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Computer-aided Acquisition &
Logistic Support (CALS) Program

Software Product Data (SPD) Current Environment Report

FINAL REPORT

April 1990

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This report describes the Air Force organization and functions employed in the acquisition, use, and management of Software Product Data (SPD). The flow od data among the Air Force and contractors during the design, development, and post-production phases has been defined. In addition, the report describes the major findings identified during the current environment analysis.
The SPD Current Environment Report identifies a baseline for the development of an automation plan (seven to ten years) to digitally receive, manage, store, use, and distribute SPD. Any comments or inputs are encouraged so that this report will be current and integral to the success of this program.

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United States Air Force
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Logistic Support (CALS) Program

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PREFACE

This report, prepared by the U.S. Department of Transportation/Transportation Systems Center (DOT/TSC), describes the analysis of the current Software Product Data (SPD) environment that was undertaken as part of the U.S. Air Force Computer-aided Acquisition and Logistic Support (CALS) Program. This investigation was coordinated by the Air Force CALS Management Integration Office (MIO) at HQ AFSC/ENXC.

The report describes the Air Force organization and functions employed in the acquisition, use, and management of SPD. The flow of data among the Air Force and contractors during the design, development, and post-production phases has been defined. In addition, the report describes the major findings identified during the current environment analysis.

The work was performed by the Information Integration Division at TSC. TSC has drawn upon the knowledge and experience of a number of consultants, and would like particularly to recognize the efforts of staff members from EG&G/DYNATREND Inc. and UNISYS Corporation. In addition, TSC would like to extend thanks and gratitude to the members of the Air Force and defense contractors who contributed to the development of this report.

The SPD Current Environment Report identifies a baseline for the development of an automation plan (seven to ten years) to digitally receive, manage, store, use, and distribute SPD. Any comments or inputs are encouraged so that this report will be current and integral to the success of this program.

EXECUTIVE SUMMARY

GOAL OF THE AIR FORCE SOFTWARE PRODUCT DATA (SPD) PROGRAM

The SPD modular planning program is part of the Air Force Computer-aided Acquisition and Logistic Support (CALS) Program. SPD is defined as the technical data, source code, and tools needed to design, test, and implement Mission Critical Computer Resources (MCCR) software during the acquisition phase of the weapon system life cycle, and to support and modify MCCR software during the operational phase. The requirement to address SPD resulted from the analysis performed for the Product Definition Data (PDD) program within CALS. During this effort, several interviews with major weapon system program offices identified the importance of SPD as well as PDD, given the increased proportion of software within a weapon system.

The Air Force CALS Program is developing automation plans that define the infrastructure, functional requirements, technologies, and implementation strategy to receive, use, and disseminate digital technical data. The program uses a phased Modular Planning Process (MPP) which: 1) examines the current environment, 2) studies the opportunities and 3) plans the future direction. The areas of technical data currently being addressed in CALS are: SPD, Technical Orders (TOs), Product Definition Data (PDD), and Logistics Support Analysis (LSA).

The goal of the SPD modular planning program is to achieve the benefits available from automating the flow of software, software documentation, and tools from industry to the Air Force. By digitizing the receipt, distribution, storage, and configuration management of SPD, the Air Force will have a stronger capability to manage SPD not only during acquisition, but throughout system deployment. Improved management and control of SPD provides the opportunity to provide the right data, to the right place at the right time. This capability will increase the potential to develop and field high quality software modifications faster. In turn, this will improve mission readiness and productivity. As weapon systems grow more dependent on software (a key element in the force multiplier equation), this effort will identify ways to provide SPD to the weapon systems so that SPD can continue to adapt to new or changed mission requirements.

In summary, the SPD program will develop a system concept plan for the digital acquisition, distribution, storage, use, and configuration management of SPD.

THE PROBLEM OF SPD IN THE AIR FORCE TODAY

Increasingly, software is playing a critical role in weapon system operations. To that end, software and software-related deliverables must be acquired, managed, and utilized efficiently to support the broader role of software within a weapon system. As newer, more software-intensive systems are produced, insufficient documentation and design information is, and will be, an ever-increasing problem. To resolve this, SPD must be addressed as an integral component of a weapon system's technical data.

Today, the vast majority of Air Force software documentation at Air Logistics Center (ALC) libraries is paper-based, which makes it difficult to use in software maintenance and modifications. This is attributed to the enormous effort that is necessary to maintain and update design information in a paper-based repository. Frequently, documentation cannot be acquired, cannot be found, or contains insufficient information to expeditiously complete software maintenance and modifications. In addition, the ALCs and involved Using Commands usually do not have automated support tools, which are becoming a prerequisite to effective Post-Deployment Software Support (PDSS). From a cost perspective, PDSS represents 80% of the software life cycle costs. Without sufficient quality documentation and automated support tools, system modifications become expensive. This affects the potential system life of weapon systems, reduces responsiveness to mission-critical software change requirements, and increases labor costs for maintenance and modifications.

PURPOSE OF THIS REPORT

The CALS *SPD Current Environment Report* documents the current functions, organizations, and findings related to the acquisition and operational processes for MCCR in weapon systems and major items. This report is part of Phase 1 of the SPD module and will be followed by additional reports. Together, these products will provide a baseline for developing and implementing an SPD System Concept Plan.

Major sections of this report are summarized as follows:

- **Organizational Assessment** – Describes the Air Force organizations and their primary functions relating to SPD throughout the life cycle.
- **IDEF$_0$ Diagrams** – Depict the functional description of how the Air Force acquires, uses, and manages SPD through IDEF$_0$ (ICOM Definitions). The diagrams also depict the Input, Controls, Output, and Mechanisms (ICOMs) and the interrelationships among the functions.
- **Findings** – Present current SPD environment findings that were identified through an extensive literature search and through interviews with various program offices, support organizations, Using Commands, and outside agencies.

CURRENT ENVIRONMENT SUMMARY

Examination of the current SPD environment revealed the following:

- **Major Organizations** – The organizational assessment established that the ALC Materiel Management (MM) and Maintenance (MA) Directorates are the predominant users of SPD for supporting post-Production support applications. The Air Force Systems Command (AFSC) Product Divisions/ System Program Offices (SPOs) are responsible for SPD acquisition and reviews; their contractors create most SPD. Finally, the Using Commands are beginning to require SPD to support base-level software maintenance and modifications.

- **Major Applications** – SPD facilitates several pre and post-production support applications:

  - *Software Development* – Throughout the development cycle described in DOD-STD-2167A, the series of reviews provides the Air Force with the opportunity to verify and validate the requirements, solution, approach, design, and final as-built product. To convey technical compliance within the design review, products (such as those available under DOD-STD-2167A) are generated. Those products are examined during the development phase and during the physical and functional configuration audits.

  - *Software Maintenance* – The ALCs and Using Commands perform a variety of maintenance tasks, such as fixing or compensating design flaws or coding errors, maximizing available memory space, and improving the software's efficiency. Use of SPD is critical to the efficient performance of software maintenance.

  - *Software Modifications* – Software modifications made by the ALCs and Using Commands either enhance the capability of the software or incorporate a change in mission. Software modification tasks mirror those of the software development cycle. Use of a current SPD baseline is the major starting point for software modifications.

  - *Reverse Engineering of Software* – Some ALCs reverse engineer software code to develop documentation for undocumented code. This usually takes place when the system life is expected to be long and the difficulties of supporting the code outweigh the costs of reverse engineering the code. Reverse engineering makes use of available SPD to begin the reconstruction process.

  - *Documentation Updates* – As software is modified and maintained, the software documentation should be updated at the same time so that a current baseline is available for future maintenance and modifications. In addition, this documentation will support the development of the TOs that are needed to implement changes in the weapon system.

- **Findings** – Specific findings are summarized below:
  - Software configuration management is impeded in the Air Force today due to a variety of factors, (e.g., lack of documentation, fragmentation of support responsibility, and lack of automated configuration management systems) which in turn hinder PDSS.
  - Lack of adequate software support documentation is currently a major problem since it affects the Air Force's capability to maintain and modify existing software inventories.
  - There is a lack of CALS standards for the digital receipt, management, and use of SPD.
  - Logistics resources to support software need to be identified during the acquisition phase, either through DOD-STD-2167A or through application of the LSA process to software.
  - Changes to software within AFLC most often require a TCTO to implement the software change.
  - The role of the Air Force Logistics Command (AFLC) and Using Commands is changing in relation to software acquisition and support. Shared software maintenance responsibilities among selected Using commands are emerging.
  - The ALCs sometimes act as the Independent Verification and Validation (IV&V) agent (either performing the IV&V directly or issuing a contract to have it done). This is an effective means to prepare the ALC for its PDSS responsibility and can lead to supportability improvements in the software design. However, this practice is not performed often enough.
  - Software that was developed under DOD-STD-2167A still represents a small percentage of AFLC software inventories; this is due to a large inventory that existed prior to this standard and to short-term cost incentives that avoid use of the standard on selected modification programs.
  - The use of Computer-Aided Software Engineering (CASE) tools is currently minimal in Air Force software maintenance.
  - Testing issues need to be identified early in the software life cycle.
  - Retention and training of software personnel in the Air Force will be critical for achieving mission readiness, productivity, and maximizing competition in PDSS contracting.

SUMMARY

This report identifies the current Air Force process for developing and fielding embedded computer software systems. It also identifies the organizations that are responsible for developing SPD, or that depend on SPD to adapt software to changing mission requirements. The report findings begin to identify potential CALS opportunities and will provide the building blocks for developing the CALS SPD System Concept Plan. The SPD effort will identify how quality SPD data can be provided at the right place and at the right time.

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LIST OF ACRONYMS

ADRIES	Advanced Digital Radar Imagery Exploration System
AFETS	Air Force Engineering and Technical Services
AFLCR	Air Force Logistics Command Regulation
AFR	Air Force Regulation
AFSCP	Air Force Systems Command Pamphlet
AFTOMS	Air Force Technical Order Management System
APSE	Ada Program Support Environment
ATD	Aircrew Training Devices
ATE	Automatic Test Equipment
ATF	Advanced Tactical Fighter
AWACS	Airborne Warning and Control System
C^3CM	Command, Control, and Communications Countermeasures
C^3I	Command, Control, Communications, and Intelligence
C-E	Communications-Electronics
CAI	Computer-aided Instruction
CAIS	Common APSE Interface Set
CALS	Computer aided Acquisition and Logistic Support
CASE	Computer-aided Software Engineering
CCB	Configuration Control Board
CCITT	Comite Consultatif Internationale de Telegraphique
CDIF	CASE Data Interchange Format
CDR	Critical Design Review
CIS	CASE Integration Services
CM	Configuration Management
CMP	Configuration Management Plan
COTS	Commercial Off–the–Shelf
CPIN	Computer Program Identification Number
CRISD	Computer Resources Integrated Support Document
CRISP	Computer Resources Integrated Support Plan
CRLCMP	Computer Resources Life Cycle Management Plan
CRWG	Computer Resources Working Group
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CSOM	Computer System Operator's Manual
CSU	Computer Software Unit

DDN	Defense Data Network
DEPS	Development Engineering Prototype Site
DFD	Data Flow Diagram
DID	Data Item Description
DPML	Deputy Program Manager for Logistics
ECP	Engineering Change Proposal
ECR	Embedded Computer Resources
EW	Electronic Warfare
FCA	Functional Configuration Audit
FFBD	Functional Flow Block Diagram
FQR	Formal Qualification Review
FSD	Full Scale Development
FSM	Firmware Support Manual
HOL	High Order Language
ICAM	Integrated Computer-Aided Manufacturing
ICBM	Intercontinental Ballistic Missile
ICOM	Inputs, Controls, Outputs, and Mechanisms
IDD	Interface Design Document
IDEF0	ICAM Definition
IGES	Initial Graphics Exchange Standard
ILS	Integrated Logistics Support
IM	Item Manager
IPR	In Process Review
IRDS	Information Resource Dictionary System
IRS	Interface Requirements Specification
IS	Information System
ISR	Information Systems Resource
IV&V	Independent Verification and Validation
J&A	Justification and Approval
JTIP	Joint Technology Insertion Program
LSA	Logistics Support Analysis
LSAR	Logistics Support Analysis Record

MCCR	Mission Critical Computer Resources
MDR	Materiel Deficiency Report
MENS	Mission Element Needs Statement
MIO	Management Integration Office
MIP	Materiel Improvement Program
MOA	Memorandum of Agreement
MPP	Modular Planning Process
NIST	National Institute of Standards and Technology
NSIA	National Security Industrial Association
O&M	Operations and Maintenance
O/S CMP	Operational Support Configuration Management Plan
OCD	Operational Concept Document
OFP	Operational Flight Program
OT&E	Operational Test and Evaluation
PAD	Program Action Directive
PCA	Physical Configuration Audit
PCTE	Portable Common Tool Environment
PDD	Product Definition Data
PDES	Product Data Exchange Standard
PDR	Preliminary Design Review
PDSS	Post Deployment Software Support
PMD	Program Management Directive
PMP	Program Management Plan
PMRT	Program Management Responsibility Transfer
PR	Procurement Request
PRAM	Productivity, Reliability, Availability, and Maintainability
RAMTIP	Reliability and Maintainability Technology Insertion Program
RAS	Requirements Allocation Sheet
REACT	Rapid Execution and Combat Targeting Program
SADT	Structured Analysis and Design Technique
SAM	Sustainability Assessment Module
SCCSB	Software Configuration Control Sub Board
SDP	Software Development Plan

SDP	Software Development Plan
SDR	Software Deficiency Report/Software Design Review
SEMP	System Engineering Management Plan
SGML	Standard Generalized Markup Language
SLCSE	Software Life Cycle Support Environment
SOC	System Operational Concept
SON	Statement of Need
SOW	Statement of Work
SPD	Software Product Data
SPM	Software Programmer's Manual
SPM	System Program Manager
SPO	System Program Office
SPR	Software Problem Report
SPS	Software Product Specification
SRR	System Requirements Review
SRS	Software Requirements Specification
SSR	Software Specification Review
SSS	System Segment Specification
STARS	Software Technology for Adaptable and Reliable Systems
STD	Software Test Description
STP	Software Test Plan
STR	Software Test Report
SUM	Software User's Manual
TCTO	Time Compliant Technical Order
TLCSC	Top Level Computer Software Component
TO	Technical Order
TPWG	Test Planning Working Group
USTS	UHF Satellite Terminal System
UUT	Unit Under Test
VDD	Version Description Document

OFFICE SYMBOLS

AAC	Alaskan Air Command
AEDC	Arnold-Engineering Development Center
AFAL	Air Force Astronautics Laboratory
AFCC	Air Force Communications Command
AFCMD	Air Force Contract Management Division
AFFTC	Air Force Flight Test Center
AFGL	Air Force Geophysics Laboratory
AFIT	Air Force Institute of Technology
AFLC	Air Force Logistics Command
AFOSR	Air Force Office of Scientific Research
AFOTEC	Air Force Operational Test and Evaluation Center
AFPRO	Air Force Plant Representatives Office
AFRES	Air Force Reserves
AFSC	Air Force Systems Command
AFSPACECOM	Air Force Space Command
AFSTC	Air Force Space Technology Center
AFWL	Air Force Weapons Laboratory
AGMC	Aerospace Guidance and Metrology Center
ALC	Air Logistics Center
ALD	Acquisition Logistics Division
AMARC	Aerospace Maintenance and Regeneration Center
ANG	Air National Guard
ASD	Aeronautical Systems Division
AU	Air University
ATC	Air Training Command
BMO	Ballistic Missile Organization
BSD	Ballistic Systems Division
CR	Directorate of Competition Advocacy
CSTC	Consolidated Space Test Center
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DOT/TSC	U.S. Department of Transportation/Transportation Systems Center

ESD	Electronic Systems Division
ESMC	Eastern Space and Missile Center
HSD	Human Systems Division
LOC	Logistics Operations Center
MA	Directorate of Maintenance
MA_	MA Product Division
MAC	Military Airlift Command
MAQ	MA Quality Assurance Division
MAS	MA Software Support Division
MASA	MA Aircraft Software Development Branch
MASM	MA Missile Systems Software Branch
MAST	MMA Software Support Branch
MAW	MA Computer Resources Management Division
MM	Materiel Management Directorate
MM_A	MM Acquisition Branch
MM_D	MM Requirement Distribution Branch
MM_H	MM Operations Branch
MM_I	MM International Logistics Branch
MM_M	MM Operations Branch
MM_O	MM Operations Branch
MM_P	MM Production Management Branch
MM_R	MM System Engineering Branch
MM_S	MM Support Branch
MMD	MM Support Division
MME	MM Engineering Division
MMEC	MM Computer Resources Branch
MMED	MM Operations and Support Branch
MMEO	MM Operations and Support Branch
MMET	MM Specialized Engineering Branch
MMI	MM Item Management Division
MMII	MM Investment/Replacement Branch
MMIM	MM Logistics Management Branch
MMIR	MM Engineering and Reliability Branch
MMIS	MM Materiel Support Branch
MMM	MM Resource Management Division

MMML	MM Logistics Planning Branch
MMMM	MM Maintenance Modification Branch
MMMR	MM Requirements Branch
MMQ	MM Quality Division
MMS	MM System Management Division
MMSR	MM Engineering and Reliability Branch
MMSS	MM Materiel Support Branch
MSD	Munitions Systems Division
NORAD	North American Aerospace Defense Command
OC ALC	Oklahoma City ALC
OO-ALC	Ogden ALC
PACAF	Pacific Air Forces
PM	Directorate of Contracting and Manufacturing
RADC	Rome Air Development Center
SA-ALC	San Antonio ALC
SAC	Strategic Air Command
SAMTO	Space and Missile Test Organization
SC	Directorate of Computer Systems
SCC	Software Control Center
SDIO	Strategic Defense Initiative Office
SEI	Software Engineering Institute
SM-ALC	Sacramento ALC
SOLE	Society of Logistics Engineers
SSC	Software Support Center
SSC	Standard Systems Center
SSD	Space Systems Division
SWSC	Space and Warning Systems Center
TAC	Tactical Air Command
TRC	Technology Repair Center
USAFE	U.S. Air Forces in Europe
UTTR	Utah Test and Training Range

W-P AFB	Wright-Patterson Air Force Base
WR-ALC	Warner Robins ALC
WRDC	Wright Research and Development Center
WSMC	Western Space and Missile Center

SECTIONS 1–4

INTRODUCTION

ORGANIZATIONAL ASSESSMENT

IDEF DIAGRAMS

FINDINGS

SECTION 1: INTRODUCTION

1.1 USAF CALS BACKGROUND

In conjunction with the Computer-aided Acquisition and Logistic Support (CALS) program used throughout the Department of Defense (DoD), the Air Force CALS program was established to improve weapon system reliability and maintainability, and to reduce the cost of acquisition and support. A major objective of CALS is to improve the flow of technical information by introducing automated techniques to improve the delivery and handling of large quantities of digitized technical data. The areas of technical data currently being addressed by the Air Force CALS Program are: Software Product Data (SPD), Technical Orders (TOs), Product Definition Data (PDD), and Logistics Support Analysis (LSA). By automating the flow of information, CALS will significantly reduce the amount of paper and labor necessary to receive, store, use, and disseminate these technical data.

In October 1985, an Air Force Program Management Directive (PMD) created a CALS Management Integration Office (MIO) at HQ Air Force Systems Command (AFSC) to coordinate the CALS program. The Air Force CALS MIO is responsible for planning, developing, and implementing the CALS initiatives. The U.S. Department of Transportation, Transportation Systems Center (DOT/TSC), is providing systems engineering and strategic planning support to the CALS MIO.

1.2 SOFTWARE PRODUCT DATA DEFINITION

SPD represents the set of technical information, such as logic diagrams, block diagrams, source code, specifications, tests, tools and other data, which is needed to both acquire and support the design, test and implementation of Mission Critical Computer Resources (MCCR) software. Specific examples of SPD information types are shown in FIGURE 1-1. A complete list of SPD-related Data Item Descriptions (DIDs) associated with DOD-STD-2167A is presented in TABLE 1-1.

Software implementation is not limited to weapon systems and can also apply to ground equipment, communication devices (both ground and platform based), radars, and end items such as smart munitions and missiles. Thus, SPD is found not only on major weapon systems, but also on major end items.

1.3 OBJECTIVE

The objective of the CALS SPD modular planning program is to develop a system concept plan for the digital acquisition, distribution, storage, use, and configuration management of SPD. The system concept plan will define a strategy for implementing CALS objectives in the arena of SPD in a manner that it consistent with long-term Air Force CALS goals. To identify these requirements, the functions that are required to acquire and support software will be identified, defined, and analyzed. The approach will include defining how the software component of a weapon system is supported, identifying the shcrtcomings, and anticipating the functional, organizational, and technical support requirements for the weapon system software of tomorrow.

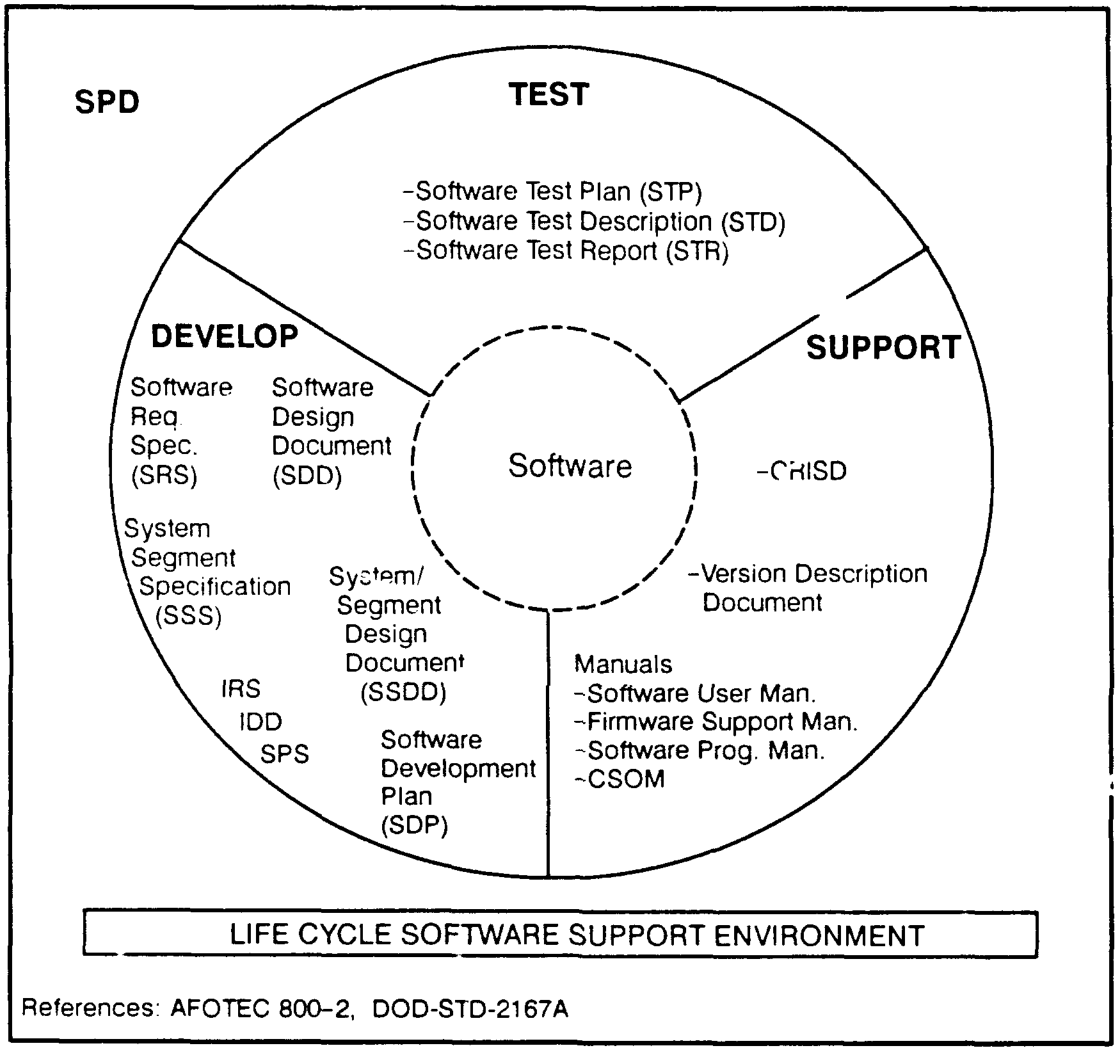


FIGURE 1-1. EXAMPLES OF SPD BY CATEGORIES

By digitizing the acquisitirn, distribution, storage, use, and configuration management of SPD, the Air Force will realize benefits by more accurately and rapidly maintaining and modifying software. This will translate into improvements in mission readiness and productivity.

1.4 SOFTWARE PRODUCT DATA SCOPE

The definition of a weapon system as a product includes both product definition and software product data as illustrated in FIGURE 1-2. PDD consists of the technical information that describes the hardware of a weapon system while software product data consists of the technical information that describes the software. In general, PDD includes engineering drawings, lists, analysis, and design data related to hardware aspects of the system.

TABLE 1-1. DoD-STD-2167A DATA ITEMS

TITLE	NUMBER
System/Segment Specification (SSS)	DI-CMAN-80008A
System/Segment Design Document (SSDD)	DI-CMAN-80534
Software Development Plan (SDP)	DI-MCCR-80030A
Software Requirements Specification (SRS)	DI-MCCR-80025A
Interface Requirements Specification (IRS)	DI-MCCR-80026A
Software Design Document (SDD)	DI-MCCR-80012A
Interface Design Document (IDD)	DI-MCCR-80026A
Software Product Specification (SPS)	DI-MCCR-80028A
Version Description Document (VDD)	DI-MCCR-80013A
Software Test Plan (STP)	DI-MCCR-80014A
Software Test Description (STD)	DI-MCCR-80015A
Software Test Report (STR)	DI-MCCR-80017A
Computer System Operator's Manual (CSOM)	DI-MCCR-80018A
Software User's Manual (SUM)	DI-MCCR-80019A
Software Programmer's Manual (SPM)	DI-MCCR-80021A
Firmware Support Manual (FSM)	DI-MCCR-80022A
Computer Resources Integrated Support Document (CRISD)	DI-MCCR-80024A

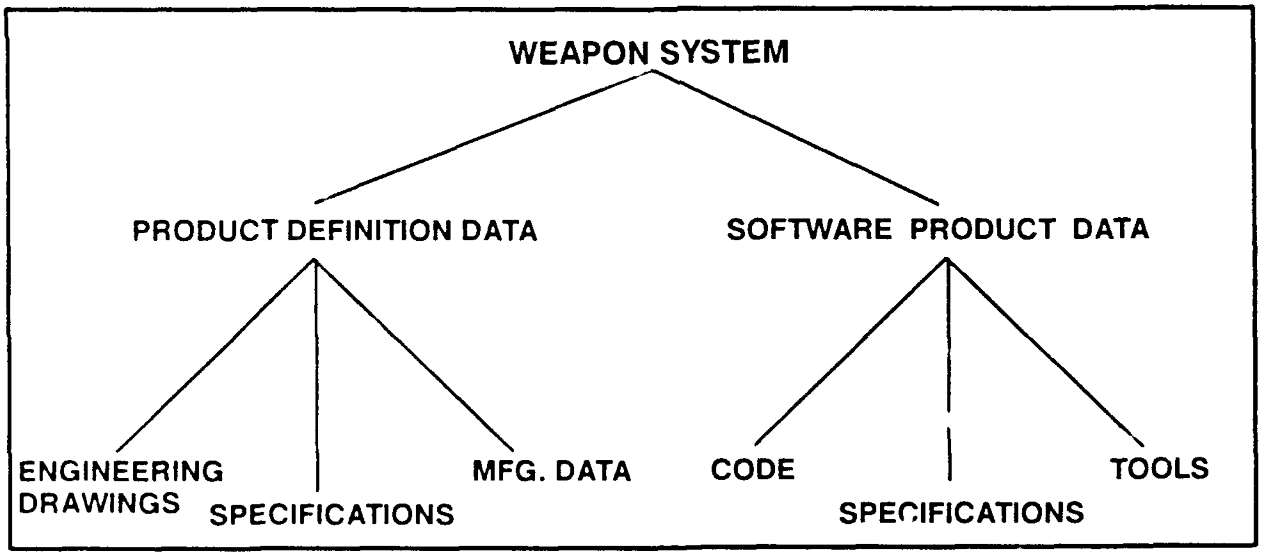


FIGURE 1-2. WEAPON SYSTEM PRODUCT DEFINITION

DoD computer resources were divided into two categories by the Warner amendment to the Congressional Brooks Bill in 1982: Mission Critical Computer Resources (MCCR) and Information System Resources (ISR). According to the AFR 700-4 definition there are five applications for MCCR, as shown in FIGURE 1-3.

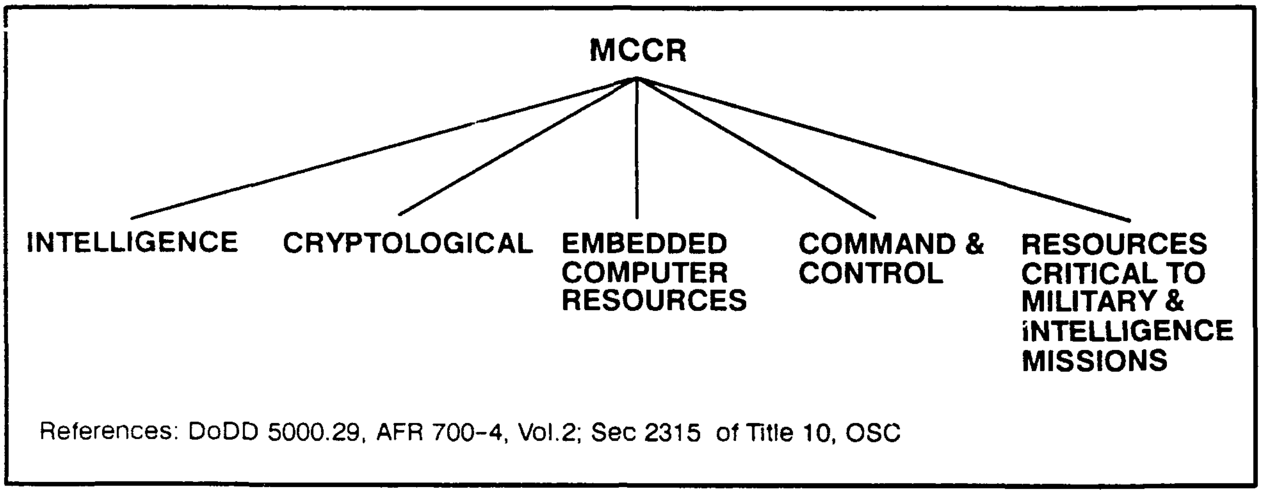


FIGURE 1-3. COMPONENTS OF MCCR

Weapon systems today utilize software–driven electronic and electro–mechanical equipment that is largely dependant on MCCR software. According to AFLCR 800–21 (Management and Support Procedures for Computer Resources Used in Defense Systems) embedded computer resources can be broken down into five application areas:

- Digital avionics system or Operational Flight Program (OFP),
- Electronic Warfare (EW) software,
- Aircrew Training Devices (ATD) software,
- Automatic Test Equipment (ATE) software, and
- Communications–Electronics (C–E) software.

The scope of the CALS SPD program, and of this report, is limited to the five types of MCCR listed above (OFP, EW, ATD, ATE, and C–E). These embedded software sub–types are central to the functioning of a weapon system and collectively represent the largest of the five MCCR categories. Subsequent work could apply the results of this study to the other MCCR categories discussed above.

Proposed changes to current regulations will redefine and broaden the scope of MCCR, and delete the use of the term Embedded Computer Resources (ECR). This would elevate the five sub–categories currently defined under ECR (shown in the above bullets), and increase the total number of categories under MCCR to nine (the other four categories are shown in FIGURE 1-3). For this report however, MCCR will still be used to describe the five categories of computer resources above (OFP, EW, ATE, ATD, and C-E). This was done to use clear, understandable terms, and to reflect in the report the current state and evolving nature of software in the mission critical environment.

The scope of the CALS SPD program is a representative subset of Air Force SPD. FIGURE 1-4 illustrates that the five types of MCCR span both the prime mission and support systems of a weapon system. It also shows that Computer Software Configuration Items (CSCIs) are the broadest or highest level of software configuration item. CSCIs are computer programs that meet an end usage function; according to DOD-STD-2167A, each CSCI is subject to full configuration management. CSCIs, in turn, are broken down into Computer Software Components (CSCs) and then into Computer Software Units (CSUs).

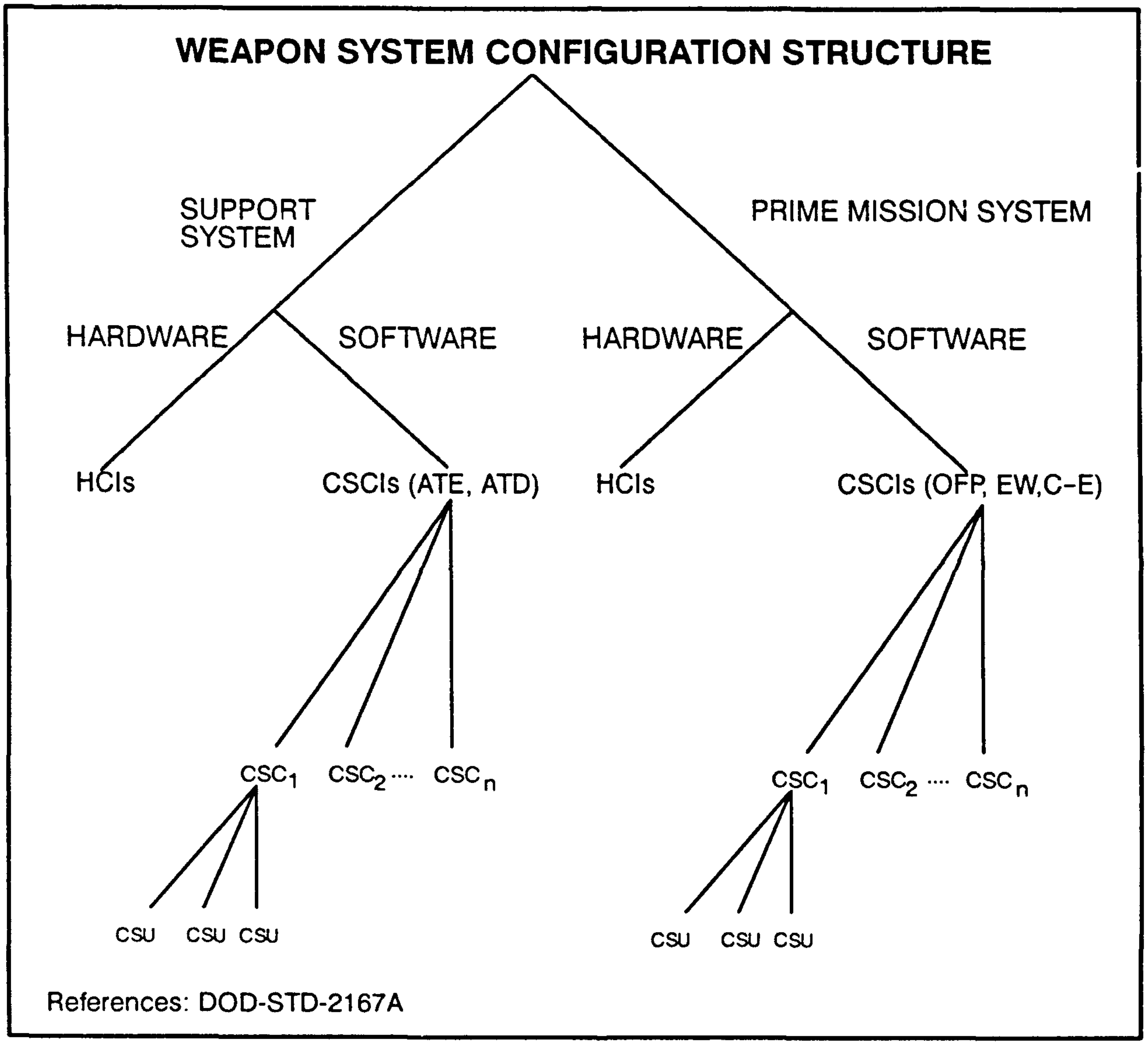


FIGURE 1-4. MCCR WITHIN A WEAPON SYSTEM

1.5 CRITICALITY OF SPD

Increasingly, software is playing a more mission-critical role in weapon system operations. This results from the evolution of the integration of computers and software into weapon systems hardware. To that end, software and software-related deliverables must be acquired, managed, and utilized efficiently to support the broader and more time-critical role of software within a weapon system. As newer, software-intensive systems are produced, any unsupported, undocumented software will represent an ever increasing problem.

MCCR is an integral component of the weapon system and must therefore be included within the technical data for each weapon system. As weapon systems grow more complex, software is being applied to the hardware to perform the sensing, processing, complex calculations, and control functions that can no longer be performed manually to support mission requirements. The software acts as the central nervous system to the entire weapon system, and must therefore be the major focus of how support is managed and provided to the weapon system.

Fundamental breakdowns in software management can be attributed primarily to the intricacies inherent in the software. Minor development deficiencies (poor documentation, insufficient testing, inadequate review, or lack of configuration control) can turn into major operational deficiencies once the weapon system is fielded. A major SPD problem facing the Air Force is that once a system is fielded, it may be too costly, or logistically impossible to retro-develop SPD that was not acquired during the acquisition phase; this in turn hinders mission capability and staff productivity.

Since post-deployment software support functions have significant similarities to software development tasks, software support requires an up-to-date baseline of software documentation, tools, and code (i.e., SPD) to perform software maintenance and modification tasks quickly and effectively. Approximately 66% of software support activities require new development of software, an indication that software support does not fall under the classic "problem correction" definition of maintenance.

During the support phase of the software life cycle, software modifications usually result from change requests by the user, or a change in the mission requirement. Currently, software changes are a labor-intensive activity, prompting major releases on an eighteen month release cycle (except safety-of-flight modifications). On average, modifications to embedded computer software take up to four times longer to implement than modifications made during the initial development. Current studies have estimated that 60% of the time required to implement a modification is devoted to retrieving and updating documentation. Therefore, successful software support (modifications, enhancements, fixes, testing, etc.) of weapon system software is significantly dependant on SPD.

1.6 METHODOLOGY

To undertake the strategic planning associated with the CALS initiatives, TSC has developed and implemented the Modular Planning Process (MPP), an information engineering approach that is designed to:

- Focus on technical plans that will not be outdated before implementation.
- Incorporate existing/on-going Air Force systems.

- Meet the information distribution requirements of the Air Force user community.
- Interface with a variety of organizations responsible for weapon systems acquisition and logistic support.

The MPP is divided into three phases: 1) an examination of the existing environment, 2) a study of opportunities, and 3) a plan of future direction (see FIGURE 1-5). Using this framework, *The Air Force Technical Order Management System (AFTOMS) Automation Plan* was developed and a concept has been approved for managing technical orders. In addition, a *Product Definition Data System Concept Plan* was developed using the MPP.

This report presents the results of an examination of the existing SPD environment, undertaken as the first phase in the MPP, and as an initial step in developing a SPD System Concept Plan. It will assist the CALS effort in planning for SPD automation over the next ten years by accommodating present Air Force acquisition and logistics requirements, meeting future Air Force requirements, and providing flexibility to take advantage of future advances in technology.

This report was prepared from site visits, an analysis of the current regulations for directing and guiding the acquisition, receipt, management, and use of SPD, background documentation, and telephone contacts. Regulations and background documentation are cited in Appendix C of this document. Air Force organizational contacts to validate the findings of the report are listed in Appendix D.

Regulations referred to in developing this report include those governing MCCR software, are contained in the 800 series regulations. Two important regulations for this report include AFR 800-14, *Life Cycle Management of Computer Resource in Systems*, and AFLCR 800-21, *Management and Support Procedures for Computer Resources Used in Defense Systems.*

1.7 RELATED STUDIES AND INITIATIVES

The DoD and the Air Force have already initiated and conducted several studies whose objectives were to understand the full context of managing software from a weapons systems perspective and identify the critical elements attributable to the labor-intensive effort of maintaining weapon system software.

As early as 1980, studies tried to determine why software so often becomes the limiting factor in mission support. In 1980, TRW developed an eight volume study for ASD that reviewed each category of embedded computer resources from a maintenance standpoint. A year later, the RAND Corporation developed a study to review Post-Deployment Software Support (PDSS) issues. The following year, the Defense Science Board formulated a task force on embedded computer resources to "review, evaluate and make recommendations concerning the acquisition, management and utilization of digital computers and technology to support the military mission of the Department of Defense". More detailed information on these and other studies is provided in Appendix A.

PHASE 1
EXAMINE THE ENVIRONMENT

Initiate the Process

Perform Initial Assessment
- Create Preliminary Description of Environment
- Identify Organizational Expectations
- Establish Priorities

Develop Specific Procedures
- Establish Management Plan
- Identify Advisory Group
- Prepare Project Plans

Conduct Structured Analysis

Describe Current Environment
- Create Functional Model
- Identify Major Data Elements
- Describe the Organizational Infrastructure
- Identify Major Information Flow Parameters

Assess Transitional Projects
- Identify Objectives
- Describe Functions and Data
- Identify Technologies
- Identify Infrastructure Affected

PHASE 2
STUDY THE OPPORTUNITIES

Assess Technology

Identify Existing Technologies
- Review Current Environment
- Review Ongoing Projects
- Identify Existing Technologies

Research Future Technology Opportunities
- Select Technology Areas
- Consult with Technology Experts
- Examine Similar Applications
- Review Development Trends

Establish Technology Alternatives
- Quantify Directions
- Specification of Implementation Issues
- Examine Benefits and Costs

Project Future Requirements

Forecast Requirements
- Review Applicable Scenarios
- Conduct Discussions with MAJCOMs
- Forecast Process Changes
- Assess Infrastructure Constraints

Examine Feasible Alternatives
- Determine Feasibility Issues
- Review Industry Trends

Define Future State

Describe Future Environment
- Define the Impact of Technology on Current State
- Define Projected Organizational Responsibilities
- Define Relevant Interface Requirements

Create Functional Model
- Develop a Description of Future State
- Identify Projected Major Information Flow Parameters

PHASE 3
PLAN THE DIRECTION

Formulate Alternatives

Assess Critical Issues
- Examine Objectives
- Identify Technologies
- Review Organizational Issues

Propose Initial Alternatives
- Select Future Requirements
- Identify Technologies
- Structure Proposals

Review and Modify Alternatives
- Review Criteria
- Identify Relationships with Transitional Projects
- Define Policies and Organizations Involved

Develop Consensus

Review Progress with Advisory Group
- Identify Discussion Topics and Priorities
- Evaluate Current Environment
- Establish Objectives
- Provide Access to Information

Develop Common Understanding
- Review Future Requirements
- Evaluate Recommended Solutions
- Examine Feasibility Issues

Expand Advocacy Network
- Identify Implementation Agencies
- Select Appropriate Forums
- Communicate the Plans

Prepare Implementation Plan

Define Activity Descriptions
- Establish Implementation Guidelines
- Establish Evaluation Criteria
- Develop Implementation Procedures

Develop Organization Plan
- Confirm Major Milestones
- Establish Transition Plan
- Identify Organizational Responsibilities

Establish Constituency
- Gain Management Acceptance of Plan
- Obtain a Commitment for Execution

Create Documentation
- Establish Goals
- Define Resource Requirements
- Recommend Technologies
- Define Organizational Impact
- Establish Financial Parameters

FIGURE 1-5. MODULAR PLANNING PROCESS OVERVIEW

Efforts to understand software maintenance have not diminished. Unique methods of impressing the importance of support issues have been developed. As recently as 1987, Blue Two visits (so designated by virtue of the goal of the effort, which was to allow industry to view the maintenance process through the eyes of the Air Force two–striper) were conducted to make industry engineers aware of the importance of supportability, maintainability, testability and other factors.

Several Air Force programs have been established to keep pace with technology. Most prominent is the Software Engineering Institute (SEI) at Carnegie Mellon University. Founded in 1984, the SEI is a federally funded research center sponsored by the DoD. Five programs research DoD aspects of software: the Software Engineering Process Program, the Engineering Methods Program, the Software Systems Program, the Education Program and the Technology Transition Program.

A variety of organizations have also taken a keen interest in the direction of software maintenance. In particular the Society of Logistics Engineers (SOLE) conducted a symposium in 1989, focusing on the issue of software logistics. According to one definition at the symposium, software logistics can be defined as "the selective application of the integrated logistic support process to the system software element". This symposium generated 32 recommendations relating to management, technology and training for software logistics. Overall, the increased value of LSA for software was stressed, as evidenced by the recommendation that DODD 5000.39 be revised to integrate software life cycle requirements within the ILS process.

Today, the vast majority of Air Force software documentation at ALC libraries is paper-based, which makes it difficult to use in software maintenance and modifications. Frequently, documentation was not acquired, cannot be found, or contains insufficient information to expeditiously complete software maintenance and modifications. From a cost perspective, PDSS represents 80% of the software life cycle costs. Without sufficient documentation, systems are becoming unsupportable. This affects the potential system life of weapon systems, reduces responsiveness to mission–critical software change requirements, and increases labor costs for maintenance and modifications. While Ada implementation was meant to provide a degree of design and language standardization, the validation efforts conducted at the ALCs for this report show only a small percentage of Ada code. For the most part, the ALCs will be tasked to maintain a variety of applications across several languages and platforms within each weapon system.

