necessary and proper expenses for travel and living which are incurred in the conduct of

<u>Description</u>	<u>Pool</u>	<u>CY '92</u>	<u>CY '93</u>
Overhead		101.7%	100.9%
Washington Area Field		35.1%	34.6%
SSP Field (On-Site)		33.0%	34.0%

Figure 12.6 Overhead Rates

company business. The current US government per diem rate is used for reimbursement of travel which encompasses overnight lodging. If no overnight lodging is involved in the travel, employees are reimbursed for those actual and reasonable expenses incurred in the conduct of company business. In all cases where the employee is traveling on company business, he/she is expected to utilize the most expedient, but economical travel and living modes, and to take advantage of commercial discount rates at every opportunity.

As a result of the substantial amount it represents to the travel industry, the company has been able to arrange discount agreements which reduce travel expense incident to contract performance. The travel and living costs that appear in this report are based on the Federal Travel Regulation (FTR)³. Allowable expenses are clearly delineated in company instructions and are independently audited. The airfares used in this proposal are based upon standard coach fares secured from a travel agent on 13 January 1992.

Travel and living costs for this effort are proposed for several trips to remote locations participating in the APMS Prototype project. The trips proposed for this activity and the purpose of each is described in Figure 12.7.

³ Federal Travel Regulations state the maximum airfare the government can be charged between two cities.

<u>TIMING</u>	<u>DESTINATION</u>	<u>PURPOSE</u>
August '92	Valley Forge, PA	Preliminary Design Discussions
August	Los Angeles, CA	Preliminary Design Discussions
October	Valley Forge, PA	Detail Design Discussions
October	Los Angeles, CA	Detail Design Discussions
January '93	Valley Forge, PA	CDR Coordination Discussions
May	Valley Forge, PA	Pre-Integration Coordination Discussions
June	Los Angeles, CA	Pre-Integration Coordination Discussions
November	Valley Forge, PA	Installation, Checkout and Testing
November	Los Angeles, CA	Installation, Checkout and Testing
December	Valley Forge, PA	Acceptance Testing
December	Los Angeles, CA	Acceptance Testing

Figure 12.7 PROPOSED TRAVEL AND LIVING

General And Administrative Expenses

This category includes Bid and Proposal (B&P), Independent Research and Development Program (IR&D), and General and Administrative (G&A) expenses.

The major function of the composite G&A, IR&D and B&P pool is the segregation and accumulation of costs of administration, finance employee relations, business planning, legal, marketing, assessments, IR&D projects and IR&D assessments, and B&P projects applicable to the business as a whole.

The activities are the management and administration of the overall business unit, the performance of marketing responsibilities and the conduct of IR&D and B&P projects. The rates applicable to this project are included in Figure 12.8.

	<u>CY'92</u>	<u>CY '93</u>
General & Administrative	11.30%	10.80%

Figure 12.8 G & A Rates

Material Handling Expense

Material handling expense (MHX) rates are liquidated on total material purchases (hardware and non-hardware). MHX includes the cost of purchasing/procurement organization, material cost estimating, receiving, incoming test and material quality assurance.

COST ESTIMATING PROCESS

The cost estimating process is broken down into four work phases. In Phase I, each major phase of the effort is reviewed. The assignments, the integration of estimating costing and the project time schedule are a part of this process.

In Phase II, man-hour estimates and material requirements are prepared and reviewed to ensure that they are reasonable and comply with the tasks as defined in the work statement. In Phase III, material costing is done by contacting vendors. Costing for man-hour estimates, and review of material costing is performed by the financial analysis and cost estimating. Summaries of costs are prepared prior to submission to the customer.

In the fourth and final phase, the cost is again reviewed and revisited. Legal counsel, when applicable, is involved, as well as the cognizant operations manager for materials, finance, and contracts. The designated operation, division, and/or group management is the final review to ensure that stated customer requirements have been addressed and ensure that the best possible

response is being provided to the customer. Figure 12.9 depicts the four phases of the cost estimating process and their inter-relationships as described previously.

Cost Estimating Methodology

Several cost estimating methodologies were employed in developing the estimates for this cost proposal. A discussion of these methodologies follows:

Labor estimates are developed using engineering estimates, previous similar experience and levels of effort for a particular time period. After applying the appropriate estimating methodology to each task identified in the work statement, it was determined that a dedicated program staff of nine individuals was appropriate to accomplish the defined work. As indicated above, some overtime will be required of program staff personnel. Experience indicates that the efficiencies gained by extending dedicated program personnel commitment far outweigh any cost savings from applying supplemental support in a non-overtime capacity. Familiarization or "spin-up" time for those supplemental support personnel can lead to additional costs and negative schedule impacts.

Overhead pool determinations were made based on the location of the performance of the tasks associated with the work statement requirement. Since the majority of the work will be performed at the customer site, the Washington Field overhead pool was quoted for the majority of the effort. Those functions residing in corporate facilities, such as finance, security, and support

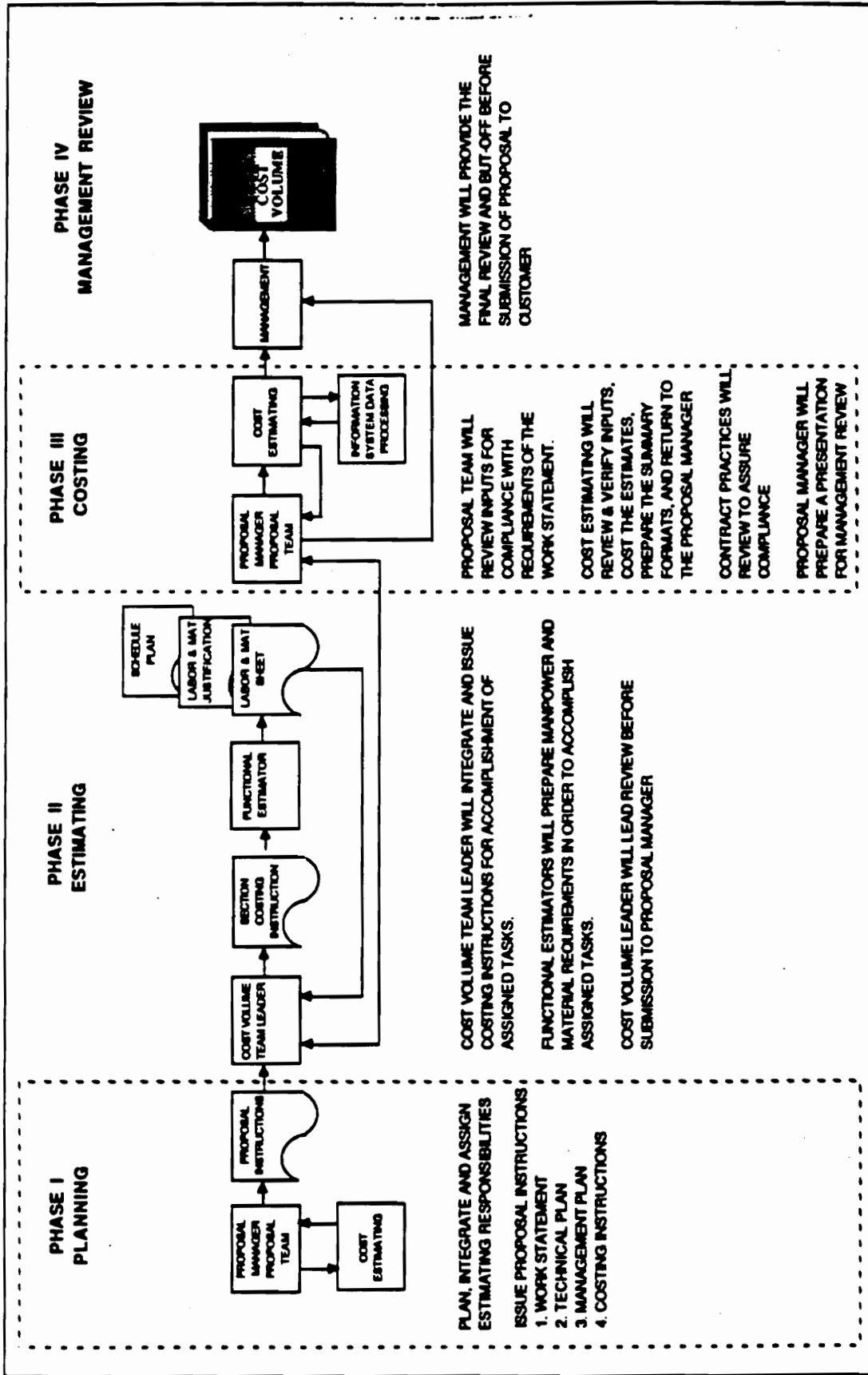


Figure 12.9 Costing Process

management were quoted from the in-house overhead pool. In addition, the supplemental support proposed for the training aspects of this activity will be provided by the personnel also residing in the field overhead pool.

Material cost estimating was accomplished through negotiations with vendors to achieve the most advantageous arrangement for this activity. An escalation factor was added to take into account minimal price increase from time of quote to time of actual order. These estimates take advantage of corporate buying agreements and reflect best efforts to provide the most cost effective and high quality solution to the customer.

TOTAL LIFE CYCLE COST

Total Life-cycle cost refers to all costs associated with the Automated Program Management System which are required to achieve the defined system objective. In general, total life-cycle cost for APMS includes the following four aspects:

1. Research and Development (R&D) Cost - feasibility studies; engineering design; initial planning and organization; product research; associated management functions.
2. System Development Costs - product and process development; quality control; operational analysis; industrial engineering; logistical support.

3. Operations and Maintenance Costs - customer operations of the office automation system; product distribution; continual logistical support throughout the system life-cycle.
4. Retirement and Disposal Costs - system retirement after obsolescence; material recycling; hazardous waste disposal; disposal of non-reparable items throughout the life-cycle; remaining logistical support requirements.

Life-cycle cost is determined by identifying the individual costs in each phase of these four aspects and determining the cost of these functions. These costs are then detailed by function on a yearly schedule, and finally accumulated for the total useful life.

The objective of the life-cycle costs analysis will show that the developer has incorporated cost in every aspect of system design. Figure 12.10 illustrates the activities affecting life-cycle cost.⁴ The analysis will show that the supplier has incorporated a design-to-cost concept as a system design parameter along with performance, effectiveness, maintainability, reliability, manability, and supportability.

This analysis will determine the total cost for implementing a new program management system at the customer site. This will identify and break out all applicable costs relating to the integration of the network. This effort will allow

⁴ Blanchard, B. S., and Fabrycky, W. J. *Systems Engineering And Analysis*. Englewood Cliffs, NJ: Prentice Hall, 1990. pg. 506.

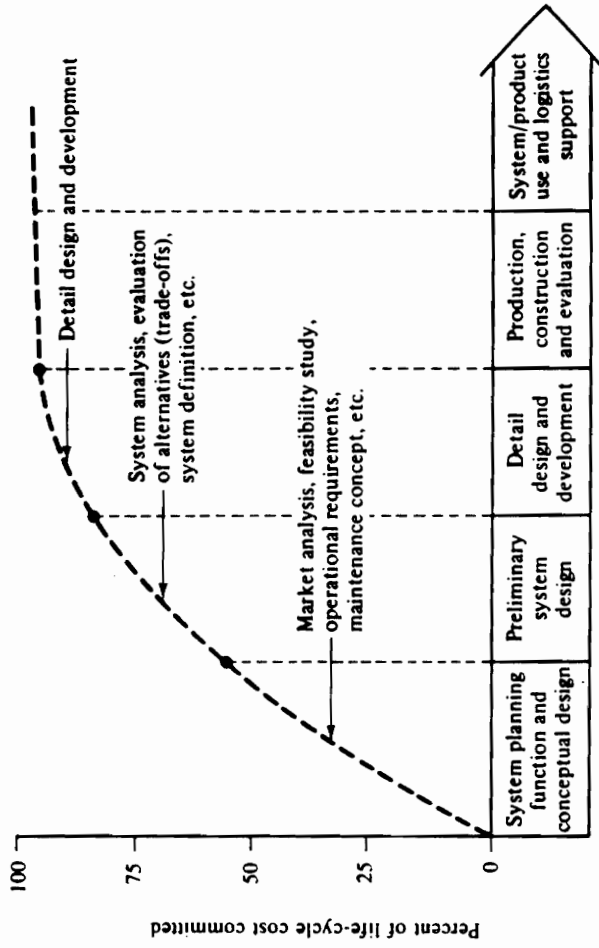


Figure 12.10 Actions affecting life-cycle cost.

the customer to verify that the system developer has established quantitative cost factors as requirements during network development.