1.8 REPORT ORGANIZATION

The report is organized to present sequentially an overview of the organizational environment, structured analysis models, and the findings identified. Section 2 assesses the organizational environment and describes how SPD is used. Section 3 summarizes the Input, Control, Output, Mechanism (ICOM) Definition ($IDEF_0$) model analysis. Section 4 presents the findings identified during the development of the report. Four appendices provide additional detail to the major sections. Appendix A summarizes major studies of Air Force software problems since the late 1970s as well as related initiatives that are within the scope of the SPD program. Appendix B presents the detailed $IDEF_0$ diagrams with related text that describes the process. Appendix C is a bibliography of the referenced regulations, standards, and other related documents. Appendix D lists the points of contact for this report.

1.9 SUMMARY

Given the growth of weapon system software, and the problems associated with the management of SPD, this CALS module will provide a logical transition to the digital-based management of SPD. The *SPD Current Environment Report* identifies the current Air Force process for developing and fielding MCCR embedded computer software systems. It also identifies the organizations who are either responsible for the development of SPD, or dependant upon SPD to adapt to changing mission requirements. Findings presented begin to identify potential CALS opportunities. In summary, SPD, like PDD, AFTOMS and LSA, will provide the opportunity to provide quality SPD technical information at the right place and at the right time.

SECTION 2: ORGANIZATIONAL ASSESSMENT

2.1 INTRODUCTION

The focus of the SPD Organizational Assessment is on organizations that support the receipt, distribution, storage, use and configuration of SPD.

2.1.1 Purpose

The purpose of the Organizational Assessment is threefold: to identify Air Force organizations involved in SPD, to formulate SPD-related functional descriptions of each organization, and to identify, through matrix analysis, the many different variables that affect the SPD organizational environment.

2.1.2 Scope

Included in the Organizational Assessment are organizations currently involved with the design, implementation, and testing of five of the nine categories of MCCR software: OFP, EW, C–E, ATD, and ATE, during the acquisition phase of the weapon system life cycle. Also included are organizations currently involved in the maintenance and modification of this software during the operational phase of the life cycle.

2.1.3 Approach

The Organizational Assessment is based on site visits and a review of applicable documentation; i.e. *PDD Current Environment Report*, Air Force Regulations and Missions, organizational regulations, and other relevant documentation.

The Organizational Assessment is divided into three sections. Section 2.2 identifies the organizations that receive, distribute, store, use, and configure SPD and outlines their responsibilities. Section 2.3 assesses the organizations and their responsibilities against two SPD variables: MCCR category and software life cycle function. Matrix analysis is then used to show how each variable affects the SPD current environment. Organizational conclusions are presented in Section 2.4.

2.2 ORGANIZATIONAL ROLES AND RESPONSIBILITIES

The SPD organizational environment is made up of multiple Air Force Commands, organizations within the commands, and other agencies, all of whom are involved in the receipt, distribution, storage, use and configuration management of SPD. The approach taken in this report is to assign relevant organizations and agencies into four categories (FIGURE 2-1).

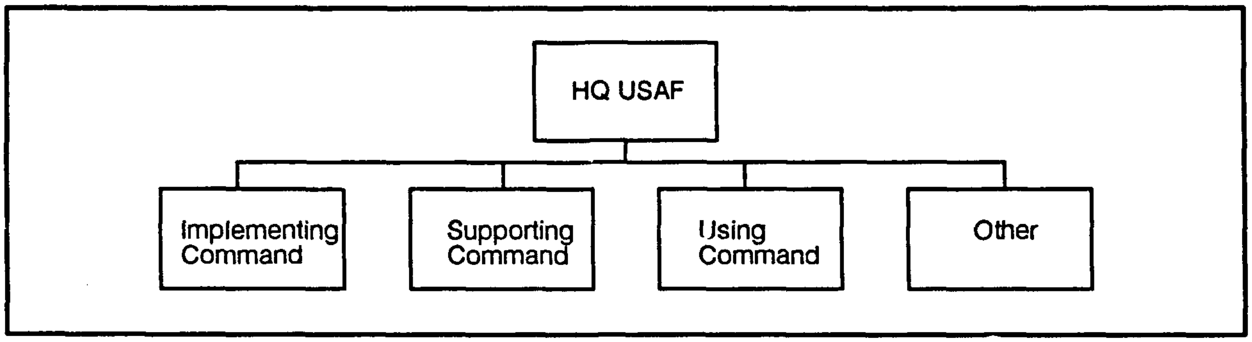


FIGURE 2-1. SPD ORGANIZATIONAL ASSESSMENT SCOPE

Roles and responsibilities for each of these categories are discussed in Sections 2.2.2 through 2.2.5. FIGURE 2-2 represents the SPD organizational structure. It is made up of multiple Air Force Commands, organizations within commands, and other agencies involved in the acquisition and support process.

2.2.1 HQ USAF

AFR 800-14, *Acquisition Management for Life Cycle Management of Computer Resources in Systems*, outlines responsibilities for MCCR software acquisition and operational support for HQ USAF and organizations within the USAF. Managerial responsibilities include: PMD input, program management definition, program guidance and direction, and program or system acquisition and support responsibility designation.

2.2.2 Implementing Command

The Implementing Command has overall responsibility for developing a weapon system program. Usually the task is contracted out and the Implementing Command is responsible for initiating and monitoring the contractor's development of the system.

AFSC is most often the Implementing Command for MCCR software. However, other commands sometimes take on acquisition responsibilities for weapon systems software. For example, Air Force Logistics Command (AFLC), Air Force Communications Command (AFCC), and Air Force Space Command (AFSPACECOM) sometimes manage the acquisition of major modifications for MCCR software. FIGURE 2-3 illustrates the organizational structure of AFSC as the Implementing Command. AFLC, AFSPACECOM, and AFCC are discussed in sections 2.2.3, 2.2.4.4, and 2.2.5.2.

2.2.2.1 Air Force Systems Command (HQ AFSC)

AFSC plays a major role in the research, development, testing, and implementation of weapon systems technology. AFSC's primary mission is to advance aerospace technology, apply it to operational aerospace systems development and enhancements, and to acquire qualitatively superior, cost-effective, and logistically-supportable aerospace systems. AFSC is also responsible for ensuring that system support disciplines and elements are improved and properly integrated into the system engineering and managing process.

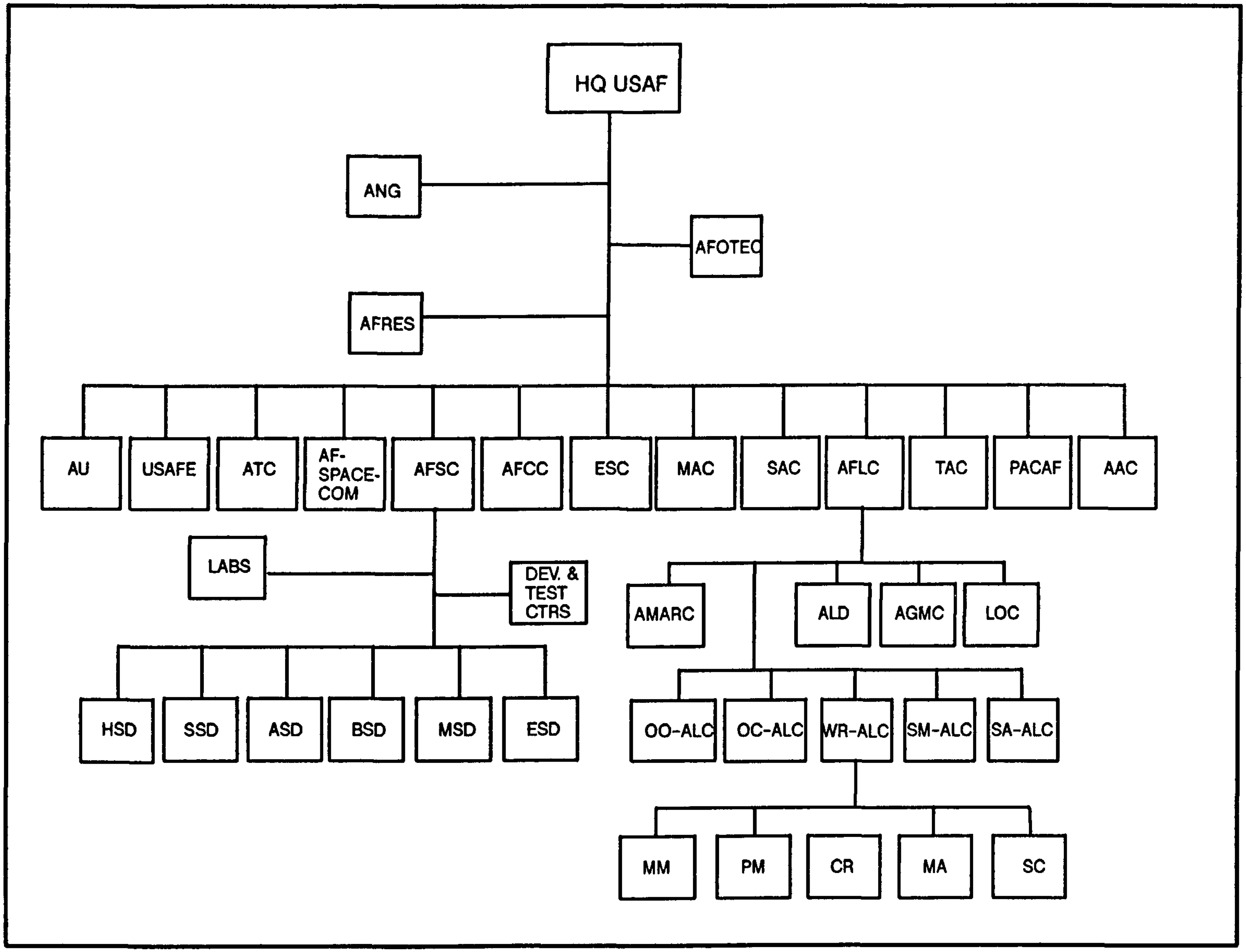


FIGURE 2-2. SPD ORGANIZATIONAL STRUCTURE

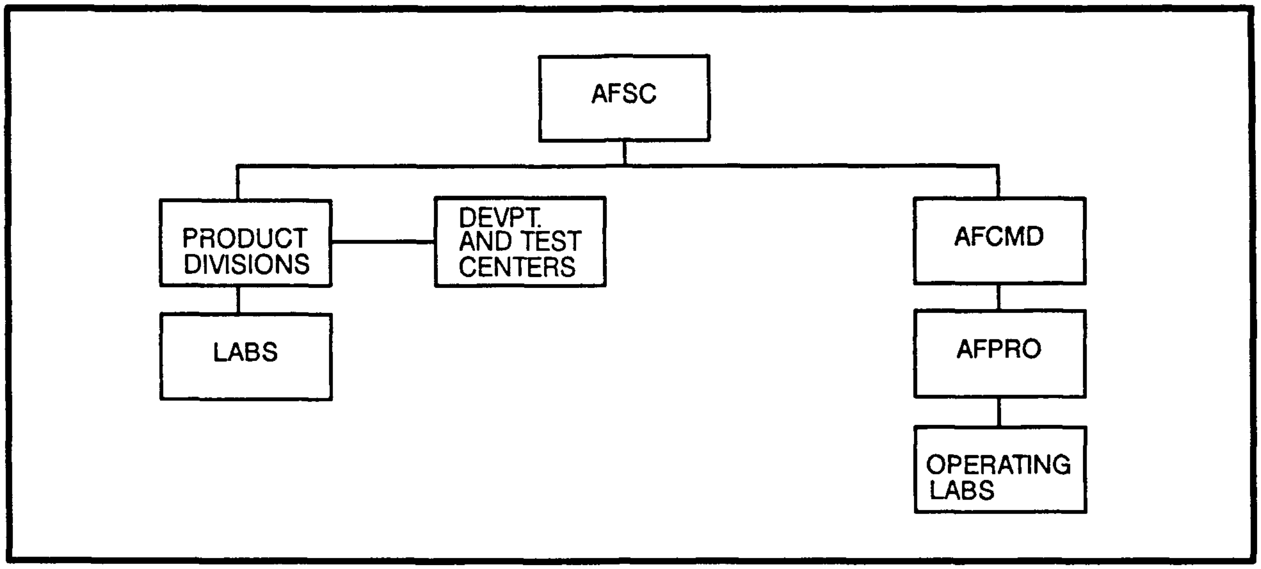


FIGURE 2-3. IMPLEMENTING COMMAND INFRASTRUCTURE

AFSC plays a major role in the acquisition, use, and management of SPD. It focuses primarily on the contractor's development of SPD. HQAFSC, issues a document, Form 56, to provide direction to subordinate organizations. AFSC also provides guidance and direction to product divisions, laboratories, and to development and test centers.

2.2.2.2 Product Divisions

The six Product Divisions within AFSC, all of which relate to SPD and provide weapon systems acquisition support, are: Aeronautical Systems Division (ASD), Electronic Systems Division (ESD), Ballistic Systems Division (BSD), Munitions Systems Division (MSD), Space Systems Division (SSD), and Human Systems Division (HSD). Product Divisions provide programmatic support for developing, testing, and acquiring weapon systems. As part of their responsibilities, Product Divisions ensure that advanced technology is applied to MCCR software.

The six product divisions contribute to the development of MCCR software. Division responsibilities are summarized below:

- **ASD** - ASD is a major AFSC organization located at Wright-Patterson AFB, OH. ASD supports and develops SPD for aerospace systems software. The division also directs the design, development, and acquisition of aerospace systems, i.e., fighters, bombers, transports, aerial tankers, tactical reconnaissance aircraft, manned vehicles, long and short range air-to-surface missiles, simulators, reconnaissance and electronic warfare systems, and aircraft engines.
- **ESD** - ESD is located at Hanscom AFB, MA, and develops acquires, and delivers electronic systems and equipment for the command, control, communications and intelligence (C3I) functions of aerospace forces. An example of an

ESD-developed system is the Ballistic Missile Early Warning System Air Force/ Army radar used to detect, track, and direct weapons against stationary or slow moving ground and airborne targets. ESD's testing responsibilities include managing the Strategic Defense Initiative Battle Management C3 National Testbed. The Rome Air Development Center (RADC), discussed in Section 2.2.2.3, is assigned to ESD.

- **BSD** – BSD is located at Norton AFB, CA, and develops ballistic missile systems and subsystems, including the Peacekeeper Intercontinental Ballistic Missile (ICBM). In addition, BSD manages the research and development of the small ICBM. On 2 April 1990 the BSD will become the Ballistic Missile Organization (BMO) under the SSD.

- **MSD** – MSD is located at Eglin AFB, FL. The division plans, researches, develops, and acquires conventional air armaments, and tests and evaluates armament and electronic combat systems and related equipment. The mission area involves lifecycle responsibility for air armaments. In conjunction with MSD development and testing of weapon systems, the Air Force Tactical Air Warfare Center and the 33rd Tactical Fighter Wing, co-located at Eglin AFB, offer supporting expertise in the tactical applications of the weapons.

- **SSD** – SSD is located at Los Angeles AFB, CA, and manages the majority of the nation's military space systems. Responsibilities include maintaining space-based communications, meteorological, navigational, and surveillance systems in support of combat forces (on the ground, at sea, and in the atmosphere), and operating the national test ranges and launch facilities to support space and missile programs.

- **HSD** – HSD is located at Brooks AFB, TX, and is the primary Air Force organization for ensuring that Air Force systems and operations are designed with human capabilities in mind. HSD is responsible for conducting research and development, and for acquiring specific operational support programs to support its mission.

Within each of the product divisions there are numerous System Program Offices (SPOs), which manage specific systems. The SPO assumes primary management responsibility for the system being acquired and prepares the Program Management Plan (PMP) for AFSC and HQ USAF to review. Most system acquisition efforts are contracted out to contractors. With assistance from the laboratories, test organizations, and Air Force Plant Representatives Office (AFPRO), the SPO is responsible for the following: contract preparation, source selection, contract monitoring, and managing the turnover of the weapon system to AFLC at Program Management Responsibility Transfer (PMRT).

2.2.2.3 Development and Test Organizations

Development and test organizations, in this section, include only those organizations that acquire, develop, and support SPD. These organizations can report directly to the product divisions. Some of these organizations have multiple functions and missions.

- **Air Force Flight Test Center (AFFTC)** - AFFTC, located at Edwards AFB, CA, conducts and supports flight testing and evaluation of manned aircraft, research vehicles and related propulsion, flight control avionics, and weapon systems in or entering the Air Force inventory. Similar tests and evaluation can also be carried out by AFFTC on aircraft belonging to other U.S. military services and government agencies, and on aircraft and related systems of certain foreign governments. AFFTC tests and evaluates remotely piloted vehicles and Air Force versions of air and ground-launched cruise missiles. AFFTC has several programs currently underway: flight testing and evaluation of the B–1B bomber, and system improvements on the F–16 and F–15 fighters and the B–52 bomber.

- **RADC** - RADC, located at Griffiss AFB, NY, is the principal organization for conducting Air Force research and development programs related to C^3I. Even though C^3I does not fall within the scope of this SPD study, RADC supports other programs that include MCCR software. RADC, which reports to ESD, helps demonstrate and acquire selected systems and subsystems within its area of expertise. RADC mission areas include: photonics research, communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data handling, information systems technology, artificial intelligence, battle management, ionospheric propagation, solid state sciences, microwave physics, and electronic reliability, maintainability, and compatibility. RADC develops and studies software quality and reliability measures. RADC also manages an SPD–related technology development program, Software Life Cycle Support Environment (SLCSE).

- **Space and Missile Test Organization (SAMTO)** - SAMTO, located at Vandenberg AFB, CA, reports to SSD. SAMTO manages field–tests and launch operations for all DOD directed space programs and long range ballistic research and development programs. SAMTO also develops, manages, and operates the research and development programs through the Western and Eastern Space and Missile Centers.

  - **Western Space and Missile Center (WSMC)** - WSMC, located at Vandenberg AFB, CA, is responsible for conducting launch and launch support of research and development ballistic missile testing and polar orbiting space launches for DOD, USAF, and other agencies. The Western Test Range supports ballistic and space test organizations. The range also supports East Coast Space Shuttle operational flight tests and other aeronautical tests, employing the same sensors and data gathering equipment used for ballistic flights.

- **Eastern Space and Missile Center (ESMC) -** ESMC, located at Patrick AFB, FL, is responsible for conducting launch and launch support activities of manned and unmanned space launches and ballistic missiles for the Air Force, DOD, foreign governments, and other government agencies. ESMC support includes the initial assembly, checkout, and ground processing for launch of the Trident II and Pershing II missile programs. Since these systems contain MCCR software, ESMC is responsible for generating, managing, and using SPD. In addition, ESMC operates Patrick AFB.

- **4950th Test Wing -** The 4950th Test Wing, located at Wright-Patterson AFB, OH, tests weapon systems. The Wing conducts flight test programs on military systems, subsystems, and test components; operates and maintains assigned test aircraft and equipment; performs Class II (research and development) aircraft modification design, fabrication, and installation; provides research technical photographic services; and furnishes flight test engineering support and technical data acquisition services for specialized missions worldwide. The wing can plan, conduct, evaluate, and report on a wide range of research and development flight test requirements, an activity that requires the creation, management and use of SPD.

- **3246th Test Wing -** The Test Wing is located at Eglin AFB, FL and is part of the MSD. The Test Wing's responsibilities include operating and monitoring the ranges and facilities. Equipment tested at these ranges include: aircraft systems, subsystems, missiles, guns, bombs, rockets, targets, high powered radars and airborne electronic countermeasures equipment. As part of the Test Wing's mission it operates a fleet of more than forty aircraft and maintains a multi-billion dollar complex of modern instrumentation.

- **6510th Test Wing -**The Test Wing is located at Edwards AFB, CA and carries out the AFFTC mission. The Test Wing tests and evaluates new and modified aerospace systems. In addition, the Test Wing is responsible for operating the USAF Test Pilot School and maintaining the Utah Test and Training Range (UTTR). At the UTTR many test and developmental flights are remotely piloted.

- **Air Force Office of Scientific Research (AFOSR) -** The Office is located at Bolling AFB, DC and is the single manager of Air Force basic research. It awards grants and contracts for research directly related to Air Force needs.

- **Arnold Engineering Development Center (AEDC)** – The Center is located at Arnold AFB, TX, and operates the largest and most advanced complex of aerospace flight simulation test facilities. AEDC's mission is to test aircraft, missiles, and space systems using flight conditions experienced during operational missions. The Center helps MCCR software developers qualify systems for flight, improve designs, and establish performance levels before production. The center assists in troubleshooting and reduces development time and cost.

- **Consolidated Space Test Center (CSTC)** – The Center is located at Onizuka AFB, CA. The center supports DOD research and development of spacecraft and performs launches, checkout, test, and development support for DOD space shuttle payloads, upper stages, and experiments. CSTC performs on–orbit tracking, data acquisition, and command and control of DOD space vehicles.

2.2.2.4 Laboratories

Laboratories are responsible for research and development of technologies. They assist the Product Divisions by performing operational flight testing, installing new weapon systems, and modifying programs. The laboratories generate and use SPD.

- **Air Force Space Technology Center (AFSTC)** – AFSTC, located at Kirtland AFB, NM, works through AFSC and AFSPACECOM to provide research results for future systems needs, and to identify key technology areas for long range plans. AFSTC directs the following three AFSC laboratories:

  - **Air Force Weapons Laboratory (AFWL)** – AFWL, located at Kirtland AFB, NM, conducts AFSC non-conventional weapons research and development in high–energy laser technology, advanced weapon concepts, and nuclear weapon technology. The non-conventional weapons research and development includes MCCR software.

  - **Air Force Astronautics Laboratory (AFAL)** – AFAL is located at Edwards AFB, CA. The laboratory conducts research and undertakes advanced development and exploratory programs on space and rocket propulsion technologies. Research and development efforts focus on improving rocket test techniques and instrumentation.

  - **Air Force Geophysics Laboratory (AFGL)** – The Laboratory is located at Hanscom AFB, MA. AFGL is the center for research, exploratory development, and advanced technology development on earth, atmosphere and space environments.

- **Wright Research and Development Center (WRDC)** – WRDC, located at Wright–Patterson AFB, OH, conducts and supports research, exploratory development, and advanced technology development of MCCR software.

WRDC is responsible for enhancing and integrating the technologies of the following four laboratories—Aero Propulsion Laboratory, Avionics Laboratory, Flight Dynamics Laboratory, and Materials Laboratory.

- **Aero Propulsion Laboratory** - The Aero Propulsion laboratory conducts research and development in the areas of aerospace power, air breathing propulsion, fuels and lubricants. The laboratory analyzes technology for potential Air Force Weapon Systems: advanced propulsion concepts, ducted rockets, and ramjet engines. There is also an aggressive in-house program to maintain technical expertise, verify contract findings, and exploit new opportunities.
- **Avionics Laboratory** - The Avionics laboratory conducts research and development for navigation, surveillance, reconnaissance, electronic warfare, fire control, weapon delivery, communications, systems architecture, information and signal processing and control, subsystems integration software, and electromagnetic devices. The laboratory's goal is to provide a broad technology base for future systems and ensure that these applications are implemented to satisfy Air Force aerospace needs. The Avionics laboratory works on new technological tools and other SPD to forecast technologies for future system development. Currently, the lab is employing expert systems and parallel processing as part of a research program called Advanced Digital Radar Imagery Exploration System (ADRIES).
- **Flight Dynamics Laboratory** - The Flight Dynamics laboratory is primarily responsible for developing flight vehicle technologies, i.e., flight simulators, performance analysis, configuration synthesis, and technology integration.
- **Materials Laboratory** - The Materials Laboratory conducts programs in materials, exploratory development, and manufacturing technology. Current areas of interest include computer-integrated manufacturing, robotics, smart processing, and flexible automated batch manufacturing.

2.2.2.5 Other AFSC Divisions and Offices Related to SPD

Most system demonstration and development efforts are contracted out; the Implementing Command's strategy must therefore involve request for proposal, source selection, and management. The following organizations assist with these tasks.

- **Air Force Contract Management Division (AFCMD)** - The AFCMD at Kirtland AFB, NM, is responsible for DOD contract management activities in 25 major contractor plants and other contractor facilities assigned to the Air Force. Its primary mission is to evaluate contractor performance and manage the administration of active contracts. Although the AFCMD does not appear to relate directly to SPD (since SPD is not generated specifically for AFCMD use) the division uses SPD to ensure that standardization i adequately addressed throughout the system life cycle.

- **AFPRO** – AFPRO is the on-site office assigned by the AFCMD to ensure that the contractors are meeting their obligations. Even though AFPROs are under the administrative control of the AFCMD, a Memorandum of Agreement (MOA) is often established with the SPO. AFPRO is primarily implemented at major defense contractors (e.g. Boeing, Northrop) where the Air Force has ongoing full scale development activities. The AFPRO has a broad scope of responsibilities covering all aspects of the Air Force's contracts with the contractor.

- **Operating Laboratories** – Operating laboratories are located at the contractor's site and are subdivisions of the AFPRO. The laboratories closely monitor the contractor's activities using SPD.

2.2.3 Supporting Command

The Supporting Command, usually AFLC, is primarily responsible for weapon system maintenance. There are five basic software support concepts described in AFR 800–14 that broadly cover the spectrum by incorporating varying levels of AFLC, Using and Operating Command involvements. The software concepts are:

- **AFLC Support** – AFLC has overall System Program Manager (SPM) responsibility, performs all changes, and maintains a support facility.

- **AFLC Support with User Augmentation–** The Using Command supports a defined set of parameters or data that allow it to select or control mission functions.

- **Partitioned Support–** The Using Command supports mission software, while AFLC supports system software.

- **User Support with AFLC Augmentation–** The Using Command performs all software support functions except distribution.

- **User Support–** The Using Command has the same software support responsibilities that AFLC has in the AFLC Support concept.

HQ AFLC

HQ AFLC located at Wright–Patterson AFB, OH, formulates policy and delegates authority and responsibility to other AFLC organizations. HQ AFLC issues a Program Action Directive (PAD), which describes the responsibilities of AFLC organizations for a specific program.

In most cases AFLC assumes overall management responsibility for a weapon system at PMRT. AFLC utilizes its network of five ALCs to procure, supply, transport, maintain, and repair the system to ensure weapon system combat readiness. Although AFLC is generally the Supporting Command for a weapon system it sometimes performs acquisition functions for selected modifications to weapon system software. FIGURE 2-4 illustrates the Supporting Command organizational structure.

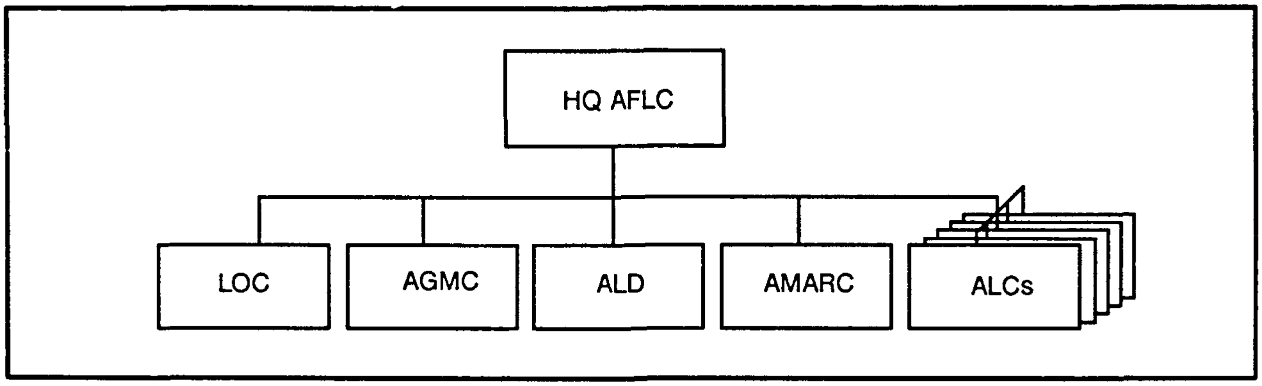


FIGURE 2-4. SUPPORTING COMMAND SPD INFRASTRUCTURE

Sections 2.2.3.1 through 2.2.3.5 discuss the responsibilities of organizations that support MCCR software.

2.2.3.1 Logistics Operations Center (LOC)

The LOC, co-located with HQ AFLC at W-P AFB, OH, monitors technical policy established by the HQ AFLC, assures readiness and supportability of weapon systems required to support USAF operational plans, ensures that all related systems, processes, and plans are oriented to sustain war plans objectives, and advocates support of program requirements in AFLC, USAF, and DOD.

2.2.3.2 Aerospace Guidance and Metrology Center (AGMC)

The AGMC, located at Newark AFB, OH, is the only center within the Air Force that provides repair and engineering services for missile and aircraft inertial guidance and navigation systems, and for certain aircraft displacement gyroscopes. The center also provides a wide scope of engineering consulting services on inertial guidance systems to the Air Force and other DOD agencies. AGMC is responsible for repairing the inertial guidance and navigation systems for various Air Force weapon systems, and, through interservice agreements, repairing inertial guidance and navigation components on systems acquired by the Navy and Army.

2.2.3.3 Acquisition Logistics Division (ALD)

The ALD, located at W-P AFB is subordinate to AFLC . ALD's MCCR responsibility is to improve Air Force readiness and to reduce life cycle costs by assuring that supportability, reliability, and maintainability are considered during the entire weapon system life cycle. The ALD provides logistics program management, engineering, and technical analysis, as well as centralized logistics expertise to AFLC and AFSC. The support ALD provides to other organizations is imperative to improving the software maintenance environment. Logistics managers require assistance from ALD to provide experienced specific software support expertise and/or supply needed or trained manpower. The ALD provides resources through the Deputy Program Manager for Logistics (DPML), who works with other SPO organizations to ensure logistics concerns are being met. In September 1989 ALD chartered a Supportable Software Acquisition Group that resulted in publication of the *Supportable Software Acquisition Guide* in October 1989. This guide contains many useful approaches relating to the acquisition of SPD.

ALD personnel are sometimes assigned to AFSC laboratories to ensure that programs in early phases of development consider logistics issues. In addition, ALD works jointly with the ASD to support the Joint Technology Insertion Program (JTIP) Office. JTIP has two activities; Productivity, Reliability, Availability and Maintainability (PRAM) and Reliability and Maintainability Technology Insertion Program (RAMTIP). PRAM invests in cost reduction projects by incorporating the latest technology into operational weapon systems and support equipment. RAMTIP invests in laboratory technologies that have not matured, making the technologies available much sooner than they would be through the normal development cycle.

2.2.3.4 Aerospace Maintenance and Regeneration Center (AMARC)

AMARC, located at Davis-Monthan AFB, AZ, is the single manager for the storage, reclamation, return to flying status, and disposition of all aircraft and specified missiles not currently required in the DOD operational inventory. The center can also preserve, store, and maintain the MCCR software systems in the aerospace vehicles, provide rapid withdrawal of parts, or return whole aircraft to flying status to meet military needs.

2.2.3.5 Air Logistics Centers (ALCs)

Five ALCs provide the majority of support functions for MCCR software post-PMRT. Each ALC has major directorates, divisions, and branches that acquire, manage, and use SPD. ALC responsibilities include depot-level maintenance and support of weapon systems and commodities, respectively. The SPMs, located at the ALCs, are responsible for managing specific weapon systems. The SPM is designated by the organization within the Air Force Supporting Command that has been assigned program management responsibility according to the HQ USAF PMD. The SPM establishes, directs, and controls the acquisition of SPD and manages the software support programs for major applications.

FIGURE 2-5 illustrates the five ALCs, and the directorates that relate to SPD within each of those ALCs.

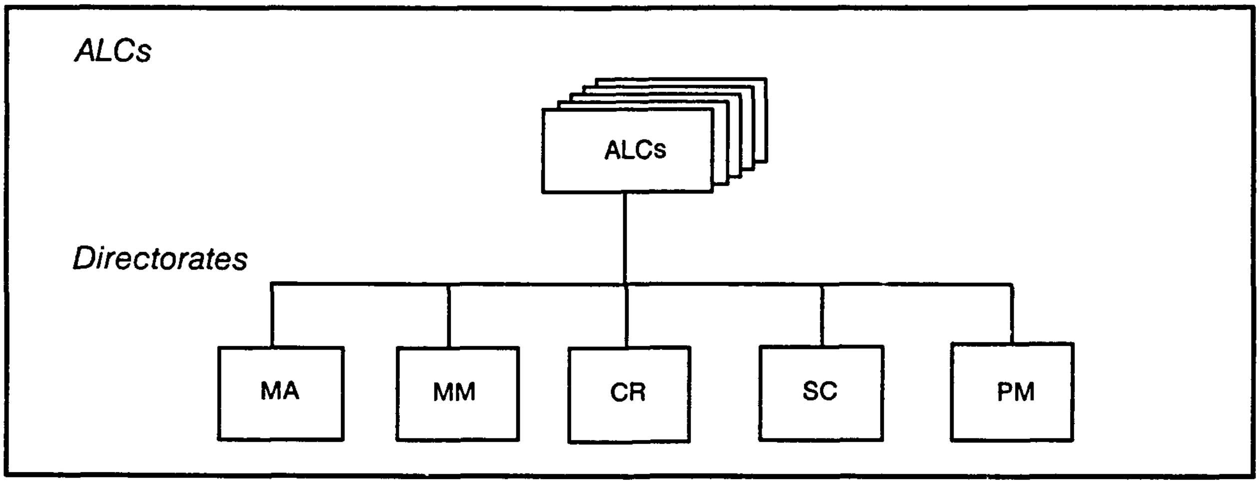


FIGURE 2-5. ALC SPD INFRASTRUCTURE

ALC DIRECTORATES, DIVISIONS AND BRANCHES

MCCR software support functions are not limited to one directorate or branch within each ALC, but are dispersed across many different directorates, branches, and divisions. Unlike hardware, the software organizational environment is structured so that organizations are aligned according to their affiliation with a specific weapon system rather than a particular function.

The PACER STRIDE initiative recently prompted a reorganization of the Directorate of Maintenance (MA) and the Directorate of Material Management (MM) at the ALCs. The initiative hopes to resolve some of the shortcomings of the original organizational structure by:

- Awarding the SPMs the necessary authority to fulfill their responsibility.
- Making the organizational structure at the different ALCs more consistent.
- Facilitating the implementation and integration of new technologies.
- Improving career development opportunities for computer engineers.
- Placing more emphasis on quality and less on time schedules.

The reorganization realigned the SPM more closely with the weapon system and its programs, and expands SPM authority, so that the SPM now has responsibility for item management of weapon system-specific items. In addition, many of the functions that were software maintenance-related were transferred from the MM directorate into the MA directorate. The responsibility to attend In-Process-Reviews (IPRs) and Critical Design Reviews (CDRs) has been typically moved from the Computer Resources Branch (MMEC) to the Software Support Division (MAS).

Even though the PACER STRIDE initiative applies to all ALCs, the organizational structures for the MM and MA directorates are not consistent across the five ALCs. For example, Warner–Robins ALC (WR–ALC) is following the PACER STRIDE initiative in functionality, but has aligned functions to organizations that differ from the other ALCs.

Responsibilities of the divisions, directorates, and branches that relate to SPD and make up the Supporting Command are described in Sections 2.2.3.5.1 through 2.2.3.5.5.

2.2.3.5.1 Directorate of Maintenance (MA)

MA is primarily responsible for management of the depot–level maintenance, production facilities, and laboratories used in the modification, local manufacturing, and repair of Air Force equipment. MA provides support to the SPM. Even though the MM Directorate, discussed in the following section, is primarily responsible for the management and support of MCCR software maintenance, MA is the Implementing Directorate for MCCR software maintenance. Many divisions and branches within MA have a significant role in the development, use, or management of SPD.

FIGURE 2-6 illustrates the most common MA infrastructure for SPD at the ALCs. The Resources Management Division (MAW), Product Division (MA_), Quality Assurance Division (MAQ) and Software Support Division (MAS) are the MA divisions that relate to MCCR software and will be discussed in this section. The Product Division symbol (MA_) varies in the third character for each different product within each ALC. The other division symbols remain constant at each ALC.

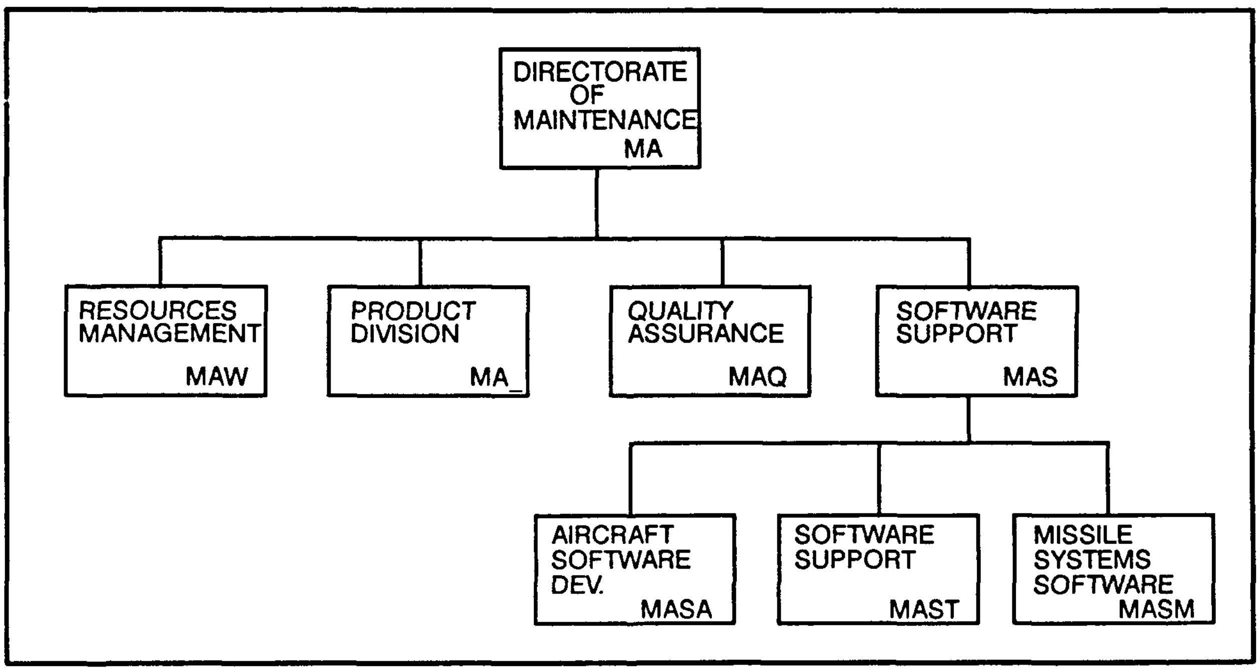


FIGURE 2-6. DIRECTORATE OF MA INFRASTRUCTURE

- MAW - MAW's primary function is to develop the directorate's policy and plans for depot-level maintenance: facilities, equipment, and skills for workloading. MAW researches and reviews engineering drawings and specifications, then works with HQ AFLC and SPM to negotiate schedules and plans and to monitor the depot-level maintenance posture and process. The division is also relevant to the SPD organizational environment because it is responsible for the acquisition of user manuals and additional related documents for MCCR weapon systems. According to AFR 800-21 for ATE software, MAW serves as the focal point for Software Support Center (SSC) responsibilities. The division maintains surveillance of the SSC workload production status, and also coordinates directives, correspondence, project studies, and requirements for ATE software.

- MA_ - The Product Division (MA_) manages the requirements, estimates source selection support, and provides technical input and logistics planning for the weapon system and end-item acquisition process. The division has many software support responsibilities. It provides on-site engineering assistance required by the production activity to identify and correct software deficiencies. The division also designs, develops, and provides new, modified test software, and updates existing avionics system software.

- MAQ - MAQ's primary function is to ensure that quality products are generated. The division supports the pre-production and operational planning phases for weapon systems, evaluating the product's integrity, participating in software verification and validation testing and reviews, and evaluating the quality of MCCR software design. MAQ verifies the configuration of MCCR software in use and determines if the system has met the defined requirements and generated the required SPD documents.

- MAS - MAS supports many MCCR software maintenance functions and provides software maintenance support to the MM directorate. Under the PACER STRIDE reorganization, MAS has been assigned additional responsibilities relating to SPD. The organizational changes under the PACER STRIDE initiatives have not been formally documented in regulations, but the ALCs have been reorganized and assigned the new responsibilities. It should be noted that WR-ALC does not have an MAS division. MAS responsibilities for the other ALCs are as follows:
    - Participate in the Preliminary Design Reviews (PDRs), Critical Design Reviews (CDRs), Computer Resources Working Group (CRWG), and other technical interchange meetings.
    - Maintain liaison with using activities to identify existing support problems.

- Develop or enhance MCCR software to correct deficiencies or provide capabilities related to systems and equipment.
- Provide Configuration Management (CM) support.
- Conduct or participate in formal verification and validation of assigned computer programs to support other Air Force agencies during weapon system acquisition.

The three branches of MAS relating to SPD are as follows:

- **Software Support Branch (MAST)** - MAST is related to SPD through its involvement in test software. The technical support capability for Unit Under Test (UUT) software is assigned by Sacramento ALC (SM-ALC), which coordinates the test software support with the MM Directorate. MAST provides centralized software engineering expertise to support the UUT SPMs requests. On request, the MAST participates in the CRWG and the production of the Computer Resources Life Cycle Management Plan (CRLCMP).
- **Aircraft Software Development Branch (MASA)** - MASA provides maintenance support for aircraft software.
- **Missile Systems Software Branch (MASM)** - MASM provides maintenance support for missile systems software.

2.2.3.5.2 Directorate of Materiel Management (MM)

MM is responsible for engineering management and development, and for controlling the design and reliability of assigned weapon systems, equipment, and modification programs. MM plays a major role in supporting MCCR software. FIGURE 2-7 illustrates the MM organizational structure.

- **Resource Management Division (MMM)** - MMM acts as the focal point for developing automation proposals and is the backup chair of the ALC Configuration Control Board (CCB), in the absence of the director or deputy director. Within the division there are branches with responsibilities related to SPD.
  - **Logistics Planning Branch (MMML)** - MMML uses and modifies planning and programming documents and is responsible for test and evaluation task planning and programming support.
  - **Maintenance Modification Branch (MMMM)** - MMMM determines the impacts on the maintenance and modification phases of logistics support by analyzing SPD (planning documents and data) for assigned items and systems.
  - **Requirements Branch (MMMR)** - MMMR ensures that the weapon system requirements are accurately identified by reviewing and revising SPD.

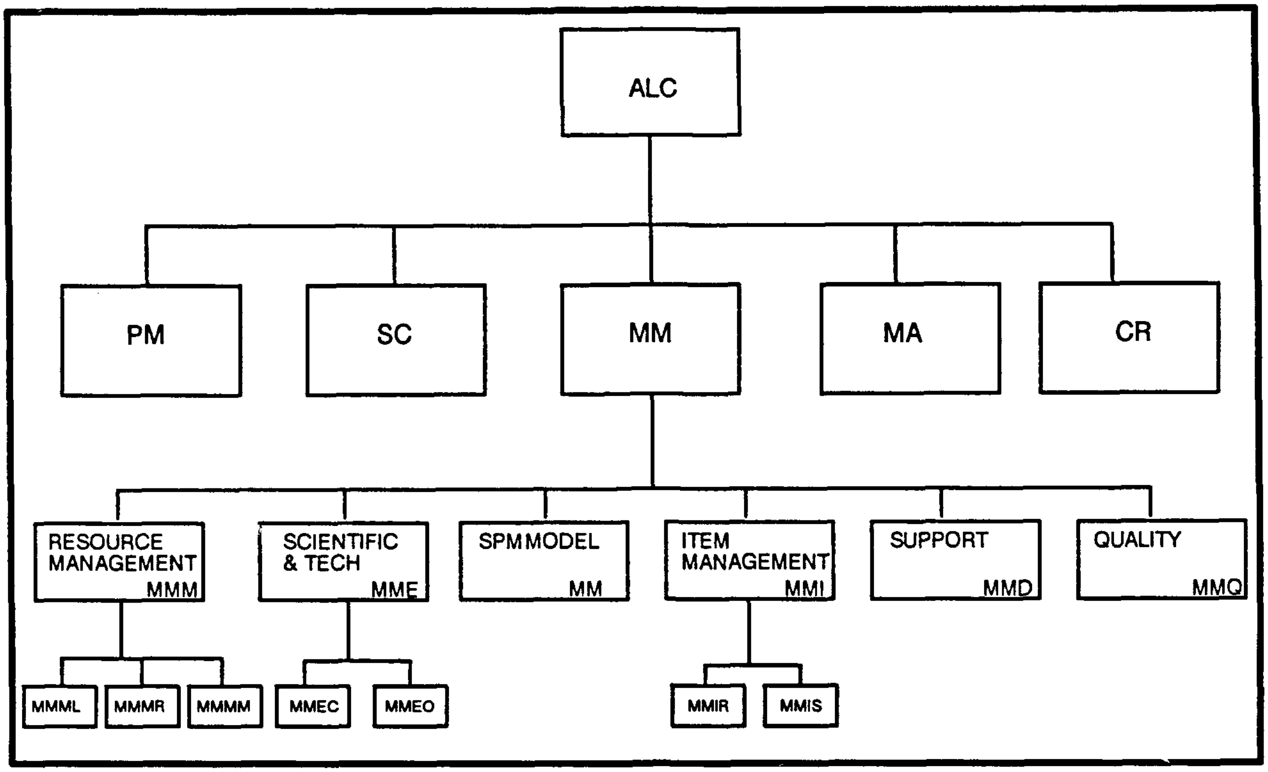


FIGURE 2-7. DIRECTORATE OF MM INFRASTRUCTURE

- **Scientific and Technical Division (MME)** – MME is the primary software engineering group. The division has a direct impact on SPD since it develops implementation procedures, makes software engineering design changes, and manages software/hardware integration support facilities. Within MME there are several branches related to SPD. However, the PACER STRIDE reorganization has recently transferred many of the responsibilities from MME to MAS.
  - **Computer Resources Branch (MMEC)** – MMEC is responsible for managing SPD. The branch ensures that support requirements are met and that technical adequacy is considered.
  - **Operations and Support Branch (MMEO)** – MMEO is responsible for supporting documentation management. Responsibilities include distribution and control of data. In addition, the branch participates in advance procurement data reviews. The Software Control Centers (SCC) resides within MMEO. The SCC is a repository (largely paper) for software documentation. It should be noted that WR–ALC does not have an MMEO branch; consequently SCC resides in the MMD division.
- **Item Management Division (MMI)** – MMI ensures that the desired performance of assigned items is maintained. The division oversees support activities to ensure that all of the different variables (i.e. software modification changes required when supporting a weapon system) are coordinated. Under the PAC-

ER STRIDE initiative MMI is responsible for item management functions related to general items, while item management functions of weapon-specific items have been transferred to the SPM.

- **Material Support Branch (MMIS)** - MMIS participates in the CRWG, which develops the CRLCMP.
- **Engineering and Reliability Branch (MMIR)** - MMIR provides engineering and technical support for assigned items to all Air Force, Air Force Reserves (AFRES) and Air National Guard (ANG) activities. Engineering and technical management responsibilities include reviewing documents to ensure maintenance concepts are up to date and determining the impact of the concepts on technical and engineering aspects of logistics support.

- **Support Division (MMD)** - MMD manages the Technical Order process. At WR-ALC, the MMD is responsible for the Software Control Center (SCC).
- **Quality Division (MMQ)** -MMQ ensures that weapon systems and end items are meeting quality and integrity standards.
- **System Management Division (MM_)** - MM_ serves as the focal point for weapon systems, and ensures that depot level maintenance capability is achieved for modified items assigned to the weapon systems. Within the MM structure resides the SPM that manages the weapon system. FIGURE 2-8 represents the SPM organizational model. Within the SPM model there are seven branches; Requirements Distribution (MM_D), Operations (MM_M), Production Management (MM_P), System Engineering (MM_R), Support Branch (MM_S), Acquisition (MM_A), and International Logisitics (MM_I). Three of the branches, MM_S, MM_A and MM_I, are optional for each SPM. MM_R, MM_D, MM_P and the Operations Branch will be discussed in more detail in this section, since they are consistent across all the ALCs and SPMs and are relevant to SPD.
  - **System Engineering Branch (MM_R)** - The primary function of MM_R is to determine requirements for MCCR software data. The branch attends design reviews and performs engineering analysis to determine requirements for modifications. MM_R performs system integration to ensure design performance and compatibility. In addition, MM_R manages the system configurations by managing and approving changes to operational flight programs and associated computer programs. They also provide engineering reviews and approve changes to computer programs. MM_R ensures that support equipment, including ATE software and test adaptors, satisfy testing requirements, provides sup-

port during OT&E, and provides configuration control over assigned systems.

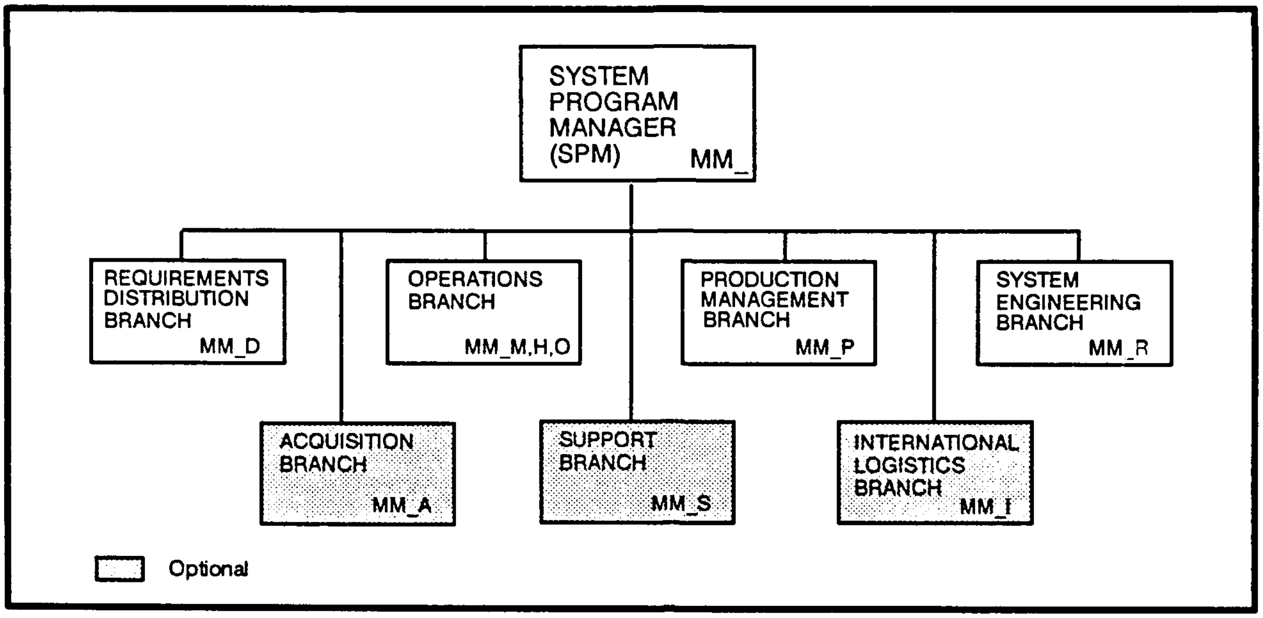


FIGURE 2-8. MODEL SPM INFRASTRUCTURE

- **Production Management Branch (MM_P)** - MM_P ensures that depot level maintenance concepts are given early consideration during the conceptual phases of system and subsystem acquisition by establishing a working relationship with the Implementing and Using Commands through the Integrated Logistics Support (ILS) directorate. The branch also reviews planning and programming documents to determine their impact on maintenance production aspects of logistics support.
- **Requirements and Distribution Branch (MM_D)** - MM_D institutes the Procurement Request (PR) and ensures that approved SPD is included. It also supports item management functions by acquiring and maintaining material inventory in support of spares, reprocurements and modifications.
- **Operations Branch (MM_M,H,O)** - The Operations Branch is responsible for ensuring that the weapon system and assigned end items maintain desired operational requirements and expectations.

2.2.3.5.3 Directorate of Competition Advocacy (CR)

CR ensures that there is increased competition and adequate requisition procedures to enhance the operational capability of weapon systems. The directorate reviews the Justification and Approval (J&A) and the Statement of Work (SOW) of proposed MCCR software acquisition and support contracts. Currently, few software modification contracts are issued competitively, requiring minimal CR involvement. This is due to Air Force reliance on the original developing contractors' knowledge of the software to perform the modification more quickly and effectively and also to the Air Force's not having procured SPD. This offsets, to some degree, the cost savings from competition.

2.2.3.5.4 Directorate of Communications - Computer Systems (SC)

SC is responsible for acquiring and controlling computer resources and technology throughout the ALCs. The functions relating to MCCR software appear to be limited due to SC's focus on Information Systems (IS). The directorate is concerned with systems that are developed for the managing SPD, i.e. digitizing data and operating CASE tools, and should therefore be considered a relevant part of the SPD organizational environment.

2.2.3.5.5 Directorate of Contracting and Manufacturing (PM)

PM covers all aspects of acquisition. The directorate's responsibilities include evaluating potential firms for contract awards, ensuring timely delivery of quality supplies, and making final payment for goods and services delivered.

2.2.4 Using Commands

The Using Commands are the Air Force commands that assume full operational responsibility for the weapon system after turnover to the Supporting Command. According to the relevant regulations and directives, AFLC is primarily responsible for software support that can be shared with or delegated to the Using Command. Even though documentation supports the trend that the Using Command is beginning to provide total or partial support for OFP, EW, and C-E programs within Military Airlift Command (MAC), Tactical Air Command (TAC) and Strategic Air Command (SAC), it was verified that these MAJCOMs are primarily supporting changes to mission software. The one exception is AFSPACECOM; the command is providing major software maintenance, and in addition is now beginning to take on the acquisition and development functions of weapon systems software. FIGURE 2-9 illustrates the model Using Command SPD infrastructure.

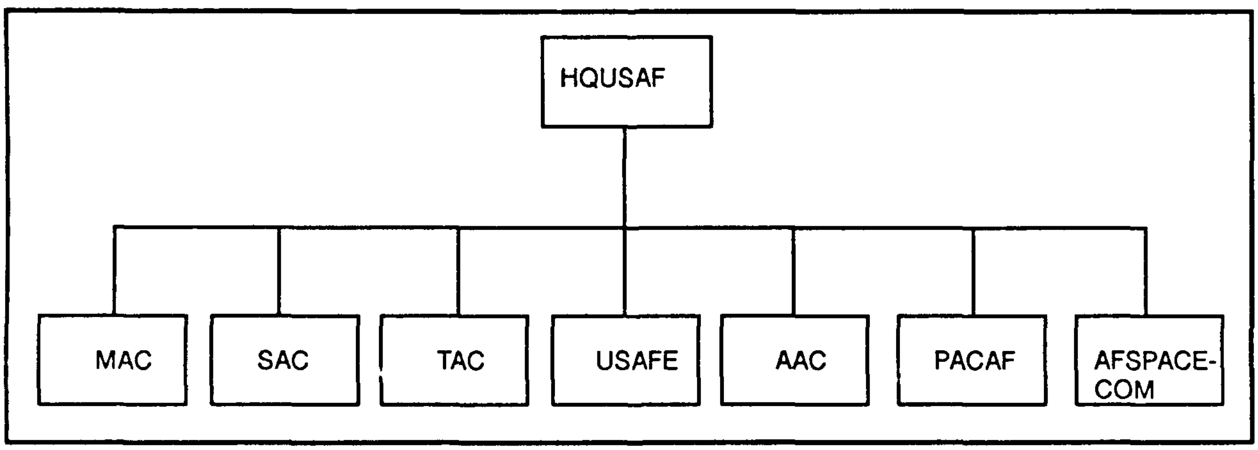


FIGURE 2-9. USING COMMAND SPD INFRASTRUCTURE

Before describing the SPD roles and responsibilities of the Using Commands the software maintenance role needs to be qualified. This is accomplished by defining two types of MCCR software: Mission Software (user-oriented) and Systems Software (hardware-oriented). In addition, a model ot the organizational structure of MAC, TAC and SAC will be discussed in detail.

SOFTWARE SUPPORT CATEGORIES

The software categories are defined in AFR 800-14 as follows:

- **Mission Software** - Designed to perform user-oriented tasks. The software implements tactics, operational concepts and operational procedures. Changes to the system's operational mission, tactics, or user procedures often require corresponding changes to mission software.
- **System Software** - Allocates, controls, monitors and supports the system's hardware resources (historically hardware tasks). System software includes operating system functions (including special purpose hardware device drivers), utilities, and generic applications such as Database Management Systems (DBMS). The System software manages external interfaces to pass information originating in mission software. System software translates mission software requests into system and hardware functions. It provides system data into mission software for processing. Software that is not specifically mission software can be defined as system software.

The Using Command focuses on mission software maintenance, with the exception of AFSPACECOM, which is also involved in the PDSS development and maintenance of both MCCR mission and system software.

ORGANIZATIONAL STRUCTURE

This section will focus on Using Commands. The organizational structure of the Using Commands are very similar. There are four divisions relating to SPD: Requirements (XR), Logistics (LG), Communication Computers (SC), and Operations (DO). Even though these divisions are in place in MAC, SAC, and TAC, the functions they perform are not consistent across all three MAJCOMS. Maintenance responsibilities for MCCR software are dispersed across several divisions and are often aligned with the weapon system. In addition, within the Using Commands there are reorganizations occurring whereby SPD-related functions are transferred from one division to another, i.e., at MAC SC responsibilities are being transferred to XR. FIGURE 2-10 is a model of the SPD organizational structure within the Using Commands.

MAC, TAC, and SAC coordinate mission changes for MCCR software with the ALCs. When major modifications are required, software maintenance is managed solely by the ALC. Using Command personnel revealed that MAC, TAC and SAC are not consistent in software maintenance functions. Even though it is documented that the current trend is to have the

Using Command maintain software, personnel did not indicate that anything more than mission software changes were performed. Extensive MCCR software modifications are still managed by the ALCs, rather than MAC, TAC and SAC.

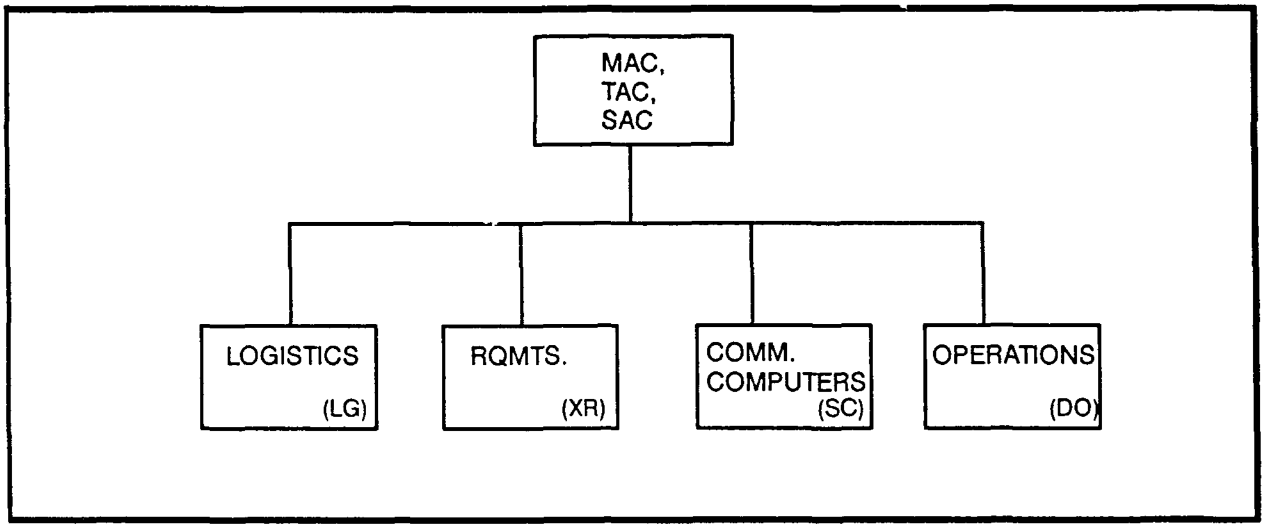


FIGURE 2-10. MODEL INFRASTRUCTURE FOR MAC, TAC, AND SAC

The software maintenance role of the divisions within the Using Commands are as follows. The Logistics Division (LG) performs maintenance planning. The Requirements Division (XR) acquires the weapon system and defines requirements for the software. The Operations Division (DO) operates and sometimes performs maintenance on the mission software. The Communications and Computer Division (SC) focuses on IS software, but in some instances, performs maintenance on MCCR software. The task of performing maintenance within the DO is characteristic of the SPD environment within the Using Command. The functions are aligned to an organization due to its affiliation with a weapon system rather than a particular function.

In most cases, the Using Commands are not responsible for changing the source code; instead they define the requirements, make maintenance plans, and install the changes for mission software.

Sections 2.2.4.1 through 2.2.4.7 discuss SPD roles and responsibilities of the Using Commands in more detail.

2.2.4.1 Strategic Air Command (SAC)

SAC has been designated both a specified Command and a Single Service Command under the strategic direction of the President and Secretary of Defense. SAC has responsibility for strategic aerospace combat and must provide nuclear capability strong enough to deter an attack on the United States or its allies. The Command's task is to support worldwide conventional power projection with its bombers and missiles. HQ SAC is located at Offutt AFB, NB. SAC is playing an increasing role in maintaining, developing, and acquiring software systems, and in training the personnel who use the weapon systems. The LG, XR, DO, and SC directorates provide software support.

The SC organization within SAC maintains some MCCR software. AFCC personnel are matrixed to SAC's SC organization to provide MCCR software maintenance resources. For example, within SAC's SC organization is the Space and Satellite Division (SCZ), which supports Air Force satellite programs. SC's primary responsibility is to operate the system; while the Product Division, contractors or ALCs coordinate MCCR software maintenance. The division may perform minor mission changes to the satellite systems.

The LG Division performs software maintenance functions for mission software and installs the changes for MCCR software; XR defines requirements for maintenance and acquisitions and DO operates the system and sometimes performs maintenance functions. The AFLC provides CM, and is focal to the software maintenance functions.

2.2.4.2 Military Airlift Command (MAC)

HQ MAC is located at Scott AFB, IL. MAC's mission is to maintain the military airlift system in a constant state of readiness. A major effort of MAC that demands MCCR support requirements is the C-17. MAC is performing some mission changes to the C-17 NAV/COM system.

Within MAC four organizations: SC, XR, LG and DO support MCCR software. Activities range from providing plans and guidance, to down-loading data bases. The level of maintenance performed at MAC is primarily low-level for mission software. Between MAC, SAC, and TAC, MAC maintains the least amount of MCCR software. The command recently was reorganized; many resources and functions previously assigned to SC have been moved under the XR Division. The SC is primarily providing IS support whereas the DO, XR and LG Divisions are providing MCCR software support. MAC's support of MCCR software is not focused to one organization but is dispersed across the entire Using Command and is aligned with the various weapon systems.

2.2.4.3 Tactical Air Command (TAC)

TAC's mission is to train, equip, and maintain combat-ready forces capable of rapid deployment and employment. TAC's forces are organized under three numbered air forces and through major direct reporting units. HQ TAC is located at Langley AFB, VA. TAC's 1st Air Force manages the USAF Air Defense Weapon Center, which provides specialized air defense weapons training and tactics development for air weapon controllers, and performs operational test and evaluation of strategic air defense systems. TAC also supports the Pacific and European command's exercises and operations. TAC's role is relevant to SPD because it must utilize SPD to carry out its mission to perform tactical fighter, reconnaissance, command, and control, and electronic combat operations during worldwide contingencies; and because of its relevant role in combat training. TAC has a similar organizational structure to SAC and MAC. The XR, LG, DO and SC organizations make up TAC's SPD organizational environment.

An example of a TAC MCCR software maintenance program exists within the LG division. The Air Force Engineering and Technical Services (AFETS) program maintains a worldwide program for TAC, PACAF, AAC and USAFE and resides within LG. AFET's software maintenance role and environment is summarized below:

- AFETS is responsible for the development, monitoring, and implementation of maintenance support programs for mission changes to OFP software.
- AFETS does not currently have access to source code and other relevant documentation. It also does not have any of the equipment to provide full maintenance support, and there are no initiatives to provide any in the future.
- The ALC is still very much involved in any software maintenance performed by TAC.

TAC does provide support to mission software. The F-16 training device in one example. Originally, the training devices were designed as a generic software package. TAC's responsibility is to customize the software package by "patching" the software. The ALC manages the overall configuration of the system and the changes to the software code; TAC coordinates these changes with the ALC.

2.2.4.4 Air Force Space Command (AFSPACECOM)

AFSPACECOM, headquartered at Peterson AFB, CO, is responsible for organizing, training, equipping and operating forces in support of strategic aerospace defense, space control and operations. As part of its mission AFSPACECOM is very involved with developing and maintaining MCCR software. Unlike TAC, MAC and SAC their organization is not supported by AFCC. The Space and Warning Systems Center (SWSC) is a unit within AFSPACECOM, responsible for the maintenance, modification, and selected development of the software intensive command and control systems that are utilized by North American Aerospace Defense Command (NORAD) and AFSPACECOM.

The AFSPACECOM supports mainly OFP systems. The software modification performed by AFSPACECOM impacts approximately three to six percent of the code for stable systems and up to ten percent on less stable systems. AFSPACECOM is maintaining approximately thirty million lines of code and is planning to maintain an additional thirty million lines of code.

2.2.4.5 Pacific Air Forces (PACAF)

PACAF plans, conducts, and coordinates offensive and defensive air operations in an area extending from the west coast of the Americas to the East Coast of Africa and from the Arctic to the Antarctic. HQ PACAF is located at Hickam AFB, HI. Introduction of newer weapon systems will maximize the effectiveness of PACAF's widely dispersed forces.

2.2.4.6 United States Air Forces in Europe (USAFE)

USAFE, headquartered at Ramstein AB, West Germany, is the air component of the U.S. European Commands. The USAFE executes its mission with the support of such weapon systems as the F-16 C/D, F-15s, F-111As, and F-111F. However, like PACAF and AAC USAFE is supported by other MAJCOM software maintenance programs, i.e AFETS.

2.2.4.7 Alaskan Air Command (AAC)

AAC, headquartered at Elmendorf AFB, Alaska, provides, trains, and equips a tactical Air Force to protect the United States. The importance of Alaskan-based forces is apparent, given their strategic location in relation to potential enemies as well as allies. The AAC Commander also serves as Commander for the Alaskan NORAD region. AAC primarily carries out its function of being an Operational Command. The AAC is supported by TAC's AFETS program.

2.2.5 Other Commands, Centers, Agencies and Working Groups

There are other Air Force agencies, commands and working groups who have responsibilities for weapon systems and MCCR. These agencies, commands, and working groups are described in Sections 2.2.5.1 through 2.2.5.10.

2.2.5.1 Air Training Command (ATC)

ATC, headquartered at Randolph AFB, TX, is dedicated to cost-effective, mission-oriented flight training. The latest advances in technology are being implemented by ATC using Computer-Assisted Instruction (CAI) and Advance Training Systems. The training is mission-specific with pilot training tailored to operational aircraft. ATC provides formal training for software maintenance personnel, operations, and computer courses in software languages. MCCR training functions are dispersed across different divisions within the Command. In most cases, weapon system training is provided by the contractor who developed the system. However, at times ATC is tasked to provide formal training for the personnel who will be operating and maintaining MCCR software.

2.2.5.2 Air Force Communications Command (AFCC)

AFCC, headquartered at Scott AFB, IL, is responsible for the acquisition, engineering, installation, operation and maintenance of telephone systems, base communication centers, computer facilities, radio and satellite stations, and air traffic control. AFCC is also responsible for improving software development and acquisition procedures. Virtually every space system relies on software; AFCC provides support for these space systems. The AFCC's Standard Systems Center (SSC) at Gunter AFB, AL, is a model standard systems software acquisition agent and life-cycle manager. The center maintains and develops software under the AFR 700 and AFR 800 series. However, the programs that are developed within the SSC, under DOD-STD-2167A, are not embedded computer systems but information systems.

2.2.5.3 Electronic Security Command (ESC)

ESC, headquartered at Kelly AFB, TX, provides electronic combat support and operations security support to Air Force units. The Command provides technical assistance to the development of Air Force EW and Command, Control, and Communications-Countermeasures (C^3CM) systems. ESC functions as a consultant for operators and acquisition commands; it does not modify or develop software but analyzes systems to advise operators and acquisition personnel on modifications or acquisitions that they should make. An example of a current ESC effort is called "EW flagging". The EW flagging system determines the systems performance and how the operator should respond to its performance. ESC is required to have access to the EW system's SPD to provide the required expertise.

2.2.5.4 Air Force Operational Test and Evaluation Center (AFOTEC)

AFOTEC is located at Kirtland AFB, NM, with an additional five detachments at Eglin AFB, FL; Nellis AFB, NV; Edwards AFB, CA; Colorado Springs, CO; and Kapaun Barracks West Germany. AFOTEC is designated a separate operating agency and is responsible for managing the operational testing of all major systems being developed and acquired by the Air Force. Its primary purpose is to reduce risk in the acquisition process by evaluating system performance in a realistic environment. AFOTEC assigns test teams to designated sites to collect, analyze, and evaluate the data; and to prepare formal reports. The center provides operational test and evaluation data to the Chief of Staff, Secretary of the Air Force, and the Secretary of Defense for use in making system acquisition decisions. The center also recommends implementation, test, and evaluation policy; monitors major commands when they conduct tests, and evaluates processes for MCCR software being acquired or developed. AFOTEC activities cover the spectrum of Air Force missions. Most of the personnel in the AFOTEC test teams are from the Major Commands. These personnel provide current operational experience to ensure that the evaluation reflect the needs of the system users.

2.2.5.5 Computer Resources Working Group (CRWG)

The CRWG is established for each weapon system program during early acquisition and ensures intercommand involvement. The group includes representatives from all commands. One of the primary responsibilities of the CRWG is to update the CRLCMP. This plan identifies the organizational relationships and responsibilities for management and technical personnel and for support of all MCCR for any program. CRWG chairmanship changes at PMRT, switching from the SPO or SPO personnel to the Supporting Command SPM.

2.2.5.6 Configuration Control Board (CCB)

The CCB has primary responsibility and authority for the overall configuration management of each system. In situations where the software support is split among Commands, the CCB controls the interfaces between mission and system software, and is responsible for overall system integrity. The CCB is chaired by the SPO in AFSC prior to PMRT and at PMRT is chaired by the SPM.

2.2.5.7 Software Configuration Control Sub-Board (SCCSB)

The SCCSBs are established to maintain CSCIs within the weapon system. Their responsibilities are the same as the CCB, except that they maintain individual CSCIs or groups of CSCIs, as opposed to the overall system. The SCCSB, as well as the CCB, depends largely on SPD to maintain systems integrity, through strong configuration management.

2.2.5.8 Air University (AU)

AU Headquarters is located at Maxwell AFB, AL. AU is responsible for providing professional military education and degree-granting programs for continuing education. The Air Force Institute of Technology (AFIT) located at Wright Patterson AFB, OH is an AU school that teaches a course in MCCR software management. The course is entitled "Mission Critical Computer Software Management" and is taught in the school of Systems and Logistics as part of the Department of Systems Acquisition Management curriculum. AU offers many related graduate courses in many facets of software management (i.e software cost estimation and software project management).

2.2.5.9 Air Force Reserves (AFRES)

AFRES is a separate operating agency that provides trained units and qualified personnel for active duty in times of emergency and supports the Air Force mission requirements as a by-product of training for peacetime missions. A larger portion of the Air Force's total airlift capability is provided by AFRES units and their crews.

2.2.5.10 Air National Guard (ANG)

The ANG federal mission is to provide units of equipped and trained personnel for prompt mobilization. ANG units are assigned to ten Major Commands of the Air Force: AFCC, AFSC, ESC, MAC, PACAF, TAC, SAC, AAC, ATC, and USAFE. All these Commands use or contribute to the development or maintenance of MCCR weapon systems.

2.3 VARIABLES THAT AFFECT THE ORGANIZATIONAL ENVIRONMENT

There are two variables affecting the organizational environment: the MCCR software category and the software life cycle functions.

2.3.1 MCCR Software Categories

The first variable affecting the organizational environment is the MCCR software category. The scope of the SPD study is defined in terms of the MCCR software categories that were originally defined in AFLCR-800-21. There are nine software categories within the MCCR umbrella, five of the nine are included in this study: OFP, EW, C-E, ATD, and ATE. These software categories are defined in TABLE 2-1.

TABLE 2-1. DEFINITION OF MCCR SOFTWARE CATEGORIES

OPERATIONAL FLIGHT PROGRAM (OFP)

The software used to execute in-flight computers and perform functions integral to the airborne system. This software support is the responsibility of the SPM.

ELECTRONIC WARFARE (EW)

The software used to execute computers for weapon systems that use electromagnetic energy.

COMMUNICATION - ELECTRONICS (C-E)

The software used to support command, control, and communications functions; to provide surveillance and warning to Air Traffic Control; and to provide meteorological support.

AIRCREW TRAINING DEVICES (ATD)

Software used to execute trainer computers; these simulate mission training functions to support primary weapon systems.

AUTOMATIC TEST EQUIPMENT (ATE)

Software used to test missile or aircraft units and to execute and maintain test programs.

Matrix analysis is used to represent the different organizations that participate in developing and acquiring the different categories of software. There are four matrices:

- ALC responsibility by MCCR software category,
- ALC responsibility by End Items and Weapon Systems,
- Maintenance support level by ALC and MCCR software category, and
- Product Division responsibility by MCCR software category.

The MCCR software categories, listed in TABLE 2-1 impact the SPD organizational support environment. Each weapon system establishes a CRLCMP that dictates which organizations have support responsibilities. In addition, a support facility is established at each ALC responsible for the weapon system or end item. Even though these two factors (CRLCMP and a support facility) should remain constant for every category of weapon system, the organizations involved in acquiring or supporting the weapon system's MCCR software category may differ.

The impact of MCCR software category on the SPD Organizational environment can be analyzed for maintenance support. There are four types of maintenance support for weapon systems software: modifying, corrective, adaptive, and perfective. TABLE 2-2 defines these support types and estimates the percentage of support provided by the five ALCs.

TABLE 2-2. TYPES AND PERCENT OF MAINTENANCE SUPPORT AT ALC

TYPES OF SUPPORT	PERCENT OF SUPPORT*
Modifying Performed to incorporate approved new or modified mission requirements	40%
Corrective Performed to identify and correct software, performance and implementation failures.	17%
Adaptive Performed to adapt software to system changes in the data requirements or the hardware/software technology base.	26%
Perfective Performed to enhance performance, improve cost effectiveness, improve processing efficiency, or improve maintainability.	17%

* Source: Software Workshop conducted by Project Bold Stroke, 8/89

ALC RESPONSIBILITY BY MCCR SOFTWARE CATEGORY

To clarify software support responsibilities the following matrices divide the MCCR software into the five SPD categories: OFP, EW, C–E, ATD and ATE. Not all organizations support all five categories. The ALCs that are responsible for providing maintenance support for each category of software are listed in TABLE 2-3. The rows represent the five MCCR software categories; the columns represent the five ALCs within AFLC that are responsible for providing maintenance support for MCCR software category. The intersecting cells are blank or are marked with an "◆" to indicate that the ALC maintains the MCCR software category. Decisions for which ALC will support a weapon system are made on a case by case basis.

TABLE 2-3. ALC RESPONSIBILITY: BY MCCR SOFTWARE CATEGORY

MCCR Category \ ALC	OO-ALC	OC-ALC	SA-ALC	SM-ALC	WR-ALC
OFP	◆	◆	◆	◆	◆
EW	◆			◆	◆
C-E	◆	◆		◆	◆
ATD	◆				◆
ATE	◆	◆	◆	◆	◆

ALCs have established expertise in specific MCCR categories and therefore weapon systems are assigned to ALCs that have experience in the MCCR category. Currently, all ALCs support OFP and ATE software. ATE software, according to the RAND study, requires more personnel resources than any other category of software. The majority of C-E software is supported at OO-ALC, OC-ALC and WR-ALC. However, the Using Command sometimes share the software support responsibilities in that category. EW software is supported by three of the ALCs: OO-ALC, WR-ALC (supports airborne software), and SM-ALC (supports ground-based software). ATD software is primarily supported by contractor personnel however, OO-ALC has Item Manager (IM) responsibility for ATD software and has some approval authority for software changes performed at the operational facilities by the contractors. WR-ALC also provides support for ATD software.

TABLE 2-3 is a general view matching ALC support with each MCCR category of software. In contrast, TABLE 2-4 is more specific in that it identifies the specific weapon system and end items within each category of MCCR software that are supported at the ALCs. The data included in the matrix is generated from previous studies (i.e PDD *Current Environment Report*, Ferens and RAND) and also from ALC site visits. The matrix gives an overall perspective on the weapon systems and end items (broken down by MCCR software category) that each ALC must support. The rows represent the five MCCR software categories; the columns represent the five ALCs. The row column intersecting cells identify the weapon systems or end items supported.

FIGURE 2-11 further demonstrates the impact of the MCCR software category on maintenance support across all ALCs. Maintenance support includes all four types of support: Modifying, Adaptive, Corrective, and Perfective. The 3-D perspective is significant because it allows one to examine simultaneously three factors: ALC, level of maintenance support, and

TABLE 2-4. ALC RESPONSIBILITY BY END ITEMS AND WEAPON SYSTEMS

MCCR CATEGORY \ ALC		OO-ALC	OC-ALC	SA-ALC	SM-ALC	WR-ALC
OFP	Operational Flight Program	MINUTEMAN, TITAN II, PEACEKEEPER, F-16, RF-4C, F-4, RF-4E, AMMO	A-7DK, ALCM, SRAM, GLCM, B-52, E-4B, Navigation Systems, E-4A, Flight Control Systems	C-17, F-5, F-5E, C-130, T-38, C-5, OU-10, Engine and related Components	F-111D, FB-111, F-111F, FB-111A, A-10, A-7, Flight Control Instruments	Target Acquisition Systems: F-15, EAR, PAVE TACK, HAST, HARM, AMRAAM, CMMR, JTIDS
EW	Electronic Warfare Software	AMMO			Electronic Equipment: AN/MST-T1A (GROUND BASED), MRS-T1	Airborne EW Equipment, Lantirn, navigational equip.: ALR-46, ALQ-131, ALQ-165, ALR-69, (AIRBORNE), ALQ-155
C-E	Comm Electronic Software	Reconnaissance Equip., TIPI	E-3, E-4		Ground CE Equipment: CWCE, FPS-117, CMC	Airborne Ground Comm.: JTIDS, GPS, MILSTAR TERMINAL
ATD	Aircrew Training Devices	Aerospace Training Equip.				FSG-70
ATE	Automatic Test Equipment	ANY OFP SOFTWARE THAT REQUIRES TEST SOFTWARE				

software category. The graph quantitatively demonstrates the distribution of maintenance support for MCCR software categories across the SPD ALC environment. It also illustrates the percentage of support provided by the individual ALC for each software category. ATE and OFP MCCR software categories are supported by all ALCs and require the most maintenance support.

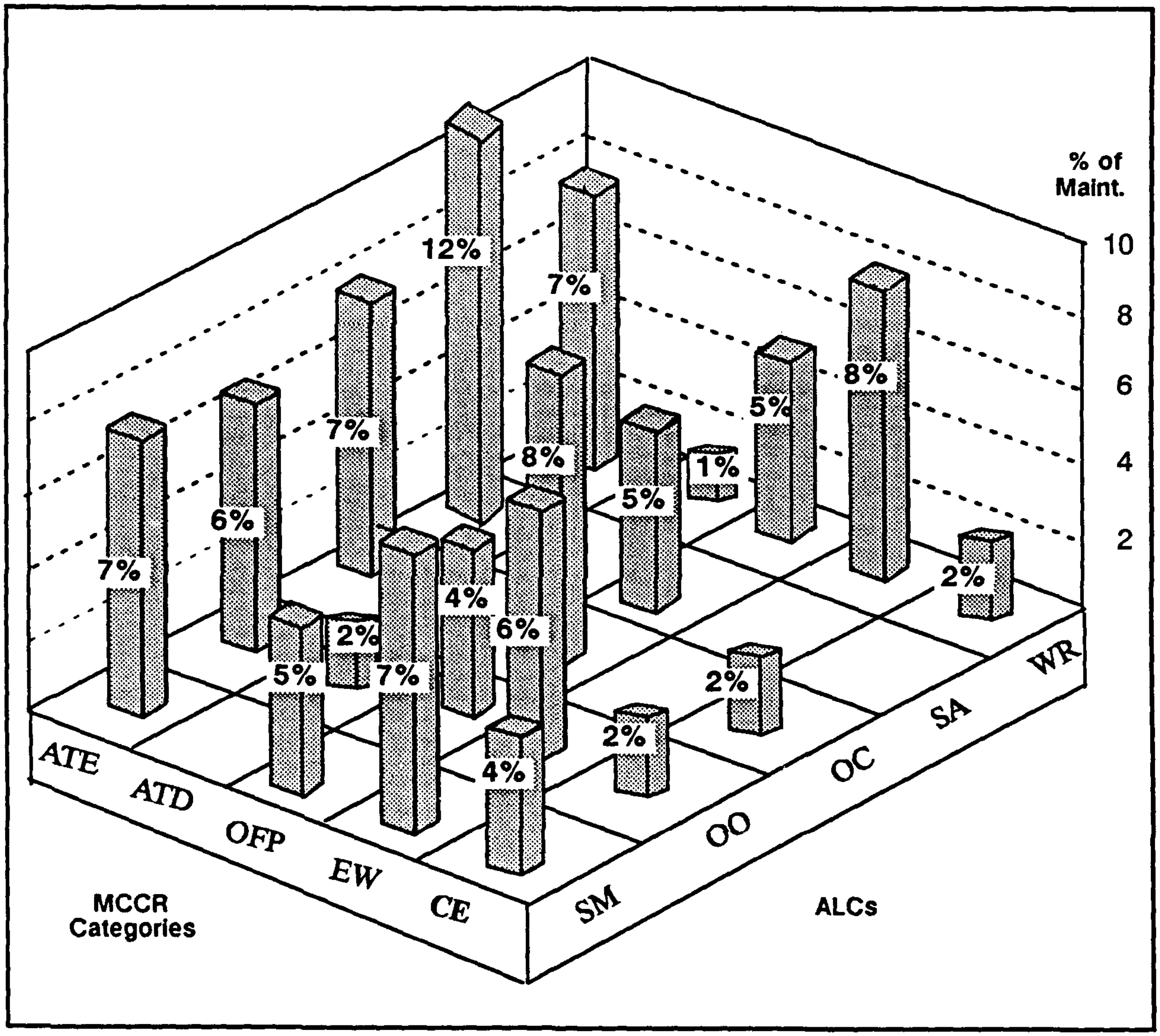


FIGURE 2-11. LEVEL OF MAINTENANCE SUPPORT PROVIDED BY ALCs: BY MCCR CATEGORY

PRODUCT DIVISIONS BY MCCR SOFTWARE CATEGORY

Matrix analysis is used to represent the different organizations that participate in developing and acquiring the different categories of software. In TABLE 2-5 the rows represent the five MCCR software categories; the columns represent the six Product Divisions, within the

AFSC that are responsible for implementing MCCR software. The intersecting cells marked with an "◆ " indicate that the Product Division acquires the MCCR software category.

TABLE 2-5. DEVELOPMENT AND ACQUISITION OF MCCR SOFTWARE: BY PRODUCT DIVISION

MCCR Category \ Product Div.	ASD	MSD	BSD	ESD	SSD	HSD
OFP	◆	◆	◆		◆	◆
EW	◆	◆		◆	◆	◆
C-E	◆	◆	◆	◆	◆	
ATD	◆			◆		◆
ATE	◆	◆	◆	◆	◆	

2.3.1.1 Life Cycle Function

A second variable that impacts the SPD organizational environment is the system software life cycle process. Often more than one organization is responsible for each function throughout the software life cycle. The life cycle functions (summarized in Section 3: IDEF Diagrams, and described in more detail in Appendix B) are cross referenced with the organizations that perform each function. TABLE 2-6 illustrates the organizations that are included in the IDEFs. The rows represent the organizations that are involved in carrying out the life-cycle function. The columns represent the life-cycle functions performed. The intersecting cells marked with an "◆ " indicate that the respective organization performs the function. The organizations and functions are consistent with those depicted in the IDEFs.

2.4 Conclusions

An understanding of the responsibilities of the Air Force organizations is essential to understand the MCCR software life cycle and the SPD environment. The organizational assessment determined that the ALC Materiel Management (MM) and Maintenance (MA) Directorates are the major users of SPD, but that the Using Commands also use SPD to support software maintenance and modifications. The assignment also determined that the AFSC Product Division/SPO is responsible for most SPD acquisition and reviews.

TABLE 2-6. ORGANIZATIONS VERSUS FUNCTIONS

LIFE CYCLE FUNCTIONS / ORGS	ACQUIRE																				DEPLOY / MANAGE										
	Concept Exploration				Demo/ Validation				Full – Scale Development							Production					Deploy					Manage					
	Engineering Studies	Concept Devel.	Prelim. Plan Docs	Select Concept	Engineering Studies	Expedite Support Funct.	Devel. Prototype	System Reqmts	Reqmts Analysis	Spec Review	Prelim. Design	Detail Design	Code & Test	Quality Evaluation	Audit	OT & E	Certification	Distribute CSDI	Main Field Sys	Execute PMRT	Turnover	Accept	Train	Deploy	Feedback	PMRT	CM	Sftwr Supp Conc (SSC)	SSC Chng Process	SSC Sftwr Devel.	Certif SSC
SPO	◆		◆	◆		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆						◆	◆				
CONTRACTOR	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		◆	◆									◆	◆		◆	
CRWG			◆			◆		◆				◆																			
DPML			◆	◆						◆	◆	◆			◆	◆	◆											◆			
SPM	◆		◆					◆	◆	◆	◆	◆	◆	◆	◆	◆	◆			◆						◆		◆			
SCC																															◆
MA																												◆			
CCB																											◆				
SCCB																											◆	◆	◆		◆
F [illegible]RTWG																				◆	◆					◆					
MAJCOMS	◆	◆	◆	◆				◆	◆	◆	◆	◆				◆	◆			◆	◆	◆	◆	◆	◆			◆			◆
AFOTEC													◆			◆															◆

Examination of the current SPD organizational environment further revealed:

- AFLC assumes management responsibility for weapon system software midway through the life cycle, at PMRT. The software modification role performed by AFLC is a function that requires a full life cycle perspective. A large software modification usually undergoes requirements analysis, design, development, test and installation; in other words, virtually a full life cycle, just like the original software development.
- The software functions of the Product Divisions and ALCs vary, according to the categories of MCCR software for which they are responsible. Some Product Divisions develop specific MCCR software categories, whereas some ALCs support specific MCCR software categories. In addition, the software category seems to dictate the amount of maintenance support required. Based on FIGURE 2-11, ATE and OFP software categories require the most ALC support.
- PACER STRIDE redefined the roles of software maintenance within the ALCs. Although the changes are not yet documented in regulations, most of the maintenance responsibilities previously tasked to MM have been transferred to MA.
- Organizations that are most involved with SPD management at the ALCs include the Operations and Support Branch (MMEO) and the Software Support Division (MAS) or their equivalents.
- The five support concepts outlined in AFR 800–14 identify the lead and support roles when more than one Command is maintaining the software. The current trend is for Using Commands to have increased maintenance responsibilities for selected MCCR mission software.
- Many intercommand organizations and working groups are formed during the software life cycle process, so that there is a clear understanding of the development, test, and support requirements and responsibilities. Examples of intercommand organizations are CCB, SCCSB, and CRWG.

SECTION 3: IDEF DIAGRAMS

3.1 IDEF IN PERSPECTIVE

IDEF was created by the USAF Integrated Computer-Aided Manufacturing (ICAM) program. IDEF originated in the 1970s with a methodology known as Structured Analysis & Design Technique (SADT). IDEF added features turned the SADT methodology into a standard language that describes the decisions, actions, and activities that make up complex organizational environments.

IDEF is required on DOD manufacturing programs. It is the standard approach for defining and understanding systems requirements.

3.2 UNDERSTANDING IDEF

IDEF is a structured methodology that uses rules for functional modeling and decomposition. The IDEF diagram uses boxes to represent functions, operations or activities. Input arrows allow each activity to be analyzed in terms of Inputs, Controls, Outputs and Mechanisms (ICOMs) and interrelationships among activities. The term IDEF is an acronym for "I"CAM "DEF"inition. The ICOMs indicate the constraints on an activity and the information and materials that are used in or produced by the activity (see FIGURE 3-1). The process name appears in each box. Information flow between activities is represented by arrows that interconnect the activity boxes.