Cost Breakdown Structure

A cost breakdown structure (CBS) has been defined for the development and installation of APMS. The CBS matches objectives and activities with resources, and constitutes a logical subdivision of cost by major elements of the system. The CBS provides a mechanism for initial cost allocation, cost categorization, and cost monitoring and control. An illustration of the components of a generic cost breakdown structure is shown in Figure 12.11.⁵

The CBS for APMS is divided into three major components: 1) research and development costs, 2) system development costs, and 3) maintenance costs. For APMS, emphasis is placed on system development with less placed on maintenance and R&D.

Research and development costs are found from ongoing research into server and workstation technology, application software, and database design. Also, the decision of what technology or mixture thereof to use. Other R&D costs are associated with initial program planning, the development of operational requirements, user surveys, feasibility studies, development of the maintenance concept and the delineation of top-level specifications.

⁵ Blanchard, B. S., and Fabrycky, W. J. *Systems Engineering And Analysis*. Englewood Cliffs, NJ: Prentice Hall, 1990. pg. 660.

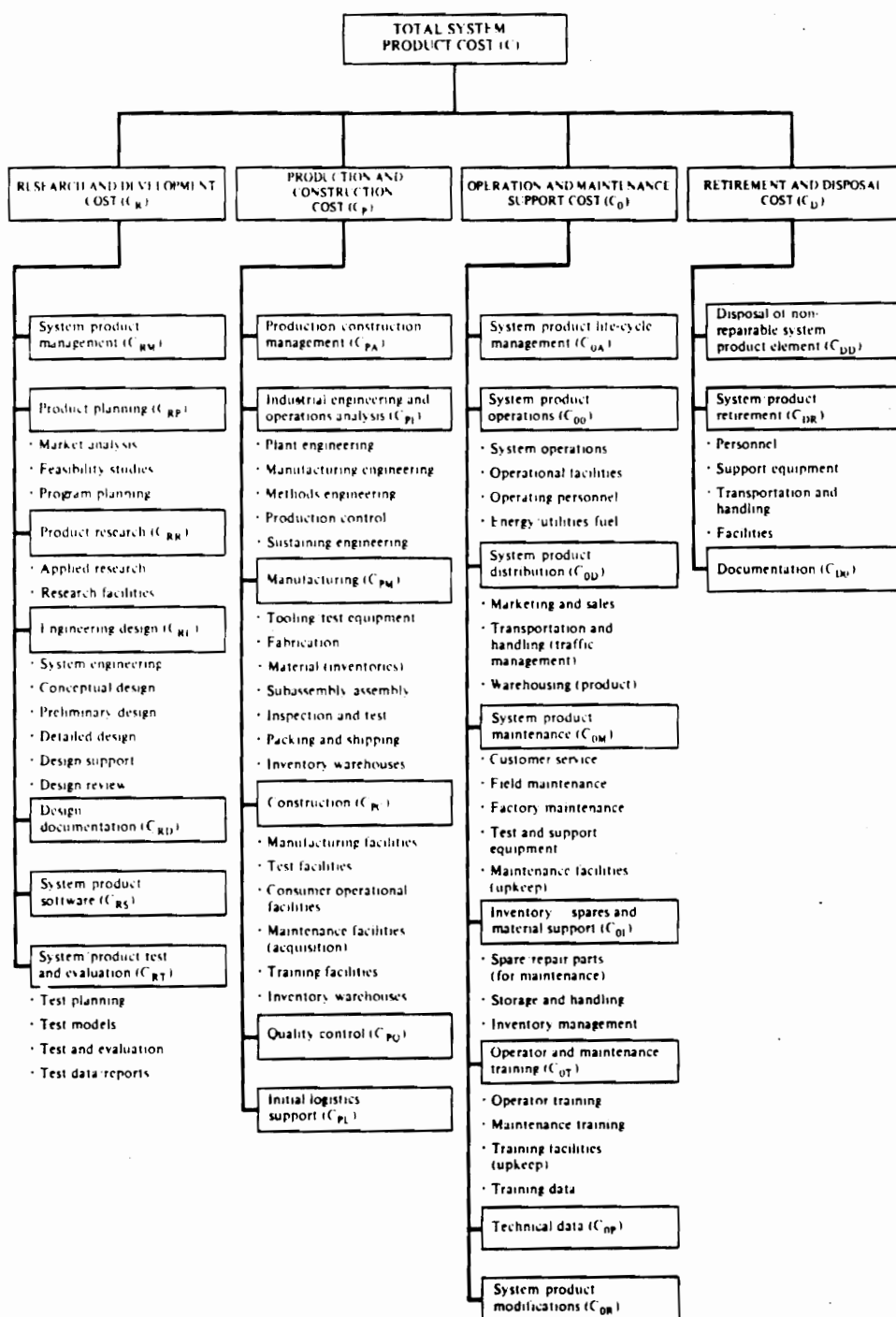


Figure 12.11 Cost breakdown structure.

Because this is a software development project, system development costs are the overwhelming bulk of the total cost. These costs are reflected in the base cost of the components which the suppliers manufacture. The expenses which are detailed here include the custom coding, system integration and unit test activities, and the networking of the workstations upon arrival at the customer site. Final acceptance test and evaluation costs are also included here.

The costs associated with system operation, logistic support and distribution are considered operation and support costs. The only cost provisions provided here are the maintenance personnel factors. Operating personnel costs are not included for the users of the system.

Maintenance costs are directly related to the personnel activity costs associated with the performance of maintenance actions on the system. This includes problem isolation, supplier contacts for repair or replacement of components, faulty part removal, and problem documentation. It is reasonable to assume that these costs will decrease over time due learning and experience of operators. This experience will reduce maintenance cost by 20% per year. Additionally, only the most complex system errors should require the intervention of the system development team after final system acceptance.

The total number of maintenance actions required (MAR) assumes that the system is in a steady state and the all failures are independent is calculated using Equation 12.1 as

$$\begin{aligned} \text{MAR} &= (1/\text{MTBF}) \times (\text{hours of system operation}). \\ &= (1/4380) \times (87,600) = 19. \quad (12.1) \end{aligned}$$

This is a reasonable number of actions for the life time of this project. Maintenance contracts have been purchased from the H/W and S/W vendors and are included in the total system cost.

The retirement and disposal costs for APMS are negligible. It is assumed that whatever salvage value the equipment has will offset any removal charges incurred. Creative means of disposal have been used in the past such as auctions, donations to charitable organizations or schools⁶, etc. It is assumed that no credit will be given by the supplier for returned equipment.

The total cost breakdown for the ten-year useful life of the Advanced Program Management System is detailed in Figure 12.12. Figure 12.13 shows the cost summary by calendar year. The material cost determination listings are included in Appendix IV.

⁶ A tax advantage can be garnered from the donation of such equipment to non-profit organizations.

A		B
	Total Life	Cycle Cost
1		
2	Material	\$412,144.00
3	Material Handling (MHX)	\$14,117.00
4	Total Material	\$426,261.00
5		
6	Direct Labor	\$632,513.00
7	Labor Overhead	\$231,919.00
8	Total Labor/Overhead	\$864,432.00
9		
10	Other Direct Cost	
11	Overtime Premium	\$4,254.00
12	Travel & Living	\$26,200.00
13	Total Other Direct Cost	\$30,454.00
14		
15	G & A	\$102,683.00
16		
17	Total Cost	\$1,423,830.00
18		
19	Profit Margin - 15%	\$213,574.50
20		
21	Total Price	\$1,637,404.50

Figure 12.12 Total Life Cycle Cost

	A	B	C	D
1	Cost Element	1992	1993	Total
2	Hours By Labor Class			
3	E2	861	1,753	2,614
4	E3	861	3,506	4,367
5	E4	1,874	1,813	3,687
6	E5	1,268	3,506	4,774
7	T1	112	234	346
8	T2	1,440	3,530	4,970
9	T3	48	96	144
10	T4	24	168	192
11	T5	892	1,780	2,672
12	Total Hours	7,380	16,386	23,766
13				
14	Cost Element			
15	Labor Dollars by Class			
16	E2	\$33,183.00	\$68,753.00	\$101,936.00
17	E3	\$26,321.00	\$109,072.00	\$135,393.00
18	E4	\$46,625.00	\$45,905.00	\$92,530.00
19	E5	\$25,677.00	\$72,259.00	\$97,936.00
20	T1	\$4,117.00	\$8,754.00	\$12,871.00
21	T2	\$41,731.00	\$104,100.00	\$145,831.00
22	T3	\$1,121.00	\$2,282.00	\$3,403.00
23	T4	\$451.00	\$3,214.00	\$3,665.00
24	T5	\$12,871.00	\$26,077.00	\$38,948.00
25	Total Hours	\$192,097.00	\$440,416.00	\$632,513.00
26				
27	Labor Overhead	\$71,543.00	\$160,376.00	\$231,919.00
28	Overtime Premium	\$324.00	\$3,930.00	\$4,254.00
29				
30	Travel & Living	\$3,000.00	\$23,200.00	\$26,200.00
31	Purchased Parts	\$200,780.00	\$48,517.00	\$249,297.00
32	Maintenance	\$11,428.00	\$3,729.00	\$15,157.00
33	Software	\$148,433.00	\$0.00	\$148,433.00
34	Vendor Discount	(\$649.00)	(\$94.00)	(\$743.00)
35	M-X	\$12,240.00	\$1,877.00	\$14,117.00
36	Total Materials	\$375,556.00	\$81,159.00	\$456,715.00
37				
38	Total Labor/OH/Material	\$639,196.00	\$681,951.00	\$1,321,147.00
39				
40	G&A	\$32,558.00	\$70,125.00	\$102,683.00
41				
42	Subtotal	\$671,754.00	\$752,076.00	\$1,423,830.00
43				
44	Profit - 15%	\$100,763.10	\$112,811.40	\$213,574.50
45				
46	Total Cost	\$772,517.10	\$864,887.40	\$1,637,404.50

Figure 12.13

Cost Summary By Calendar Year

XII. CONCLUSION/RECOMMENDATION

The objective of this project and report is to provide a life-cycle analysis¹ of the Advanced Program Management System Prototype using sound Systems Engineering and Computer Science tools. The Advanced Program Management System Prototype will, when implemented, provide the customer with the desired configuration management functionality in a softcopy format. The cost data support the conclusion that the cost to implement APMS far outweigh those incurred if the APMS prototype is not delivered. Not only will the government save on its expenditures, but the system could set the configuration management standard for all government agencies.

Structured analysis methodology has been proven as an effective method of building and delivering software modules. In this project, it has greatly reduced the efforts of preliminary design, defining system functionality and allocating system functions at the CSC level. These accomplishments will facilitate final system delivery and acceptance by the customer.

It should be understood that while this project and report details the Advanced Program Management System as a prototype, the hope is that the system will gain wide acceptance and be installed in U.S. government agencies around the world. With this in mind, the prototype has been designed to include the maximum amount of program management and configuration management

¹ Life-cycle analysis is defined as a process by which one a) defines the need for analysis, b) select a model to facilitate the evaluation process, c) generate the appropriate data for each alternative being considered, d) evaluate the alternatives, and e) recommend a proposed solution.

tools. I feel that through the Joint Requirement Definition Sessions and the Joint Application Design Sessions, all specified user functions are incorporated in APMS.

In the development of this system, I have recommendations for future growth and system development. In the age of increasing processing power with decreasing hardware prices, it is feasible that the system could be implemented on the next generation of high-end personal computers such as the IBM PC, the NEXT system or the APPLE Macintosh. Although not immediately feasible, it is possible that in the 1994-95 time-frame, personal computers will achieve the processing power needed to implement APMS. A Graphical User Interface such as Coreographer and a database product such as Sybase-SQL by Microsoft would be suitable options.