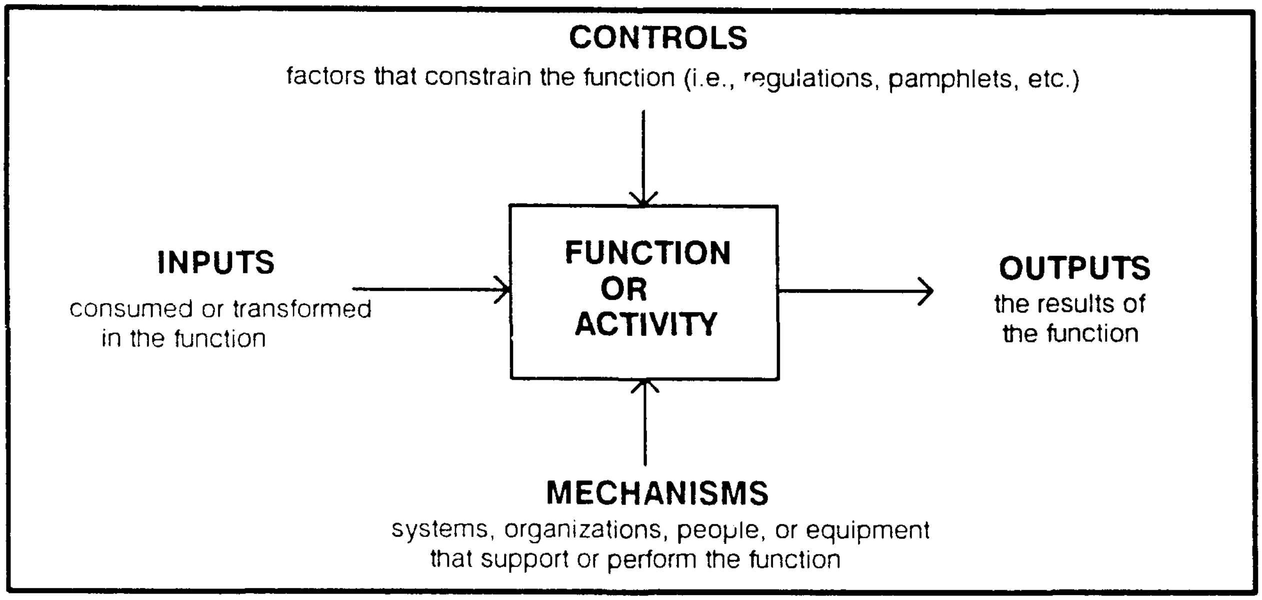


FIGURE 3-1. IDEF METHODOLOGY APPROACH

IDEF models work on a hierarchical structure in which functions are decomposed into sub-functions; each of those sub-functions is broken down into its respective sub-functions.

This decomposition continues until the needed level of detail is reached. FIGURE 3-2 uses the IDEF model structure to illustrate a series of four diagrams and their interrelationships.

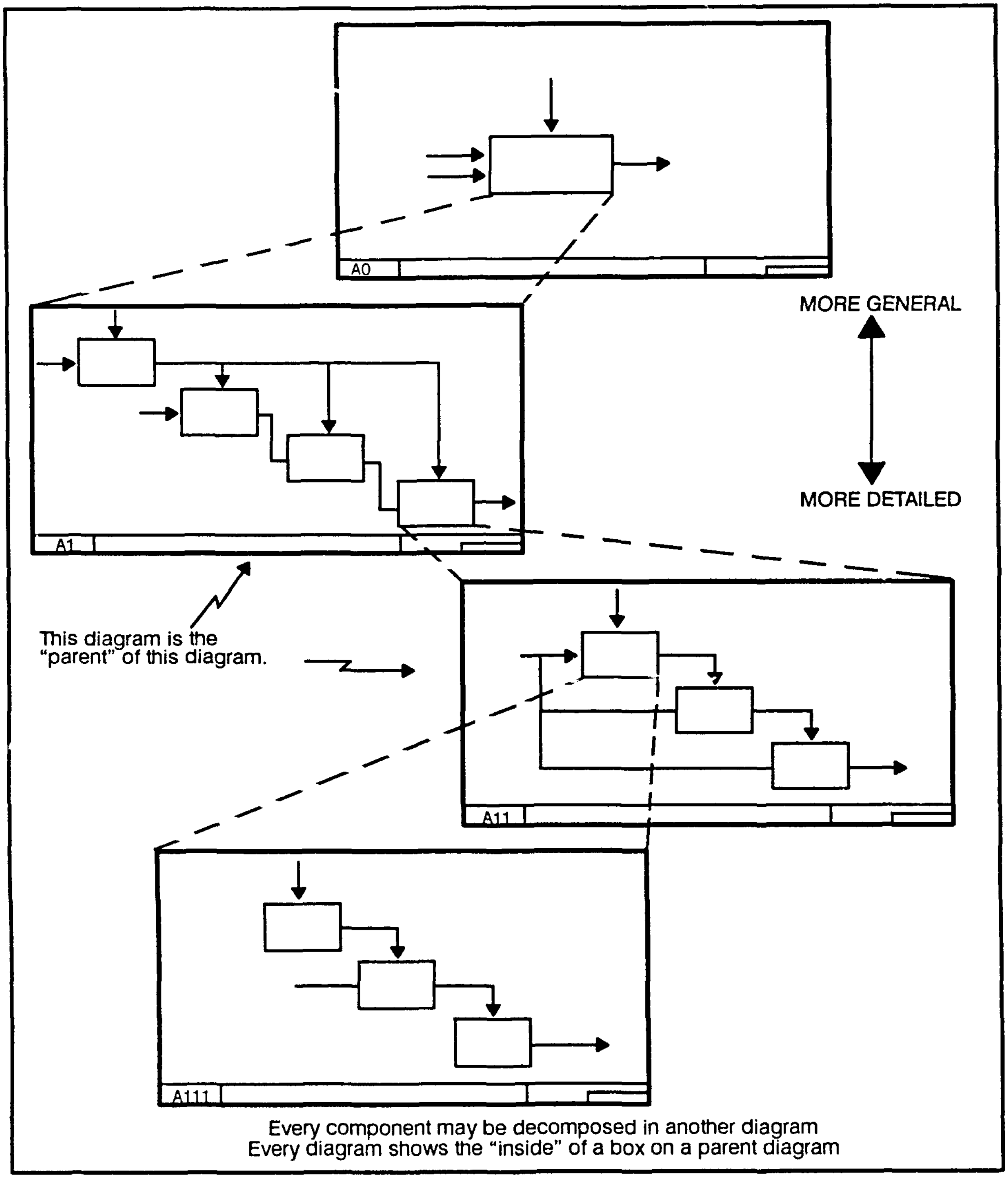


FIGURE 3-2. IDEF MODEL STRUCTURE

3.3 USE OF IDEF

IDEF methodology is primarily used for understanding functions that are carried out and the relationships between the functions within the current environment. IDEF can then be used to depict the model for future operations. IDEF methodology is frequently used in Air Force-related projects.

IDEF has been adopted to model the software development and maintenance processes because of its similarity to the manufacturing process. To control complexity, a given module or CSU should ideally consist of between 100–200 lines of code which process a single input to produce a single output. These modules are aggregated into CSCs and ultimately into CSCIs. Each CSU module has controls or constraints in terms of timing, accuracy, dependencies, etc. The mechanisms by which each module performs its processing task are the compilers, operating systems, languages and computer hardware.

The node tree diagram shown in FIGURE 3–3 provides a "road map" to the SPD environment. The node tree does not illustrate the flow of information, but it does show the breakdown of functions from the most general (level 0 diagram) down to the most detailed sub-function (level 4 diagrams). The node tree provides a reference point for understanding the activities and decomposition represented in the IDEF diagrams.

3.4 DESIGN, DEVELOP AND MANAGE WEAPON SYSTEM SOFTWARE – NODE A0

Node A0 (FIGURE 3-4) provides the context and a high level overview of the entire SPD process. Node A0 is comprised of two major activities: the acquisition (Node A1) and the deployment/management (Node A2). The acquisition node is responsible for creating the majority of software products. These products are needed throughout the PDSS cycle. The system must adjust to changes in the mission, so that "software maintenance" is predominantly software development.

This section presents levels 0 and 1 IDEF diagrams only. The entire set, describing the current software environment from levels 0 to 4, is contained in Appendix B of this document.

3.4.1 Acquire Weapon System Software – Box A1

This activity comprises all development activity up to and including PMRT. The acquisition is decomposed into four phases. It is not until FSD that software actually is developed. However, the system concept will have an effect on what software will be required. Node A1 (FIGURE 3-5) illustrates this activity.

INPUTS:	Mission Requirements, PMD, MENS, SON, PMP, SEMP, CMP, SOC
OUTPUTS:	Tested CSCIs, SPD, CRLCMP, Configuration Data, CRISP, O/S CMP
CONTROLS:	DODD 5012.19, AFR 65-3, DOD-STD-480A, AFSCP 800-7, MIL-STD-493A, AFR 800-4, DODD 5000.31, AFR 700-9, DODD 5000.3, AFR 80-14, AFR 800-19, DOD-STD-2167A, MIL-STD-2168
MECHANISMS:	Product Divisions, Using Commands, ALCs, Contractors

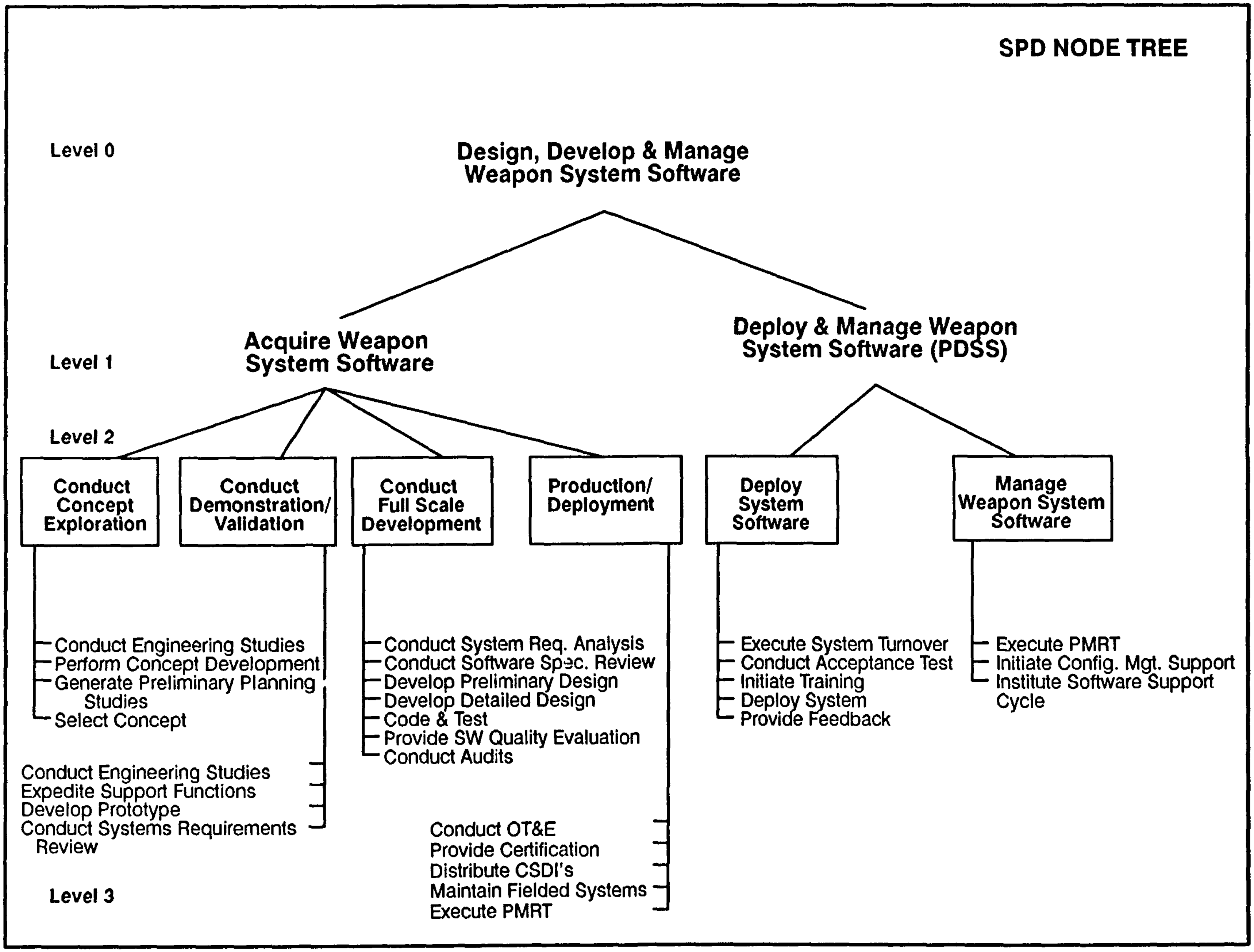


FIGURE 3-3 SPD IDEF NODE TREE

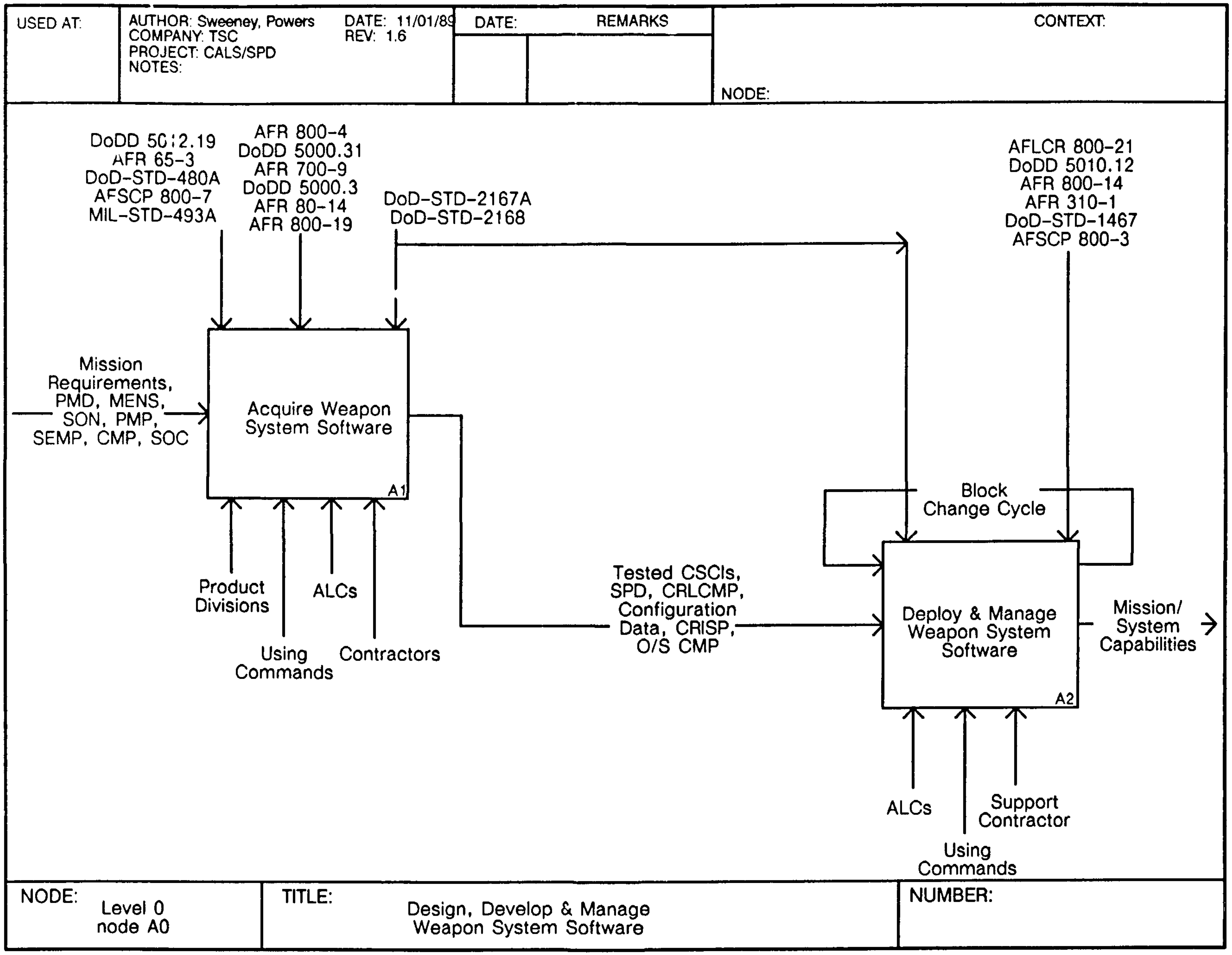


FIGURE 3-4. DESIGN, DEVELOP AND MANAGE WEAPON SYSTEM SOFTWARE

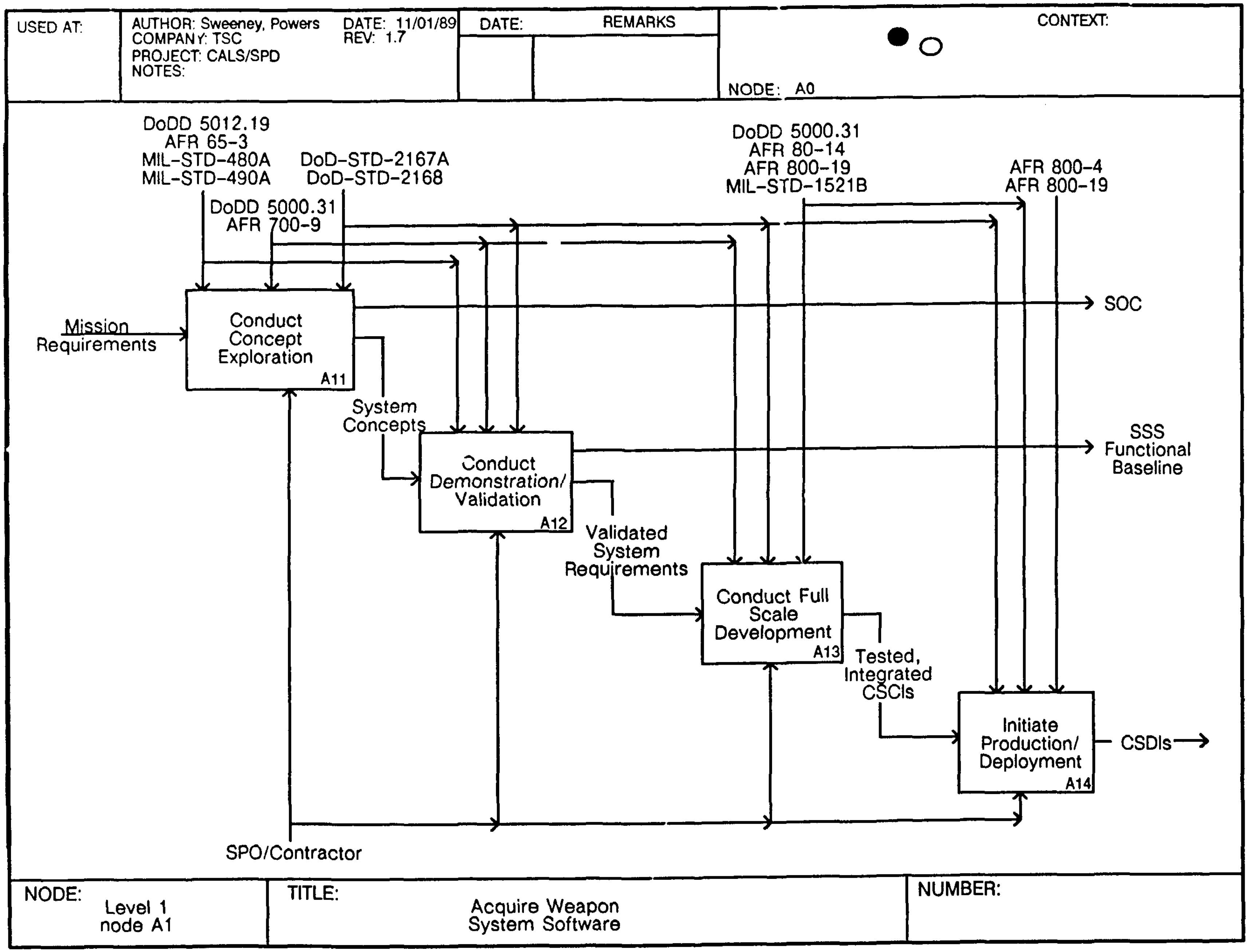


FIGURE 3-5. ACQUIRE WEAPON SYSTEM SOFTWARE

3.4.2 Deploy & Manage Weapon System Software - Box A2

This node encompasses the life cycle of the software Post-PMRT. It consists of two major activities; system deployment and system support. System deployment is the primary activity outlined for the Using Command. Maintenance of the system and the ECS software, is depicted in node A22 (see Appendix B). Node A2 (FIGURE 3-6) illustrates this activity.

INPUTS:	Block Change Cycle, Tested CSCIs, SPD, CRLCMP, Configuration Data, CRISP, O/S CMP
OUTPUTS:	Mission/System Capabilities
CONTROLS:	AFLCR 800-21, DODD 5010.12, AFR 800-14, AFR 310-1, DOD-STD-1467, AFSCP 800-3
MECHANISMS:	ALCs, Using Commands, Support Contractor

3.5 IDEF SUMMARY

Through developing the IDEF diagrams, five major pre- and post-production support applications of SPD were identified. For virtually all of these applications, the continual process of SPD review prior to each change must occur. During development, SPD review serves as the primary method of conveying design concepts and features. Major support applications are summarized below.

- *Software Development* – Throughout the development cycle described in DOD-STD-2167A, the design review provides the Air Force with the opportunity to verify and validate the requirements, approach, design, and final product. For virtually every review it is neccesary to develop various products that will make up the set of SPD. This process is repeated in a series of audits held towards the end of the acquisition phase.

- *Software Maintenance* – The ALCs and Using Commands perform a variety of tasks related to software maintenance: compensating for a design flaw or coding error, and/or to perfecting the software to maximize the use of available memory space and improve efficiency.

- *Software Modifications* – The ALCs and Using Commands perform software modifications either to enhance the capability of the software or to incorporate a change in mission. Software modification tasks mirror software development cycle tasks.

- *Reverse Engineering of Software* – Some ALCs reverse engineer software code to develop documentation for undocumented code. This usually takes place when the system life is expected to be long and the difficulties of supporting the code outweigh the costs of reverse engineering the code.

- *Documentation Updates* – As software is modified and maintained, the software documentation must be updated so that a current baseline is available for future maintenance and modifications. Furthermore, this documentation will support the development of the TOs needed to implement changes in the weapon system.

In developing the IDEF diagrams, reference material from several sources were used: applicable regulations, pamphlets, and directives, as well as several text books that interpret the use of these regulatory items. These sources are listed in Appendix C of this document. It was noted that differences existed between the various reference sources as to when design reviews should take place. There were also interpretive differences in MIL-STD-1521B. Each reference assigns a different degree of freedom in the management of a highly structured process.

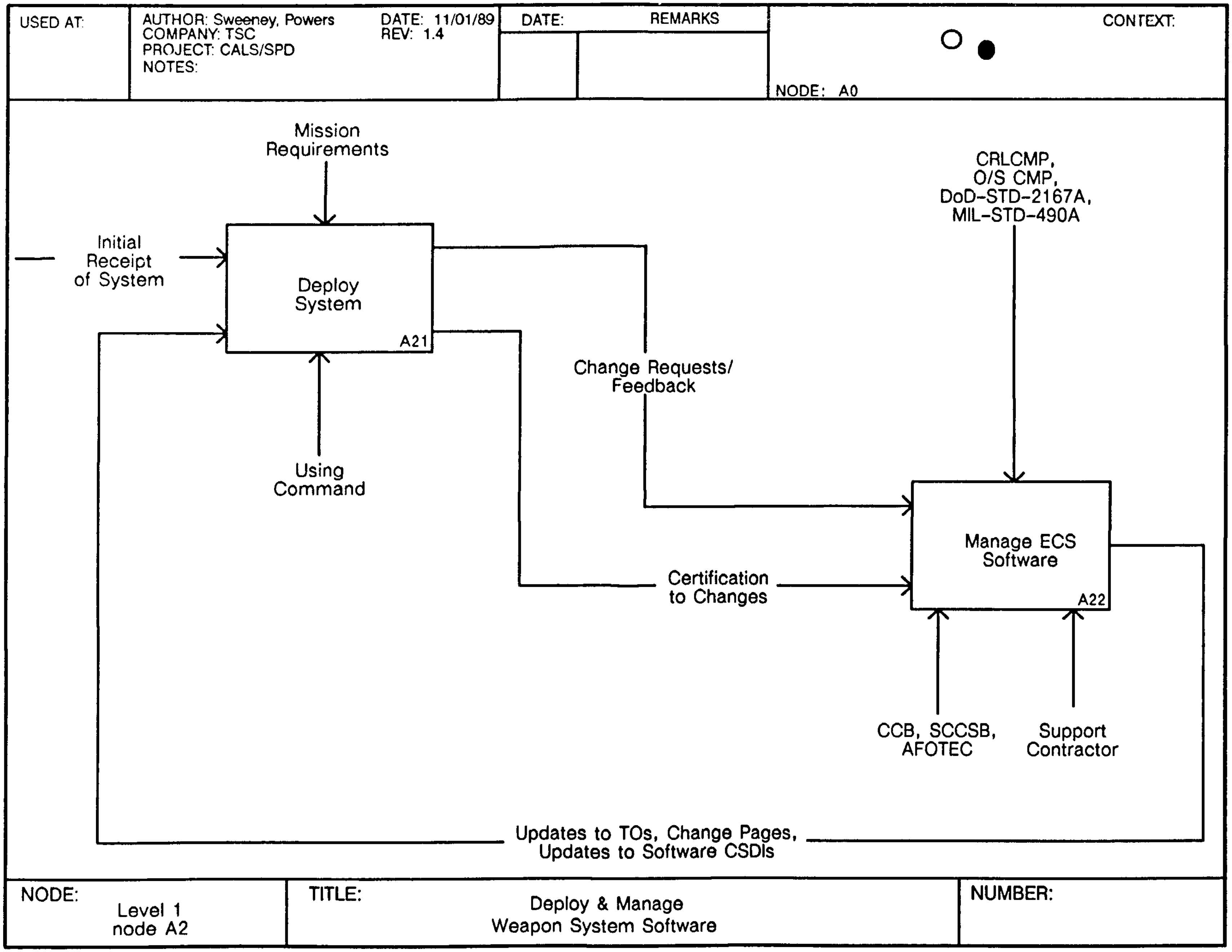


FIGURE 3-6. DEPLOY AND MANAGE WEAPON SYSTEM SOFTWARE

SECTION 4: FINDINGS

4.1 INTRODUCTION

This section identifies some of the major issues facing the Air Force today in software development and support, based on the analysis of the current Air Force environment for those aspects of MCCR relating to a weapon system. The findings describe areas needing improvement and will be researched further in Phases 2 and 3 of the modular planning process (see FIGURE 1-5).

In addition, a quantitative description of the volume of SPD in the Air Force is provided. With this information, trends in the growth and management of SPD can be identified, and reflected in the technical requirements of the To-Be Concept.

4.2 SPD DIMENSIONS

This section presents a quantitative view of current SPD within the Air Force, and the anticipated volume of SPD that can be expected in the future. The data to support this view was acquired through phone surveys of the SCCs within each ALC, and through the SPD Validation Package, which was used to assess current Air Force SPD-related functions and processes.

The Computer Program Identification Number (CPIN) system was found to be the only operational software tracking and identification program currently implemented within the Air Force that could provide hard, quantifiable sizing estimates related to SPD.

4.2.1 CPIN System

CPINs are sight-recognizable numbers that identify software items or their associated documentation. CPINs are part of the MCCR CSCI CM process since they identify:

- General category of the CSCI,
- Major function,
- Weapon system and subsystem in which the CSCI resides,
- Version,
- Whether the number is for an actual item or associated documentation, and
- The number of revisions the item has undergone.

CPIN management is coordinated by and the numbers assigned by OC–ALC. As of 29 January 1990, the CPIN system was handling 66,147 CPINs. It is generally accepted that this number may be broken in half to reflect the two types of CPINs: CSCIs themselves (Item CPINs) and associated documentation packages (Documentation CPINs). A documentation package consists of one or any combination of the following pieces of documentation that support CSCI items: source code, DOD-STD-2167A Data Items, TOs, indexing and cross referencing information. The estimated number of documentation CPINs across the five ALCs is approximately 33,073.

4.2.1.1 Characteristics

The quantity of documentation assigned to each CPIN can vary dramatically from one CSCI to another. Similarly, the average number of pages per documentation CPIN can vary from one ALC to another. These variations can be ascribed to the differences in complexity of the weapon systems at the various ALCs. For example, OC-ALC averages approximately 4100 pages per documentation CPIN due to its support of highly complex weapon systems, such as the B-1B. In contrast, SA-ALC averages approximately 150 pages to support mostly transport planes and tankers. These weapon systems are far less software intensive than the B-1B. The average number of pages per documentation CPIN was computed for each ALC by dividing the total pages of documentation by the number of documentation CPINs.

4.2.1.2 Trends

TABLE 4-1 and TABLE 4-2 illustrate current trends in software documentation. Even though OC-ALC has the fewest number of CPINs by a large margin, it has the highest average number of pages per documentation CPIN, and approximately 4 million more pages of documentation than the other four ALCs combined (see TABLE 4-3). The total amount of software documentation associated with MCCR CSCIs supported by the five ALCs presently stands at approximately 20.6 million pages. OC-ALC currently supports 12.5 million of these pages, or 60% of the total.

The fact that OC-ALC supports the majority of the more recent embedded CSCIs within the Air Force accounts for this trend in increased pagination. OC-ALC also exemplifies the growing problems associated with CM of CSCIs. In an attempt to save time and money spent on documentation tasks set by DOD-STD-2167A, many contractors group together several items into one CSCI. This allows them to deliver one set of documentation for a group of software items. The ALCs must then decide which of two complex and troublesome options to implement: break up the CSCI into modules and assign individual CPINs, or attempt to manage a large, unmodular CPIN assigned to the CSCI, as is. In many cases, several CSCIs that make up a system are assigned one CPIN. This accounts for much of the increased pagination per documentation CPIN.

Within newer weapon systems, this trend may in fact help CSCI CM. In the past, many systems had no support documentation, with the exception of the source code listing. Today, a large percentage of the DOD-STD-2167A Data Items are purchased; this drives up both the increase in pages per CPIN and the potential system supportability. The number of Data Items procured under DOD-STD-2167A has risen to a current level of approximately 50%. The potential exists for the Air Force to take advantage of this information and substantially increase system supportability. However, due to the lack of an automated SPD capability, 60% of software modification time is currently devoted to the retrieval and analysis of documentation.

TABLE 4-1. CPIN VOLUME ACROSS ALL ALCs

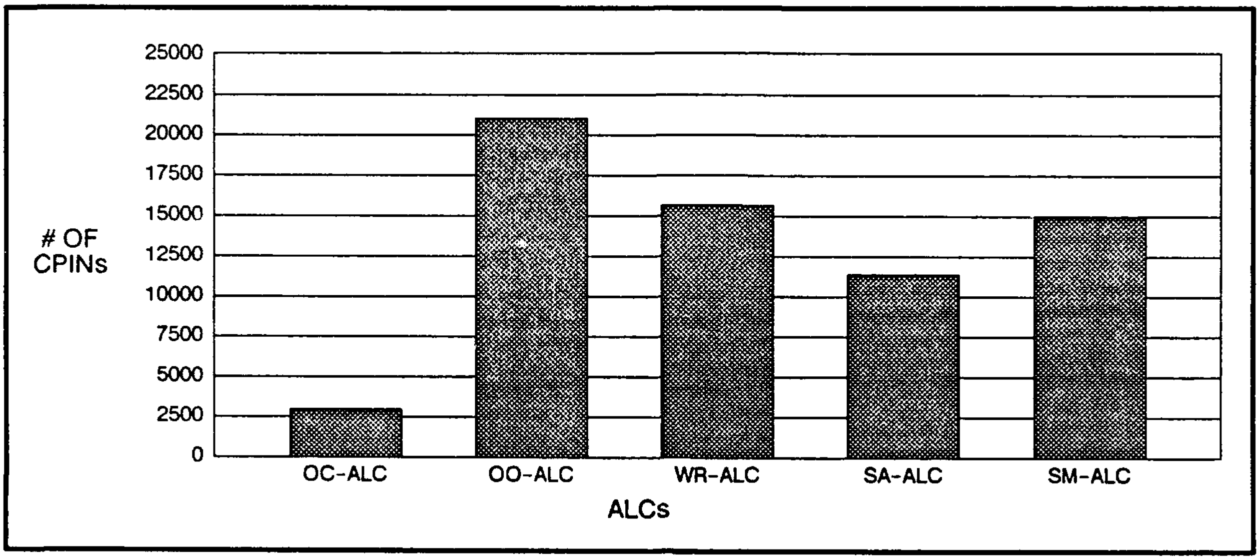
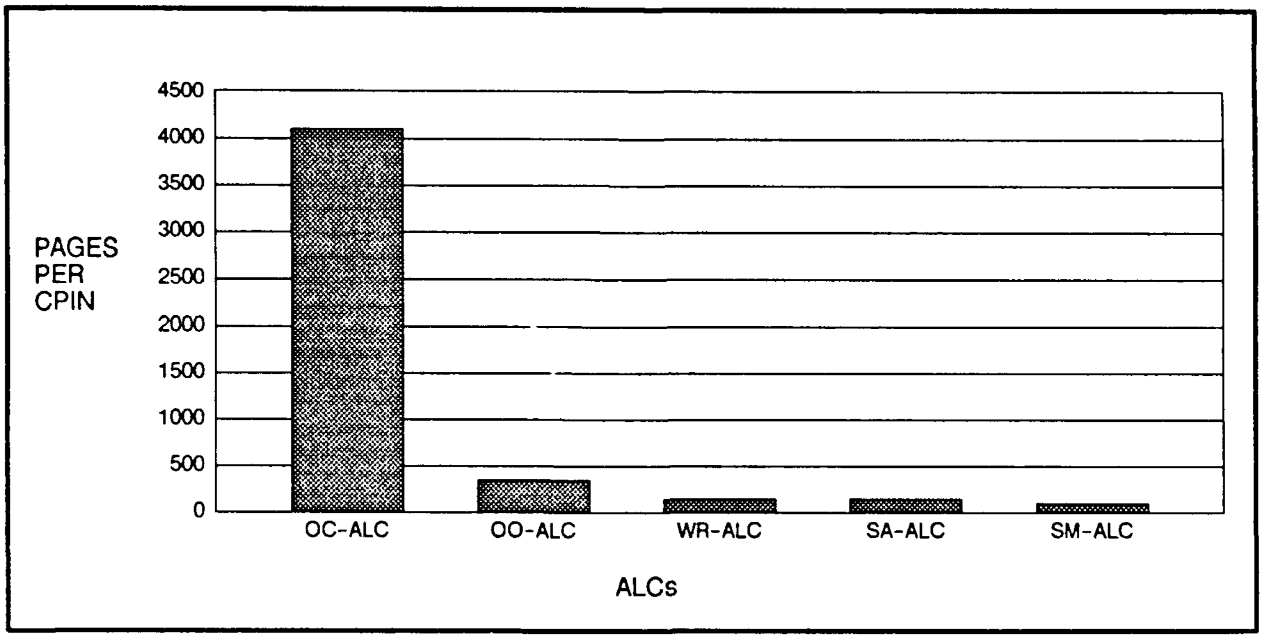
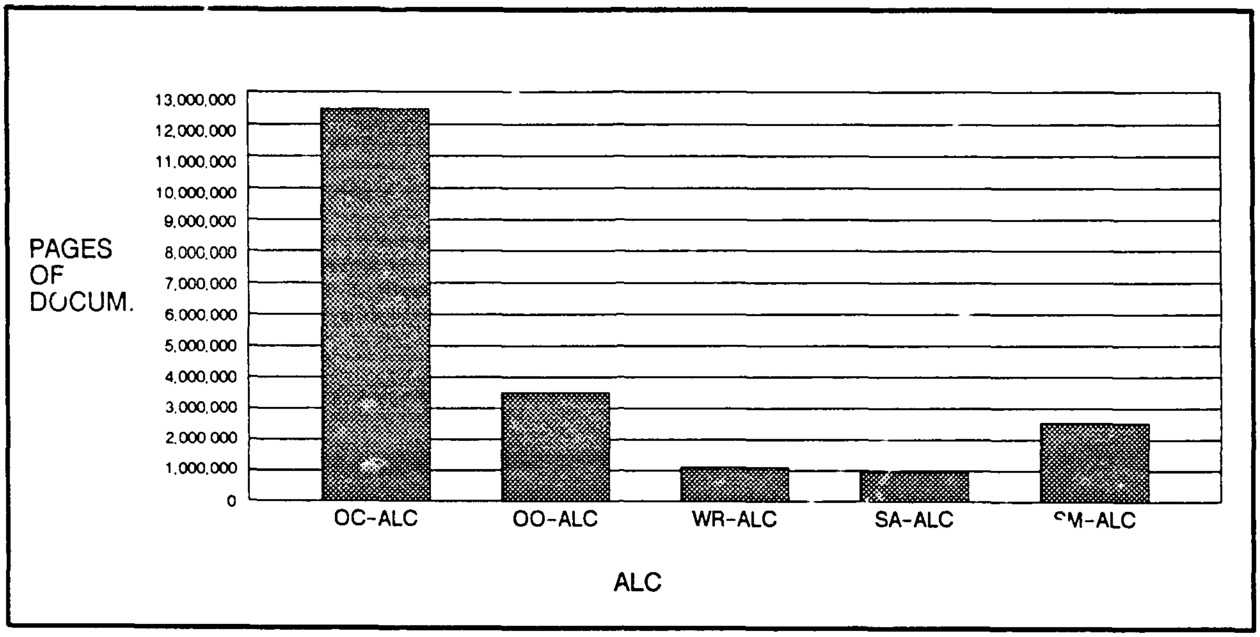


TABLE 4-2. AVERAGE PAGES PER DOCUMENTATION CPIN BY ALC



CSCI cross referencing and indexing are functions of CM which currently are being performed more often. This trend may translate to an increase in pages per CPIN, yet be looked at positively in that it enhances overall system supportability. However, this information is only useful if it is managed properly and can be accessed in a timely manner.

TABLE 4-3. TOTAL SPD PAGES ACROSS ALCs



4.2.2 SPD Growth

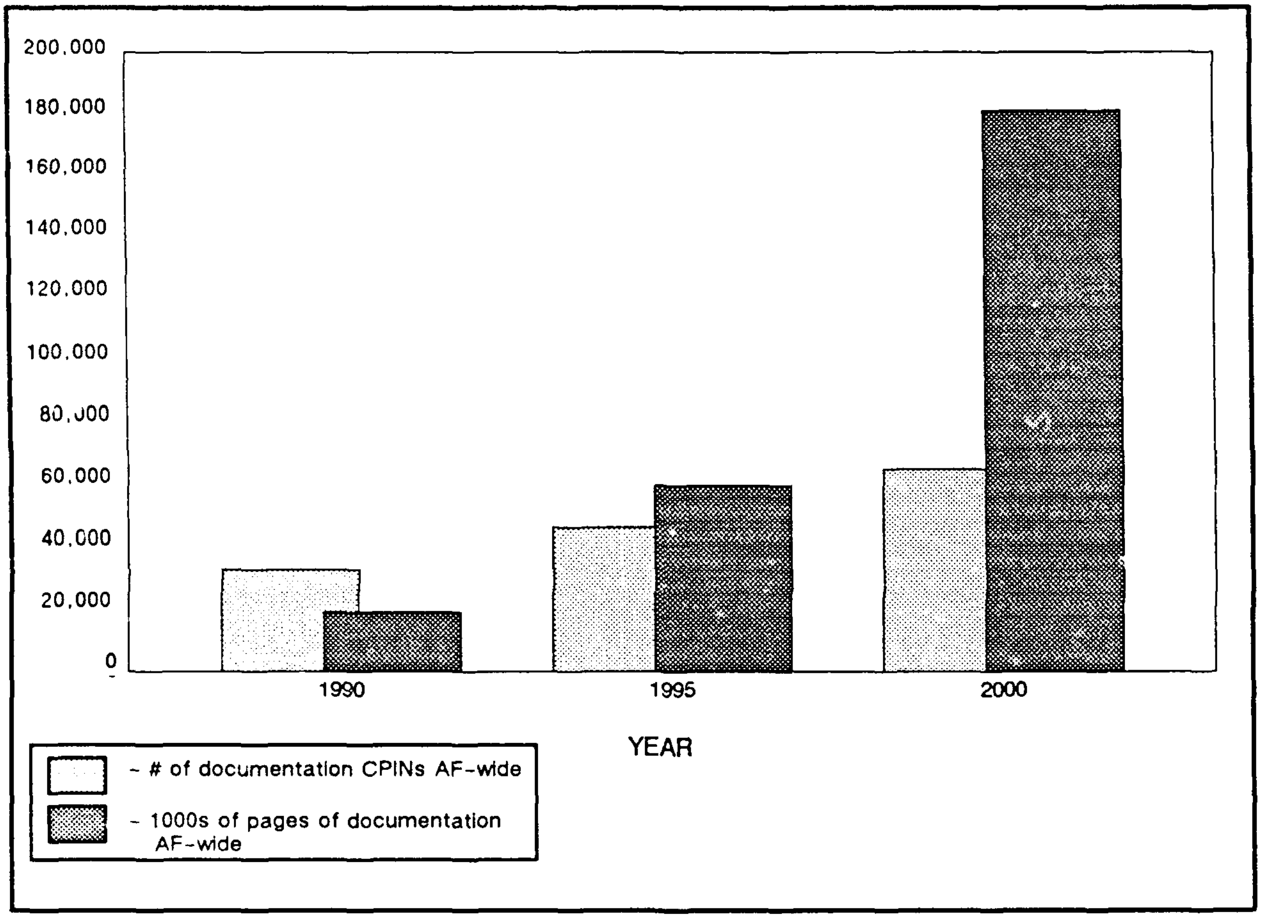
Based on interviews with several ALCs, overall Air Force software documentation is increasing at a rate of approximately 25% per year. This percentage is expected to increase further with the influx of new, software intensive weapon systems within the next ten years. For example, SM-ALC SPD levels are expected to increase dramatically with the acquisition of the Advanced Tactical Fighter (ATF). SA-ALC SCC personnel currently report that their software documentation is expanding at a rate of 35–50% per year. OC-ALC personnel have reported that the CPIN system is assigning new numbers at a rate of 7% per year and this rate is expected to remain constant. These trends indicate that the average number of pages of documentation for each documentation CPIN at the various ALCs will approach the level currently seen at OC-ALC (over 4000 pages/documentation CPIN).

As seen in TABLE 4-4, software documentation is going to increase exponentially in the next ten years, yet CSCIs are expected to continue growing at a 7% annual rate (reflected by CPIN assignments). ALC PDSS organizations may encounter resource difficulties managing this tremendous amount of documentation that will support future CSCIs. The documentation levels in TABLE 4-4 are based on a 25% increase rate per year (based on Air Force projections). However, newer software-intensive systems are likely to increase this rate up to or above the current SA-ALC level of 35–50%. TABLE 4-4 therefore represents a conservative view of software documentation growth.

4.2.3 CPIN Summary

Currently, the overall Air Force level of pages of software documentation is approximately 600 pages per CPIN. TABLE 4-4 shows that this level will expand, Air Force-wide, to approximately 2800 pages per CPIN within the next 10 years.

TABLE 4-4. TRENDS IN TOTAL CPINs AND SOFTWARE DOCUMENTATION



Using the present growth rate, software documentation will approach approximately 180 million pages in the next 10 years. Compared to the current level of approximately 20 million pages, 180 million pages translates to a 800% increase. These data need to be produced to support and manage Air Force software. The current SCC infrastructure may not be adequate to manage this volume of data unless improved techniques are used for automated support.

4.3 FINDINGS

The findings are summarized below and discussed further in Sections 4.3.1 through 4.3.11:

- Software CM in the Air Force is impeded by a variety of factors (e.g., lack of documentation, fragmentation of support responsibility, and inadequate CM systems), which in turn hinder PDSS.
- Lack of detailed documentation for software support is a major problem that slows down the Air Force's capability to maintain and modify existing software inventories.
- There is a lack of CALS standards for the digital receipt, management, and use of SPD.
- Logistics resources to support software need to be identified during the acquisition phase either through DOD-STD-2167A or through application of the LSA process to software.
- Changes to software most often require a TCTO to implement the software change.
- There is a relationship between SPD and TOs. Most software changes require issuance of a Time Compliant Technical Order (TCTO).
- The role of AFLC and Using Command software acquisition and support is changing. Whereas in the past lines of responsibility were clearly established, under today's regulations, these roles are not limited to specific or singular commands. In fact, sharing of development and maintenance is now possible.
- The ALCs sometimes act as the Independent Verification and Validation (IV&V) agent, either performing the IV&V directly or issuing a contract to have it done. This is an effective means of preparing the ALC for its PDSS responsibility and can lead to supportability improvements in software design. This approach should be used more widely.
- Software developed under DOD-STD-2167A still represents a small percentage of AFLC software inventories; this is due to a large inventory that existed prior to this standard's implementation and to short-term incentives to avoid using the standard on selected modification programs.
- The use of CASE tools is minimal in Air Force software support.
- Testing issues need to be identified early in the software life cycle to ensure reliable performance.
- Retention and continued training of Air Force software personnel will be critical for achieving mission readiness and productivity, and for maximizing competition in PDSS contracting.

4.3.1 Software Configuration Management

There is insufficient CM in software system development and software support. From the validation meetings, it was determined that software changes were generally made under the CCB. Updating and analyzing potential changes in documentation and related SPD became a task for which the system was ill-defined and the engineer ill-prepared. In several instances, computer hardware resources were made available, yet the resources did not exist to evaluate and develop changes in the SPD. FIGURE 4-1 breaks down CM into four functions: Audit, Status Accounting, Control, and Identification. One flaw in current practices is the Status Accounting function. Various versions/configurations of code and documentation are kept in a software development library. However, this may not be called out as a deliverable. Consequently, the complete development history of a software system is not available to turn over to AFLC at PMRT. It is important to retain versions of developing software for future modification purposes.

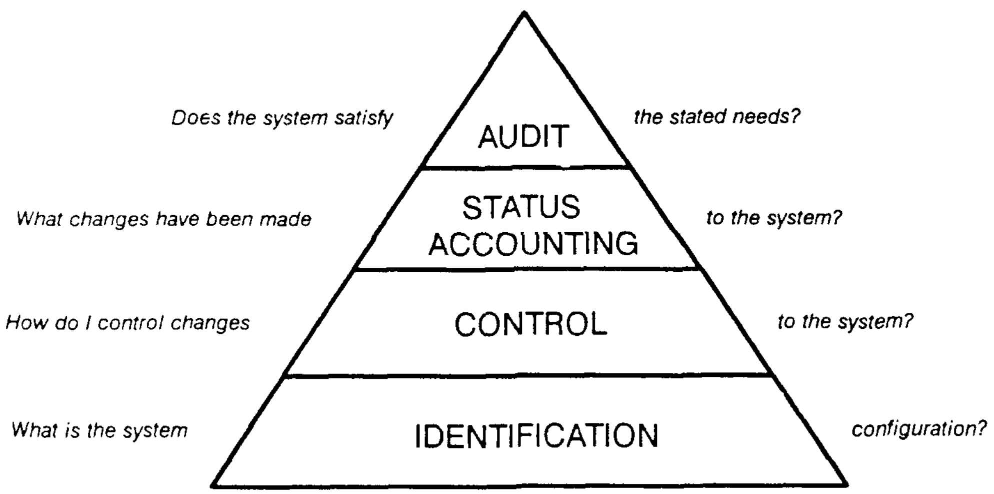


FIGURE 4-1. CONFIGURATION MANAGEMENT

So specific are CSCIs in relation to the mission they support that currently software is tracked to the level of individual aircraft tail numbers; this results in the potential for unique configurations on each platform. While tracking software by tail number in itself may not require dedicated resources, the ability to effect a multiplicity of different changes over several series of aircraft requires not only tracking support, but analysis, expertise, and intelligence in the implementation of such changes.

Since the Air Force frequently has automated CM performed by the prime contractor, the Air Force should be able to acquire CM baseline information and to implement it at their user support facilities and maintenance support facilities. Lack of effective CM can lead to informal CM practices by software engineers. This practice is characterized by islands of automation and conflicting, uncontrolled baseline information. A similar practice was also cited in the *PDD Current Environment Report* in which engineers, faced with inadequate CM support, maintained unauthorized drawing stores on their own.

In general, there is a lack of automated tools that support CM in the Air Force, creating an intensive paper-bound process. For instance, the USTS Program at ESD and the F-111 program both rely heavily on a manual CM process. The kind of software CM currently performed by the Air Force is sometimes fragmented between user and maintenance organizations; this makes CM ineffective. The 1980 TRW Study of ECS Software found that CM of ATD software suffered from a lack of communication between the responsible ALC and Development Engineering Prototype Site (DEPS) teams at each user location. Frequently the DEPS teams and the ALC both made the same change, or the DEPS team mads a change without updating the documentation (except for the source code) and without notifying the ALC.

There are exceptions to ineffective software CM in the Air Force. The AWACS Program has relied on the Boeing Corporation to provide overall CM. Likewise, several programs at OO-ALC report effective CM through their support contractors, partly due to the use of the prime contractor as the support contractor.

The need for a comprehensive CM approach is not limited to the software arena. In a previous Air Force CALS study (*PDD Current Environment Report*, May 1989), it was shown that poor CM for engineering data impacted the quality of support for the weapon system.

In a much broader context, future weapon systems will depend on a much higher degree of integration to support such new operational concepts as graceful degradation. CM of SPD needs to be identified and the SPD and PDD CM repositories integrated. It is only when these capabilities exist that support issues can recognize the multiplicity in both hardware and software across several versions of the platform.

4.3.2 Adequacy of Documentation for Software Support

In many ways, the term "software maintenance" is a misnomer because this type of work actually involves a significant amount of software development. The 1989 BOLD STROKE briefing material cites an OO-ALC/MMET source which states that 66% of the changes occurring during PDSS are dedicated towards new development. This figure is broken down into 40% towards new capabilities and 26% for adaptive changes. The remaining 34% is equally distributed between corrective and perfective improvements. Since software maintenance involves changing some pieces of an existing structure in a way that will not disturb the other pieces of the structure, a complete set of current documentation is needed that fully describes both the externals and internals of the structure. The importance of documentation is further supported by a recent *Journal of Air Force Logistics* article, which stated that of the total time required to accomplish software maintenance, 60% of the time is devoted to the retrieval and analysis of appropriate SPD.

Documentation must be emphasized during the acquisition process to avoid the costs incurred in maintaining an undocumented product. Unfortunately, when program funds are reduced, documentation can be one of the first deliverables to be traded away. This significantly increases long term life cycle costs. In most cases, documentation is baselined once during the development cycle and is seldom updated to reflect coding changes. At PMRT, the source code and supporting documentation are often inconsistent. To be considered complete, documentation must describe the problem that the software is trying to solve, the design choices and tradeoffs, the standards and specifications used, and the software design. DOD-STD-2167A addresses most of these needs, but falls short of identifying the choices made by the software designer during the acquisition phase, the tradeoff analyses performed, and the trade-off decisions. This information can be critical to PDSS functions.

The Air Force does not subject software documentation to the same rigorous validation and verification process used for TOs. The TO validation process involves Air Force maintenance personnel in live, test-use of a proposed TO, and they uncover any missing maintenance steps or inadequate descriptions and instructions. Even though validating software documentation is an equally complex and labor-intensive process, few or no expert systems or other automated tools are currently in use in the Air Force to make software documentation reviews more effective and efficient. In addition, software documentation validation assumes a high level of technical expertise. Under a similarly vigorous process for software documentation, the documentation would be validated against the appropriate standard, such as DOD-STD-2167A, prior to being baselined. The documentation would then be verified by having government software support personnel use it to perform a series of support tasks.

As part of its effort to obtain sufficient documentation to efficiently and effectively perform PDSS functions, the Air Force needs to be certain that it acquires the data rights to software purchased. This issue was highlighted in ALD's 1989 *Supportable Software Acquisition Guide* and is a generic problem for CALS; without data rights to re-use data or even distribute data to a new contractor for modification work, there is limited value in digitally acquiring technical information. In the software arena, contractors may claim proprietary data rights to preserve their position for PDSS modification contracts.

Requirements traceability is a critical capability that documentation can begin to provide. For any software change request, the Air Force evaluates the potential system impact and mission impact. These impact analyses can best be performed by tracing requirements through the design and the code. Only when these analyses have been performed can the Air Force adequately judge whether or not to proceed with the proposed software change. Good documentation can help to support this capability; automated CASE tools are another means (see Section 4.3.9).

So critical is the need for adequate documentation that some ALCs have initiated the process of developing or "reverse engineering" the SPD. In cases where PDSS is severely impeded without adequate SPD, the ALCs have used manual means or CASE tools to extract a current baseline of information from the code.

4.3.3 Lack of CALS Standards for SPD

There is a lack of guidance and standards for applying CALS to SPD on current Air Force contracts. None of the MIL-STD-1840A standards were designed for SPD and, as a result, it is difficult for SPOs to specify how to receive SPD digitally for PDSS management and use. In addition, while many of the emerging CASE/software standards will eventually provide an answer, there are limited choices currently available to a SPO. Since software documentation (a subset of SPD) is primarily textual information with two-dimensional graphics information, it is possible that some of the MIL-STD-1840A standards (e.g., IGES, SGML, and Comite Consultatif Internationale de Telegraphique (ENGLISH: International Consultative Committee on Telegraphy and Telephony [CCITT] Group 4 Raster) could be applied to SPD in the interim. However, these solutions could limit the support community's capability to digitally update graphical representations such as data flow diagrams, structure charts, and data base schemas. The capability to modify diagrams and related products will exist, but the intelligence of a CASE environment to support mission impact analysis, requirements traceability, and/or intelligent updates may be impeded. Ideally, a neutral data exchange standard will evolve that will allow data from a contractor's CASE tool to be ported for use in an Air Force CASE tool at an ALC or Using Command.

4.3.4 LSA for Software

To support software after deployment, several types of logistics resources are needed. These include test equipment, system software (operating systems, diagnostic software, software tools, CASE tools, CM tools, compilers, computer operations management software, etc.), hardware parts, hardware support equipment, technical manuals (e.g. software documentation, DOD-STD-2167A, DIDs), system training materials, etc. Definition and quantification of these resources should be performed during the acquisition phase. This can be achieved through DOD-STD-2167A using the DID entitled Computer Resources Integrated Support Document (CRISD), MI-MCCR-80024A. Alternatively, it can be achieved through application of the LSA process to software. Independent of either choice, the analysis provides an opportunity to identify the relationship between prime item software and support elements under one comprehensive CM system. It is anticipated that future planned revisions to the LSA regulation, MIL-STD-1388-1A and -2A, are expected to expand the Logistics Support Analysis Records (LSAR) to capture software logistics resource requirements.

Several studies, including ALD's *Supportable Software Acquisition Guide* and the Society of Logistics Engineer's National Workshop on Software Logistics (15-16 August 1989), have advocated that the discipline of the LSA process (defined in MIL-STD-1388-1A) be applied to the software components of a weapon system (or major equipment item), not just the hardware components, as is most often the case today. The value of LSA is that it forces an analysis of the support needs for the total system in an integrated way. Each level of the weapon system's indenture structure is analyzed to define the operations and maintenance (O&M) tasks required to support that component of the weapon system. Each task is then analyzed to define the logistics resources (e.g., parts, support equipment, technical manuals, training, facilities, etc.) needed to perform that task. Various modelling techniques may be employed, including level of repair analysis to identify the most cost-effective approaches. Finally, the logistics resources are aggregated, redundancy is minimized, and a total set of estimates of the logistics resources is reached. The estimates are then used to initiate logistics support for the system and to prepare AFLC to support the new system.

Separating software from the LSA process can detract from a total systems analysis and can result in software support requirements not being met. The ATF program is investigating the application of LSA to software.

As the Air Force implements a two level maintenance concept (placing maintenance either at the flightline or at the depot without an intermediate maintenance site) there may be an increasing requirement for performing LSA on software. LSA would specify which software maintenance tasks would be performed at the depot or on the flightline. This, in turn, would more clearly define ALC responsibilities for PDSS and Using Command responsibilities.

4.3.5 Software and TOs

There is a significant relationship between software and TOs within the Air Force today. Before an ALC can issue revised software code for installation on a weapon system it must obtain a revised TO to provide directions on how to install the software and describe the change (see AFLCR 800-21 and TO-005-15). Since the TO change process can take between six to nine months, this greatly increases the block change process for software modifications. It should be noted that Using Commands are not subject to this AFLC requirement.

Once the CPIN is assigned to software, it can then be referenced to TOs; this is a key issue for providing software CM. Frequently TOs do not reference CPINs; this hinders the AFLC in modifying software and its related TOs. Since CPIN assignments involve a complex four page form that takes time to process, AFSC product divisions and their contractors often do not assign CPINs to software and software documentation. This results in TOs with no CPIN references, creating a costly retrofit problem for AFLC.

It is also important that CPINs be updated when there are significant software changes. This is not currently practiced and is not required by the applicable regulations.

4.3.6 Changing Roles and Responsibilities

As software becomes an evermore critical component of Air Force weapon systems and items, roles of various Air Force organizations evolve to keep pace.

Program office priorities do not always integrate well with support requirements. This is similar to the findings in the *PDD Current Environment Report*, i.e. the relationship between the

SPO and Logistics Command representatives should be complementary, not adversarial. Frequently, AFSC focuses on cost and schedule constraints to the detriment of long term support issues. AFLC must move forward to play a more active role during acquisition so that the weapon system is not merely fieldable but supportable. This could be accomplished through the early identification and allocation of resources to carry the system through PMRT. In turn, this would provide the potential ALC with opportunities to lead the development of support requirements, support training, and other related issues. Probably the most critical task during development is participating in the design reviews. Valuable insight can be gained by the people who will eventually be responsible for supporting the system. This section focuses on the changing roles and related issues affecting software in AFLC and Using Commands.

4.3.6.1 AFLC Role

Projections show that in the near future the ratio of software life cycle costs to hardware life-cycle costs will be approximately four to one. The majority of software costs will occur in the post-deployment support phase. Currently, AFLC personnel have limited participation in the acquisition phase. As a result, they are not familiar with the software and associated products before deployment. Characteristics of the level of AFLC participation include:

- Limited or no input to the CRLCMP, the CRWG, and other support vehicles,
- Limited training for software issues,
- Insufficient time to prepare for participation, and
- Limited or no participation in design reviews for software where much of the knowledge about the system can be conveyed.

Funding source ambiguity is a major reason for limited AFLC participation in the acquisition phase. AFLCR 800-21 states that the acquisition agency is required to fund AFLC travel for software technical reviews. However, the acquisition agencies are not subject to this regulation and do not have this requirement. As a result, SPD is not subject to a thorough review by AFLC prior to PMRT. MA_ personnel rarely have access to travel funds while MM personnel may have limited funding for these purposes. This continues to a point where the resulting documentation is often of such poor quality that the software cannot be supported effectively.

Little or no coordination between Commands in preparing to support weapon system software can often result in AFLC establishing software support facility requirements without proper input from the user or acquisition agencies. This makes the acquisition agency hesitant to commit funding for the support facility. As a result, the support facility is often not available until after support responsibility has been transferred to AFLC. Even though some recent programs such as the ESD Rapid Execution and Combat Targeting (REACT) Program have not followed this practice, the problem continues to occur.

AFLC has assigned DPMLs to increase the AFLC's visibility in the acquisition process. The DPML is often responsible for more than one acquisition program at a time (particularly for small programs), and is therefore unable to provide in-depth coverage of logistics on any one acquisition program. Another disadvantage is that the DPMLs duties are management-oriented; this results in AFLC software development technical issues not being addressed in detail. Finally, DPMLs are frequently not adequately supported by either ALD or the ALCs in providing detailed requirements.

4.3.6.2 Using Command Role

The role of Using Commands in PDSS is growing. In many instances, the Using Command is responsible for supporting the applications software (mission-unique software), while AFLC is responsible for the system software (operating system, Commercial Off-The-Shelf (COTS) software, etc.). AFR 800-14 describes five alternative approaches to PDSS, ranging from 100% AFLC support of all MCCR software for a weapon system to 100% Using Command support, with variations of shared support in between. An example of growing Using Command involvement is ESD's REACT Program. Under this program, SAC will receive a User Maintenance Facility (consisting of computers and automated tools) and maintenance training to support SAC's PDSS efforts. Another example is within the AWACS Program, in which TAC may initiate changes to mission software as well as development and coding of changes.

The user is one of the few participants involved in both the acquisition and support processes throughout the life cycle. The user and the designer are two key participants in the acquisition process, in contrast to the user and the maintainer in the support processes. There is continuity in the role of the Using Command from the Statement of Need to disposal/retirement of the system.

4.3.7 Use of IV&V

The IV&V process is the review of software products for functional and technical sufficiency by an independent organization. Currently, IV&V is performed only when the acquisition agency has adequate funding. Rarely is it initiated before coding has begun. To to be effective, IV&V should be initiated during the definition of requirements. In this way, the IV&V agent can review the requirements, the design, and the code before each gets approved against the available baselines. Since IV&V is the primary method for insuring that support issues are adequately addressed during the acquisition process, the ALC sometimes acts as the IV&V agent, either by doing the work itself or by hiring a contractor. With this role, the ALC is better able to ensure that the software is supportable since the center will have support responsibility for several decades. Examples of ALC management of IV&V include: OO-ALC/MAS, which uses 20% of its workload to perform IV&V; and SA-ALC/MM for the F-111. FIGURE 4-2 shows the traditional relationship between the acquisition agency, the prime contractor, and the IV&V contractor. FIGURE 4-3 shows how this relationship is emerging in some programs today in a manner which better achieves supportability objectives. The approach of having the ALC manage IV&V processes should be practiced more widely.

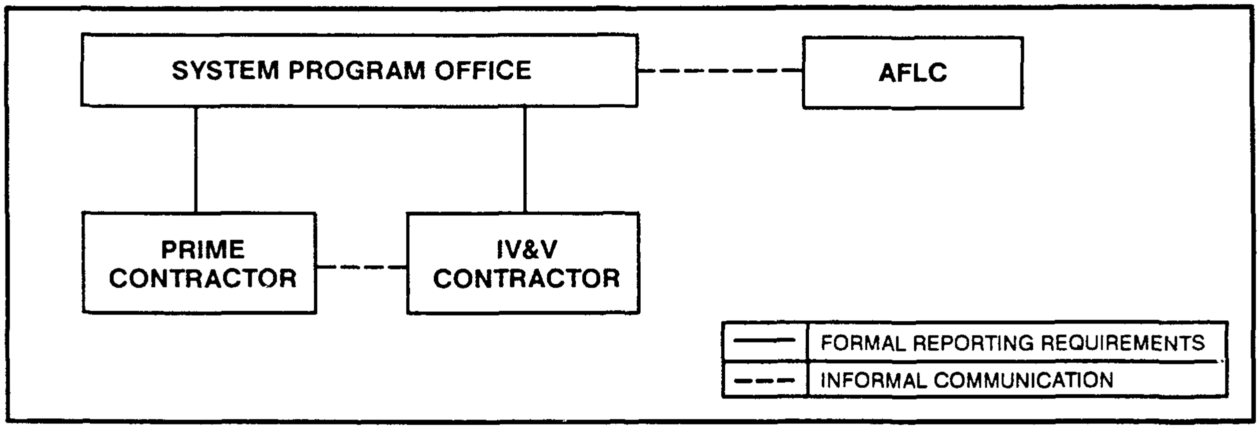


FIGURE 4-2. TRADITIONAL IV&V RELATIONSHIPS

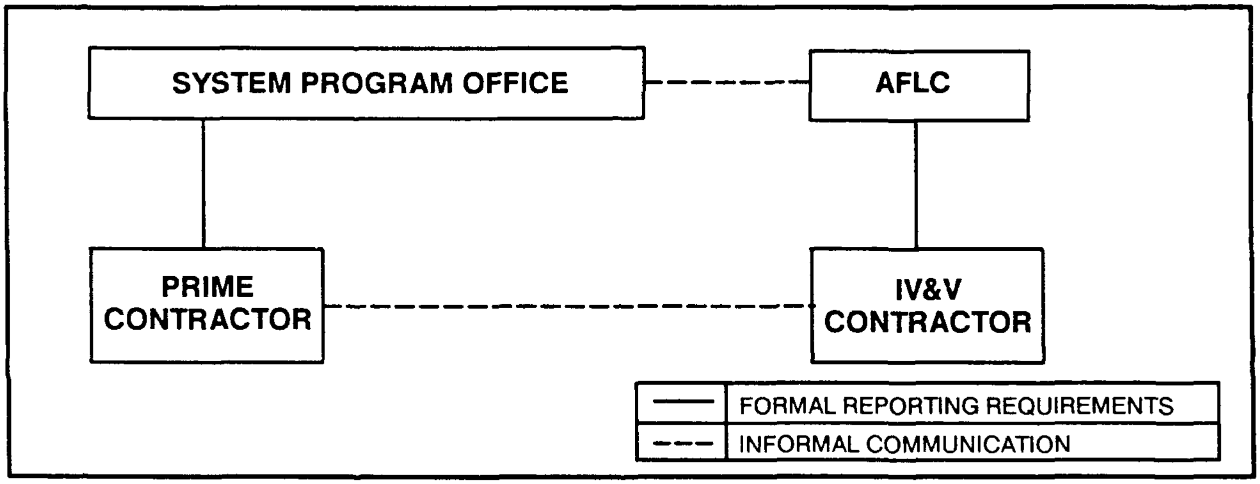


FIGURE 4-3. EMERGING IV&V RELATIONSHIPS

4.3.8 DOD-STD-2167A

Use of DOD-STD-2167A in Air Force acquisitions is evolving slowly. The majority of past acquisition programs do not use the standard; similarly, most software modification programs do not follow the standard. As a result, the majority of ALC software personnel and software projects do not use DOD-STD-2167A. One example is the Rail Garrison Program, which does not plan to use the standard because the original missile program did not follow it.

DOD-STD-2167A is the primary standard governing MCCR software development and, indirectly, the entire MCCR software life cycle. Its slow implementation creates a lack of documentation and rigor in the software acquisition process. Although 2167A has its limitations (primarily due to advances in software approaches and technology), it is still a sound framework from which to undertake a software development project by using classical steps in systems analysis and by providing tailoring flexibility where particular requirements do not apply to a program or are not cost-effective.

Some recent acquisition programs that do use DOD-STD-2167A include: the USTS, AWACS Radar Improvement Program, a current modification to the A-10, and the F-117A ATF. The ATF is using DOD-STD-2167A with additional, newly created DIDs that meet ATF requirements. These DIDs expand the amount of information that the Air Force will receive for PDSS functions, including more detail on the design approach and trade-offs involved in the software design process. These items will also address combining several ancillary documents available under DOD-STD-2167A into one deliverable.

4.3.9 CASE Tools

The Air Force PDSS community is not utilizing CASE tools to the same degree as private industry. While many acquisition programs have contractors who are using CASE tools, Air Force PDSS personnel often do not receive or obtain CASE tools to support software and documentation maintenance. This results in a labor-intensive process for PDSS. In selected recent acquisition programs, CASE tools are being employed. For example, at ESD, the contractor supporting the REACT Program is employing ICONIX (in contrast, within the same division, the USTS program is not using CASE tools). In recent AFSPACECOM acquisitions contractor are also using CASE tools.

Current CASE tool products are largely confined to the front end of the life cycle (requirements and design) and the back end (programming). It is anticipated that CASE tools will soon offer full integration over the entire life cycle; this would support the automated generation of design documentation and source code from requirements. The real value of such an automated tool is that once the documentation and code are available, a change to either one could conceivably generate the appropriate change in related SPD.

Some CASE tools offer a limited capability to generate software documentation in DOD-STD-2167A format. However, these capabilities are usually limited to document templates, which must then be completed by an analyst copying documentation and diagrams into the templates. Hopefully, in the future, these capabilities will improve the software documentation process. FIGURE 4-4 illustrates the evolution of CASE tools from the current stand-alone capability of providing in-depth support only during programming, to a future capability of using a common database to support a diverse set of documentation, design, and coding tools.

Significant improvements in productivity require a common database or repository that would have in its lexicon the ability to freely translate between requirements language, design language, and implementation language. This would require a series of compilers or interpreters that would be similar in function to the compiler that translates source code into object code. The Information Resource Dictionary System (IRDS) Standard Committee at the National Institute of Standards & Technology (NIST) is helping to meet this goal. It would function as a meta data dictionary that would be an automated data administrator and integrator of all the software engineering environments acceptable to the Air Force. Enforcement of this concept will be similar to the Air Force's approach to selection of Higher Order

Languages (HOLs), i.e., as long as the HOL is on the list of acceptable HOLs to the Air Force, a contractor is free to select it.

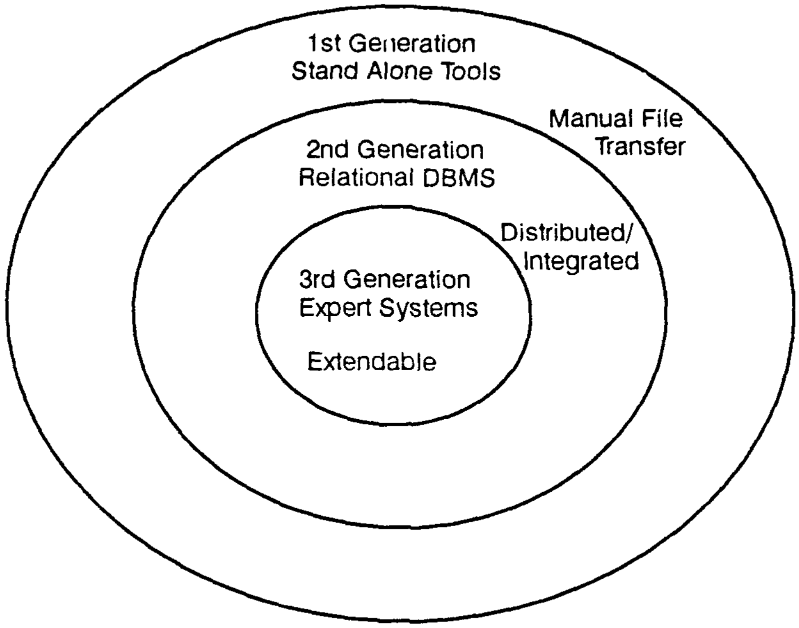


FIGURE 4-4. CASE TOOL EVOLUTION

4.3.10 Testing Issues Need to Be Identified Early

Previous studies on ECS software, such as the 1980 TRW study, reported that as much as 40% of all software delivered at PMRT does not function as intended due to inadequate time spent on software testing. Ideally, a greater portion of the development life cycle (not necessarily a longer life cycle) should be devoted to requirements, design and testing, in contrast to the current practice.

The Air Force does not emphasize the need for independent test agencies responsible for OT&E to actively participate in the initial requirements and design phases of the life cycle. Such early involvement would allow test agencies to identify problems that could cause complications during testing, in the initial stages of the development cycle. Problems corrected in the design phase are less costly to fix than those identified during coding. This independent and operational test is important for two reasons: developers should not be the sole testers of their code, and an operational test can reveal problems that might not arise in a test environment. Under current practices, software support environments are identified so late in the acquisition cycle that they are not adequately tested during OT&E. As a result, their adequacy for software support cannot be evaluated.

A further hindrance to adequate testing is the failure to ensure that stated requirements meet the following criteria:

- **Realistic** – requirements can be feasibly met by a computer system within cost, schedule, scope and supportability constraints.
- **Unambiguous** – requirements are understandable by journeyman–level software engineers, without in–depth project understanding.
- **Consistent** – requirements do not conflict across related documents.
- **Necessary** – requirements are essential to meet the mission and constitute a reasonable resulting expenditure.
- **Complete** – requirements are comprehensive and support all mission requirements.

These criteria are necessary for structuring testing so that there is tangible proof that the software satisfies each stated requirement. FIGURE 4-5 describes some of the requirements that should be testable.

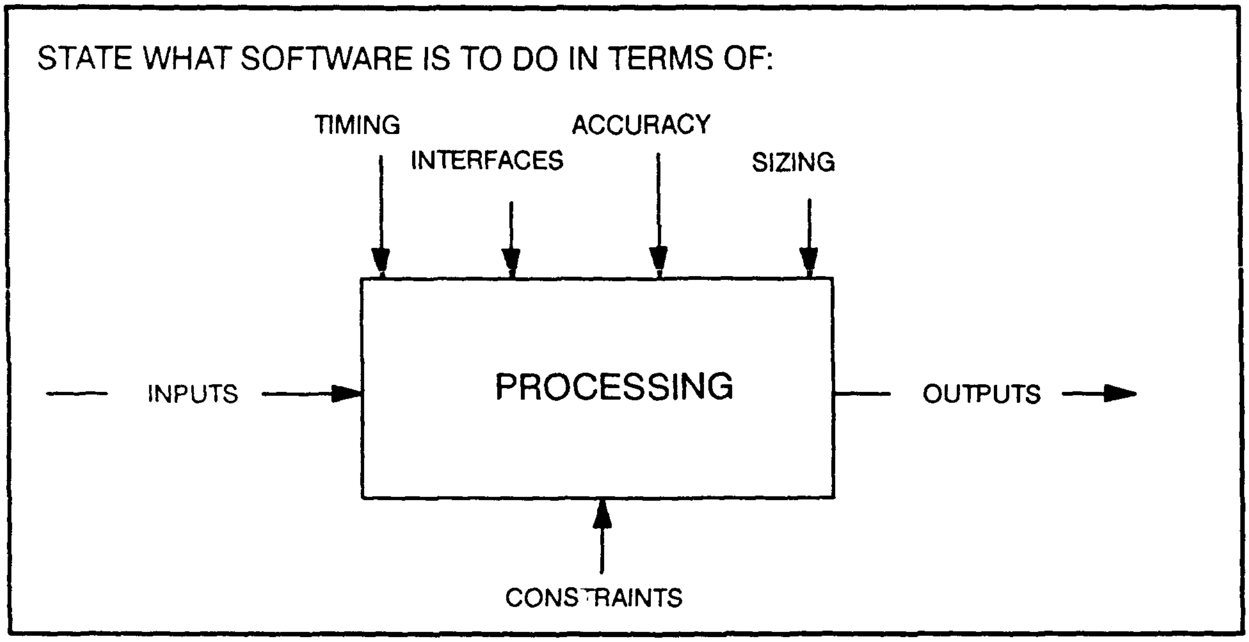


FIGURE 4-5. TESTABLE REQUIREMENTS

4.3.11 Retention and Training of Software Personnel

Current employment surveys indicate that the United States will experience a severe shortage of software engineering personnel in the 1990s. With large (> 1 million line of code) software–intensive systems such as the B–1, B–2, ATF, C–17, SDI, etc., coming into the inventory, this projected shortage of software personnel may eventually impair mission readiness. The projected demand for software engineering personnel will allow engineers to choose the most appealing software area in which to work. Most software personnel prefer development work over maintenance work. This projected shortage will become even more severe for the Air Force, whose primary need is software maintenance personnel. In one instance, the AWACS Program initiated no modifications from PMRT in 1976 until 1988 due to the extensive training required to "ramp up" the software engineering personnel, and to the high turnover of personnel.

Even though several ALCs have increased the grade levels for some software personnel (at OO-ALC, several software maintenance engineering positions have been established at the GS-13 level), there remains a sizeable pay disparity between the government and private industry, which makes it difficult for the Air Force to retain personnel.

The Air Force is not providing adequate *training* for either software acquisition or software maintenance personnel. The Air Force fills many of its software acquisition positions with personnel in transition from another career. Even though these individuals are provided with some formal software acquisition training, they have little on-the-job experience in software acquisition prior their assignment as program manager of a complex software-based system. Currently, training for software maintenance personnel focuses on developing familiarity with source code and operating systems, with little emphasis on orientation to the overall weapon system and the requirements that the system was meant to satisfy.

A study of ECS personnel by TRW in 1980 indicated that it can require as long as three years for software support personnel to master a CSCI containing 10-20 thousand lines of code if they were not intensively involved in developing the code. The Air Force still tends to view software training as a subset of hardware training. There is little recognition that the training philosophies are significantly different.

4.4 CONCLUSION

This section described the major findings from an examination of the current Air Force software environment relating to CALS. These findings also include a quantitative view of SPD in the Air Force. The findings show that there are significant opportunities to apply CALS to the digital receipt, management, storage, distribution, use, and configuration management of SPD.

APPENDICES

RELATED STUDIES

IDEF DIAGRAMS

BIBLIOGRAPHY

POINTS OF CONTACT

APPENDIX A: RELATED STUDIES

A.1 INTRODUCTION

There have been several studies of Air Force software problems since the late 1970s. Some of these studies address only the acquisition phase of the software development life cycle. Many of the problems identified in these studies have remained unresolved and are identified again in the later studies. Among the most common problems are:

- Ineffective configuration management,
- Insufficient documentation,
- Shortage of software maintenance personnel, and
- Insufficient integration of CASE tools.

Other studies were reviewed to help understand and define the current Air Force software development and support environments. Some of these studies are summarized below, in Section A.2.

A.2 MAJOR STUDIES

A.2.1 Air Force Studies Board (1976, 1983, 1985)

The Board published studies of Air Force software management practices in 1976, 1983, and 1985. All three studies found that the Air Force was not adequately defining software requirements for its systems prior to coding. They recommended that an evolutionary approach be used, i.e., build only what has been thoroughly defined, test it, and then use it to stimulate additional well-defined requirements for building additional software. Another problem the Board found was that while people know and accept the limitations of hardware, the limitations of software were not so readily understood and accepted.

The Board noted the absence of integrated Computer-aided Software Engineering (CASE) tools. While these tools promise a great deal, their usefulness is limited to selected portions of the development cycle. The Board recommended that the Air Force select an off-the-shelf software engineering environment containing CASE tools for the short term, and develop a customized environment for the long term. This customized environment should rely heavily on expert systems so that a proposed change to a portion of the software can be automatically analyzed to determine the potential impact on the software as a whole.

The Board criticized the Air Force for not providing long-term technical training to software development and maintenance personnel. The quality of the training should be similar to that provided for pilots. The Board was also critical of the fragmented software configuration management practices of the Air Force.

A.2.2 U.S. Navy Software Maintenance Study (1987)

Even though this is a study of Navy software, its findings are of interest to the Air Force. This study found that software support people need to have knowledge of the weapon system, on–

the–job training with software developers, hardware/operating system training, and extensive experience with the HOL used by the system. A truly integrated support environment requires that all tools, from documentation through programming, utilize a common data base. An effective tool is one that is non–modal. A non–modal tool can be used in more than one mode at a time, e.g., to perform debug and edit operations simultaneously.

This study emphasizes that integrated tools are available mostly for the development phase. Few are useful in the support phase. This study also stated that regression testing is a major part of software support since it ensures that a change to a part of the software does not adversely affect overall software performance. It is imperative that software support personnel be thoroughly familiar with the software because of the wide–ranging implications of changing the software. The software support task is best served by an approach that stresses the importance of knowing how the software was developed, i.e., what its design philosophy is. More time should be devoted to requirements analysis and software design. If requirements and design are properly completed, coding should not require more than 20% of the development time.

Frequent, in–depth walk–through of design and code are the key to ensuring that the software performs as required. The military should use communication networks such as the Defense Data Network (DDN) and engineering workstations to establish software development and support networks for use by development, user, and support personnel. Such networks would provide a real–time review of documentation and automatic update of documentation concurrent with code changes. It would improve communications and reduce travel time and expenses. To do this, either a structured, graphical technique or translating devices should be used to link requirements, design, and coding in much the same way that compilers link source and object code.

A.2.3 TRW Study of Air Force ECS Software (1980)

This study reviewed the problems associated with all five categories of ECS software. The study identifies shortage of trained software support personnel, lack of software configuration management, and poor quality/incomplete documentation as the major problems plaguing software. The study concludes that the documentation issue is a major reason for the failure of software configuration management. One of the major findings is that 25–40% of all ECS software does not function properly when turned over to AFLC at PMRT. Support of most ECS software is fragmented between AFLC and the user. The failure to centrally manage software development also contributes to ineffective software configuration management. The study emphasizes that software support for changes/modifications to existing software is usually more complex than the original development effort. As a result, a complete life cycle software support facility and full set of documentation must be available for software support. Yet software support personnel often have little more than source code with which to work. Documentation either does not reflect the current configuration of the code or is unavailable. Lack of current documentation hinders not only software support but also competitive re-procurement. To be effective, IV&V should start during the review of system requirements and design.

A.2.4 Journal of Defense Systems Acquisition Management Studies of Software Maintenance (1982)

This study emphasizes the need to address maintenance and training requirements at the same time that mission and technical requirements are addressed. This usually does not happen because AFLC is not adequately represented during the development process. Requirements need to be stated in a way that makes them testable. Experience shows that the more completely automated and testable the software requirements are, the lower the development cost. Current communications electronics systems represent the initial departure from previous manual systems, and their users find it difficult to articulate requirements. In such circumstances, iterative prototyping is the most efficient way to define requirements. The structured methodology of DOD-STD-2167A is not suited to this type of software development. The government should state only what is required and not dictate how the requirements are to be satisfied. Configuration control of software should not start until software baselines have been established. The length of time needed for software support personnel to acquire in-depth knowledge depends on how involved they are in the development cycle. All software and documentation changes and configuration management should be centralized. Testing of changes should be performed by the user.

A.2.5 PDSS Study for the F-16 (Current)

The Software Engineering Institute (SEI) is currently studying how software for the F-16D is supported by OO-ALC. A behavioral analysis tool called State Mate is being used in the study. It depicts information flows among all the Ogden functions that support F-16D software. The SEI's methodology includes many detailed interviews with a carefully selected group of key F-16 software support personnel. These interviews have been going on for over a year. They will be used to model the current support process. The F-16D is equipped with 15 complete systems, 300 digital processors, and has over 250,000 lines of code.

A.2.6 DOD Master Plan (1989)

The DOD has started to assess all of the software improvement studies performed for the services over the past decade. This study will be used to develop a plan for implementing some of the specific recommendations of the studies. This DOD effort has recognized that most of the problems uncovered by the earliest studies (pre 1979) continue to be found by the more recent studies. The study will therefore focus on what are considered to be the twelve best previous studies. Another characteristic of all of the studies is that recommendations were too general, e.g., enhance the education of software personnel, and that there was very little detail about how to implement recommendations. The DOD Software Master Plan Study is committed to provide detailed solutions to these problems. The first task of the study is to analyze all of the government directives, standards, etc., for software development and support to determine the applicability, redundancy, and consistency of the material. To date the study has identified over 200 documents related to software development and support. The study is also cataloging DOD's current software research and development efforts and will identify all DOD units that have software management roles. The goal of the Master Plan is to lay out a five-year implementation plan to determine responsibilities, schedules, milestones, and required funding. A draft of the DOD Software Master Plan was issued in February 1990.

A.2.7 Software Technology for Adaptable and Reliable Systems (STARS) (1988)

This program is administered by the Defense Advanced Research Projects Agency (DARPA) to improve software engineering techniques and disseminate them to industry. To date, three contracts have been awarded to develop tools for creating and managing re-usable machine-independent Ada code. STARS has recently been criticized for making it difficult for industry to obtain the tools being developed under the program. The program has also recently announced a change in goal due to the need for a standardized environment; to focus on developing a life cycle software support environment.

A.2.8 Purdue University Study on Software Development Documentation (1988)

This study focuses on documentation for software development. It does not address the need for documentation during the support phase. Recommendations are that documentation be transferred electronically between the Air Force and contractors during development.

A.2.9 MITRE SPD Study (1989)

MITRE Corporation has begun a study on the management of C3 documentation in a digital format. Currently, MITRE is trying to establish a standard for transferring cost data between the government and industry via floppy disks. There are no current plans to consider the issue of electronically transferring all software-related data between the government and industry.

A.3 RELATED INITIATIVES

There are a number of initiatives concerning the scope of the SPD Program. These include:

- **BOLD STROKE** – This is an Air Force Senior Officer Software Management course offered by the Technology Management School at Maxwell AFB, AL. The course originated from a Software Management Action Plan issued on 29 November 1985 and summarizes Air Force management approaches, fundamentals, and problems involving software. It includes a series of briefings to apprise senior officers of software management. The course states that the ability of the Air Force to manage software is the key to mission readiness and that software must by treated as a key component of the system life cycle.

- **Joint Logistics Commanders Workshop on Post Deployment Software Support (Orlando I and II)** – Logistics Commands from the Army, Navy, Air

Force and Marine Corps sponsored conferences on software support concerns in 1983 (Orlando I) and 1987 (Orlando II). The topics addressed included IV&V, cost of ownership, software support environment, software change process and configuration management, forecasting PDSS resource requirements, and PDSS standards.

- **NSIA Committees** – The National Security Industrial Association (NSIA) is sponsoring several committees that are active in addressing CALS. The Information Technology Committee includes two subcommittees; a Software Subcommittee and a Software Standards Subcommittee. Committee members have recently added a Software Products Interest Group to the effort to develop the Product Data Exchange Standard (PDES).

- **Software Standards** – A variety of software standards are in development that will facilitate a neutral exchange of software and data. These efforts address some or all of the following issues: tool portability, open architecture, data exchange, tool integration, repository architecture, and user interface, in the United States as well as Europe, and Japan. These efforts include:

  - Information Resource Dictionary System (IRDS),
  - Portable Common Tool Environment (PCTE),
  - CASE Integration Services (CIS),
  - Common APSE Interface Set (CAIS) – Ada environments, and
  - CASE Data Interchange Format (CDIF).

Phase II of the modular planning process, Technology Assessments, will examine these further.

APPENDIX B: IDEF DIAGRAMS

B.1 INTRODUCTION

Section 3 of this report contains an explanation of the IDEF methodology and why it was used in the analysis of the SPD current environment. This appendix presents the complete set of IDEF diagrams required to describe the current software environment in detail down to level 4. FIGURE B-1 is a top level IDEF node tree of the SPD environment. By showing the hierarchy of functions from general to detailed the node tree provides a reference point for understanding the activities and decomposition represented in the detailed IDEF diagrams which follow.

B.2 DETAILED IDEFs OF THE SPD PROCESS

The SPD process covers two major activities: acquisition and deployment/management. This appendix examines both activities and presents a high level node tree for each activity followed by detailed IDEF diagrams and text describing each IDEF. For a better understanding of the process, text and the IDEF diagrams appear on opposite pages.

B.2.1 Acquisition IDEFs

The SPD acquisition node tree (FIGURE B-2) shows that the acquisition function is responsible for the majority of software products. These products are needed throughout the PDSS cycle. The system must adjust to changes in the mission, so that "software maintenance" is, in essence, further software development.