The major obstacle to implementing APMS on a personal computer is the speed and size of the processors. The 386 and 486 processors primarily utilized in PCs today simply do not have the speed to process large amounts of data or perform a large number of complex mathematical operations. Research in the future should be concentrated in the areas of either developing newer and faster microprocessor chips or utilizing other techniques to increase the MIPS of PCs.² Currently, areas of study such as distributed and parallel processing, reduced instruction set (RISC) microprocessors and smart software are promising for future PC applications.

² Millions of Instructions per Second

In the software arena, object oriented programming is making sophisticated custom application building easier to manage. Also, prominent in software development is the proliferation of graphical user interface (GUI) builders for the PC platform. These tools will help make future transitions from the workstation to the PC environment a seamless and smooth one.

In performing this analysis, I have learned a great deal and feel that through systems analysis and software development methodologies, effective systems can be developed. The lessons learned in this study will remain with me in both my academic and professional careers.

APPENDIX A. RFC PROCESSING

In this section, a complete analysis of recommendation for change processing performed. This analysis shows how RFCs and their control are developed in the APMS system. This complete analysis is an example of how each identified process in the system would be decomposed and designed in the detailed design phase. It is not within the scope of this report to complete a design to this level of detail. This section merely illustrates the process to arrive at such detail.

RFC PROCESSING DETAIL DESIGN

This appendix includes three elements of the detail design of RFC Processing:

- Decomposition of the functions of the RFC Data Flow Diagram,
- RFC Data Base design, and
- Sample Graphical User Interface for RFC processing.

The following pages include these elements.

The Request for Change (RFC) processing bubble of Figure 9.14 is decomposed into the flow diagram shown in Figure A1.1.

The process "generate RFC" (bubble 1.2.1 of Figure A1.1) allows the user to create and edit an RFC for submission to an RFC administrator. RFC data, which is input to this process will be used to populate various pieces of an RFC package, whether it is a new package or an existing package which may need to be updated or corrected. Other inputs to this process are Baseline Documents, which will be used in the creation of redlined pages, and optional requirement traces, used to insure all impacted documents are included in the RFC. The output to this process is a completed draft RFC package which will be stored in the RFC data system. The RFC data system consists of both the Interleaf "books" which contain the pieces of each RFC, and the Sybase data tables which contain the relational database information for RFCs. An example of the Interleaf "book" comprising an RFC package is shown in Figure A1.4. The RFC package is contained in the opened "book" window titled "RFC#0123456." As the RFC package progresses through the approval cycle, various pieces are added to the "book" by the appropriate parties.

One of the functions performed within process "generate RFC" (bubble 1.2.1 of Figure A1.1) is the creation of the RFC faceplate. The creation of the faceplate will be accomplished by invoking a custom external process from within Interleaf via an Interleaf menu option. The external process will consist of a GUI front end to the Sybase RFC data table. An example of a prototype faceplate entry screen is shown in Figure A1.2. The user will be able to easily tab between fields and select data for certain fields through scrollable lists and button selections.

Upon completion of the data entry, the information will be stored in the Sybase RFC data table. The field information for the RFC data table and the relations to other tables are provided in Figure A1.3.

Once the data from the custom RFC faceplate entry process has been placed into the Sybase RFC data table, a new Interleaf document containing the formatted RFC faceplate is created within the RFC package. The populating of the formatted RFC faceplate with Sybase RFC data table information is accomplished through the COTS Smartleaf capability. An example of the Interleaf formatted RFC faceplate is shown in Figure

Another function which will be performed from within the process "generate RFC" (bubble 1.2.1 of Figure A1.1) is the creation of redlined pages to Baseline Documents. The user shall be able to view a read-only Baseline Document from within Interleaf to determine pages which need to be changed by the current RFC. A custom external process consisting of a GUI front end to a Sybase table will allow the user to specify the identify pages for copying to the RFC package. The use of the external process to create the change pages will ensure that the accessing of the Baseline Document for use in a potential RFC is recorded so that queries can report on pending changes. The user will be able to query whether any of the pages specified have any local RFCs currently in progress (either submitted or unsubmitted) which effect the same pages. The user will also be able to check against submitted system level RFCs for similar potential impacts to their RFC. Once the pages have been placed within the RFC "book," the user may use the Interleaf redlining capabilities to make the appropriate changes. The user will use the RFC change page external process once again prior to the submittal of the RFC to remove any change pages that are not to be included in the RFC. The control of the creation and deletion of change pages within RFC packages will insure the integrity of the RFC change page tracking data.

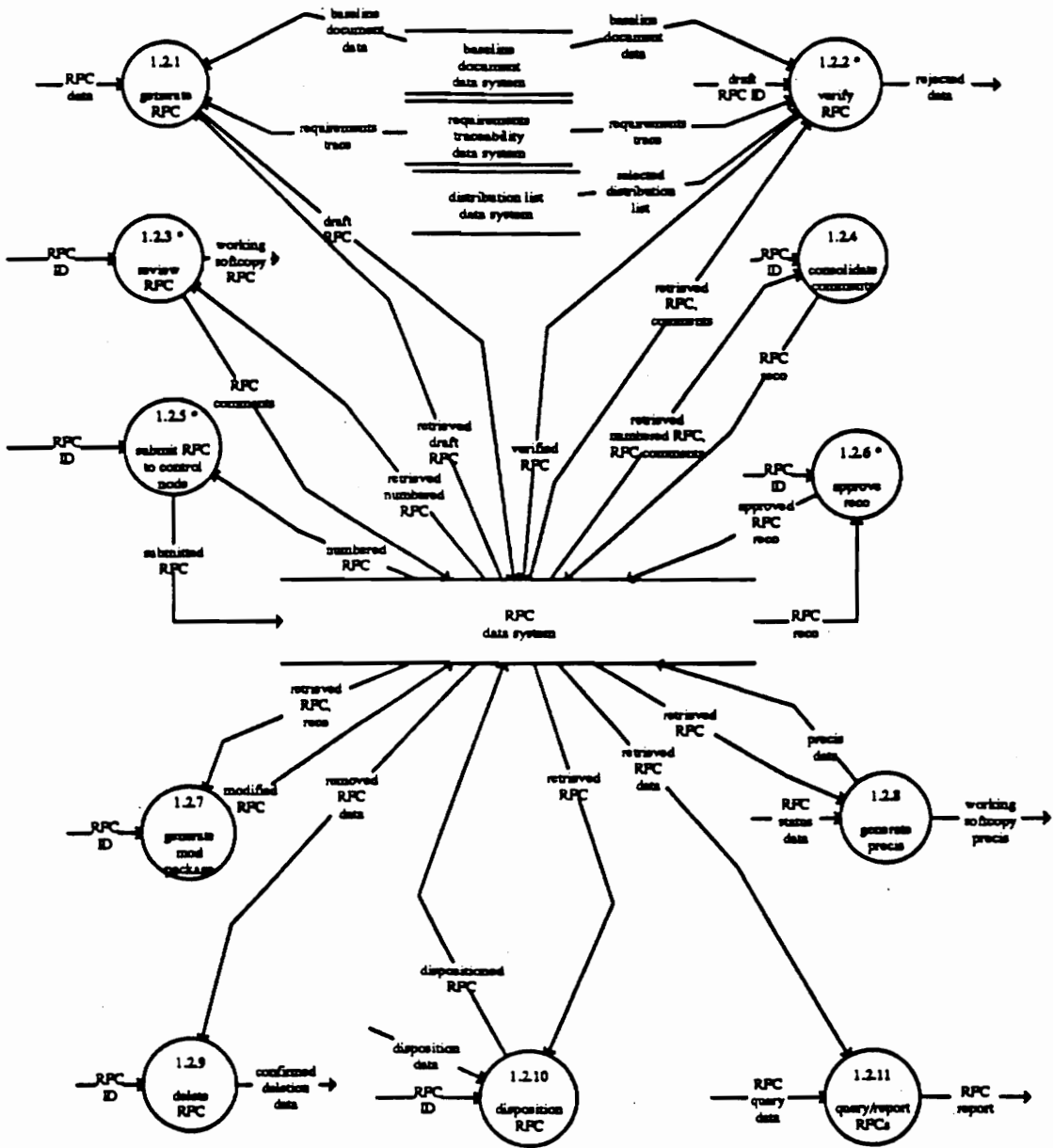


Figure A1.1 Flow Diagram 1.2 (DCM_RPC)

RFC Faceplate Data

Title: _____ RFC Number: None

Date Logged: Mon Dec 02 1991

Originator: _____ Telephone: _____

Approval for Submit: _____

Need for Change:

Description of Change:

Change Affects: Hardware Software Documentation Facility

Documents Impacted:

<div style="border: 1px solid black; height: 20px; width: 100%;"></div>	Doc Name: _____
	Doc Num: _____
	(Document List View)

Effectivity: _____

Impacts: Impact Description:	Impacts: Impact Description:
Cost: Yes <input type="checkbox"/> No <input type="checkbox"/>	Schedule: Yes <input type="checkbox"/> No <input type="checkbox"/>
Weight: Yes <input type="checkbox"/> No <input type="checkbox"/>	Power: Yes <input type="checkbox"/> No <input type="checkbox"/>
	Interface: Yes <input type="checkbox"/> No <input type="checkbox"/>

Impact if not Implemented:

Alternatives to Suggested Change:

Save RFC Faceplate

Figure A1.2 Custom RFC Faceplate Entry Screen

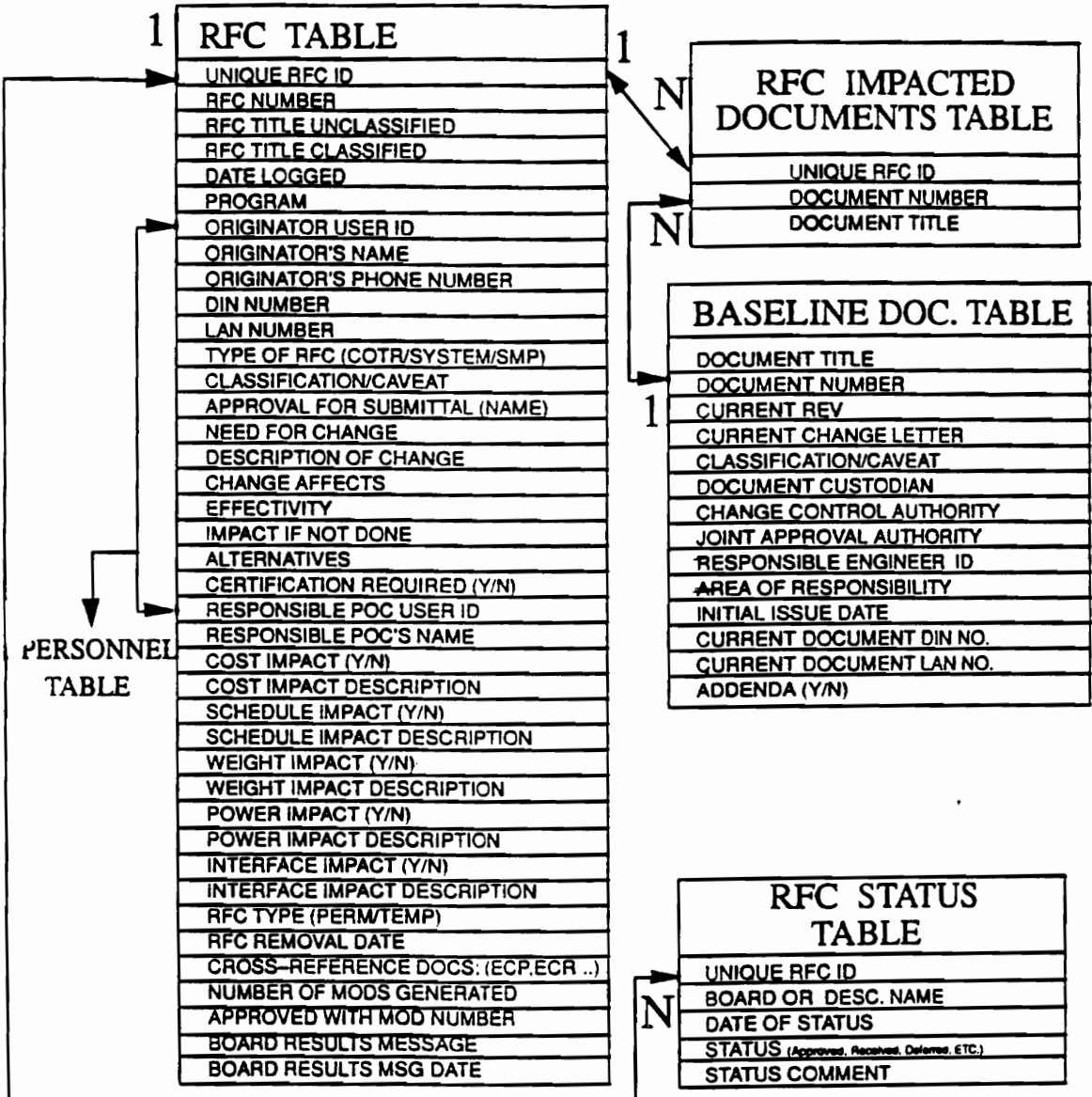


Figure A1.3 RFC Database Tables and Relations

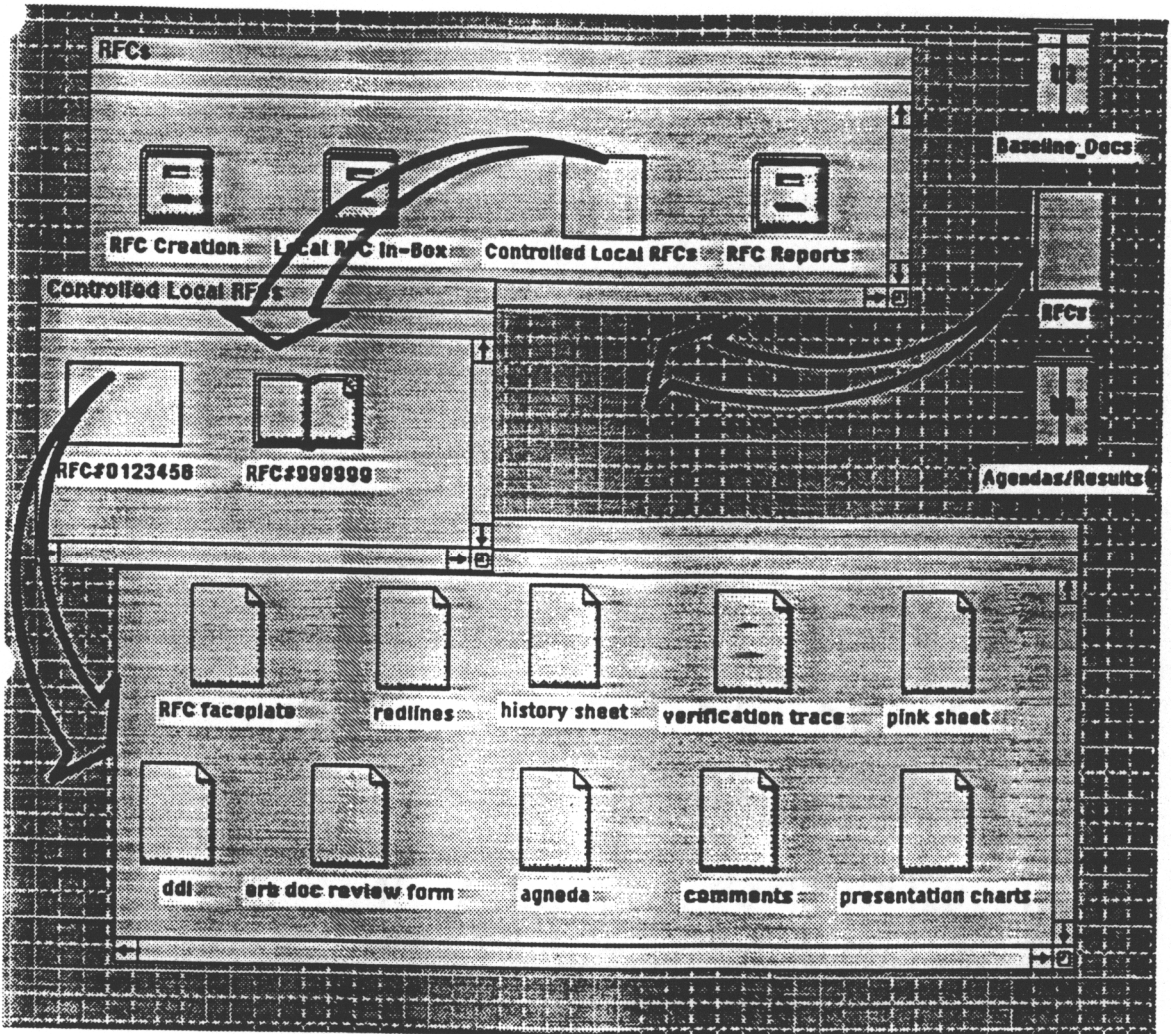


Figure A1.4 Viewing Controlled RFCs within Interleaf

The RFC Database will manage all the pertinent data items concerning RFCs generated on the APMS system and their related status as they are processed. The actual database fields and their respective lengths are shown in the RFC Data Requirements section. The RFC design concept is to have three separate RFC databases at each node on the system: a local database, a SI controlled database and a Program Office controlled database. Figure A1.5 shows how each of the databases will exist across the three nodes. Three separate databases was utilized because this offers the highest level of database integrity and consistency. It also greatly simplifies the process of updating remote database. From the standpoint of a user the three databases will appear as one large database. The designed GUI will decide which database to query when a user wants to gather information about an RFC.

A typical scenario of RFC databases functionality would begin with a user at any one of the nodes creating and then submitting an RFC. At this point, the data from the newly created RFC would reside at the users local read/write database. The status of the RFC would be tracked through whatever control gates exist at the RFC's home node and the local RFC administrator would have complete control over the statusing of the RFC. Any user could query this local database to determine the status of an RFC generated locally (within the constraints of the security policy). When the RFC has passed all the local control gates, the RFC's data would be forwarded to either the SI or the Program Office (depending on the level of the RFC). This data would become part of the master database at the appropriate node. The statusing of this RFC would now be the responsibility of the appropriate node's RFC administrator. The changes and additions to the RFCs status within the master database would be cascaded to all the other nodes for querying purposes.

Local RFC Database

The first database will be used to track locally submitted RFCs up to the point of external submission to the SI or the Program Office. This database will give local users read access to all the locally generated RFC data. In this context, the word "local" means any user or data that is logically assigned to or generated within the domain of a particular node. Local users will also have write access to this database, however after an RFC is formally submitted by a user to the local RFC administrator he will not be able to modify the data in any way. Only the local RFC administrator will be able to modify data that has been submitted to the local database. This local database will remain autonomous at its home node and will not be cascaded or copied to any other node on the system. However, individual data items from this local database will be sent to other nodes when an RFC is submitted externally to the SI or the Program Office. The RFC external submission process will be completely controlled at the RFCs home node. Thus, no RFC data will leave a node until it is specifically instructed to do so, by a local RFC administrator. The ability to view, from a remote node, the status of locally submitted RFCs prior to formal external submission is a feature that can be implemented. However, it will be the responsibility of the local RFC administrator to grant read access to individual from other nodes. It is important to note that each RFC administrator have complete control over the statusing and modification of the RFCs within that node's functional domain. By the same token, an RFC administrator will have no control over RFCs that are not within that node's functional domain. For example, the SI RFC administrator will have no status input capability to RFCs generated at the WCC that have not yet been submitted outside the domain of the WCC. However, once an RFC is submitted to the SI, the domain of the RFC changes and it is now the responsibility of the SI RFC administrator to input status information.

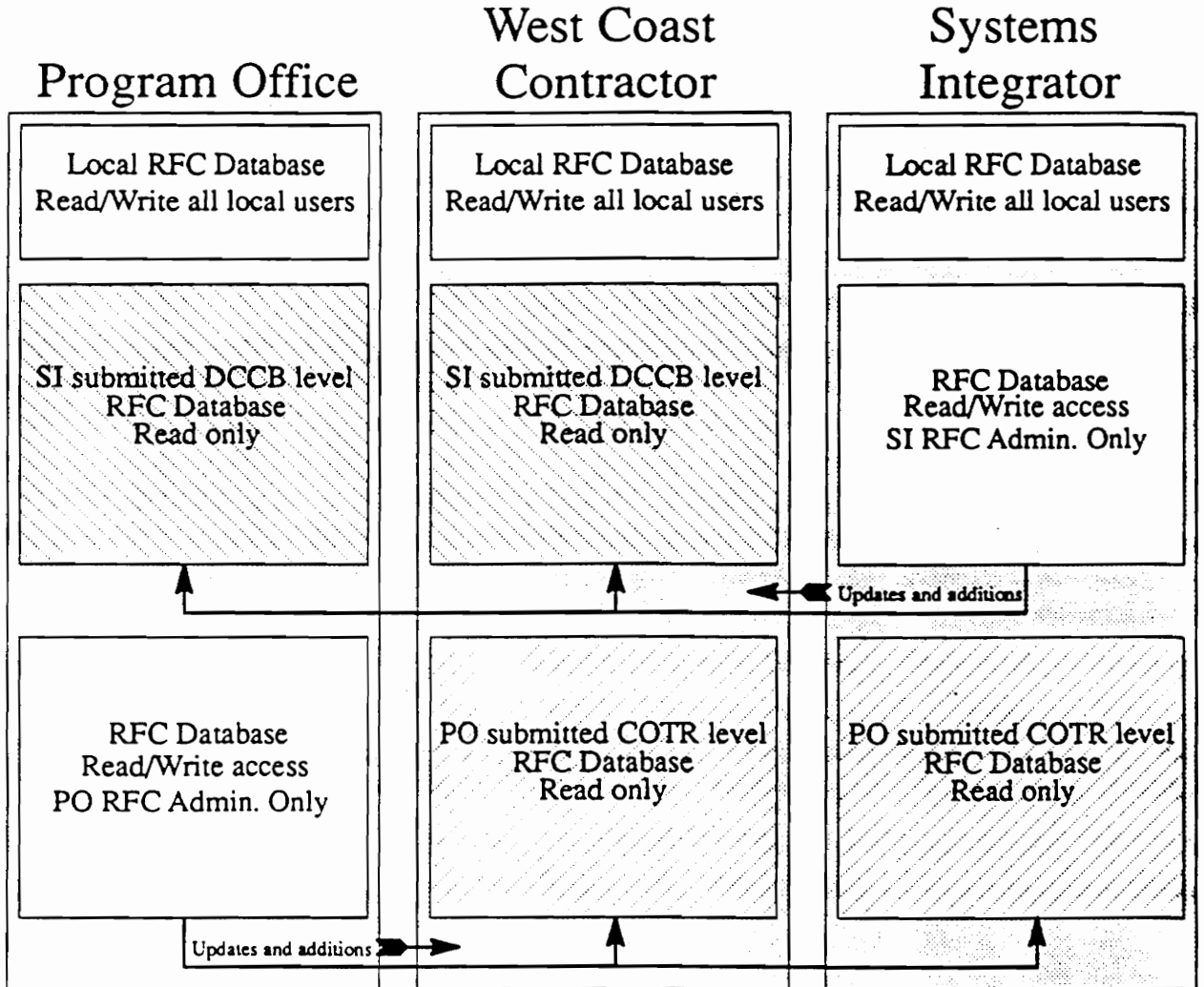


Figure A1.5 RFC Databases Across Three Nodes

SI Controlled RFC Database

The second database will be used to track the status of all the RFCs submitted to the SI, including RFCs generated within and submitted to the SI. This database will be controlled at the SI node. At the SI, all users will have read access to the data. Write access will be granted to SI RFC administrators only. All other nodes will have read only copies of the SI master database. As changes are made to the master database at the SI node the changes will be cascaded, on a timely basis, to the other nodes for querying purposes.

Program Office Controlled RFC Database

The third database will be used to track all the COTR level RFCs submitted to the Program Office, el or lower. This database will function exactly like the SI database just described except that the Program Office RFC administrators will control the master database.

APPENDIX B. STRUCTURED ANALYSIS STANDARDS

This section describes the Structured Analysis standards and guidelines that will be used on the APMS program.

OVERVIEW

Convention

APMS structured analysis models shall use Data Flow Diagrams (DFDs), a Data Dictionary, Process Specifications (P-Specs), Control Specifications (C-Specs), and Entity Relationship Diagrams (ERDs) as developed through the Software Through Pictures Computer Aided Software Engineering (CASE) tool.

Rationale for Convention

Models developed using the Software Through Pictures tools will provide greater development efficiency, consistency and completeness across segments, as well as a better understanding and communication of the requirements.

Exceptions and their Justification

None

DFDs

Definition

A Data Flow Diagram (DFDs) is a picture of a system from the data's point of view. It is a simple sketch that shows all the various parts of the system that are visited by the data. A DFD consists of five elements:

- Solid Arrow - Represents a data flow or the path along which the data moves
- Dashed Arrow - Represents a control flow and , if applicable, data associated with the of control
- Box - Represents a terminator depicting an external interface
- Bubble - Represents a process, or a piece of the system where inputs are received and processed and outputs are produced
- Parallel Lines - Represents data stores

GENERAL STANDARDS AND CONVENTIONS

Number of Bubbles

Convention

All DFDs shall have a minimum of 2 bubbles. Generally, DFDs shall contain 3 to 7 bubbles.

Rational for Convention

DFDs which only consist of 1 bubble show no decomposition from a higher level and should instead be represented as P-Specs. The recommendation to use 3-7 bubbles is given to enhance the diagram's readability while providing a reasonable level of detail.

Exceptions and their Justification

Context Diagrams shall only contain 1 bubble. This is a limitation of structured analysis.

This is a guideline only and should not be followed to the exclusion of common sense; if it makes more sense to have 10 bubbles on a DFD than to add an artificial level, then use 10 bubbles. However, such exceptions must be justified at the review for the DFD.

Use Of Stores

Convention

A store shall be shown on a DFD only when it is the interface between at least 2 processes on the DFD. When the same store interfaces with multiple processes on multiple levels of a model, the store shall be shown on all of those levels, not only the highest level.

Rationale for Convention

Stores that interface with multiple bubbles on one diagram represent an external interface to each bubble that uses it. If a store has only one interfacing bubble on a DFD, it is either internal to that bubble and should be reflected as an interface on a lower-level DFD (when it has data flow in both directions), or its an external interface that should be represented on a higher-level DFD (when the data flow is only in one direction).

Exceptions and their Justification

Lowest-level DFDs may show stores that interface with only one bubble if there are both input and output data flows between the bubble and the store, since there are no lower levels in which to show the sub-processes that interface with the flow. The data flow must be 2 ways between the bubble and the store to show that the store is internal to the bubble. A one way flow here would indicate that the store is external and that the true interface is on a higher-level DFD, not on a lower one.

Flow Labeling

Convention

All Flows shall be labelled.

Rationale for Convention

Although Software Through Pictures does not require this, DFDs are difficult to interpret when unlabeled flows are present.

Exceptions and their Justification

None

Crossing Flows

Convention

Flow lines on DFDs shall not cross.

Rationale for Convention

DFDs with crossing flows are difficult to read and understand.

Exceptions and their Justification

None

Abbreviations

Convention

Abbreviations shall be used consistently for both flows and bubble names.

Rationale for Convention

The use of standard, consistent abbreviations makes DFDs easier to understand.

Exceptions and their Justification

None

Bubble Numbering

Convention

When a DFD is initially developed, its bubbles shall be numbered consecutively beginning with 1. Once a diagram has been placed under CM control, the bubbles shall not be renumbered, even if a bubble was deleted on the DFD.

Rationale for Convention

Initially, sequential bubble numbering provides a logical mechanism by which capabilities and their requirements can be uniquely identified. However, bubble renumbering within controlled DFDs causes serious maintenance effort in documentation and requirements traceability, and therefore must be avoided.

Exceptions and their Justification

None

DFD Numbering

Convention

DFD diagrams shall contain the identifying number and title in the upper left-hand corner as supplied by Software Through Pictures.

Rationale for Convention

The Software Through Pictures-supplied title and number give DFD readers a reference point for understanding the role of the DFD.

Exceptions and their Justification

None

Flow Of DFDs

Convention

Horizontal flows shall be used on DFDs rather than an "around the world" style (see Figure A2.1). Inputs shall appear on the left and outputs on the right. The flow of processing between bubbles on a DFD shall flow from left to right and top to bottom.

Rationale for Convention

This provides a consistent method for understanding DFDs.

Exceptions and their Justification

Having all flows be horizontal, all inputs on the left, and all outputs on the right is not always possible depending on the position of interfacing bubbles, stores, and terminators (for Context Diagrams) on the DFD. These objects should be placed on the DFD so that this convention can be as closely adhered to as possible. This shall be employed for off-page flows.

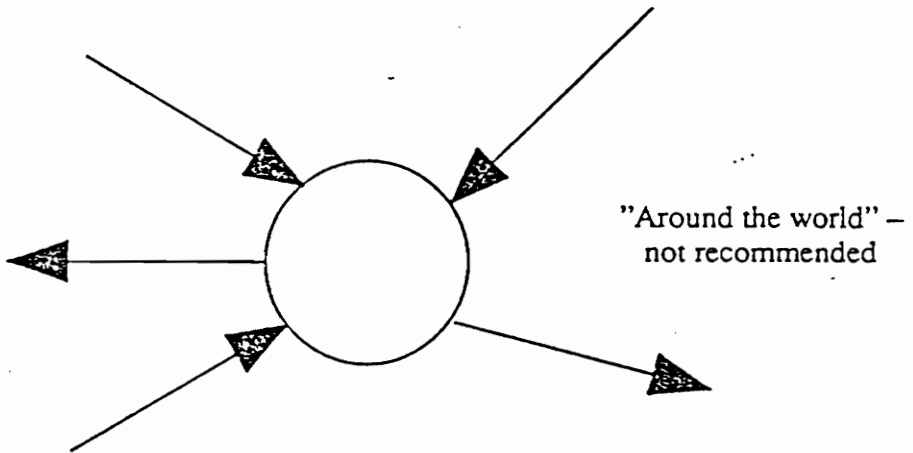
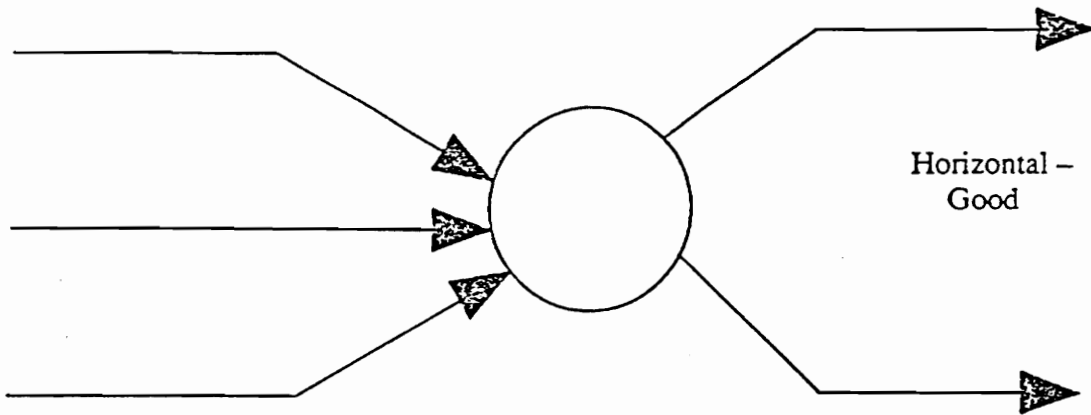


Figure A2.1 Use Of Flows On DFDs

APPENDIX C. APMS H/W PERFORMANCE

In this section, a computer simulation analysis is performed. This analysis shows that for the intended use of the APMS system the communication design will support the growth to a 22 node configuration. As new users for the APMS network are realized, the design provides for the capability to increase the bandwidth of the links between the hub nodes or if required to a secondary link.

PROCESSING RESOURCES OVERVIEW

The APMS Prototype processing resources are divided into two categories defined as nodal processing resources and communications resources. The nodal processing resources include the APMS prototype data server, the APMS workstation, the local area network and the COTS software. The APMS workstation and data server are the Sun Microsystems SPARCStation 2 workstation platform. The APMS local area network is based on the IEEE 802.3 ethernet network standard. The communications resources utilized in the APMS prototype are the communications server, the COTS communications software and the 19.2 Kilobits/second communications lines. The APMS prototype communication server is the Sun SPARCstation 2 workstation that is also being utilized as the data server. In this section the processing resources are described and performance analysis is provided.

NODAL PROCESSING RESOURCES

Inter-Nodal Response Time Requirements

Below is a restatement of the inter-nodal response time requirements as is found in the operational requirements section of this report.

- a) Response time for interactive editing sessions, menu navigation, and other processes requiring continuous user input to proceed shall not exceed two seconds from user request to system response during peak load times.
- b) Average response time for file and database storage and retrieval shall not exceed four seconds in interactive mode.
- c) Average response time for reports, queries, searches, sorts and other I/O intensive processes shall not exceed thirty minutes.
- d) Average time for backup and archival processed shall not exceed 4 hours.

SOFTWARE RESOURCE ALLOCATION

The Sun SPARCStation 2 (the APMS data server and workstation) provides the necessary processing resources for the APMS prototype. In Figure A3.1, the APMS prototype software is allocated to the specific processing resource. The resources identified are the data server, the user workstation and the data server/user workstation combination. The data server/user workstation represents the SPARCStation 2 workstation that will be utilized in the APMS prototype phase as both a workstation and a server. The data server has all the software that is not specifically designated as client software. The data

Processing Resource S/W Allocation	Data Server	User Workstation	Data Server / User Workstation
Operating System (OS)	●	●	●
TCP/IP	●	●	●
Internet Router	●		●
Network File System (NFS)	●	●	●
X-Windows Server		●	●
X-Windows Client	●		●
Sybase Server	●		●
Sybase Client		●	●
Interleaf 5.2	●	●	●
Smartleaf	●		●
Simplify SQL	●	●	●
DPMS Configuration Management CSCI	●	●	●
DPMS Program Management CSCI	●	●	●
DPMS Operating Environment CSCI	●	●	●
DPMS Data Files	●		●

Figure A3.1 Processing Resource Software Allocation.

Computer Hardware Characteristics	Data Server	User Workstation
Memory Size	32MB	16 MB
Word Size	32-Bit	32 Bit
Processing Speed (Millions of Instructions Per Second - MIPS)	28.4 MIPS	28.4 MIPS
Processing Speed (SPECmark - benchmark)	21.0 SPECmarks	21.0 SPECmarks
Disk Access Speed	550KB/s sequential 320KB/s random	550KB/s sequential 320KB/s random
Character Set Standard	ASCII	ASCII
Operating System Standard	UNIX	UNIX
Auxiliary Storage	2 GB	414 MB
Growth Capabilities	7.6 GB	414 MB
Local Area Network Interface Support	IEEE 802.3	IEEE 802.3
Processing Resource Allocation	OS, TCP/IP, NFS, Sybase Server	OS, TCP/IP, NFS
Wide Area Network Interface Support	Sun IR	

Figure A3.2 Computer Hardware Characteristics

server/user workstation has all of the server and client software. Data files reside only on the data server.

APMS NODAL PERFORMANCE CHARACTERISTICS

Computer Hardware Performance

The APMS nodal hardware provides the performance level required to meet operational requirements in a secure environment. Figure A3.2 presents the Hardware Performance characteristics for the APMS prototype data server and user workstation. The two data processing performance benchmarks utilized to measure processing speed are MIPS and SPECmarks. THE MIPS (million instructions per second) rating is an average of the number of computer instructions performed per second for a standard test suite. The SPECmark is an alternative performance metric developed by a consortium of computer vendors, including Sun, DEC, IBM and HP. Assigning the DEC VAX 11/780 a performance metric of one, the SPECmark compares CPU performance for the other hardware suites.

Computer Hardware Characteristics

The memory configuration is critical to the system response time. The APMS prototype workstations and servers are configured with 16 MBytes of Random Access Memory (RAM) and 32 MBytes of RAM, respectively. This configuration provides sufficient memory to reduce disk access, enhancing system response

time. Both the server and workstation have a 32 bit word length, which allows 4 bytes of data to transfer on a single bus cycle.

System responsiveness is also dependant on the disk system throughput. The disk system proposed for the APMS prototype transfer 550 KBytes per second for sequential access (read/write) and 320 KBytes/sec for random access (read/write). The data server supports 7.6 Gigabytes and the workstation supports 414 Megabytes of disk storage.