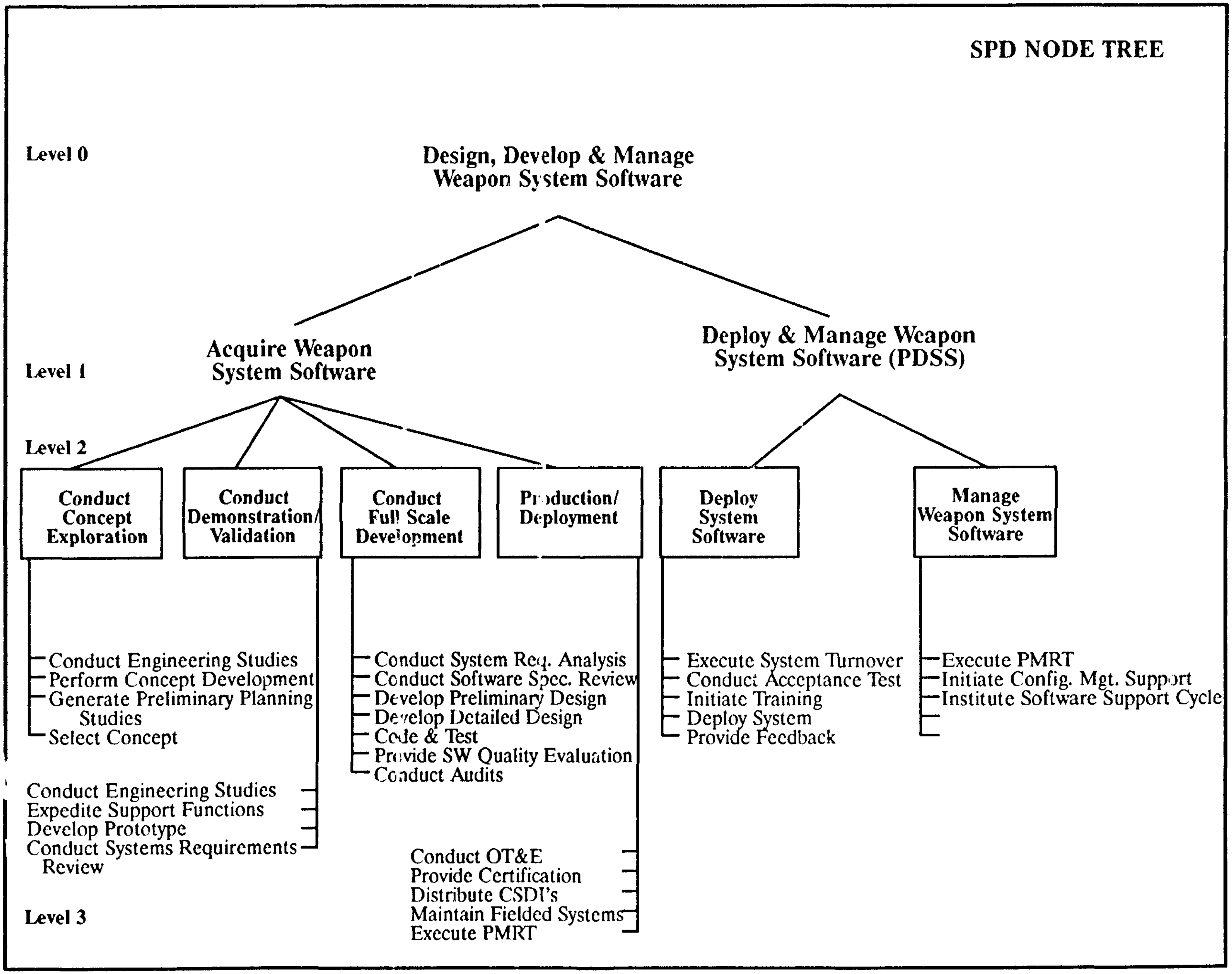


FIGURE B-1. SPD TOP LEVEL NODE TREE

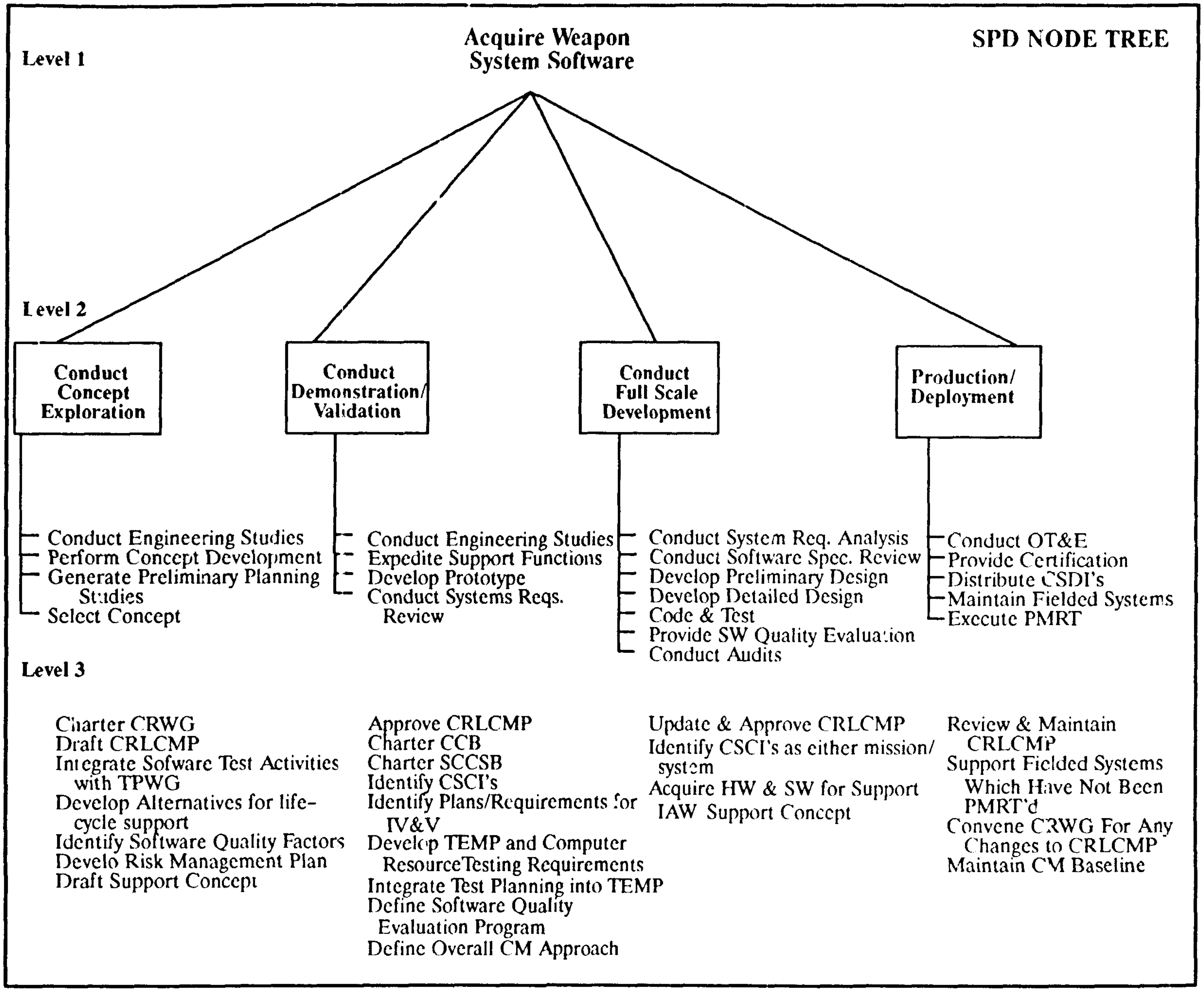


FIGURE B-2. SPD ACQUISITION NODE TREE

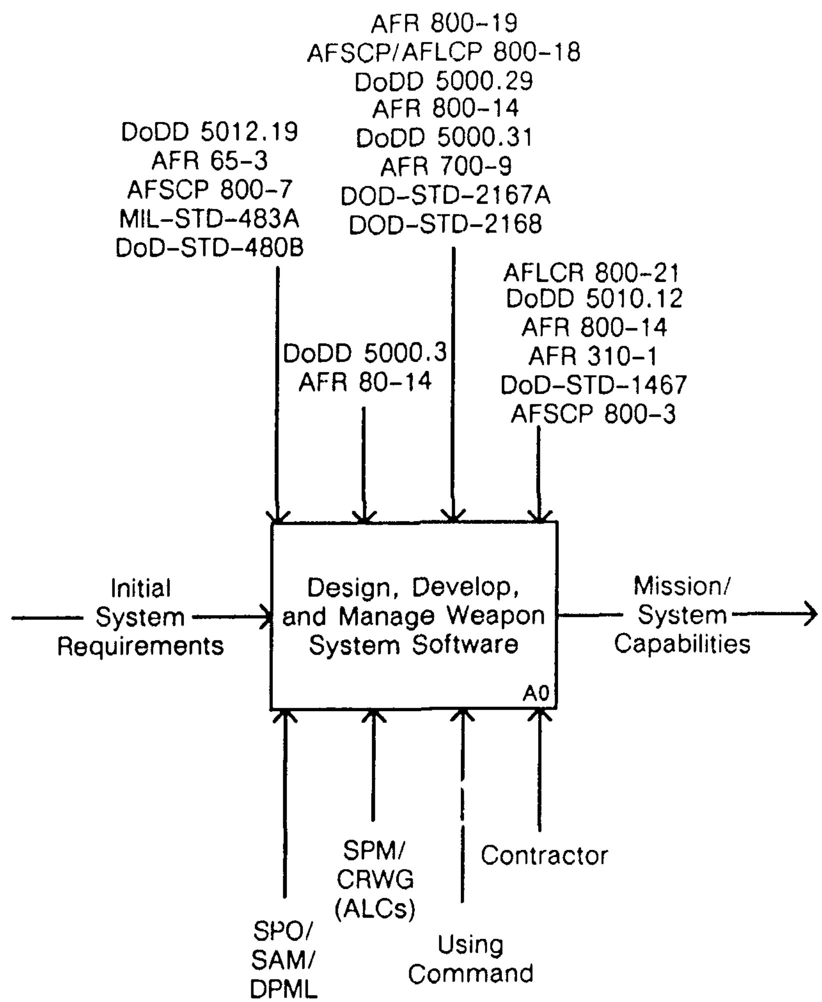
B.2.1.1 Design, Develop & Manage Weapon System Software - Node A-0

This is the top level node in the network, representing all activity within the ECS software life cycle. At this level, the major inputs are the system requirements. The activities include the design work, development of the software, integration into the weapon system or end item, and management throughout the system life cycle. The output of this activity is to provide the system capabilities that satisfy system requirements.

Design, Develop & Manage Weapon System Software - Box A-0

INPUTS:	Initial System Requirements
OUTPUTS:	Mission/System Capabilities
CONTROLS:	DODD 5012.19, AFR 65-3, AFSCP 800-7, MIL-STD-483A, DOD-STD-480B, DODD 5000.3, AFR 80-14, AFR 800-19, AFSCP/AFLCP 800-18, DODD 5000.29, DODD 5000.31, AFR 700-9, DOD-STD-2167A, MIL-STD-2168, AFLCR 800-21, DODD 5010.12 AFR 800-14, AFR 310-1, DOD-STD-1467, AFSCP 800-3
MECHANISMS:	SPO/SAM/DPML, SPM/CRWG (ALCs), Using Command, Contractor

USED AT:	AUTHOR: Sweeney, Powers COMPANY: TSC PROJECT: CALS/SPD NOTES:	DATE: 11/01/89 REV: 1.4	DATE	REMARKS	CONTEXT: NODE:



NODE: Level 0 node A-0	TITLE: Design, Develop & Manage Weapon System Software	NUMBER:

B.2.1.2 Design, Develop & Manage Weapon System Software – Node A0

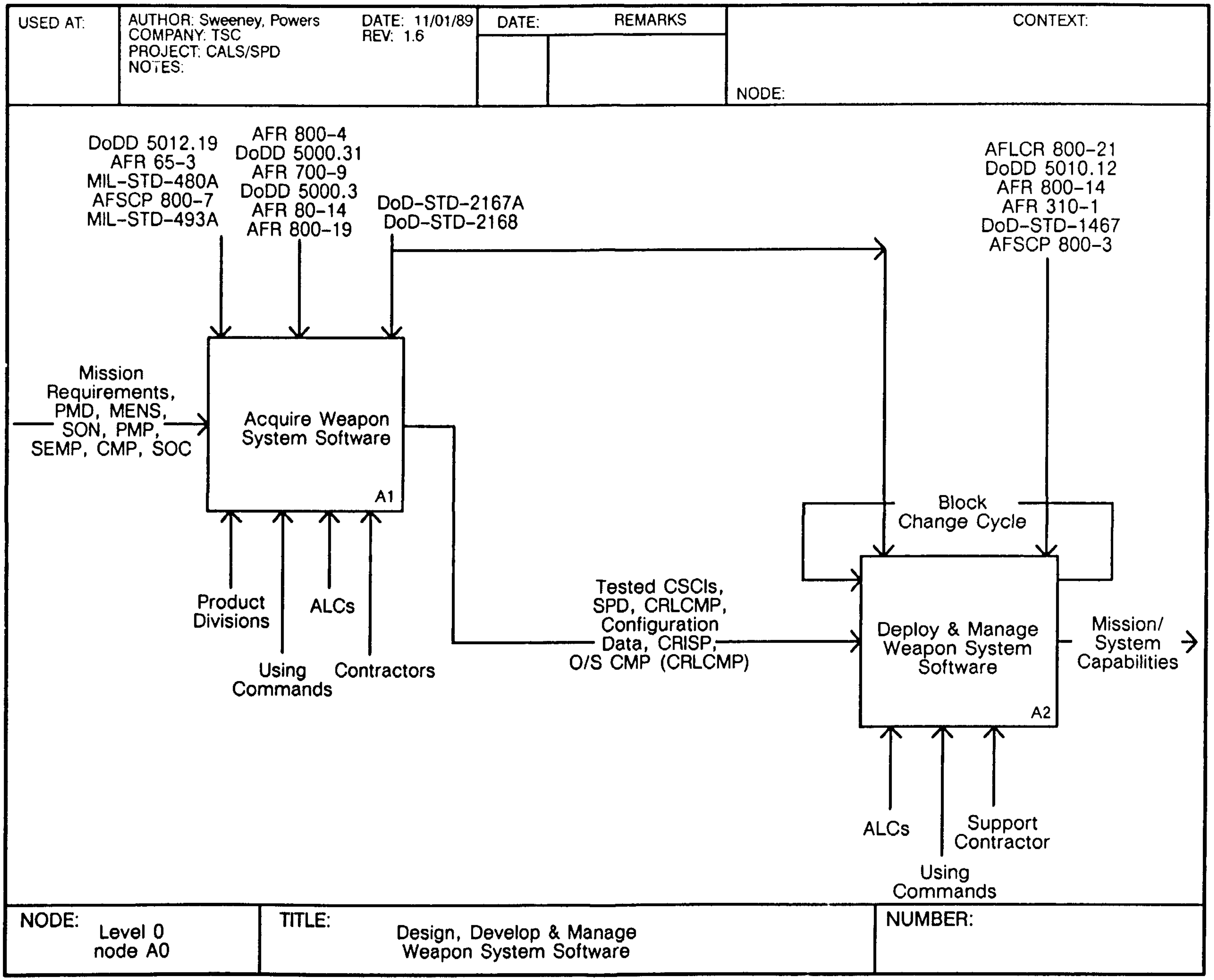
Node A0 is comprised of two major activities, the acquisition (Node A1) and the deployment/ management (Node A2). The acquisition node is responsible for the majority of software products. These products are needed throughout the PDSS cycle. The system must adjust to changes in the mission, so that "software maintenance" is predominantly software development.

Acquire Weapon System Software – Box A1

INPUTS:	Mission Requirements, PMD, MENS, SON, PMP, SEMP, CMP, SOC
OUTPUTS:	Tested CSCIs, SPD, CRLCMP, Configuration Data, CRISP, O/S CMP
CONTROLS:	DODD 5012.19, AFR 65-3, MIL-STD-480, AFSCP 800-7, MIL-STD-493A, AFR 800-4, DODD 5000.31, AFR 700-9, DODD 5000.3, AFR 80-14, AFR 800-19, DOD-STD-2167A, DOD-STD-2168
MECHANISMS:	Product Divisions, Using Commands, ALCs, Contractors

Deploy & Manage Weapon System Software – Box A2

INPUTS:	Block Change Cycle, Tested CSCIs, SPD, CRLCMP, Configuration Data, CRISP, O/S CMP (CRLCMP)
OUTPUTS:	Mission/System Capabilities
CONTROLS:	AFLCR 800-21, DODD 5010.12, AFR 800-14, AFR 310-1, DOD-STD-1467, AFSCP 800-3, DOD-STD-2167A, DOD-STD-2168
MECHANISMS:	ALCs, Using Commands, Support Contractor



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AFSCP 800-7
MIL-STD-493A
AFR 800-4
DoDD 5000.31
AFR 700-9
DoDD 5000.3
AFR 80-14
AFR 800-19
DoD-STD-2167A
DoD-STD-2168
AFLCR 800-21
DoDD 5010.12
AFR 800-14
AFR 310-1
DoD-STD-1467
AFSCP 800-3
Mission Requirements, PMD, MENS, SON, PMP, SEMP, CMP, SOC
Acquire Weapon System Software
A1
Product Divisions
Using Commands
ALCs
Contractors
Tested CSCIs, SPD, CRLCMP, Configuration Data, CRISP, O/S CMP (CRLCMP)
Block Change Cycle
Deploy & Manage Weapon System Software
A2
Mission/ System Capabilities
ALCs
Using Commands
Support Contractor
NODE:
Level 0
node A0
TITLE:
Design, Develop & Manage Weapon System Software
NUMBER:

B.2.1.3 Acquire Weapon System Software - Node A1

This activity comprises all development activity up to and including PMRT. The acquisition is broken out into the four phases. It is not until FSD that software actually is developed. However, the system concept will have an effect on what software will be required.

Conduct Concept Exploration - Box A11

INPUTS:	Mission Requirements
OUTPUTS:	System Concepts, SOC
CONTROLS:	DODD 5012.19, AFR 65-3, MIL-STD-480, MIL-STD-490A DODD 5000.31, AFR 700-9, DOD-STD-2167A, DOD-STD-2168
MECHANISMS:	SPO/Contractor

Conduct Demonstration/Validation - Box A12

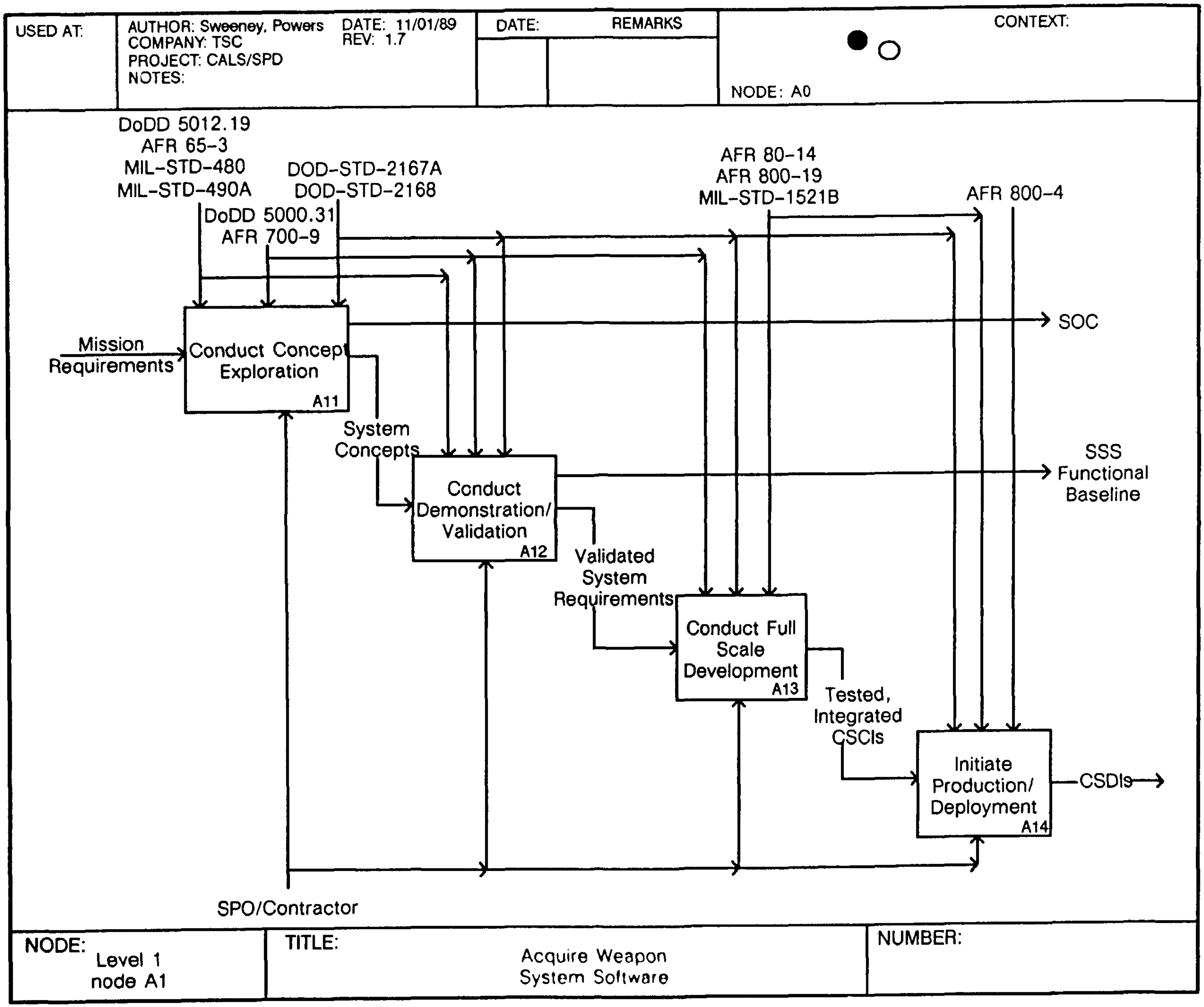
INPUTS:	System Concepts
OUTPUTS:	Validated System Requirements, SSS Functional Baseline
CONTROLS:	DODD 5012.19, AFR 65-3, MIL-STD-480, MIL-STD-490A DODD 5000.31, AFR 700-9, DOD-STD-2167A, DOD-STD-2168
MECHANISMS:	SPO/Contractor

Conduct Full Scale Development - Box A13

INPUTS:	Validated System Requirements
OUTPUTS:	Tested, Integrated CSCIs
CONTROLS:	DODD 5000.31, AFR 700-9, DOD-STD-2167A, DOD-STD-2168, AFR 80-14, AFR 800-19, MIL-STD-1521B
MECHANISMS:	SPO/Contractor

Initiate Production/Deployment - Box A14

INPUTS:	Tested, Integrated CSCIs
OUTPUTS:	CSDIs
CONTROLS:	DOD-STD-2167A, DOD-STD-2168, AFR 80-14, MIL-STD-1521B, AFR 800-4, AFR 800-19
MECHANISMS:	SPO/Contractor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MIL-STD-490A
DoDD 5000.31
AFR 700-9
DOD-STD-2167A
DOD-STD-2168
AFR 80-14
AFR 800-19
MIL-STD-1521B
AFR 800-4
Mission Requirements
Conduct Concept Exploration
A11
SOC
System Concepts
Conduct Demonstration/ Validation
A12
SSS Functional Baseline
Validated System Requirements
Conduct Full Scale Development
A13
Tested, Integrated CSCIs
Initiate Production/ Deployment
A14
CSDIs
SPO/Contractor
NODE:
Level 1
node A1
TITLE:
Acquire Weapon
System Software
NUMBER:

B.2.1.4 Conduct Concept Exploration – Node A11

The concept exploration phase, the primary phase in the system acquisition life cycle, is responsible for the development of proposals which initially satisfy the system need. To determine the viability of these proposals, risk and schedule assessments are performed, as well as a general feasibility study.

Conduct Engineering Studies – Box A111

INPUTS:	Mission Requirements
OUTPUTS:	Feasibility Studies, Alternative Approaches Cost/Schedule Estimates, Risk Assessment
CONTROLS:	SPO
MECHANISMS:	Contractor

Perform Concept Development – Box A112

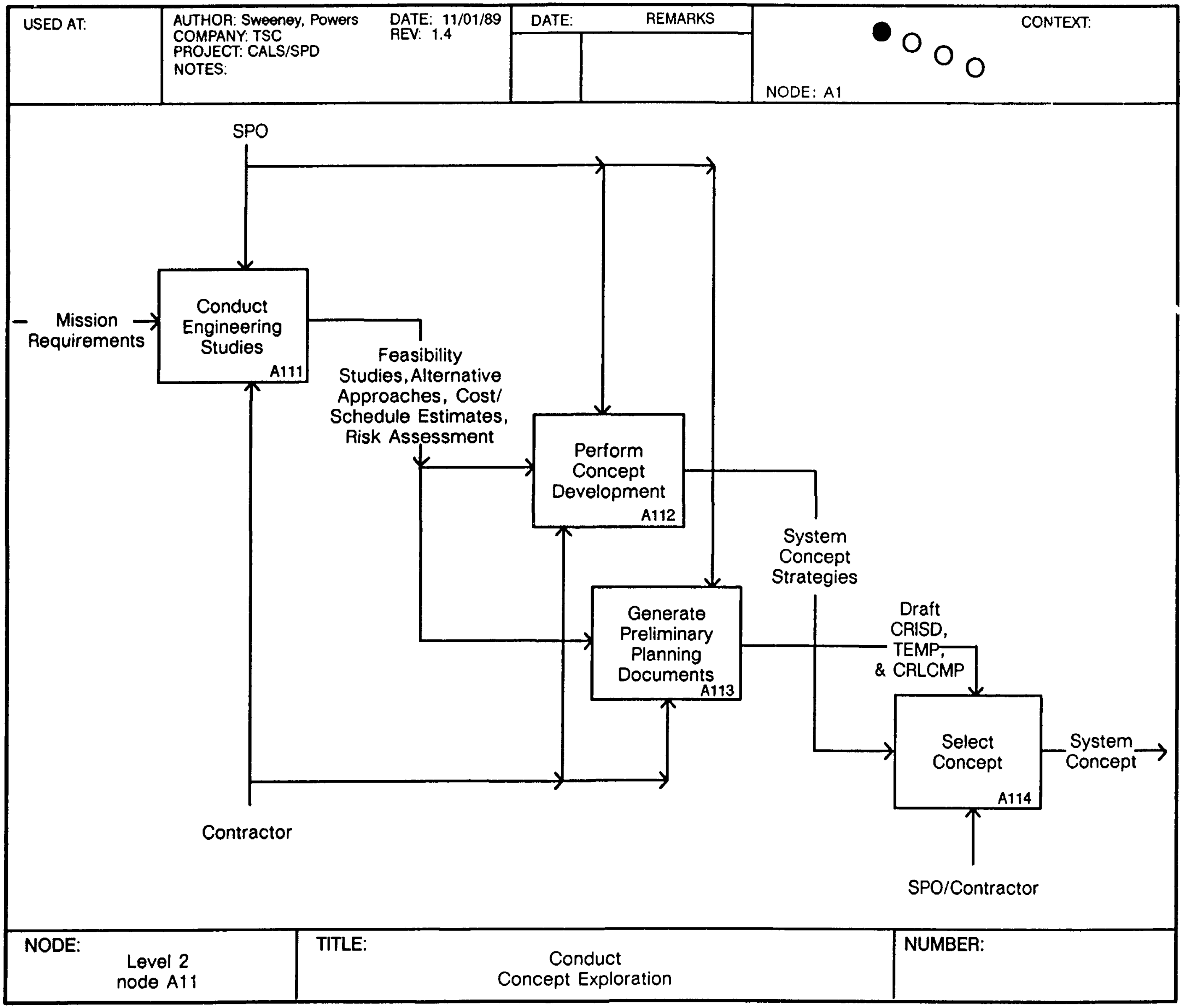
INPUTS:	Feasibility Studies, Alternative Approaches, Cost/Schedule Estimates, Risk Assessment
OUTPUTS:	System Concept Strategies
CONTROLS:	SPO
MECHANISMS:	Contractor

Generate Preliminary Planning Document – Box A113

INPUTS:	Feasibility Studies, Alternative Approaches, Cost/Schedule Estimates, Risk Assessment
OUTPUTS:	Draft CRISD, TEMP, CRLCMP
CONTROLS:	SPO
MECHANISMS:	Contractor

Select Concept – Box A114

INPUTS:	System Concept Strategies
OUTPUTS:	System Concept
CONTROLS:	Draft CRISD, TEMP, CRLCMP
MECHANISMS:	SPO/Contractor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DATE:
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CONTEXT:
NODE: A1
SPO
Mission Requirements
Conduct Engineering Studies
A111
Feasibility Studies, Alternative Approaches, Cost/ Schedule Estimates, Risk Assessment
Perform Concept Development
A112
Generate Preliminary Planning Documents
A113
System Concept Strategies
Draft CRISD, TEMP, & CRLCMP
Select Concept
A114
System Concept
Contractor
SPO/Contractor
NODE:
Level 2 node A11
TITLE:
Conduct Concept Exploration
NUMBER:

B.2.1.5 Conduct Demonstration/Validation - Node A12

The purpose of the demonstration/validation phase is to validate the selection made from the alternatives provided in the previous phase. While actual software requirements may not have been defined, the software development methodologies may be defined at this time.

Conduct Engineering Studies - Box A121

INPUTS:	System Concept
OUTPUTS:	Feasibility Studies, FFBD, Trade-Off Studies
CONTROLS:	AFR 800-14
MECHANISMS:	Contractor

Expedite Support Functions - Box A122

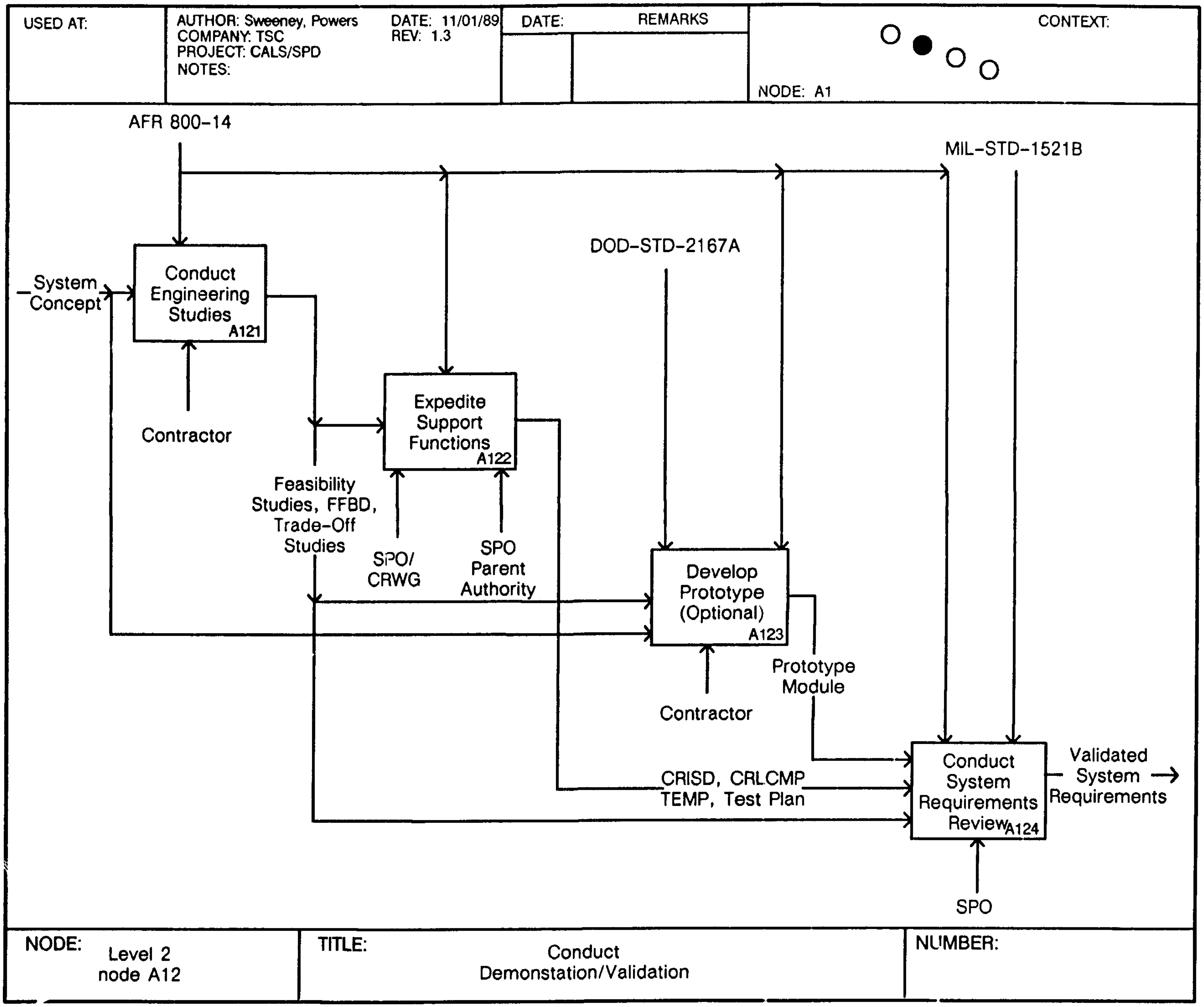
INPUTS:	Feasibility Studies, FFBD, Trade-Off Studies
OUTPUTS:	CRISD, CRLCMP, TEMP, Test Plan
CONTROLS:	AFR 800-14
MECHANISMS:	SPO/CRWG, SPO Parent Authority

Develop Prototype (Optional) - Box A123

INPUTS:	System Concept, Feasibility Studies, FFBD, Trade-Off Studies
OUTPUTS:	Prototype Module
CONTROLS:	AFR 800-14, DOD-STD-2167A
MECHANISMS:	Contractor

Conduct System Requirements Review - Box A124

INPUTS:	Prototype Module, Feasibility Studies, FFBD, Trade-Off Studies CRISD, CRLCMP, TEMP, Test Plan
OUTPUTS:	Validated System Requirements
CONTROLS:	AFR 800-14, MIL-STD-1521B
MECHANISMS	SPO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AFR 800-14
MIL-STD-1521B
DOD-STD-2167A
System Concept
Conduct Engineering Studies A121
Contractor
Expedite Support Functions A122
Feasibility Studies, FFBD, Trade-Off Studies
SPO/ CRWG
SPO Parent Authority
Develop Prototype (Optional) A123
Contractor
Prototype Module
CRISD, CRLCMP TEMP, Test Plan
Conduct System Requirements Review A124
Validated System Requirements
SPO
NODE: Level 2 node A12
TITLE: Conduct Demonstation/Validation
NUMBER:

B.2.1.6 Conduct Full Scale Development – Node A13

During the full scale development phase, the design and development of the system takes place. This phase includes the entire software development cycle. Towards the end of this phase, the software configuration items are integrated with the hardware, prior to system testing.

Perform System Requirements Analysis – Box A131

INPUTS:	Validated System Requirements (B5), Feedback/Comments to Developer
OUTPUTS:	Software Requirements
CONTROLS:	DODD 5000.31, AFR 700-9, MIL-STD-490A, DOD-STD-2167A, DOD-STD-1521B
MECHANISMS:	Contractor

Develop Preliminary Design – Box A132

INPUTS:	Validated Specification, Feedback/Comments to Developer
OUTPUTS:	Developmental Configuration
CONTROLS:	DOD-STD-2167A, DOD-STD-1521B
MECHANISMS:	Contractor

Develop Detailed Design – Box A133

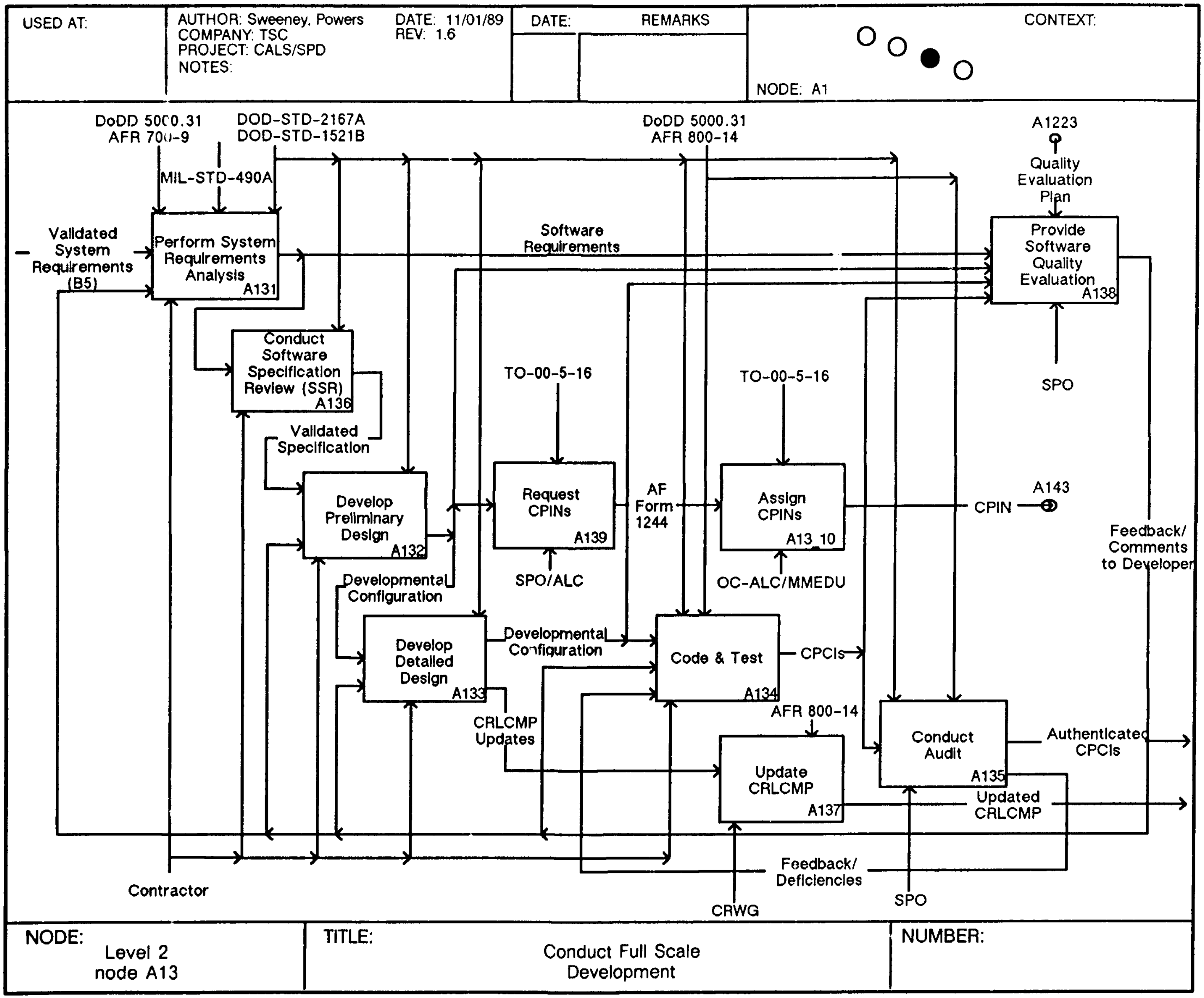
INPUTS:	Developmental Configuration, Feedback/Comments to Developer
OUTPUTS:	CRLCMP Updates, Developmental Configuration
CONTROLS:	DOD-STD-2167A, DOD-STD-1521B
MECHANISMS:	Contractor

Code & Test – Box A134

INPUTS:	Developmental Configuration, Feedback/Comments to Developer, Feedback/Deficiencies
OUTPUTS:	CPCIs
CONTROLS:	DOD-STD-2167A, DOD-STD-1521B, DODD 5000.31, AFR 800-14
MECHANISMS:	Contractor

Conduct Audit – Box A135

INPUTS:	CPCIs
OUTPUTS:	Authenticated CPCIs, Feedback/Deficiencies
CONTROLS:	DOD-STD-2167A, DOD-STD-1521B, DODD 5000.31, AFR 800-14
MECHANISMS:	SPO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COMPANY: TSC
PROJECT: CALS/SPD
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AFR 700-9
MIL-STD-490A
DOD-STD-2167A
DOD-STD-1521B
DoDD 5000.31
AFR 800-14
A1223
Quality Evaluation Plan
Validated System Requirements (B5)
Perform System Requirements Analysis
A131
Software Requirements
Provide Software Quality Evaluation
A138
Conduct Software Specification Review (SSR)
A136
Validated Specification
TO-00-5-16
TO-00-5-16
SPO
Develop Preliminary Design
A132
Request CPINs
A139
AF Form 1244
Assign CPINs
A13 10
CPIN
A143
SPO/ALC
OC-ALC/MMEDU
Feedback/ Comments to Developer
Developmental Configuration
Develop Detailed Design
A133
Developmental Configuration
Code & Test
A134
CPCIs
CRLCMP Updates
AFR 800-14
Conduct Audit
A135
Authenticated CPCIs
Update CRLCMP
A137
Updated CRLCMP
Feedback/ Deficiencies
Contractor
CRWG
SPO
NODE:
Level 2
node A13
TITLE:
Conduct Full Scale Development
NUMBER:

Conduct Software Specification Review (SSR) - Box A136

INPUTS:	Software Requirements
OUTPUTS:	Validated Specification
CONTROLS:	DOD-STD-2167A, DOD-STD-1521B
MECHANISMS:	Contractor

Update CRLCMP - Box A137

INPUTS:	CRLCMP Updates
OUTPUTS:	Updated CRLCMP
CONTROLS:	AFR 800-14
MECHANISMS:	CRWG

Provide Software Quality Evaluation - Box A138

INPUTS:	Software Requirements, Developmental Configuration, CPCIs
OUTPUTS:	Feedback/Comments to Developer
CONTROLS:	(A1223) Quality Evaluation Plan
MECHANISMS:	SPO

Request CPINs - Box A139

INPUTS:	Developmental Configuration
OUTPUTS:	AF Form 1244
CONTROLS:	TO-00-5-16
MECHANISMS:	SPO/ALC

Assign CPINs - Box A13_10

INPUTS:	AF Form 1244
OUTPUTS:	CPIN (A143)
CONTROLS:	TO-00-5-16
MECHANISMS:	OC-ALC/MMEDU

B.2.1.7 Production/Deployment - Node A14

Production/Deployment is the final phase of the acquisition cycle. During this phase, weapon systems are produced using the design developed during FSD. In terms of software, the SPO is still responsible for the initial maintenance of the software, but this function may eventually be performed by the developing contractor.

Conduct Operational Test & Evaluation - Box A141

INPUTS:	(A21) Authenticated CSCIs (Imbedded w/in System)
OUTPUTS:	Test Results
CONTROLS:	AFR 80-14
MECHANISMS:	Using Command, SPM

Provide Operational Certification - Node A142

INPUTS:	Test Results
OUTPUTS:	Certification
CONTROLS:	AFR 80-14
MECHANISMS:	Using Command

Distribute CSDIs - Box A143

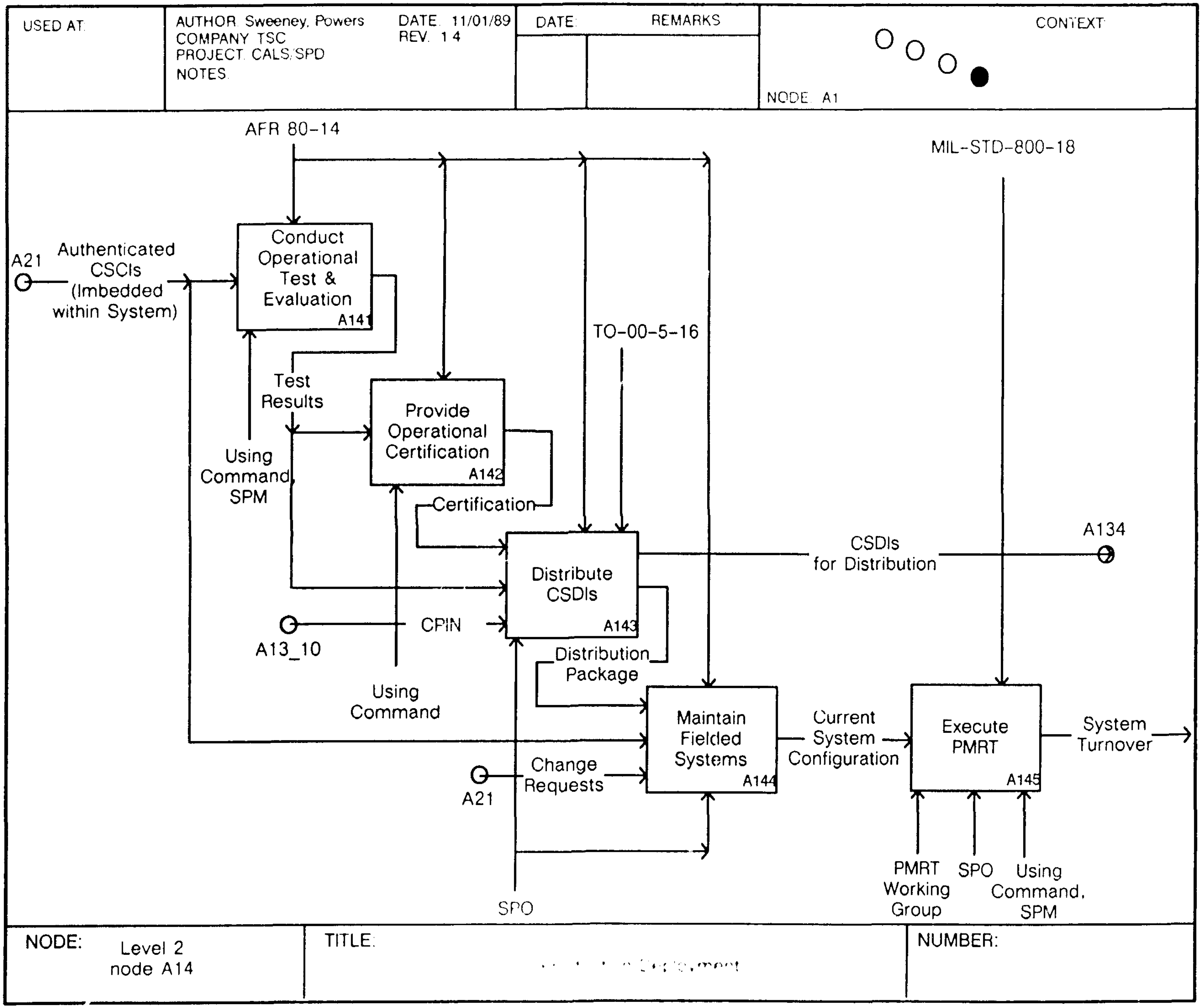
INPUTS:	CPIN Assignment (A13_10), Test Results, Certification
OUTPUTS:	Distribution Package, CSDIs for Distribution (A134)
CONTROLS:	AFR 80-14, TO-00-5-16
MECHANISMS:	SPO

Maintain Fielded Systems - Box A144

INPUTS:	Change Requests (A21), Distribution Package, Authenticated CSCIs (Imbedded within System)
OUTPUTS:	Current System Configuration
CONTROLS:	AFR 80-14
MECHANISMS:	SPO

Execute PMRT - Box A145

INPUTS:	Current System Configuration
OUTPUTS:	System Turnover
CONTROLS:	MIL-STD-800-18
MECHANISMS:	PMRT Working Group, SPO, Using Command, SPM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COMPANY: TSC
PROJECT: CALS/SPD
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DATE: 11/01/89
REV: 1 4
DATE:
REMARKS
CONTEXT
NODE: A1
AFR 80-14
MIL-STD-800-18
A21
Authenticated CSCIs (Imbedded within System)
Conduct Operational Test & Evaluation
A141
TO-00-5-16
Test Results
Provide Operational Certification
A142
Using Command, SPM
Certification
Distribute CSDIs
A143
CSDIs for Distribution
A134
A13_10
CPIN
Distribution Package
Using Command
Maintain Fielded Systems
A144
Current System Configuration
Execute PMRT
A145
System Turnover
A21
Change Requests
SPO
PMRT Working Group
SPO
Using Command, SPM
NODE:
Level 2 node A14
TITLE:
NUMBER:

B.2.1.8 Conduct Engineering Studies - Node A111

One of the initial technical tasks during the Concept Exploration is the technical assessment of the mission requirements. This analysis is developed through preliminary engineering studies. These studies include feasibility reports, cost/schedule estimates, risk estimates, etc. These studies form the basis of development of the preliminary concepts. While software requirements will not be addressed until the latter part of the Demonstration/Validation phase, computer resources needed to support the system are initially identified.