Network Performance

The network performance is a combination of the traffic throughput over the local area network and the Sun Network File System (NFS) performance. The maximum network throughput supported by Ethernet is 10 Mbits/sec. The NFS response times are measured in terms of file server response to workstation read, write, and update requests received over the network. The NFS response time for an assumed workload of no greater than 150 NFS operations per second, average 15-18 msec.

Database Performance

Superior database performance is critical to acceptable user response time for many APMS functions. Database performance is measured by the number of transactions it can process per second (TPS) for a given number of concurrent

users. The Sybase SQL server provides more 25 transactions per second with 30 database concurrent users on a Sun Sparcstation 2 data server.

Nodal Performance Conclusions

The performance of the proposed hardware and software components assures a responsive APMS system. The results shown are generated using the Sun 4.X operating system. The Sun CMW will result in slightly lower performance due to security auditing and meditation, however this performance degradation should be less than 10%. The proposed APMS architecture provides sufficient capability to meet or exceed the System to User Intra-Nodal Response Times.

COMMUNICATION PROCESSING RESOURCES

Wide Area Communication Requirements

Below is a restatement of the inter-nodal response time requirements as is found in the operational requirements section of this report.

- a) Digital data up to 19.2 kbps, synchronous, full-duplex, serial, 24 hours/day, 7 days/week.
- b) The Bit Error Rate introduced by transmission shall be less than one error in 10 bits 98% of the time as measure over any 24-hour period. A BER of less than one error in 10 bits 99.5% of the time shall be provided.

COMMUNICATIONS PROCESSING RESOURCES

The processing resources utilized to provide APMS wide area communications are the government furnished communication line which have a specified bandwidth of 19.2 kbps and the Sun Sparcstation 2 with the Sun Internet Router communication software. Meeting the communications requirements of the APMS users is driven by the bandwidth of the communication line. An analysis of the performance of these communication resources is provided in the following section.

COMMUNICATIONS PERFORMANCE ANALYSIS

To determine the necessary bandwidth if the APMS communication line, an analysis was performed for the Initial Operating Capability of the three APMS nodes and for expected expansion scenario for the full up APMS system. The expansion analysis was provided to determine if the communication lines specified today would meet APMS needs as it grows in the future. A larger bandwidth of 56 kbps was utilized in the analysis as a point of comparison. The analysis performed is provided in this section.

Purpose

The purpose of wide area communication analysis is to determine the performance of proposed APMS Architecture from IOC thru FOC. The analysis

provides insight into the effects of varying data rate parameters on the message time-lines and link utilizations. The analysis provides the basis for the specification of the communication line bandwidth.

Architectures

- a. IOC - 3 Nodes, Figure A3.3.
 - 1. CASE 1 - Backbones operate at 19.2 KBPS
 - 2. CASE 2 - Backbones operate at 56 KBPS
- b. IOC - 6 Nodes, Figure A3.4.
 - 1. CASE 1 - Backbones operate at 19.2 KBPS
 - 2. CASE 2 - Backbones operate at 56 KBPS
- c. FOC - 22 Nodes, Figure A3.5.
 - 1. CASE 1 - Backbones operate at 19.2 KBPS
 - 2. CASE 2 - Backbones operate at 56 KBPS

Traffic Assumptions

- a. IOC (3 Nodes) Traffic
 - 1. Representative day 111 page message sent to 4 organizations (104 pages text, 7 pages graphics)
 - 2. 13 Text page response for 2 organizations
 - 3. 3 minute staggered starting times for 111 page messages.
- b. IOC (6 Nodes) Traffic
 - 1. Representative day 111 page message sent to 4 organizations (104 pages text, 7 pages graphics)
 - 2. 13 Text page response for 3 organizations
 - 3. 3 minute staggered starting times for 111 page messages.
- c. FOC Traffic
 - 1. Representative day 111 page message sent to 4 organizations (104 pages text, 7 pages graphics)
 - 2. 13 Text page response for 3 organizations
 - 3. 3 minute staggered starting times for 111 page messages.
 - 4. 1 minute staggered starting times for 5 page messages.

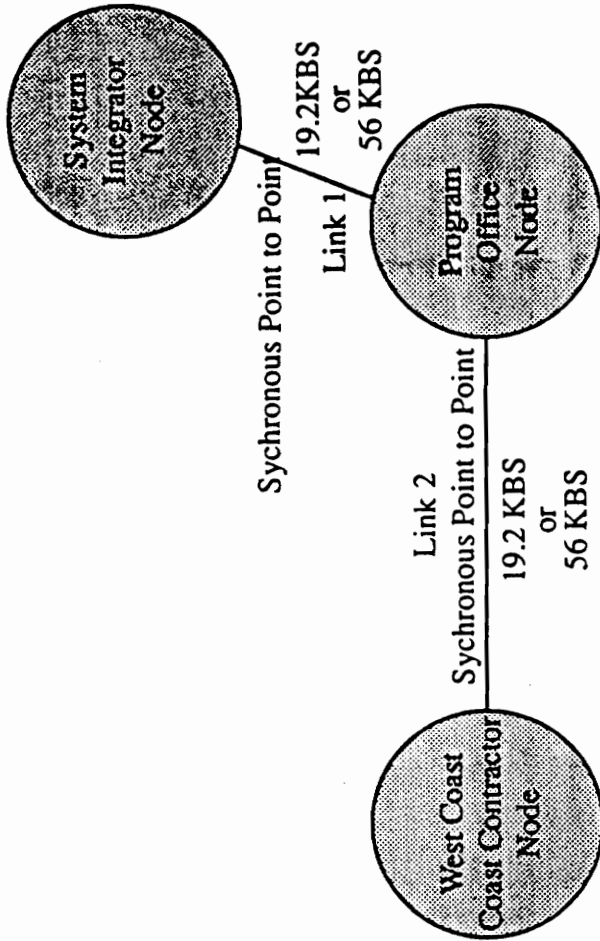


Figure A3.3 Initial Operating Configuration 3 Nodes

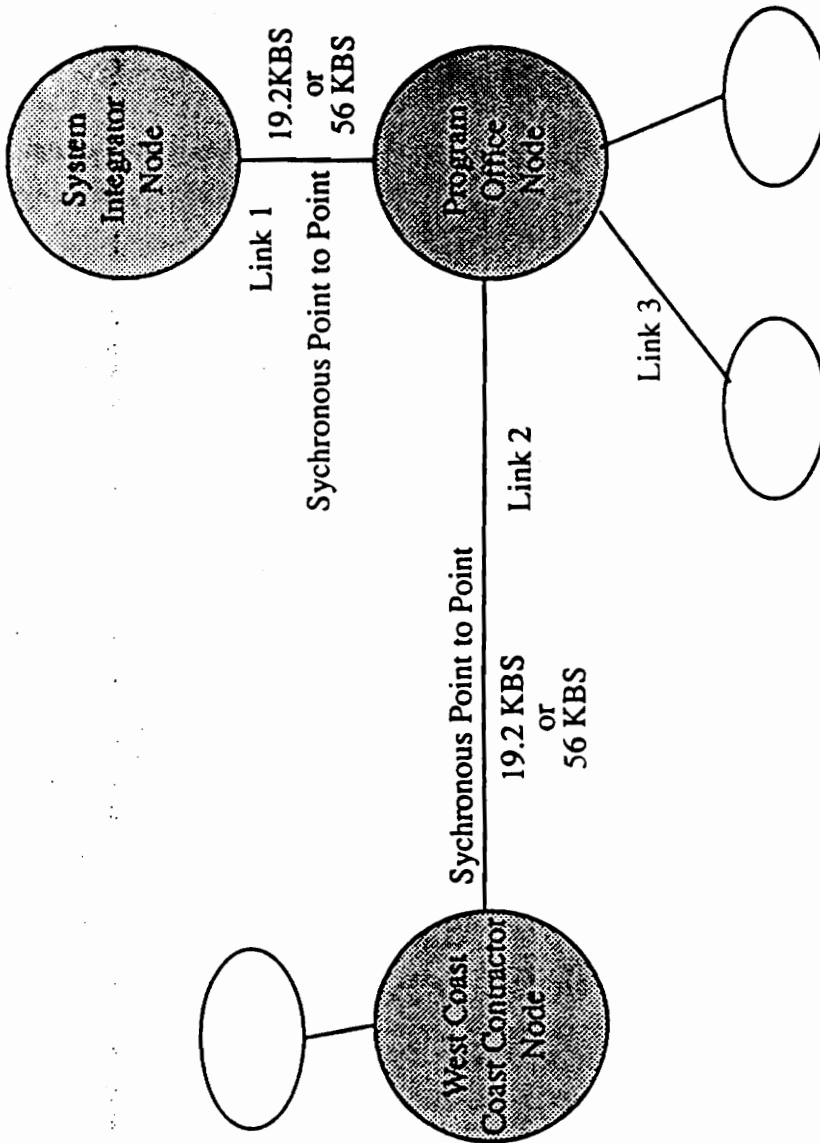


Figure A3.4 Initial Operating Configuration 6 Nodes

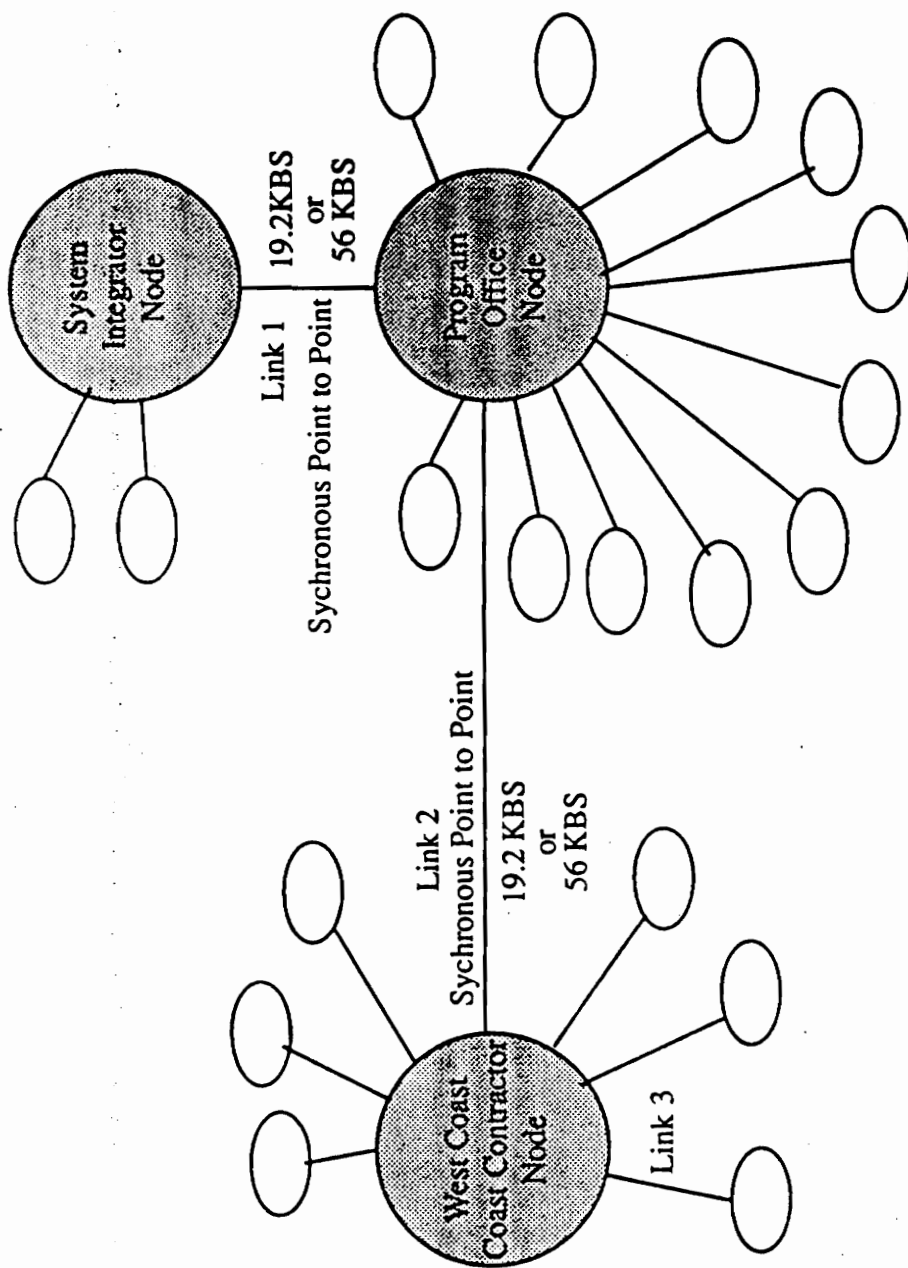


Figure A3.5 Final Operating Configuration

d. Messages

1. Interleaf Files
2. Average of: 10 KBytes/Page (graphics)

File Size Calculations

a. 111 Pages of Interleaf Files

1. Test show an average of: 10 KBYTES/Page for text
250 KBYTES/Page for graphics
2.

104 pages * 10 KBYTES/Page	=	1.04 MBYTES
7 pages * 250 KBYTES/Page	=	1.75 MBYTES
Total	=	2.79 MBYTES

Network Assumptions

a. TCP/IP Connects

1. Retransmission from last received packet
2. Packet size = 1024 Bytes, 800 Byte data
3. 7 packet window.

b. Network

1. 0.1 second link delays
2. 1% packet discard probability
3. Hub router performance of 200 pkts/sec based on CMW Gateway

c. **Communication Data Rates**

1. 19.2 or 56 KBPS Backbone, 19.2 KBPS Local loop

Results

The results of the computer simulation are provided in this section. Figure A3.6 shows the utilization of the linked over a 24 hour period based on the data supplied. Figure A3.7 shows the utilization of the links over the time it takes to send all the data.

SUMMARY

The Backbone link between the SI HUB and the PO is the most utilized link. When viewed over a 24 hour period, however, the utilizations of the backbones and local loops are low. As long as the time-line requirements are on the order of hours instead of minutes then the 19.2 KBPS backbone data rate is accepted as APMS expands to a 22 node configuration.

The traffic assumptions for this analysis are accurate for initial APMS planned use. However, since this will be a multi-compartment network, extremely flexible, and user friendly; the potential is great for many other uses being found for this system. These additional uses may prompt the need to revisit the link data rate analysis due to the increased traffic load. Based on this potential increased load, significant improvements in response time-lines can be

	TIME TO SEND ALL MESSAGES	Utilization (over 24 Hours)		
		Link1	Link2	Link3
IOC-3 NODES				
	CASE 1	7.5%	2.0%	N/A
	CASE 2	2.6%	0.7%	N/A
IOC-6 NODES				
	CASE 1	13.8%	4.0%	2.0%
	CASE 2	4.6%	1.3%	2.0%
FOC-22 NODES				
	CASE 1	22.3%	10.8%	2.1%
	CASE 2	7.6%	3.6%	2.0%

Figure A3.6 Link Utilization Over a 24 Hour Period

IOC-3 NODES				Utilization (Over Time To Send All Messages)		
				Link1	Link2	Link3
	CASE 1	1 HR 50 MIN	99.1 %	26.2 %	N/A	
	CASE 2	38 MIN	98.2 %	25.1	N/A	
IOC-6 NODES						
	CASE 1	3 HR 20 MIN	99.4 %	29.0 %	14.5 %	
	CASE 2	1 HR 7 MIN	99.5 %	28.0 %	42.3 %	
FOC-22 NODES						
	CASE 1	5 HR 22 MIN	99.8 %	48.3 %	9.3 %	
	CASE 2	1 HR 49 MIN	99.8 %	48.0 %	26.7	

Figure A3.7 Link Utilization Over the Time To Send All Messages

obtained by increasing the bandwidth from 19.2 to 56 kbps on APMS backbone communication links.

APPENDIX D. MATERIAL COST DETERMINATION

Material Cost Determination Sheets

This appendix includes five figures which detail the material cost of implementing APMS.

RESOURCE CODES
 1. Purchase of
 2. Call
 3. Engineer Estimate
 4. Actual Cost
 5. Subcontract

UNIT OF MEASURE CODES
 1. Pieces
 2. Gallons
 3. Feet
 4. Inches
 5. Sets/Cases/Pkgs/Boxes
 6. Months
 7. Hours
 8. Other

RAW MATERIAL/PURCHASE PARTS
 MAINTENANCE
 SOFTWARE

MATERIAL SUBSTANTIATION PAGE

W/C SEARS	TOTAL QTY	UNIT CODE	DESCRIPTION	IDENI. NUMBER	REFERENCL NO.	SD	UNIT COST	PERCENT	OTHER CHG.	TOTAL COST	CURRENT TOTAL COST	COMMIT DAY COST
61	EA	10	G BYTE REMOVABLE	401HD1000-F	G1515R1-40		5.955	E		35.730	35.730	35.730
31	EA	15	SUM INTERFACE OPTION (CABLE)	5401SUN	G1515-14		288	E		864	864	864
31	EA	15	TEMPEST CABLE FOR SCANNER	CXX-0015	G1515-1		122	E		366	366	366
11	EA	15	TEMPEST OVERHEAD PROJECTOR	ECP-4100T	G1515R1-29		42.750	E		42.750	42.750	42.750
61	EA	15	CABLING-82 5 LM-10 METER EA	FIBER-OPTIC-CABLE	G1515-5		420	E		420	420	420
11	EA	15	TEMPEST INTERFACE	IN-2000T	G1515R1-29		3.865	E		3.865	3.865	3.865
31	EA	15	TEMPEST SCANNER	MICROTEK-300Z-TEMPEST	G1515R1-3		7.900	E		7.900	7.900	7.900
501	FT		CABLING	OMD-PROJ-CABLING	G1515-2		550	E	50	550	550	550
11	EA		CEILING MOUNT	OMD-PROJ-CEIL-MOUNT	G1515-2		355	E		355	355	355
61	EA		SPARC STA 1+ W 19 CRT 16MB 1 44MB FLOP	T4/65/GX-16	G1515-26		7.045	E		7.045	7.045	7.045
31	EA		TEMPEST APPLE LASER	15271	G1515R1-17		2.454	E		2.454	2.454	2.454
31	EA		TEMPEST DISK CAB BASE UNIT	15401-B	G1515R1-40		1.615	E		1.615	1.615	1.615
31	EA		TEMPEST DISK CAB EXP UNIT	15401-XA	G1515R1-40		1.250	E		1.250	1.250	1.250
61	EA		TEMPEST FO-W/S ETHERNET ADAPTER	WHILSPER-LAN/SPT-T	G1515R1-36			E				
31	EA		UPGRADE 16MB MEMORY	X116H	G1515-26			E				
61	EA		KEYBOARD	X1300H	G1515-26			E				
31	EA		CD ROM	X1559H	G1515-26			E				
31	EA		150MB 1/4" TAPE	X1660H	G1515-26			E				
121	EA		104MB SCSI REMOVABLE DISK	X18551H	G1515-26			E				
ORIGINAL TOTAL DOLLARS											149,442.00	
ESCALATION											1,004.97	
COMMIT TOTAL DOLLARS											150,446.97	

Figure A4.1 Material Cost Determination

RESOURCE CODES
 11 RAW MATERIAL/PURCHASE PARTS
 12 MAINTENANCE
 13 SOFTWARE

UNIT OF MEASURE CODES
 1 Pieces
 2 Gallons
 3 Prints
 4 Sets/cases/pkgts/boxes
 5 Months
 6 Hours
 7 Other

SOURCE OF DATA CODES
 1 Purchases
 2 Orders
 3 Catalogs
 4 Engineering Estimate
 5 Other
 6 Subcontract

MATERIAL SUBSTANTIATION PAGE

ORG. CODE	RC	ENG. QTY	MFG. QTY	TOTAL QTY	LW. DESCRIPTION	IDENT. NUMBER	RELEASE NO.	SD	SOURCE DATA			INDICATES MINIMUM PURCHASE		COMMIT DAY. LOST
									UNIT COST	PER L. LOT	OTHER CHG.	TOTAL COST	CURRENT	
4020	00	11	11	11	SYBASE SQL SERVER (1ST COPY)	1003	G1515R2-A	2	5 500 001	F		5 500 001	5 500 001	5 500 00
4020	00	11	11	11	SYBASE SQL SERVER (2ND COPY)	1037	G1515R2-A	2	4 125 001	F		4 125 001	4 125 001	4 125 00
4020	00	11	11	11	SYBASE WAST DRI IRC (1ST COPY)	1032	G1515R2-A	2	450 001	F		450 001	450 001	450 00
4020	00	41	41	41	SYBASE WAST DRI IRC (2ND COPY)	9269	G1515R2-A	2	337 001	F		1 348 001	1 348 001	1 348 00
4020	00	11	11	11	SYBASE SQL STATION (2-RUISERS)	CCC-1 0-4-34R-5	G1515-26	2	10 200 001	F		10 200 001	10 200 001	10 200 00
4020	00	31	31	31	ANSI C PROGRAMS	CCC-X-X-X-0	G1515-26	2		F				
4020	00	31	31	31	DOS WIPNOMS SHELL	IMI-1 0-4-14-13	G1515-26	2		F				
4020	00	31	31	31	DOS WIPNOMS SHELL	IMI-X-X-X-0	G1515-26	2		F				
4020	00	31	31	31	SEN X DIV GDIH	GM-1 1-4-34R-5	G1515-26	2		F				
4020	00	31	31	31	SEN X DIV GDIH	GM-X-X-X-0	G1515-26	2		F				
4020	00	51	51	51	INTERLEAF 5-PROD	INIRLEAF-5	G1515R1-51	2	2 400 001	F		12 000 001	12 000 001	12 000 00
4020	00	11	11	11	INTERLEAF TECH PWR VER 5D	INIRLEAF-51-PROD	G1515R1-51	2	15 000 001	F		15 000 001	15 000 001	15 000 00
4020	00	11	11	11	INTERLEAF DDC PROD APPL	INIRLEAF-51-DOC	G1515R1-51	2	400 001	F		400 001	400 001	400 00
4020	00	11	11	11	FULL DOCUMENTATION	INIRLEAF-51-01A	G1515-26	2	350 001	F		350 001	350 001	350 00
4020	00	31	31	31	WIN WIPNOMS	OPN-2 0-4-4-5	G1515-26	2		F				
4020	00	31	31	31	WIN WIPNOMS RIGHT TO USE	OPN-X-X-X-0	G1515-26	2		F				
4020	00	31	31	31	WIN OS MEDIA	SS2-07	G1515-26	2		F				
4020	00	31	31	31	WIN OS MEDIA	SS2-CMM-21	G1515-26	2	71 150 001	F		71 150 001	71 150 001	71 150 00
4020	00	11	11	11	WIN OPERATING SYSTEM	SW-CMM-05	G1515-26	2		F				
4020	00	31	31	31	MICROTECH SCANNER CONT SW	SW-PERFECT-SCAN	G1515R1-41	2	1 495 001	F		4 485 001	4 485 001	4 485 00
4020	00	11	11	11	OCR SOFTWARE	SW-READ-RIGHT	G1515-8	2	2 985 001	F		2 985 001	2 985 001	2 985 00
4020	00	11	11	11	INTERLEAF IWR INFIG. PROD	SW-SMARTLEAF	G1515R1-49A	2	2 500 001	F		2 500 001	2 500 001	2 500 00
4020	00	11	11	11	SMARTLEAF COMPARE	SW-SMARTLEAF-COMPARE	G1515R1-49A	2	1 000 001	F		1 000 001	1 000 001	1 000 00
4020	00	11	11	11	SMARTLEAF LIBRIAN	SW-SMARTLEAF-LIBR	G1515R1-49A	2	1 000 001	F		1 000 001	1 000 001	1 000 00
4020	00	11	11	11	SW THROUGH PICTURES(CASE TOOL)	SW-THROUGH-PICTURES	G1515R1-37A	2	11 000 001	F		11 000 001	11 000 001	11 000 00
4020	00	11	11	11	SW THROUGH PICTURES(CASE-SA)	SW-THROUGH-PICTURES(SA)	G1515R1-37A	2	4 900 001	F		4 900 001	4 900 001	4 912 35 4
4020	00	31	31	31	SEN OS ENCRYPTION KIT	SW-09	RC-VI-50	2		F				
4020	00	61	61	61	2 USER 505 RTU LICENSE	SVS12	G1515-26	2		F				
4020	00	61	61	61	SEN OS CMM RIGHT TO USE	SVS12-CMM	G1515-26	2		F				
4020	00	11	11	11	SEN TRAC PROJ RIGHT SYS	TRC-1 3-4-34R-5	G1515-26	2		F				