Requirements Allocation – Box A1111

INPUTS:	PSOC, SOC, SON
OUTPUTS:	Initial Requirements Allocation
CONTROLS:	SPO, AFR 800-14
MECHANISMS:	Contractor

Conduct Operational Concept Analysis – Box A1112

INPUTS:	Initial Requirements Allocation
OUTPUTS:	Concept of Operations, Cost & Schedule Estimates
CONTROLS:	SPO, AFR 800-14
MECHANISMS:	Contractor

Conduct Trade-Off & Optimization Studies – Box A1113

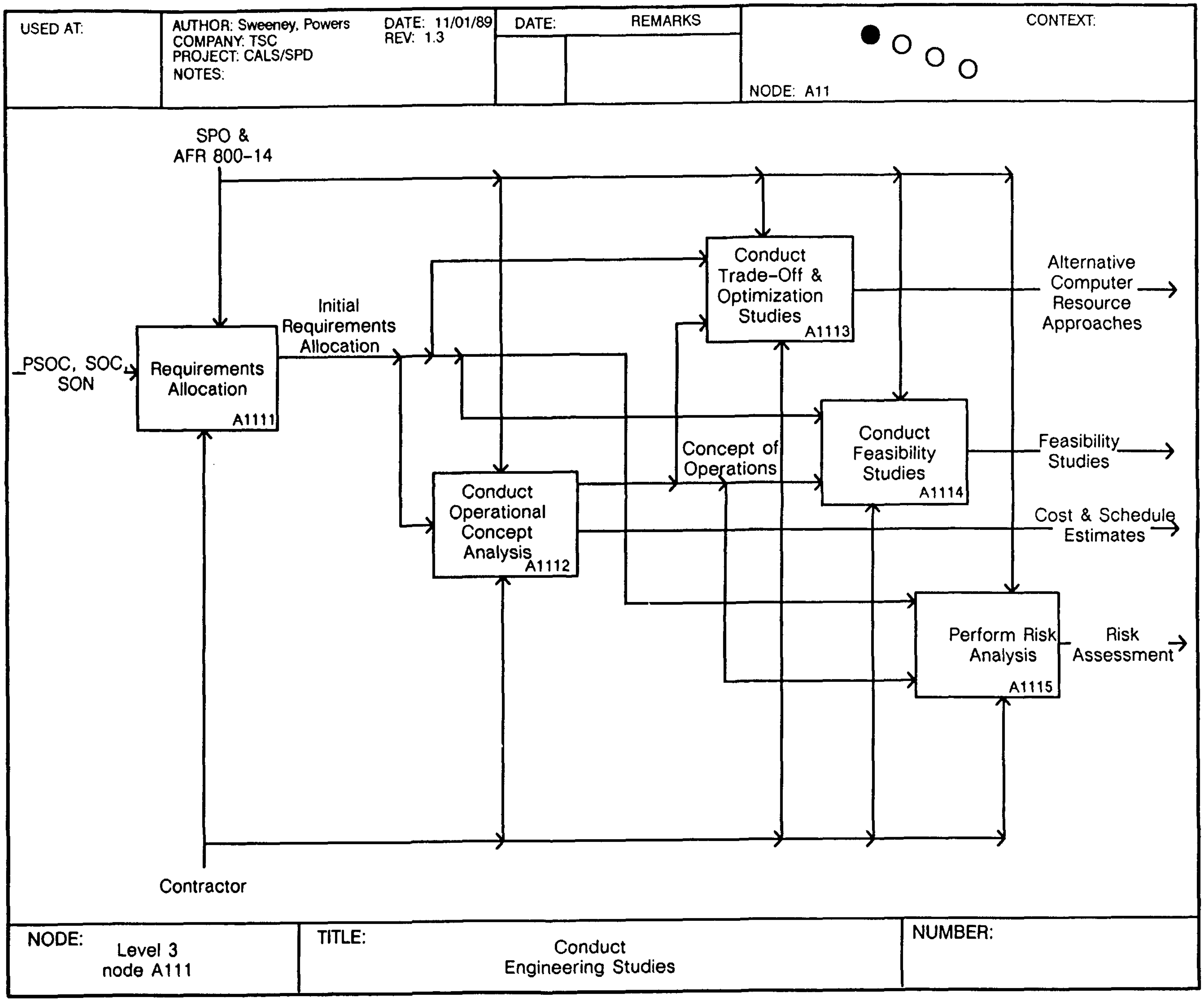
INPUTS:	Initial Requirements Allocation, Concept of Operations
OUTPUTS:	Alternative Computer Resource Approaches
CONTROLS:	SPO, AFR 800-14
MECHANISMS:	Contractor

Conduct Feasibility Studies – Box A1114

INPUTS:	Initial Requirements Allocation, Concept of Operations
OUTPUTS:	Feasibility Studies
CONTROLS:	SPO, AFR 800-14
MECHANISMS:	Contractor

Perform Risk Analysis – Box A1115

INPUTS:	Initial Requirements Allocation, Concept of Operations
OUTPUTS:	Risk Assessment
CONTROLS:	SPO, AFR 800-14
MECHANISMS:	Contractor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DATE: 11/01/89
REV: 1.3
DATE:
REMARKS
CONTEXT:
NODE: A11
SPO &
AFR 800-14
PSOC, SOC,
SON
Requirements
Allocation
A1111
Initial
Requirements
Allocation
Conduct
Operational
Concept
Analysis
A1112
Conduct
Trade-Off &
Optimization
Studies
A1113
Concept of
Operations
Conduct
Feasibility
Studies
A1114
Perform Risk
Analysis
A1115
Alternative
Computer
Resource
Approaches
Feasibility
Studies
Cost & Schedule
Estimates
Risk
Assessment
Contractor
NODE:
Level 3
node A111
TITLE:
Conduct
Engineering Studies
NUMBER:

B.2.1.9 Perform Concept Development – Node A112

Node A112, Perform Concept Development, identifies the activities associated with developing working concepts based on functional analysis as well as trade–off analysis. The concepts developed during this activity are used in other activities such as trade–off analysis. The objective of this process is to provide an approach which may take advantage of more than one concept.

Perform Functional Analysis – Box A1121

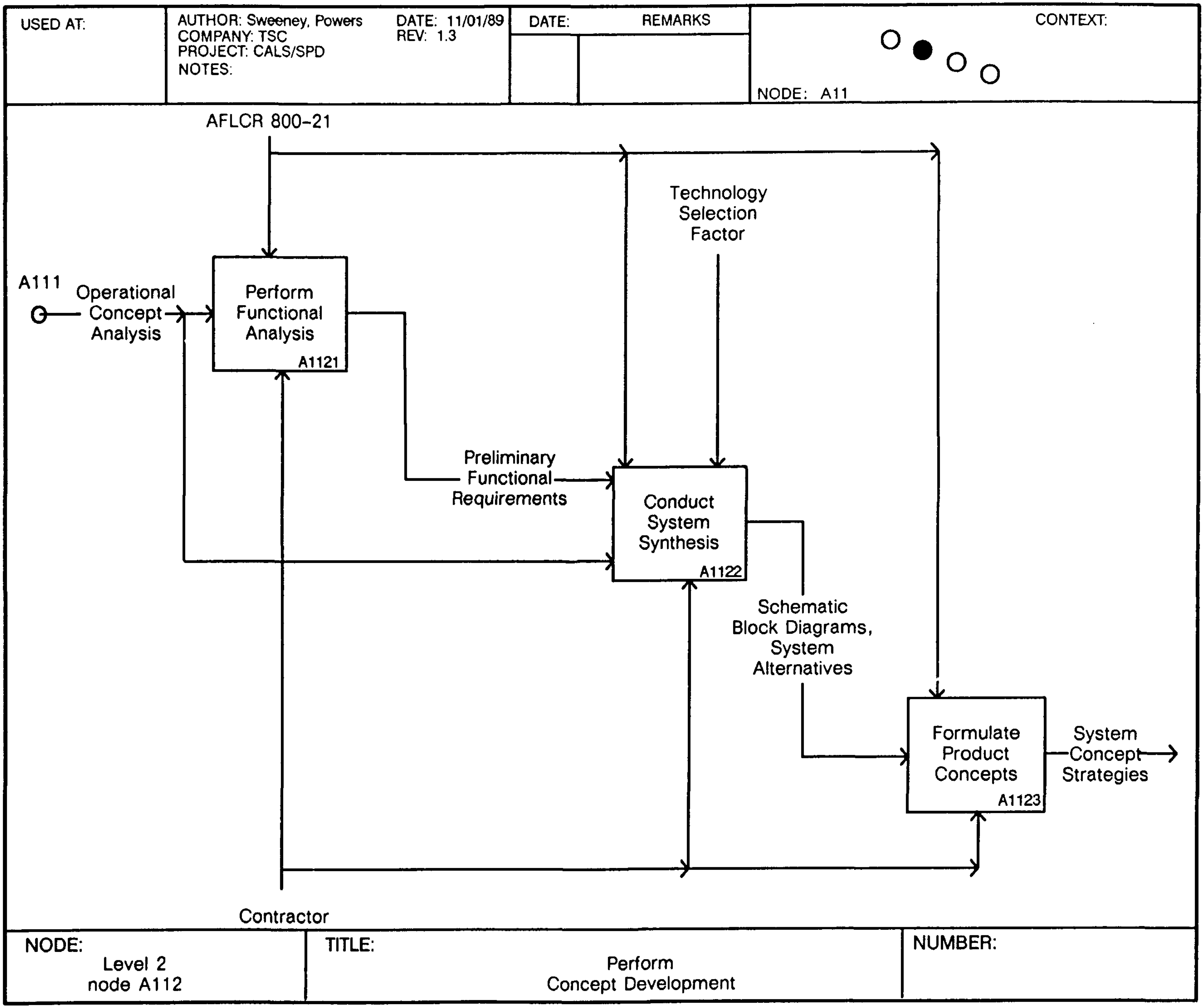
INPUTS:	Operational Concept Analysis (A111)
OUTPUTS:	Preliminary Functional Requirements
CONTROLS:	AFLCR 800–21
MECHANISMS:	Contractor

Conduct System Synthesis – Box A1122

INPUTS:	Operational Concept Analysis (A111), Preliminary Functional Requirements
OUTPUTS:	Schematic Block Diagrams, System Alternatives
CONTROLS:	AFLCR 800–21, Technology Selection Factor
MECHANISMS:	Contractor

Formulate Product Concepts – Box A1123

INPUTS:	Schematic Block Diagrams, System Alternatives
OUTPUTS:	System Concept Strategies
CONTROLS:	AFLCR 800–21
MECHANISMS:	Contractor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REV: 1.3
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REMARKS
CONTEXT:
NODE: A11
AFLCR 800-21
A111
Operational Concept Analysis
Perform Functional Analysis
A1121
Technology Selection Factor
Preliminary Functional Requirements
Conduct System Synthesis
A1122
Schematic Block Diagrams, System Alternatives
Formulate Product Concepts
A1123
System Concept Strategies
Contractor
NODE:
Level 2
node A112
TITLE:
Perform
Concept Development
NUMBER:

B.2.1.10 Generate Preliminary Planning Documents - Node A113

Node A113, Generate Preliminary Planning Documents, identifies activities associated with the development of various planning documents. These documents identify the requirements for the testing, integration and management of ECS software throughout the system life cycle.

Charter CRWG – Box A1131

INPUTS:	CRWG Requirements
OUTPUTS:	CRWG
CONTROLS:	AFR 800–14
MECHANISMS:	SPO, DPML, Using Command

Perform Test Planning – Box A1132

INPUTS:	System Analysis Information
OUTPUTS:	Test Objectives
CONTROLS:	AFR 80–14, DODD 5000.3
MECHANISMS:	TPWG

Draft CRLCMP – Box A1133

INPUTS:	System Analysis Information
OUTPUTS:	Draft CRLCMP
CONTROLS:	CRWG
MECHANISMS:	SPO, DPML, Using Command

Draft CRISP – Box A1134

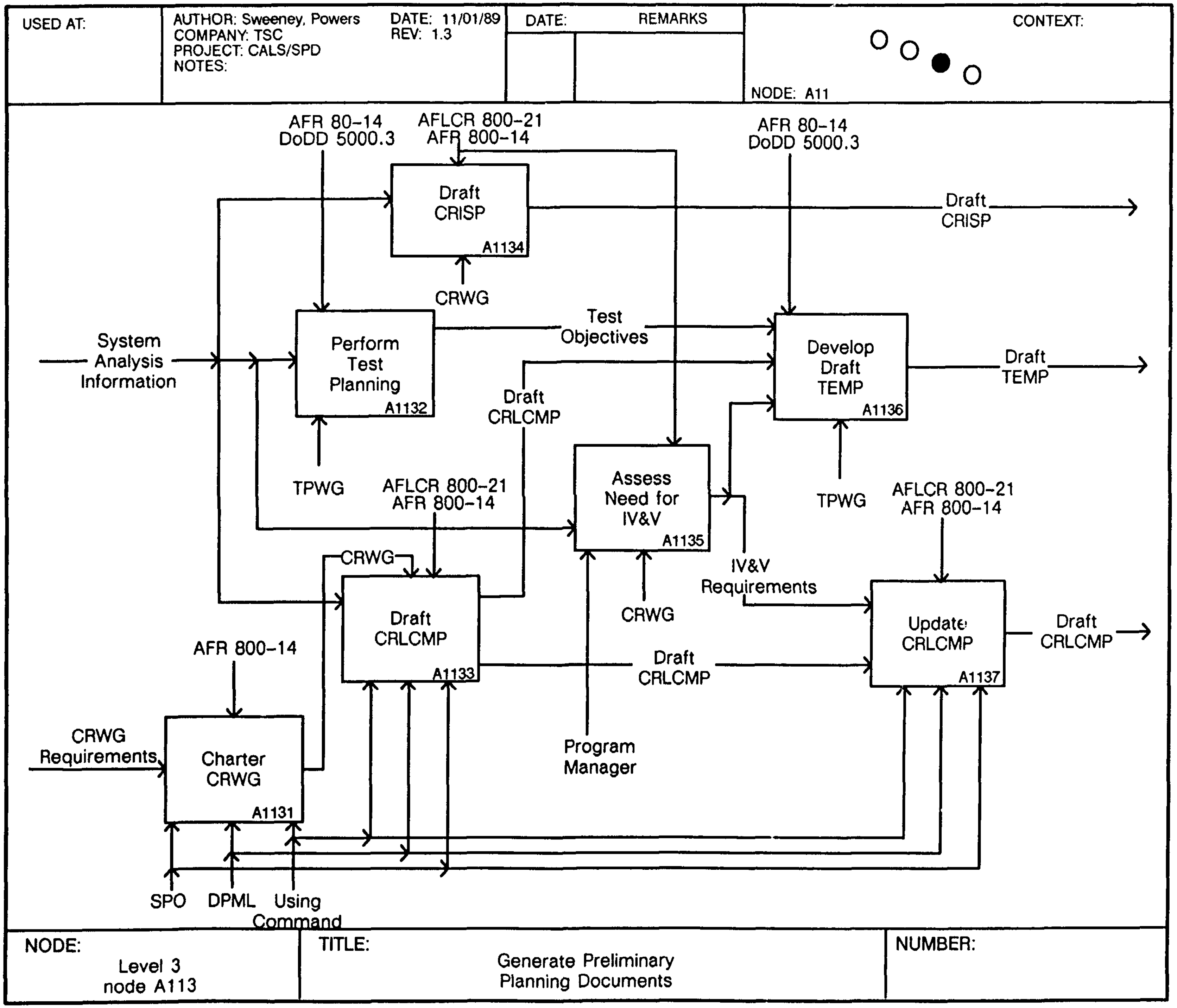
INPUTS:	System Analysis Information
OUTPUTS:	Draft CRISP
CONTROLS:	AFLCR 800–21, AFR 800–14
MECHANISMS:	CRWG

Assess Need for IV&V – Box A1135

INPUTS:	System Analysis Information
OUTPUTS:	IV&V Requirements
CONTROLS:	AFLCR 800–21, AFR 800–14
MECHANISMS:	CRWG

Develop Draft TEMP – Box A1136

INPUTS:	Test Objectives, Draft CRLCMP, IV&V Requirements
OUTPUTS:	Draft TEMP
CONTROLS:	AFR 800–14, DODD 5000.3
MECHANISMS:	TPWG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COMPANY: TSC
PROJECT: CALS/SPD
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DATE: 11/01/89
REV: 1.3
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REMARKS
CONTEXT:
NODE: A11
AFR 80-14
DoDD 5000.3
AFLCR 800-21
AFR 800-14
Draft CRISP
A1134
CRWG
Draft CRISP
System Analysis Information
Perform Test Planning
A1132
TPWG
Test Objectives
Draft CRLCMP
Develop Draft TEMP
A1136
Draft TEMP
TPWG
Assess Need for IV&V
A1135
CRWG
IV&V Requirements
AFLCR 800-21
AFR 800-14
CRWG
Draft CRLCMP
A1133
Draft CRLCMP
Update CRLCMP
A1137
Draft CRLCMP
AFR 800-14
CRWG Requirements
Charter CRWG
A1131
Program Manager
SPO
DPML
Using Command
NODE:
Level 3
node A113
TITLE:
Generate Preliminary Planning Documents
NUMBER:

Update CRLCMP - Box A1137

INPUTS:	Draft CRLCMP, IV&V Requirements
OUTPUTS:	Draft CRLCMP
CONTROLS:	AFLCR 800-21, AFR 800-14
MECHANISMS:	SPO, DPML, Using Command

B.2.1.11 Select Concept – Node A114

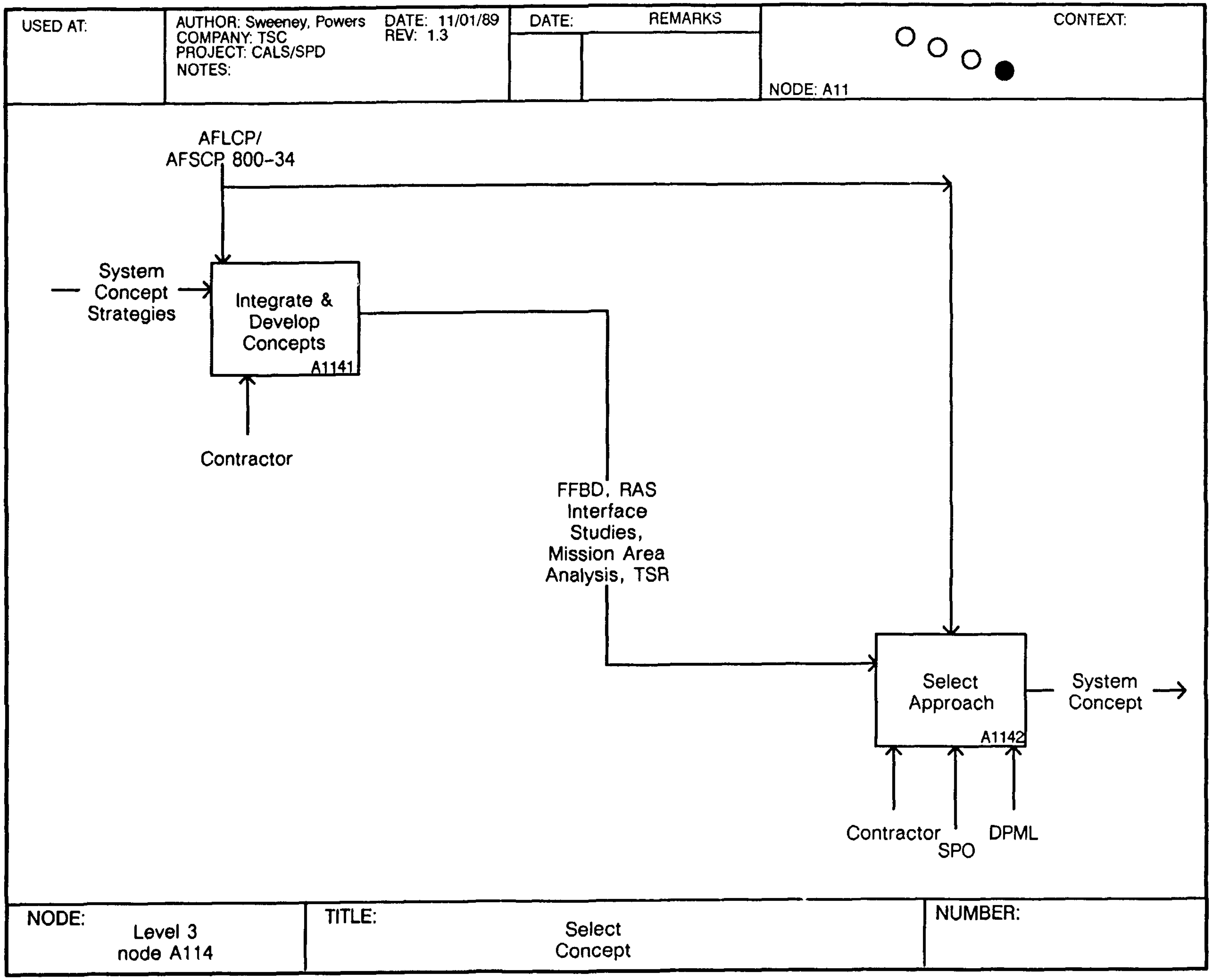
Using the concepts and strategies developed in Node A112, an approach is selected. As pointed out in the DMSC System Engineering Management Guide, this selection is less a selection of a particular approach, but "more an identification of feasible, affordable ranges of cost and system effectiveness." This information formulates the basis of the Type A System Specification.

Integrate & Develop Concepts – Box A1141

INPUTS:	System Concept Strategies
OUTPUTS:	FFBD, RAS Interface Studies, Mission Area Analysis, TSR
CONTROLS:	AFLCP/AFSCP 800-34
MECHANISMS:	Contractor

Select Approach – Box A1142

INPUTS:	FFBD, RAS Interface Studies, Mission Area Analysis, TSR
OUTPUTS:	System Concept
CONTROLS:	AFLCP/AFSCP 800-34
MECHANISMS:	Contractor, SPO, DPML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REV: 1.3
DATE:
REMARKS
CONTEXT:
NODE: A11
AFLCP/
AFSCP 800-34
System
Concept
Strategies
Integrate &
Develop
Concepts
A1141
Contractor
FFBD, RAS
Interface
Studies,
Mission Area
Analysis, TSR
Select
Approach
A1142
System
Concept
Contractor
SPO
DPML
NODE:
Level 3
node A114
TITLE:
Select
Concept
NUMBER:

B.2.1.12 Conduct Engineering Studies - Node A121

A variety of engineering studies based on the concepts selected in the previous phase take place during the Demonstration/Validation phase. These studies include feasibility studies, risk assessments and trade-off studies. The products generated within this activity support the System Requirements Review (SRR), the IRS and the Software Development Risk Management Plan.

Determine Initial Allocation of Software CI Requirements - Box A1211

INPUTS:	A-Spec
OUTPUTS:	Change to Preliminary Allocation of Software Requirements
CONTROLS:	AFR 800-14
MECHANISMS:	Contractor

Determine Interface Requirements - Box A1212

INPUTS:	A-Spec
OUTPUTS:	Interface Requirements Specification
CONTROLS:	AFR 800-14
MECHANISMS:	Contractor

Conduct Tradeoff & Optimization Studies - Box A1213

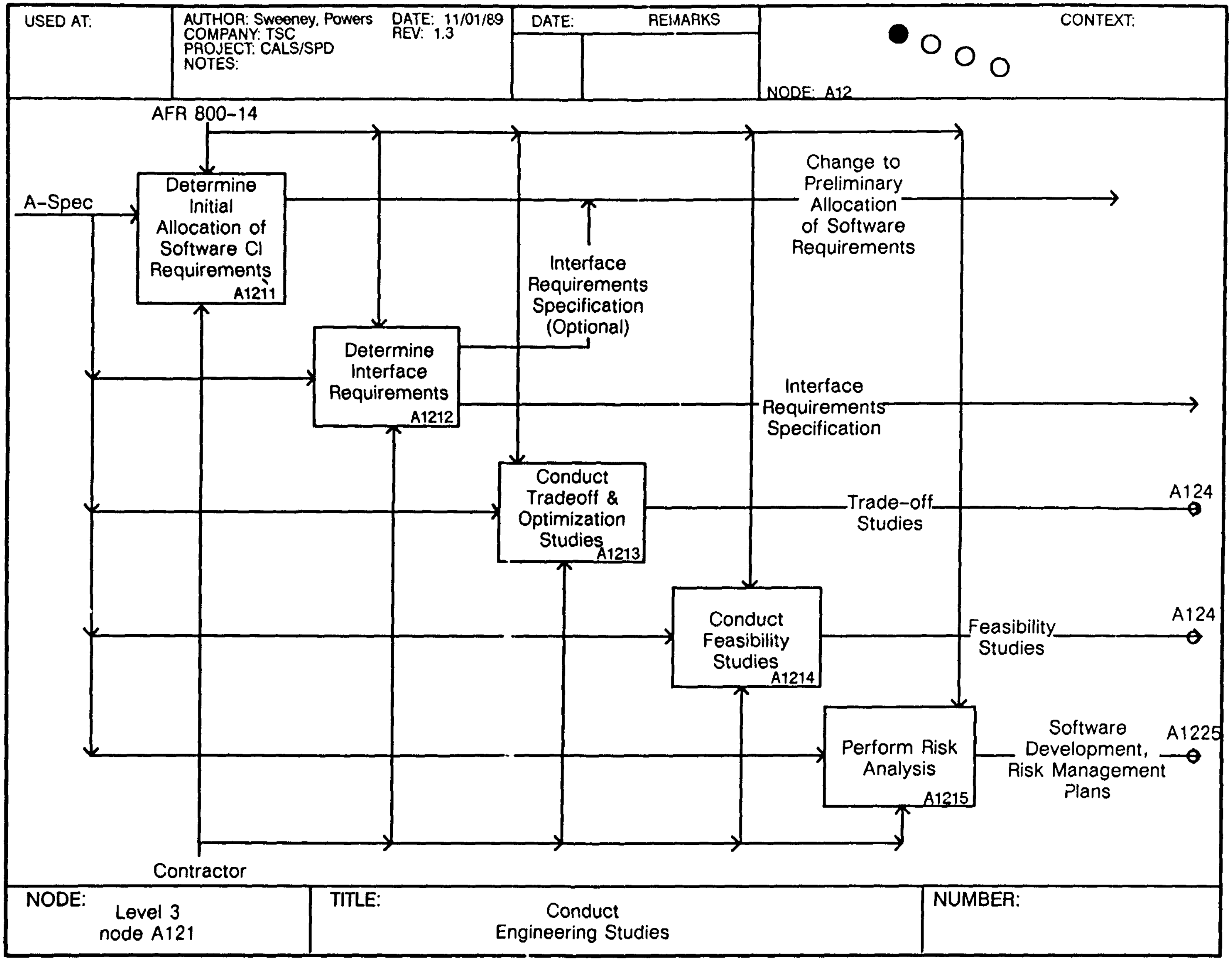
INPUTS:	A-Spec
OUTPUTS:	Trade-off Studies (A124)
CONTROLS:	AFR 800-14
MECHANISMS:	Contractor

Conduct Feasibility Studies - Box A1214

INPUTS:	A-Spec
OUTPUTS:	Feasibility Studies (A124)
CONTROLS:	AFR 800-14
MECHANISMS:	Contractor

Perform Risk Analysis - Box A1215

INPUTS:	A-Spec
OUTPUTS:	Software Development, Risk Management Plans (A1225)
CONTROLS:	AFR 800-14
MECHANISMS:	Contractor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NOTES:
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REV: 1.3
DATE:
REMARKS
CONTEXT:
NODE: A12
AFR 800-14
A-Spec
Determine Initial Allocation of Software CI Requirements
A1211
Determine Interface Requirements
A1212
Interface Requirements Specification (Optional)
Change to Preliminary Allocation of Software Requirements
Interface Requirements Specification
Conduct Tradeoff & Optimization Studies
A1213
Trade-off Studies
A124
Conduct Feasibility Studies
A1214
Feasibility Studies
A124
Perform Risk Analysis
A1215
Software Development, Risk Management Plans
A1225
Contractor
NODE:
Level 3
node A121
TITLE:
Conduct Engineering Studies
NUMBER:

B.2.1.13 Expedite Support Functions – Node A122

A number of support related activities that take place during the Demonstration/Validation phase are identified in Node A122 as "Expedite Support Functions". As the definition of the system software begins to take shape, test plans for the software can be formulated.

Along with the initial allocation of CSCIs, a CM plan defining all aspects of CM will be developed. This process would include change processing, the role of the contractor during development, management of the development library, etc.

Prior to FSD, a software quality evaluation program is developed. This program sets the criteria by which the software could be evaluated throughout the development. The items evaluated include software engineering, software management, and software configuration management. To prepare for support of the system throughout its life cycle, a support concept must be developed. Generally, previous concepts outlining the major support roles can be used. It is in the CRLCMP that the support concept is enhanced.

Detail Software Test Plans – Box A1221

INPUTS:	Draft TEMP, A–Spec
OUTPUTS:	Test Plan (A134)
CONTROLS:	AFOTECP 800–2
MECHANISMS:	Contractor

Define CM Approach for Computer Resources – Box A1222

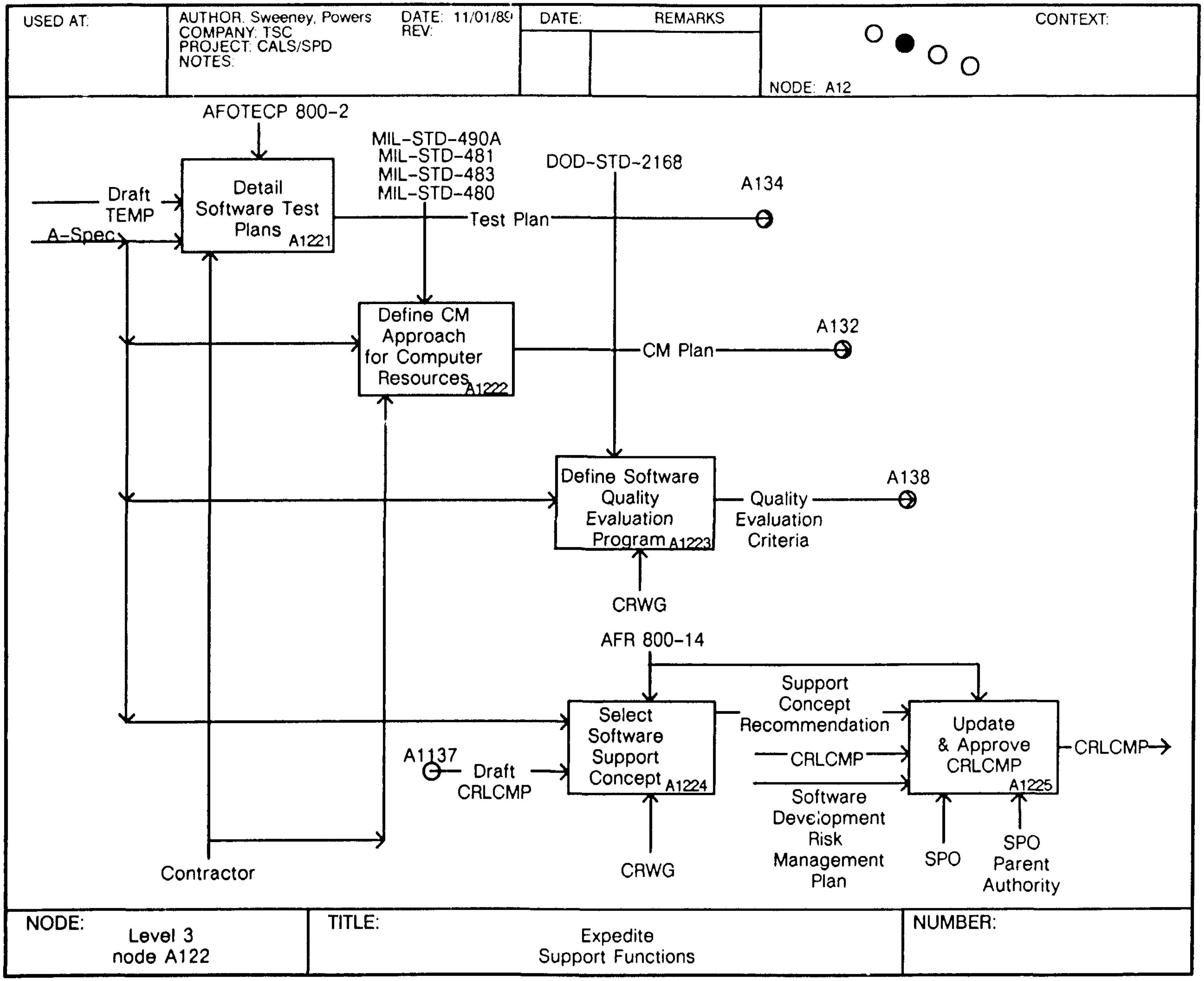
INPUTS:	A–Spec
OUTPUTS:	CM Plan (A132)
CONTROLS:	MIL–STD–490A, MIL–STD–481, MIL–STD–483, MIL–STD–480
MECHANISMS:	Contractor

Define Software Quality Evaluation Program – Box A1223

INPUTS:	A–Spec
OUTPUTS:	Quality Evaluation Criteria (A138)
CONTROLS:	DOD–STD–2168
MECHANISMS:	CRWG

Select Software Support Concept – Box A1224

INPUTS:	A–Spec, Draft CRLCMP (A1137)
OUTPUTS:	Support Concept Recommendation
CONTROLS:	AFR 800–14
MECHANISMS:	CRWG



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DATE:
REMARKS
CONTEXT:
NODE: A12
AFOTECP 800-2
Draft TEMP
A-Spec
Detail Software Test Plans
A1221
MIL-STD-490A
MIL-STD-481
MIL-STD-483
MIL-STD-480
Test Plan
DOD-STD-2168
A134
Define CM Approach for Computer Resources
A1222
CM Plan
A132
Define Software Quality Evaluation Program
A1223
Quality Evaluation Criteria
A138
CRWG
AFR 800-14
Support Concept Recommendation
Select Software Support Concept
A1224
A1137
Draft CRLCMP
CRLCMP
Software Development Risk Management Plan
Update & Approve CRLCMP
A1225
CRLCMP
CRWG
SPO
SPO Parent Authority
Contractor
NODE:
Level 3
node A122
TITLE:
Expedite
Support Functions
NUMBER:

B.2.1.14 Update and Approve CRLCMP - Box A1225

INPUTS:	CRLCMP, Support Concept Recommendation, Software Development Risk Management Plan
OUTPUTS:	CRLCMP
CONTROLS:	AFR 800-14
MECHANISMS:	SPO, SPO Parent Authority

B.2.1.15 Develop Prototype – Node A123

Although still in the Demonstration/Validation phase it is possible for a prototype to be developed. While this would normally be executed during FSD, it may be necessary to develop a prototype to determine the feasibility of a technology. This activity to a large extent is mirrored by the activity depicted in Node A13.

Perform Software Requirements Analysis – Box A1231

INPUTS:	System Concept, System Analysis Data (Feasibility Studies, Trade-off Studies, FFBD, Feedback
OUTPUTS:	SRS
CONTROLS:	MIL-STD-1521B
MECHANISMS:	Contractor

Conduct Software Specification Review – Box A1232

INPUTS:	SRS
OUTPUTS:	Authenticated SRS, Feedback
CONTROLS:	MIL-STD-1521B
MECHANISMS:	SPO, Contractor

Develop Preliminary Design – Box A1233

INPUTS:	Authenticated SRS, Feedback
OUTPUTS:	Preliminary Design
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

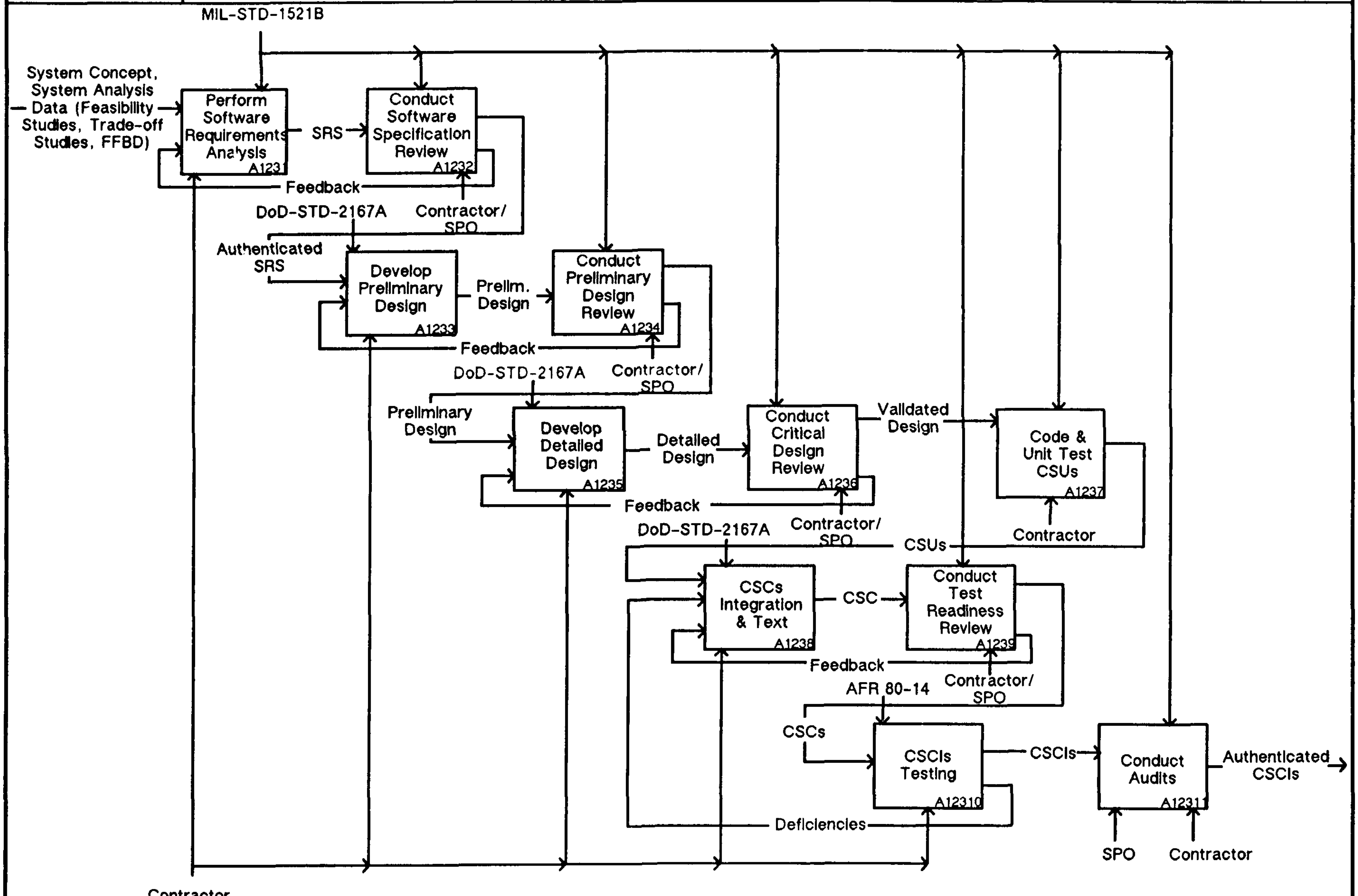
Conduct Preliminary Design Review – Box A1234

INPUTS:	Preliminary Design
OUTPUTS:	Preliminary Design, Feedback
CONTROLS:	MIL-STD-1521B
MECHANISMS:	SPO, Contractor

Develop Detailed Design – Box A1235

INPUTS:	Preliminary Design, Feedback
OUTPUTS:	Detailed Design
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

USED AT:	AUTHOR: Sweeney, Powers COMPANY: TSC PROJECT: CALS/SPD NOTES:	DATE: 11/01/89 REV: 1.3	DATE:	REMARKS	NODE: A12	CONTEXT:



NODE: Level 3 node A123	TITLE:	NUMBER:

Conduct Critical Design Review – Box A1236

INPUTS:	Detailed Design
OUTPUTS:	Validated Design, Feedback
CONTROLS:	MIL-STD-1521B
MECHANISMS:	SPO, Contractor

Code & Unit Test CSUs – Box A1237

INPUTS:	Validated Design
OUTPUTS:	CSUs
CONTROLS:	MIL-STD-1521B
MECHANISMS:	Contractor

CSCs Integration and Text – Box A1238

INPUTS:	CSUs, Deficiencies, Feedback
OUTPUTS:	CSC
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

Conduct Test Readiness Review – Box A1239

INPUTS:	CSC
OUTPUTS:	CSCs, Feedback
CONTROLS:	MIL-STD-1521B
MECHANISMS:	SPO, Contractor

CSCIs Testing – Box A123_10

INPUTS:	CSCs
OUTPUTS:	CSCIs, Deficiencies
CONTROLS:	AFR 80-14
MECHANISMS:	Contractor

Conduct Audits – Box A123_11

INPUTS:	CSCIs
OUTPUTS:	Authenticated CSCIs
CONTROLS:	MIL-STD-1521B
MECHANISMS:	SPO, Contractor

B.2.1.16 Conduct System Requirements Review – Node A124

The objective of the SRR is to determine the adequacy of the requirements identified to date. This is done through the review of documents which represent the system engineering efforts completed at this time. These documents include the FFBD, the RAS, Mission area analysis, system trade studies, system/cost effectiveness, life cycle cost estimates, system interface studies, preliminary manufacturing plans, manpower requirements. These documents formulate the basis of the baseline.

Appendix A of MIL–STD–1521B identifies in more detail the entire spectrum of products which may need review. While these products represent the functional analysis of the system requirements, other products identifying the risk, risk avoidance and trade–offs provide a clearer representation of workable concepts or strategies.

Identify Items to be Reviewed – Box A1241

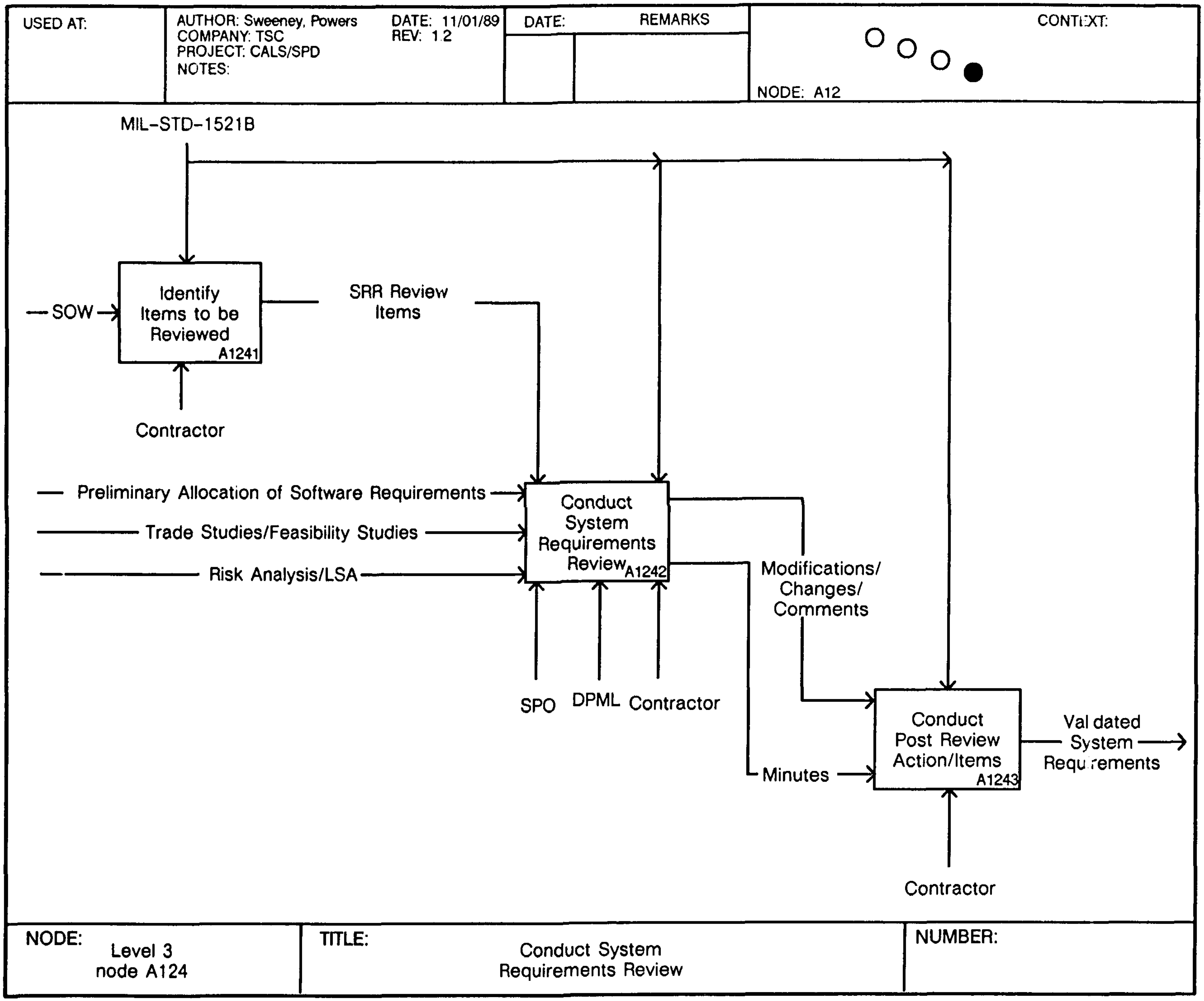
INPUTS:	SOW
OUTPUTS:	SRR Review Items
CONTROLS:	MIL–STD–1521B
MECHANISMS:	Contractor

Conduct System Requirements Review – Box A1242

INPUTS:	Preliminary Allocation of Software Requirements, Trade Studies/ Feasibility Studies, Risk Analysis/LSA
OUTPUTS:	Modifications/Changes/Comments, Minutes
CONTROLS:	MIL–STD–1521B
MECHANISMS:	Contractor, SPO, DPML

Conduct Post Review Action/Items – Box A1243

INPUTS:	Modifications/Changes/Comments, Minutes
OUTPUTS:	Validated System Requirements
CONTROLS:	MIL–STD–1521B
MECHANISMS:	Contractor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DATE:
REMARKS
CONTEXT:
NODE: A12
MIL-STD-1521B
SOW
Identify Items to be Reviewed
A1241
Contractor
SRR Review Items
Preliminary Allocation of Software Requirements
Trade Studies/Feasibility Studies
Risk Analysis/LSA
Conduct System Requirements Review
A1242
SPO
DPML
Contractor
Modifications/ Changes/ Comments
Minutes
Conduct Post Review Action/Items
A1243
Contractor
Validated System Requirements
NODE:
Level 3
node A124
TITLE:
Conduct System Requirements Review
NUMBER:

B.2.1.17 Perform System Requirements Analysis - Node A131

The requirements analysis generated here identifies the initial software requirements. This initial set of requirements is usually allocated to the CSCI level. Documents such as the preliminary SRS, the IRS, and the SOC are used during this process.