ORIGINAL TOTAL DOLLARS 148,393.00
 ESCALATION 40.07

COMMIT TOTAL DOLLARS 148,433.07

Figure A4.2 Material Cost Determination (Continued)

RESOURCE CODES
 11 RAW MATERIAL/PURCHASE PARTS
 83 MAINTENANCE
 89 SOFTWARE

UNITS OF MEASURE CODES
 1 Pieces
 2 Pallets
 3 Pallets
 4 Gallons
 5 Feet
 6 Pallets
 7 Inches
 8 Months
 9 Weeks
 0 Other
 S Sets/Cases/Pkgs/Boxes

SOURCE OF DATA CODES
 1 Purchase Order
 2 Vendor Quotations
 3 Catalog Prices
 4 Engineering Estimate
 5 Subcontract

MATERIAL SUBSTANTIATION PAGE

ORG CODE	RC	QTY	DESCR	UNIT	QTY	MFG	SPARE	TOTAL	LUM	DESCRIPTION	IDENT NUMBER	REFERENCE NO	SD	SOURCE DATA			TOTAL COST	CURRENT	COMMIT
														UNL COST	PER L OT	OTHER CHG			
40201	83	121	MAINT FOR SYBASE SQL SERVER (1ST COPY)	MO	121			1,375.00			MAINT-1003				1,375.00	1,375.00	1,375.00		
40201	83	121	MAINT FOR SYBASE SQL SERVER (2ND COPY)	MO	121			1,031.25			MAINT-1003/				1,031.25	1,031.25	1,031.25		
40201	83	121	MAINT SYBASE WKST DR1 ITC (1ST COPY)	MO	121			112.50			MAINT-1032				112.50	112.50	112.50		
40201	83	481	MAINT SYBASE WKST DR1 ITC (2ND-5TH COPY)	MO	481			84.25			MAINT-1032/				337.00	337.00	337.00		
40201	83	121	MAINT SYBASE SQL STATION (2-4USERS)	MO	121			2,550.00			MAINT-9269				2,550.00	2,550.00	2,550.00		
40201	83	451	MAINT SUN X DEV GUIDE	MO	451			600.00			MAINT-GR-1 1-4-348-5				600.00	600.00	618.79		
40201	83	101	MAINT INTERLEAF TECH PWR VIB 50 (5UNITS)	MO	101			600.00			MAINT-INTERLEAF-5				600.00	600.00	600.00		
40201	83	51	MAINT INTERLEAF TECH PWR VIB 50 (5UNITS)	MO	51			600.00			MAINT-INTERLEAF-5				600.00	600.00	600.00		
40201	83	21	MAINT INTERLEAF TECH PWR VIB 50 (5UNITS)	MO	21			3,000.00			MAINT-INTERLEAF-5-PROD				3,000.00	3,000.00	3,110.11		
40201	83	11	MAINT SUN INTERLEAF-5-PROD	MO	11			3,000.00			MAINT-INTERLEAF-5-PROD				3,000.00	3,000.00	3,015.15		
40201	83	451	MAINT SUN INTERLEAF-5-PROD	MO	451			3,000.00			MAINT-IR-5 0-4-2348-3				3,000.00	3,000.00	3,000.00		
40201	83	51	MAINT SUN INTERLEAF-5-PROD	MO	51			3,000.00			MAINT-OMN-2 0-4-4-5				3,000.00	3,000.00	3,000.00		
40201	83	351	MAINT OPEN WINDOWS	MO	351			3,000.00			MAINT-SB-COM-05				3,000.00	3,000.00	3,000.00		
40201	83	351	MAINT CAMP OPERATING SYSTEM	MO	351			3,000.00			MAINT-SB-COM-05				3,000.00	3,000.00	3,000.00		
40201	83	121	MAINT SUN TRAC PROJ MGMT SYS	MO	121			3,000.00			MAINT-TRC-1.3-4-348-5				3,000.00	3,000.00	3,000.00		
ORIGINAL TOTAL DOLLARS																	15,005.75		
ESCALATION																	151.61		
COMMIT TOTAL DOLLARS																	15,157.36		

Figure A4.3 Material Cost Determination (Continued)

RESOURCE CODES

11 RAW MATERIAL/PURCHASE PARTS
 83 MAINTENANCE
 89 SOFTWARE

UNIT OF MEASURE CODES

1 Pieces
 2 Feet
 3 SPTS/Cases/PAGE/Boxes
 4 Gallons
 5 Rolls
 6 Inches
 7 Months
 8 Heads
 9 Other

SOURCE OF DATA CODES

1 Purchase Order
 2 Vendor Quotations
 3 Catalog
 4 Estimate
 5 Actual Cost
 6 Subcontract

MATERIAL SUBSTANTIATION PAGE

ORG CODE	FIC	ENC	MFG	SPARES	MFG QTY	TOTAL QTY	LN CODE	LN	DESCRIPTION	IDENT NUMBER	REFERENCE NO	SD	SOURCE DATA			CURRENT TOTAL COST	COMMIT DAY COST
													UNIT COST	IPER LOT	OTHER CHG		
4020	11						11	EA	HW	SUN-	G1515R1-26A	2		98,850.00	E	98,850.00	98,850.00
* Indicates Minimum Purchase																	
ORIGINAL TOTAL DOLLARS 98,850.00																	
ESCALATION 0.00																	
COMMIT TOTAL DOLLARS 98,850.00																	

Figure A4.4 Material Cost Determination (Continued)

RESOURCE CODES

UNIT OF MEASURE CODES

SOURCE OF DATA CODES

11 RAW MATERIAL/PURCHASE PARTS
 02 MAINTENANCE
 03 SOFTWARE

1 Pieces
 2 Pallets
 3 Pints
 4 Gallons
 5 Sets/Cases/Pkgs/Boxes
 6 Months
 7 Inches
 8 Other

1 Purchase Orders
 2 Catalog Prices
 3 Engineer Estimate
 4 Actual Cost
 5 Subcontract

MATERIAL SUBSTANTIATION PAGE

CNC CODE	CNC QTY	MFG	TOTAL QTY	LN	DESCRIPTION	IDENT NUMBER	REFERENCE NO.	SD	UNIT COST	PERIOD	OTHER CHG	TOTAL COST		CURRENT COMMIT	DAY COST	
												ORIGINAL	ESCALATION			
40701 03	12		12	MO	H/W YEARLY SERVICE CONTRACT	MAINT-SVCE-SUN	G1515-26	2								
													ORIGINAL TOTAL DOLLARS	0.00		
													ESCALATION	0.00		
													COMMIT TOTAL DOLLARS		0.00	

Figure A4.5 Material Cost Determination (Continued)

APPENDIX E. DEFINITIONS

The following definitions apply as used in this document:

Baseline - The baseline is a configuration identification document, or set of such documents, formally designated and fixed at a specific time during a configuration item's life cycle. The baseline, plus approved changes to the baseline, constitutes the current configuration identification.

Change Review - Change review is the process of engineering evaluation, trade-offs, and recommendations, followed by assessment and impact determination of all affected areas.

Computer Software Configuration Item (CSCI) - A computer configuration item is an aggregation of which satisfies an end use function and is designated for configuration management.

Configuration - The configuration is the functional and/or physical characteristics of configuration items such as hardware or software, as set forth in technical documentation and achieved in a product.

Configuration Control - Configuration Control is the systematic evaluation, coordination, approval or disapproval, and implementation of all approved changes to configuration item.

Configuration Identification - Configuration identification is the currently approved, or conditionally approved, technical documentation for a CI as set forth in specifications, drawings and associated lists, and documents referenced therein.

Configuration Item - An item which satisfies an end use function and which is designated for configuration management.

Configuration Management - CM is a discipline applying technical and administrative direction and surveillance to (1) identify and document the functional and physical characteristics of a CI, (2) control changes to those characteristics, and (3) record and report change processing and implementation status.

Configuration Status Accounting - Configuration status accounting is the recording and reporting of information that is needed to manage the configuration effectively, including a listing of approved configuration identification items, the status of proposed changes to the configuration items and the implementation status of approved changes.

Deviation - A deviation is a specific written authorization, granted prior to the manufacture of an item, to depart from a particular performance or design requirement of a specification, drawing or other document for a specific number of units or a specific period of time.

Discrepancy Report - A configuration control form used to document discrepancies with approved configuration items.

Engineering Change - An engineering change is an alteration in the configuration of a configuration item or items delivered, to be delivered, or under development, after formal establishment of its configuration identification.

Request For Change (RFC) - A configuration control form used to propose changes to the current baseline.

To Be Determined (TBD) - A term indicating that specific value has not been determined yet.

To Be Resolved (TBR) - A term indicating that there is residual uncertainty or issue concerning a stated value or condition.

Waiver - A waiver is written authorization to accept a configuration item which, during production or after having been submitted for inspection or test, is found to depart from specific requirements, but nevertheless is considered suitable for use "as is" or after rework by an approved method.

A waiver is written at either the CCB or Contracting Officer's Technical Representative (COTR) level. Each is authorization to depart from either the DCCB authorized requirements or the COTR authorized requirements respectively.

APPENDIX V. ABBREVIATIONS/ACRONYMS

The following abbreviations apply as used in this document :

AI	- Action Item
API	- Application Program Interface
APMS	- Advanced Program Management System
BER	- Bit Error Rate
C-Spec	- Control Specification
CASE	- Computer Aided Software Engineering
CBS	- Cost Breakdown Structure
CCB	- Configuration Control Board
CD-ROM	- Compact Disk - Read Only Memory
CDRL	- Contract Data Requirements List
CI	- Configuration Item
CM	- Configuration Management
CMW	- Compartment Mode Workstation
CO	- Contracting Officer
COB	- Close of Business
COTR	- Contracting Officer's Technical Representative
COTS	- Commercial Off-The-Shelf
CSC	- Computer Software Component
CSCI	- Computer Software Configuration Item
CSU	- Computer Software Unit
CY	- Calendar Year
DAC	- Discretionary Access Control
DBMS	- Database Management System
DDL	- Document Distribution List
DEC	- Digital Equipment Corporation
DIA	- Defense Intelligence Agency
DR	- Discrepancy Report
ECP	- Engineering Change Page
ERB	- Engineering Review Board
ERD	- Entity Relationship Diagram
FOC	- Final Operating Capability
GFE	- Government Furnished Equipment
GFY	- Government Fiscal Year
GUI	- Graphical User Interface
H/W	- Hardware
HP	- Hewlitt Packard
IBM	- International Business Machines
IC&T	- Installation Checkout and Test
ICD	- Interface Control Document
IEEE	- Institute of Electronic and Electrical Engineers
IOC	- Initial Operating Capability
IR	- Internet Router

JAD	- Joint Application Design
JRD	- Joint Requirements Definition
LAN	- Local Area Network
MAC	- Mandatory Access Control
MIPS	- Millions of Instructions Per Second
MLS	- Multi-Level Secure
MTBF	- Mean Time Between Failure
MTTR	- Mean Time To Repair
NCSC	- National Committee for Security Certification
NFS	- Network File System
OCR	- Optical Character Recognition
P-Spec	- Process Specification
PDR	- Preliminary Design Review
PES	- Project Engineering Staff
PES	- Project Engineering Staff
PM	- Program Management/Manager
POC	- Point of Contact
PVP	- Performance Verification Plan
R&D	- Research and Development
RAM	- Random Access Memory
RAR	- Requirements Analysis Review
RDBMS	- Relational Database Management System
RFC	- Request for Change
RISC	- Reduced Instruction Set
S/W	- Software
SA	- System Administrator
SCN	- Specification Change Notice
SI	- System Integrator
SMP	- Senior Management Panel
SOW	- Statement of Work
SQL	- Structured Query Language
TBD	- To Be Determined
TBR	- To Be Resolved
TCP/IP	- Internet Protocol
TEM	- Technical Exchange Meeting
TIM	- Technical Interchange Meeting
TPS	- Transactions Per Second
UPAL	- Unapplied Labor
WAN	- Wide Area Network
WCC	- West Cost Contractor
WYSIWYG	- What You See Is What You Get

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