Analyze System Requirements - Box A1311

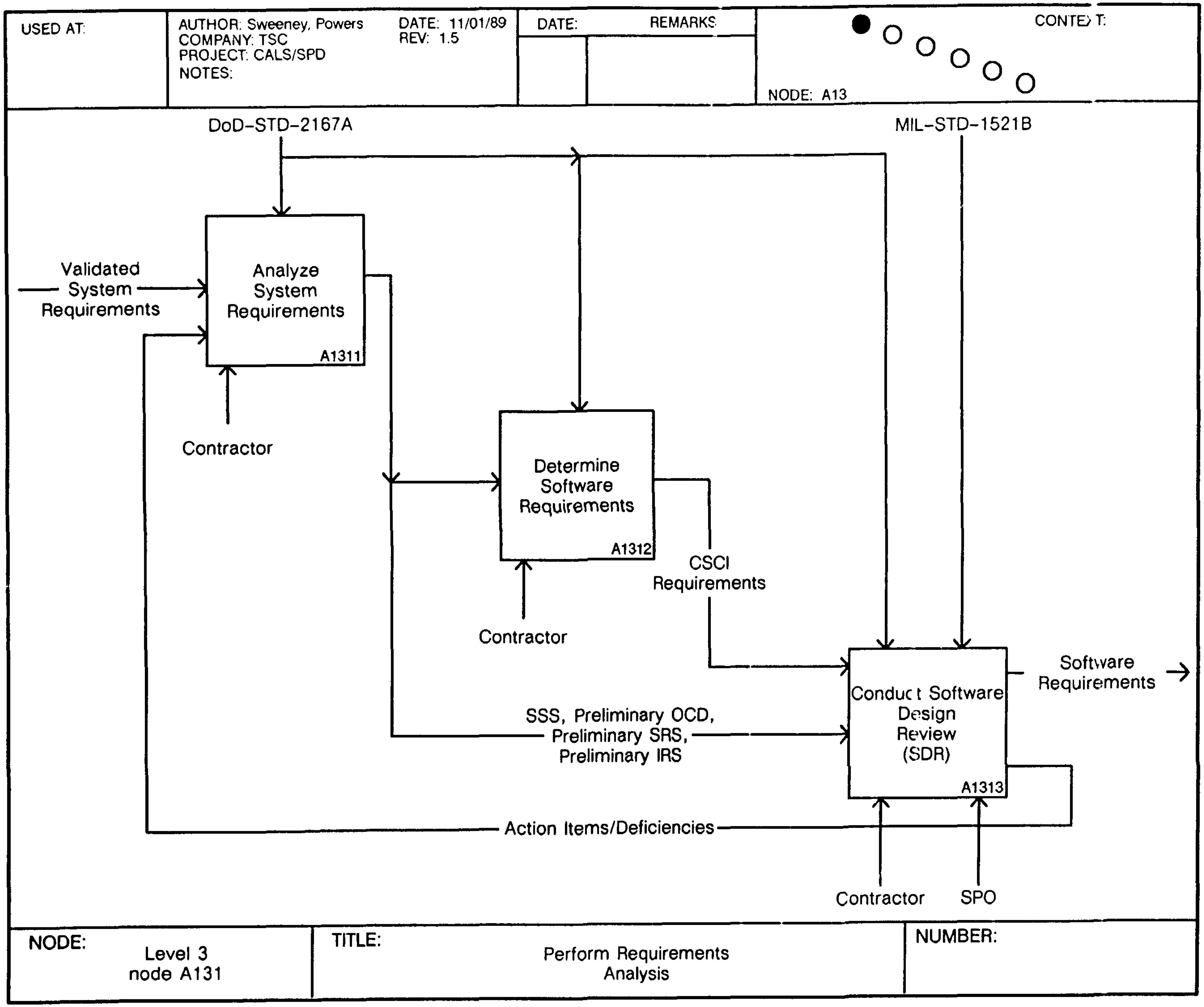
INPUTS:	Validated System Requirements
OUTPUTS:	SSS, Preliminary OCD, Preliminary SRS, Preliminary IRS
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

Determine Software Requirements - Box A1312

INPUTS:	SSS, Preliminary OCD, Preliminary SRS, Preliminary IRS
OUTPUTS:	CSCI Requirements
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

Conduct Software Design Review (SDR) - Box A1313

INPUTS:	SSS, Preliminary OCD, Preliminary SRS, Preliminary IRS, CSCI Requirements
OUTPUTS:	Software Requirements, Action Items/Deficiencies
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B
MECHANISMS:	Contractor, SPO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REMARKS
CONTE) T:
NODE: A13
DoD-STD-2167A
MIL-STD-1521B
Validated System Requirements
Analyze System Requirements
A1311
Contractor
Determine Software Requirements
A1312
Contractor
CSCI Requirements
SSS, Preliminary OCD, Preliminary SRS, Preliminary IRS
Conduct Software Design Review (SDR)
A1313
Software Requirements
Action Items/Deficiencies
Contractor
SPO
NODE:
Level 3
node A131
TITLE:
Perform Requirements Analysis
NUMBER:

B.2.1.18 Develop Preliminary Design - Node A132

Using the validated specification from the Software Specification Review (SSR), a preliminary design or "developmental configuration" is established. The preliminary design is composed of several products which comprise a "first cut" at the development of a working software model. These products include data flow diagrams, functional flow block diagrams, and trade-off studies. The activity within this node is the PDR. The PDR is used to validate the initial design prior to the development of a detailed design.

Analyze Specification Documents - Box A1321

INPUTS:	SRS, OCD
OUTPUTS:	Analyzed SRS, OCD
CONTROLS:	Contractor Practices
MECHANISMS:	Contractor

Analyze Interface Requirements - Box A1322

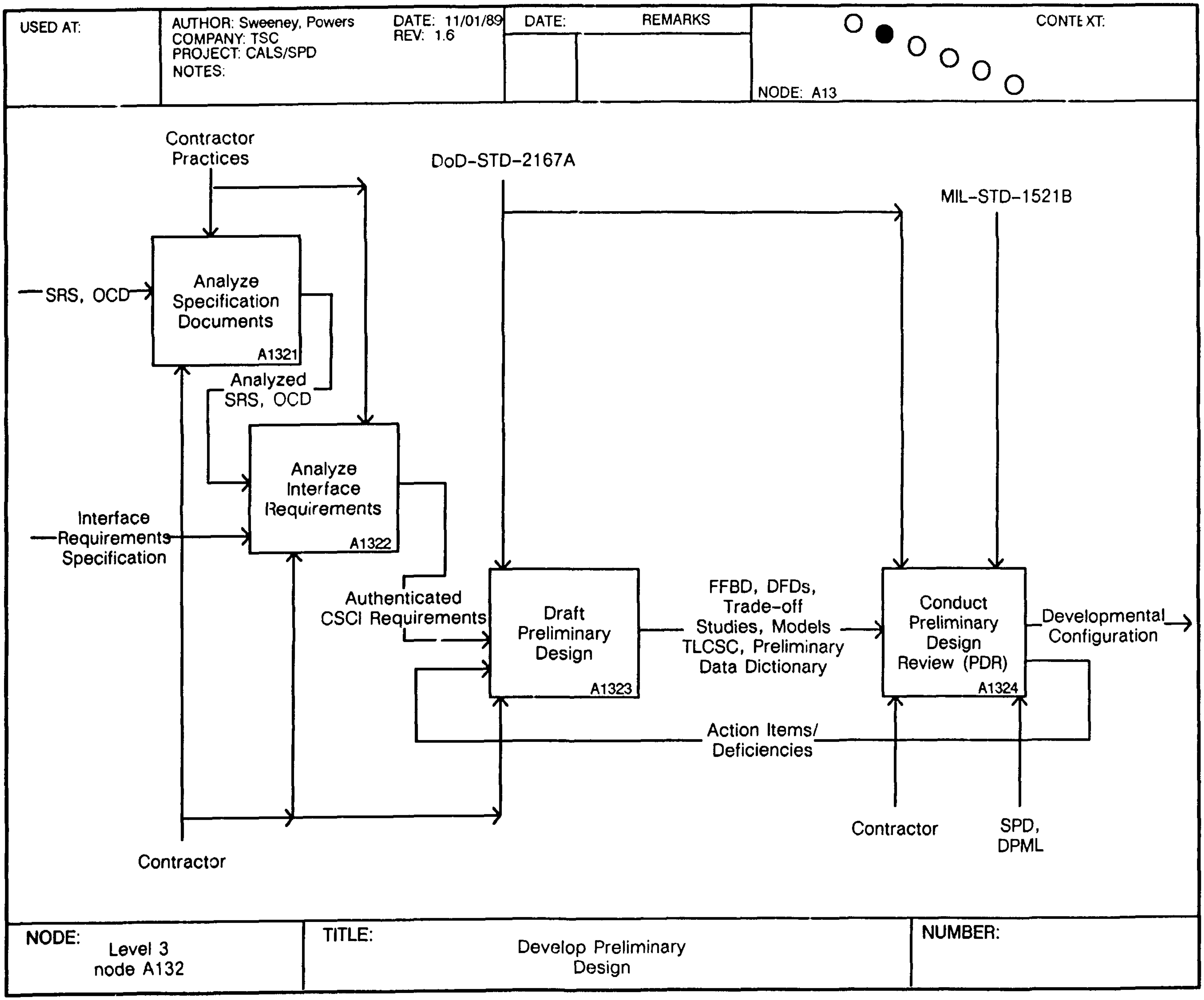
INPUTS:	Analyzed SRS, OCD, Interface Requirements Specification
OUTPUTS:	Authenticated CSCI Requirements
CONTROLS:	Contractor Practices
MECHANISMS:	Contractor

Draft Preliminary Design - Box A1323

INPUTS:	Authenticated CSCI Requirements, Action Items/Deficiencies
OUTPUTS:	FFBD, DFDs, Trade-off Studies, Models, TLCSC, Preliminary Data Dictionary
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

Conduct Preliminary Design Review - Box A1324

INPUTS:	FFBD, DFDs, Trade-off Studies, Models, TLCSC, Preliminary Data Dictionary
OUTPUTS:	Developmental Configuration, Action Items/Deficiencies
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B
MECHANISMS:	Contractor, SPD, DPML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COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.6
DATE:
REMARKS
NODE: A13
CONTEXT:
Contractor Practices
DoD-STD-2167A
MIL-STD-1521B
SRS, OCD
Analyze Specification Documents
A1321
Analyzed SRS, OCD
Analyze Interface Requirements
A1322
Interface Requirements Specification
Authenticated CSCI Requirements
Draft Preliminary Design
A1323
FFBD, DFDs, Trade-off Studies, Models TLCSC, Preliminary Data Dictionary
Conduct Preliminary Design Review (PDR)
A1324
Developmental Configuration
Action Items/ Deficiencies
Contractor
Contractor
SPD, DPML
NODE: Level 3 node A132
TITLE: Develop Preliminary Design
NUMBER:

B.2.1.19 Develop Detailed Design – Node A133

Node A133, Develop Detailed Design, identifies the activities associated with developing a preliminary design into a detailed design. This process involves the analysis of the preliminary design package, and the development of the detailed design information. This process generally involves the breakdown or decomposition of CSCs into Lower Level CSC (LLCSCs). It can also involve the identification of internal and external interfaces. This detailed information, in the form of a detailed design package, is presented for review at the Critical Design Review (CDR).

Analyze Preliminary Design Package – Box A1331

INPUTS:	Developmental Configuration (A1324)
OUTPUTS:	Analysis
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

Detail Preliminary Design Functions – Box A1332

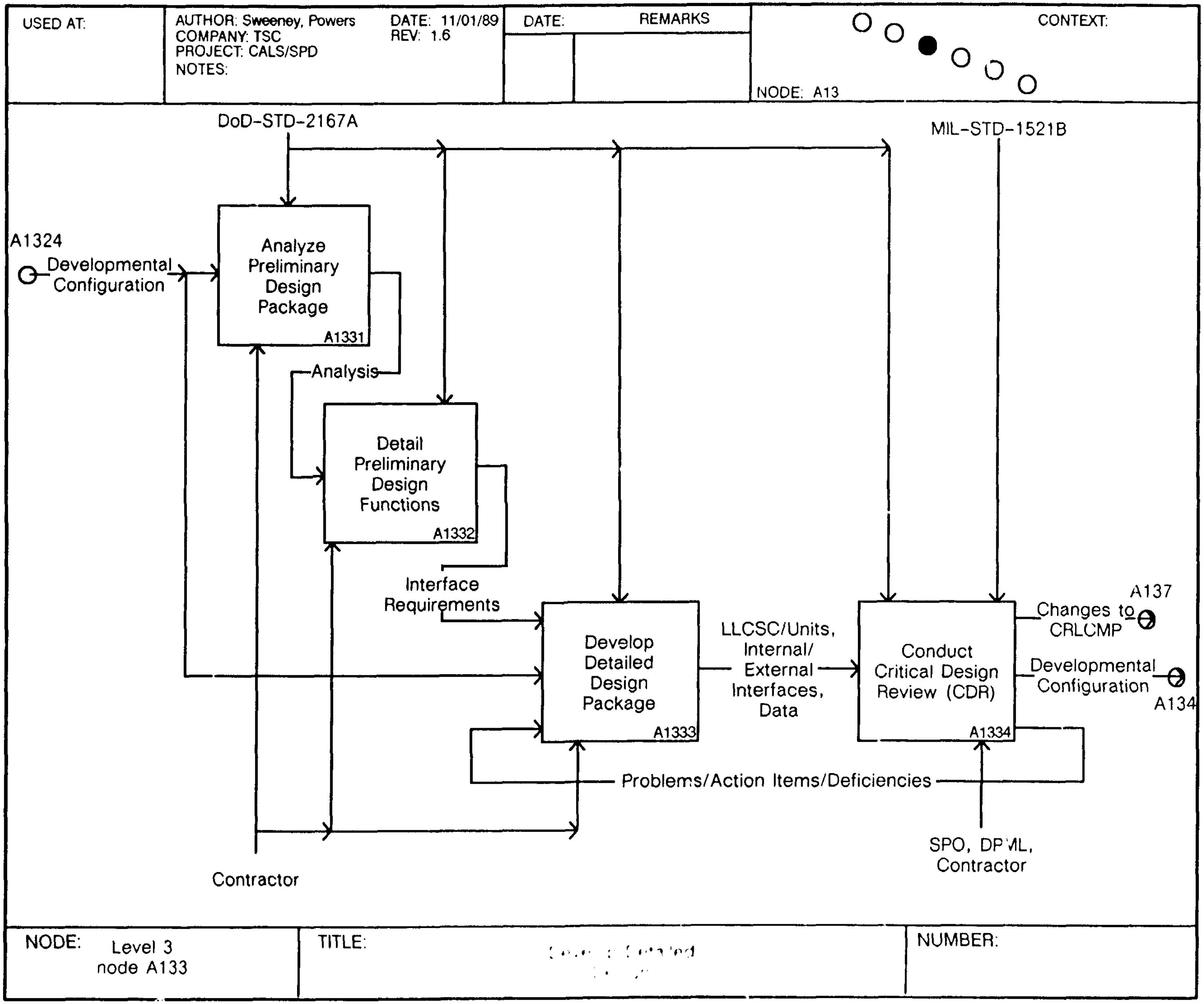
INPUTS:	Analysis
OUTPUTS:	Interface Requirements
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

Develop Detailed Design Package – Box A1333

INPUTS:	Interface Requirements, Developmental Configuration, Problems/ Action Items/Deficiencies
OUTPUTS:	LLCSC/Units, Internal/External Interfaces, Data
CONTROLS:	DOD-STD-2167A
MECHANISMS:	Contractor

Conduct Critical Design Review – Box A1334

INPUTS:	LLCSC/Units, Internal/External Interfaces, Data
OUTPUTS:	Changes to CRLCMP (A137), Developmental Configuration (A134)
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B
MECHANISMS:	SPO, DPML, Contractor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AUTHOR: Sweeney, Powers
COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.6
DATE:
REMARKS
CONTEXT:
NODE: A13
DoD-STD-2167A
MIL-STD-1521B
A1324
Developmental Configuration
Analyze Preliminary Design Package
A1331
Analysis
Detail Preliminary Design Functions
A1332
Interface Requirements
Develop Detailed Design Package
A1333
LLCSC/Units, Internal/ External Interfaces, Data
Conduct Critical Design Review (CDR)
A1334
Changes to CRLCMP
A137
Developmental Configuration
A134
Problems/Action Items/Deficiencies
Contractor
SPO, DPML, Contractor
NODE:
Level 3
node A133
TITLE:
NUMBER:

B.2.1.20 Code & Test - Node A134

Subsequent to CDR, preliminary coding and testing efforts are initiated. These activities are identified in Node A134, Code & Test. The process is cyclical in that code is generated, tested, then integrated at the CSU, CSC, and CSCI level respectively. It should be noted that at each cycle, Software Deficiency Reports (SDRs) loop back to the developer in the event of an unsuccessful test. Upon successful completion of the CSCI test, the approved items are now available for integration into the system, prior to system test.

Generate Code for Each CSU - Box A1341

INPUTS:	(A133) Developmental Configuration, Software Deficiency Reports
OUTPUTS:	CSU Code
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B, DODD 5000.31, AFR 800-14
MECHANISMS:	Contractor

Generate Preliminary Documentation - Box A1342

INPUTS:	CSU Code
OUTPUTS:	CSU Document
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B, DODD 5000.31, AFR 800-14
MECHANISMS:	Contractor

Test CSU - Box A1343

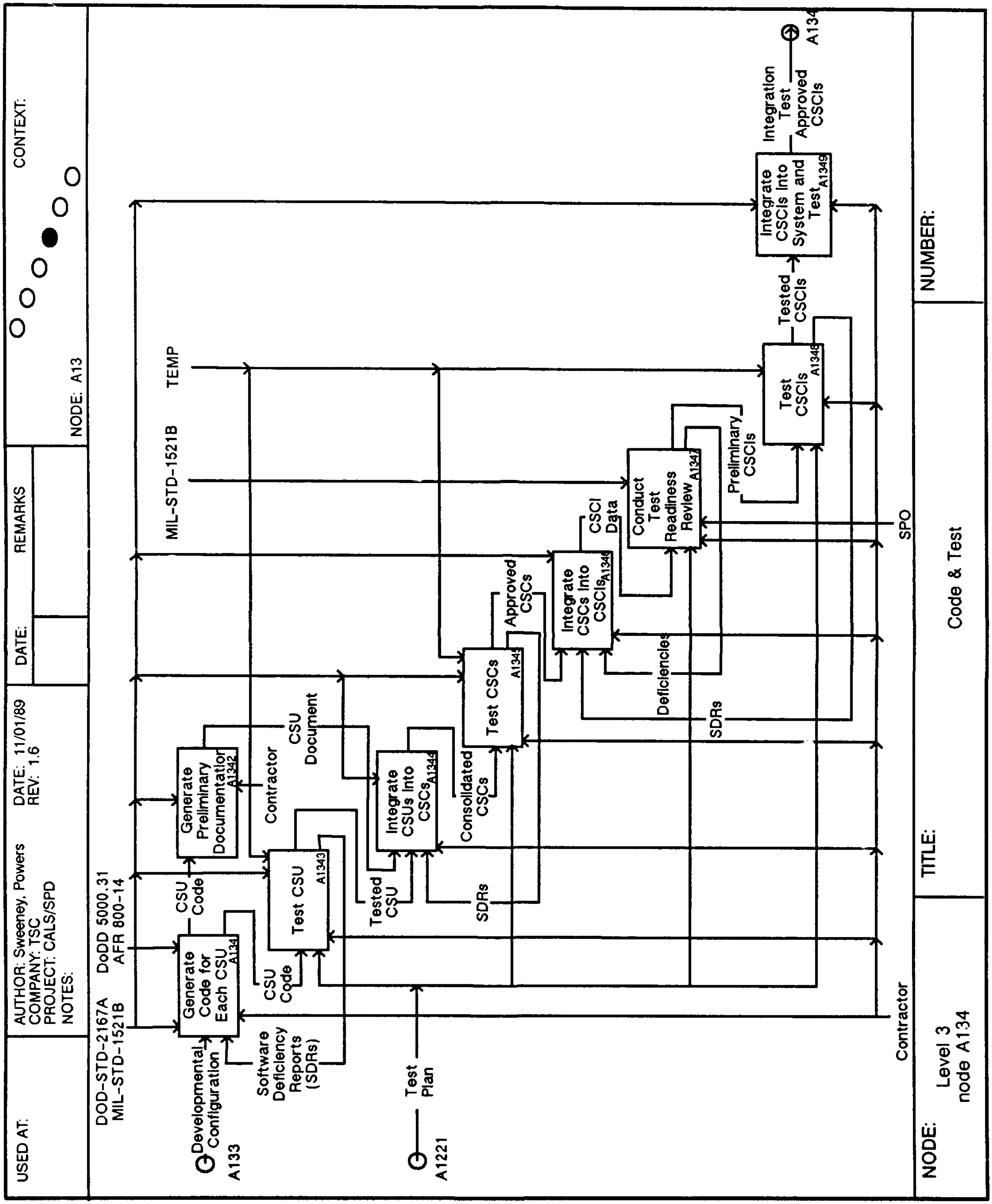
INPUTS:	CSU Code, Test Plan
OUTPUTS:	Tested CSU, SDRs, CSU Document
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B, TEMP
MECHANISMS:	Contractor

Integrate CSUs Into CSCs - Box A1344

INPUTS:	CSU Tested, CSU Document, SDRs
OUTPUTS:	Consolidated CSCs
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B
MECHANISMS:	Contractor

Test CSCs - Box A1345

INPUTS:	Consolidated CSCs, Test Plan
OUTPUTS	Approved CSCs, SDRs
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B, TEMP
MECHANISMS:	Contractor



USED AT:
AUTHOR: Sweeney, Powers
COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.6
DATE:
REMARKS
NODE: A13
CONTEXT:
DOD-STD-2167A
MIL-STD-1521B
DoDD 5000.31
AFR 800-14
MIL-STD-1521B
TEMP
Developmental Configuration
A133
Software Deficiency Reports (SDRs)
Test Plan
A1221
Generate Code for Each CSU
A1341
CSU Code
Generate Preliminary Documentation
A1342
Test CSU
A1343
Contractor
CSU Document
Tested CSU
Integrate CSUs Into CSCs
A1344
Consolidated CSCs
SDRs
Test CSCs
A1345
Approved CSCs
Integrate CSCs Into CSCIs
A1346
Deficiencies
CSCI Data
Conduct Test Readiness Review
A1347
Preliminary CSCIs
Test CSCIs
A1348
Tested CSCIs
Integrate CSCIs Into System and Test
A1349
Integration Test Approved CSCIs
A134
SPO
Contractor
NODE:
Level 3
node A134
TITLE:
Code & Test
NUMBER:

Integrate CSCs Into CSCIs – Box A1346

INPUTS:	Approved CSCs, SDRs, Deficiencies
OUTPUTS	CSCI Data
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B
MECHANISMS:	Contractor

Conduct Test Readiness Review – Box A1347

INPUTS:	CSCI Data, Test Plan
OUTPUTS	Preliminary CSCIs, Deficiencies
CONTROLS:	MIL-STD-1521B
MECHANISMS:	SPO, Contractor

Test CSCIs – Box A1348

INPUTS:	Preliminary CSCIs
OUTPUTS	Tested CSCIs, SDRs
CONTROLS:	TEMP
MECHANISMS:	Contractor

Integrate CSCIs Into System and Test – Box A1349

INPUTS:	Tested CSCIs
OUTPUTS	Integration Test Approved CSCIs (A134)
CONTROLS:	DOD-STD-2167A, MIL-STD-1521B
MECHANISMS:	Contractor

B.2.1.21 Conduct Audits – Node A135

Node A135, Conduct Audits, identifies the audits and reviews available to the Air Force. These audits and reviews provide an opportunity to determine compliance with functional and contractual requirements. Each one is described below.

Appendix G of MIL–STD–1521B describes the objective and requirements for conducting a Functional Configuration Audit (FCA). While this appendix applies to both hardware and software, only the software component is discussed here.

There are several components to the FCA for CSCIs. They are as follows:

- A briefing for each CSCI, those requirements which were not met by that CSCI, and proposed solutions,
- Test plan documentation audited against official test data, and
- An audit of the STR to verify the accuracy.

As part of the update process, Engineering Change Proposal (ECPs) and updates to previously delivered documentation will be reviewed for consistency with the CSCI and the specification will be documented.

The objective of the Physical Configuration Audit (PCA), is to verify the configuration item against the design documentation. Specifically, this review will include the Software Product Specification (SPS), the *Version Description Document* (VDD), and the Programmer, User, System Operator and Firmware Support manuals. This review will focus on the completeness and format aspects of these items. ' ɜ manuals will not be formally accepted until system testing has taken place, thereby contırming procedural validity.

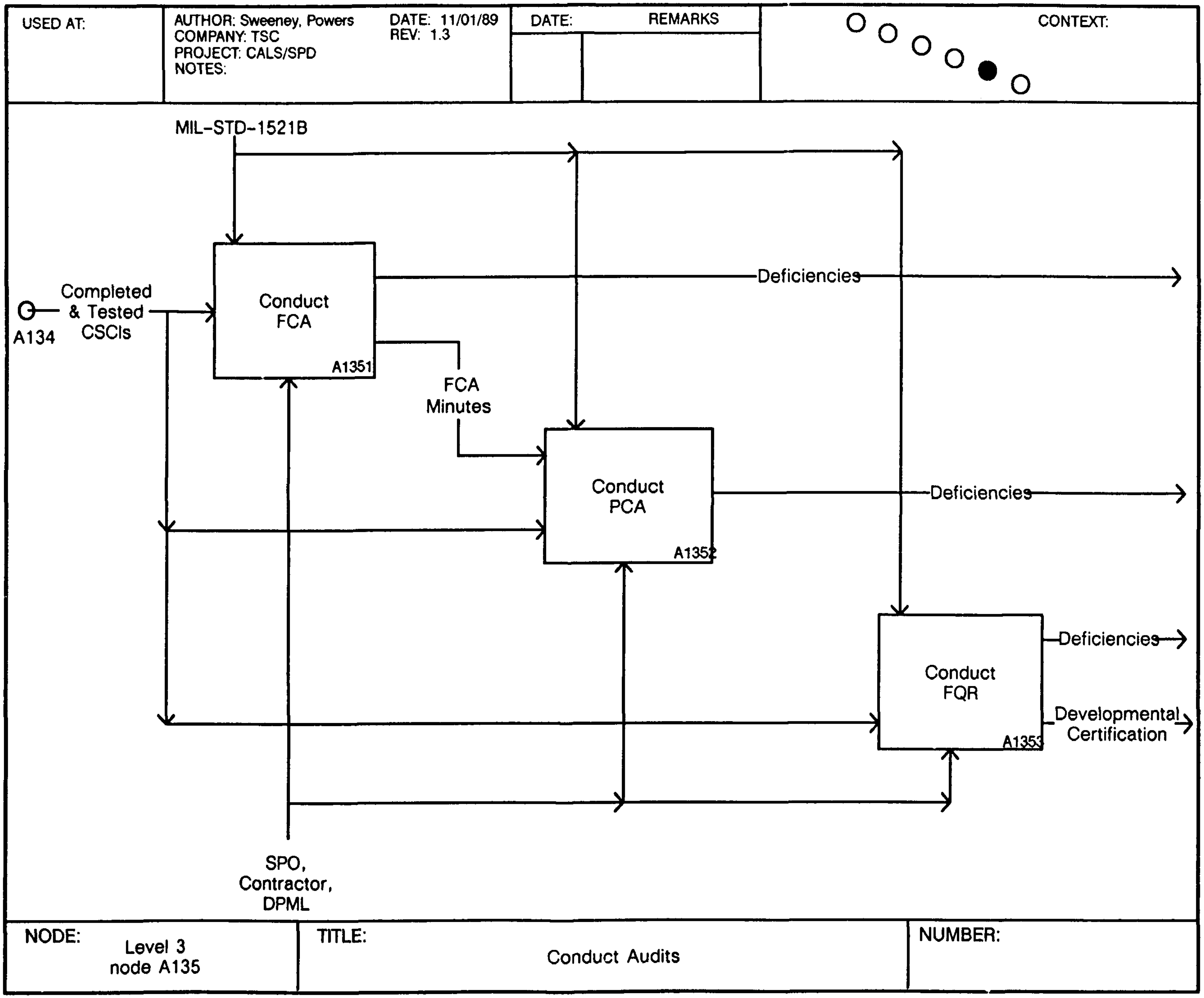
Formal Qualification Review (FQR) should coincide with FCA, however if this is not possible, FQR can be conducted independently. As with the previous two audits, the objective of the FQR is to establish compliance of the system configuration items with appropriate specifications. This is generally accomplished through verification of test data.

Conduct FCA – Box A1351

<u>INPUTS:</u>	Completed and Tested CSCIs (A134)
<u>OUTPUTS</u>:	FCA Minutes, Deficiencies
<u>CONTROLS</u>:	MIL–STD–1521B
<u>MECHANISMS</u>:	SPO, Contractor, DPML

Conduct PCA – Box A1352

<u>INPUTS:</u>	FCA Minutes, Completed and Tested CSCIs (A134)
<u>OUTPUTS</u>:	Deficiencies
<u>CONTROLS:</u>	MIL–STD–1521B
<u>MECHANISMS:</u>	SPO, Contractor, DPML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AUTHOR: Sweeney, Powers
COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.3
DATE:
REMARKS
CONTEXT:
MIL-STD-1521B
A134
Completed & Tested CSCIs
Conduct FCA
A1351
FCA Minutes
Deficiencies
Conduct PCA
A1352
Deficiencies
Conduct FQR
A1353
Deficiencies
Developmental Certification
SPO, Contractor, DPML
NODE:
Level 3 node A135
TITLE:
Conduct Audits
NUMBER:

Conduct FQA – Box A1353

INPUTS:	Completed and Tested CSCIs (A134)
OUTPUTS:	Deficiencies, Developmental Certification
CONTROLS:	MIL-STD-1521B
MECHANISMS:	SPO, Contractor, DPML

B.2.1.22 Conduct Software Specification Review – Node A136

Node A136, Conduct Software Specification Review, identifies the activities associated with the review of the SRS and the IRS. Appendix C MIL–STD–1521B details the items within both specifications to be reviewed. These factors include, but are not limited to functional and physical characteristics of each CSCI, interface characteristics, as well as other logistic characteristics (usability, maintainability, portability, etc.).

Plan for Software Specification Review (SSR) – Box A1361

INPUTS:	Program Management Plan (A11)
OUTPUTS:	SSR Requirements
CONTROLS:	MIL–STD–1521B
MECHANISMS:	SPO, Contractor

Develop SRS – Box A1362

INPUTS:	Software Requirements (A131)
OUTPUTS:	SRS
CONTROLS:	MIL–STD–490A
MECHANISMS:	SPO, Contractor

Conduct Software Specification Review – Box A1363

INPUTS:	OCD, IRS, SRS
OUTPUTS:	Review Minutes
CONTROLS:	MIL–STD–1521B
MECHANISMS:	SPO, Contractor

Correct Deficiencies in Requirements Allocation – Box A1364

INPUTS:	Review Minutes, Requirements Documents (SRS, IRS, OCD)
OUTPUTS:	Validated Requirements Specification (A132)
CONTROLS:	MIL–STD–1521B
MECHANISMS:	Contractor

USED AT:

AUTHOR: Sweeney, Powers
COMPANY: TSC
PROJECT: CALS/SPD
NOTES:

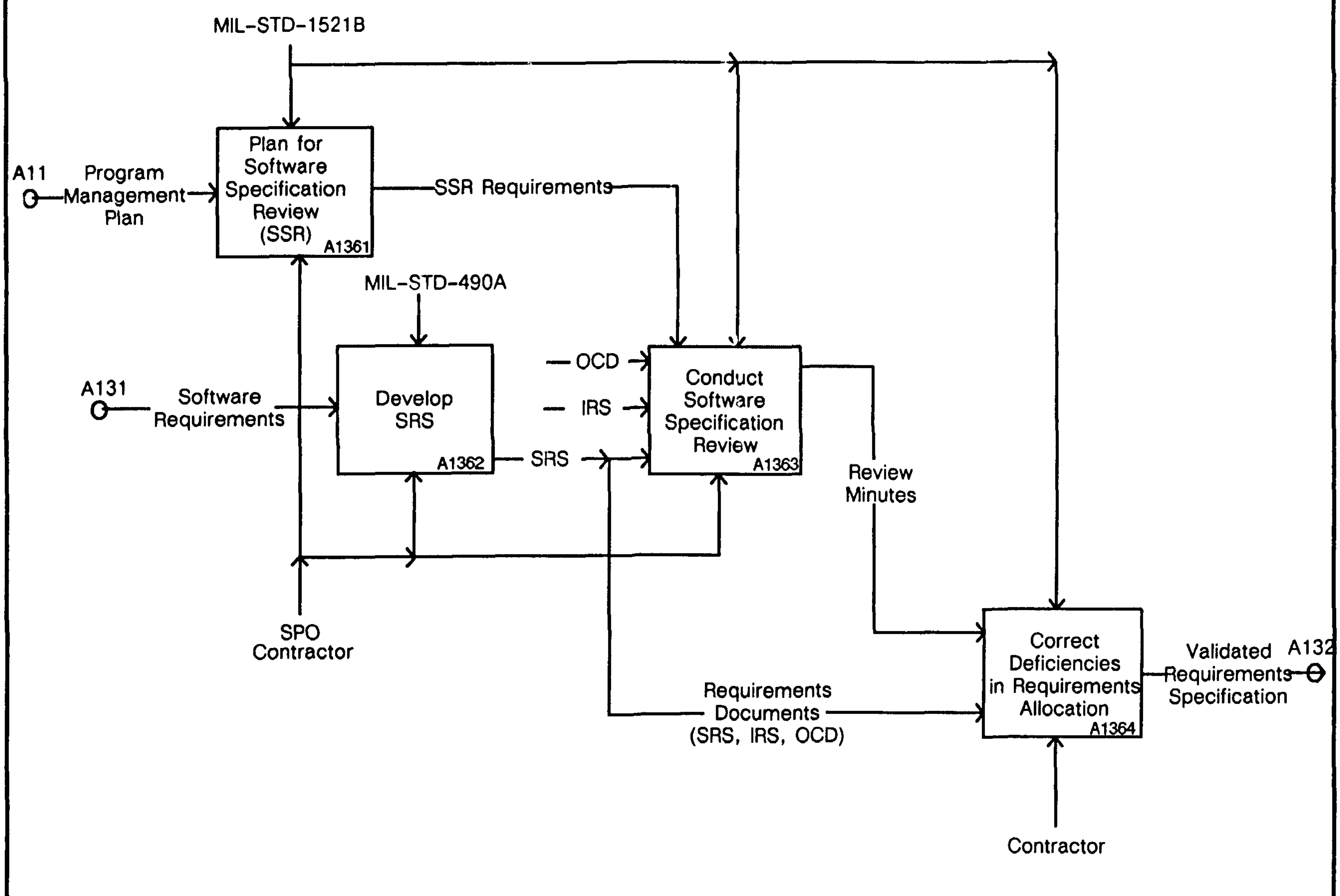
DATE: 11/01/89
REV: 1.3

DATE:

REMARKS

NODE: A13

CONTEXT:



NODE: Level 3 node A136

TITLE: Conduct Software Specification Review

NUMBER:

B.2.2 Deployment and Management IDEFs

The SPD deplcyment and management node tree (FIGURE B-3) includes life cycle of the software after PMRT. It consists of two major activities; system deployment and system support. System deployment is the primary activity outlined for the Using Command.

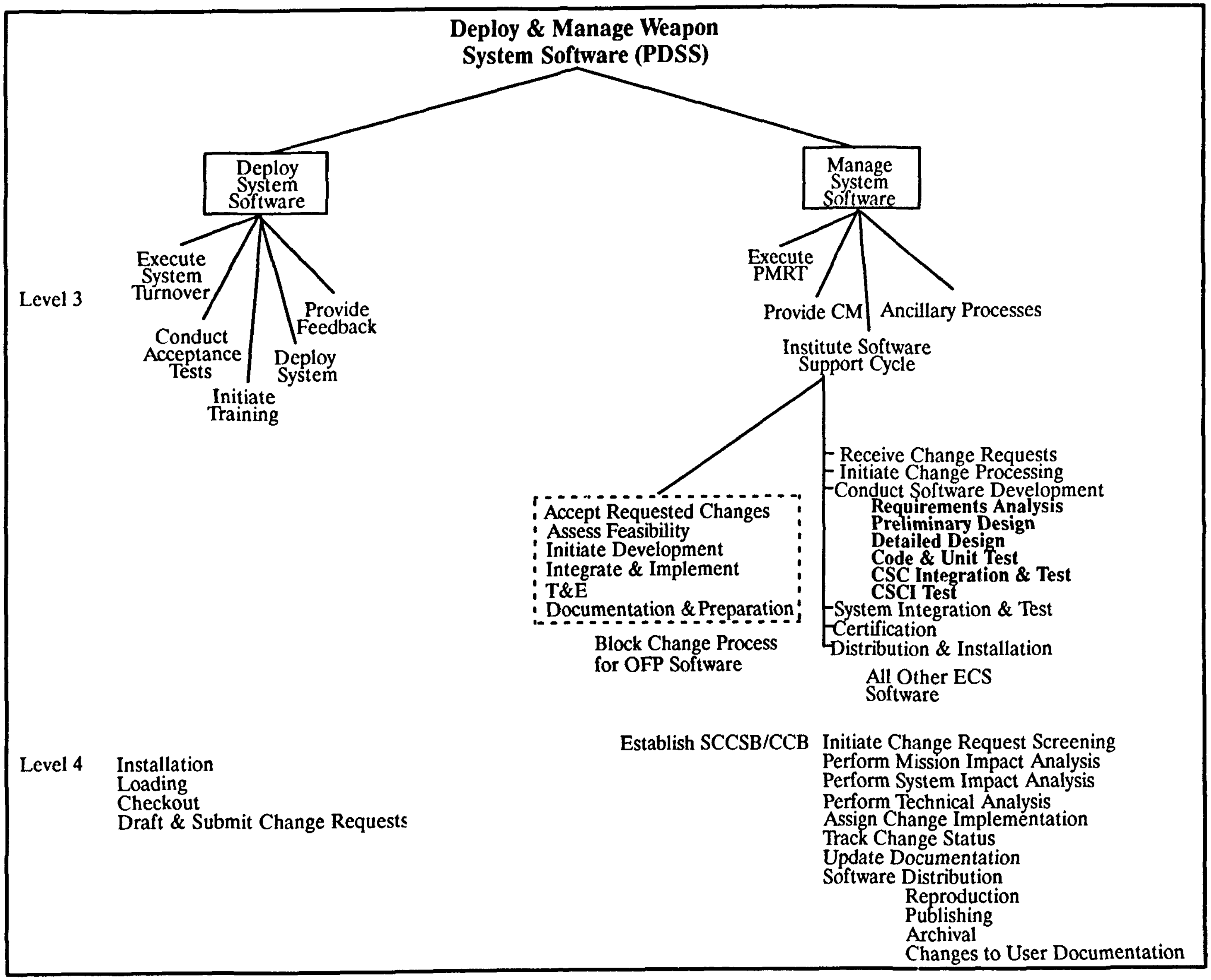


FIGURE B–3. SPD DEPLOY & MANAGE NODE TREE

B.2.2.1 Deploy & Manage Weapon System Software - Node A2

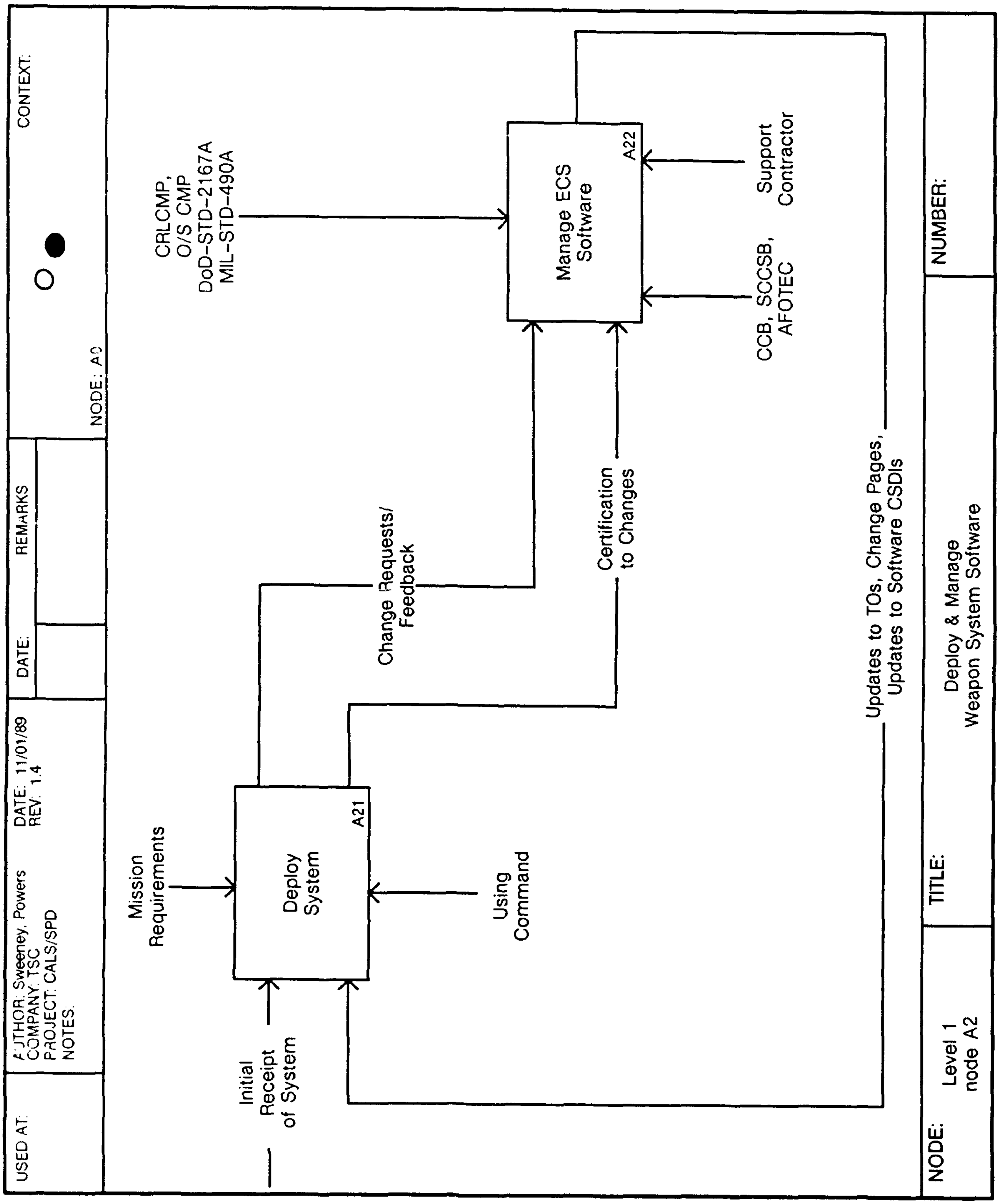
Node A2 encompasses the life cycle of the software subsequent to PMRT. It consists of two major activities; system deployment and system support. The system deployment is the primary activity outlined for the using command (Node A21). Maintenance of the system and the ECS software is depicted in Node A22.

Deploy System - Box A21

INPUTS:	Initial Receipt of System, Updates to TOs, Change Pages, Updates to Software CSDIs
OUTPUTS:	Change Requests/Feedback, Certification to Changes
CONTROLS:	Mission Requirements
MECHANISMS:	Using Commands

Manage ECS Software - Box A22

INPUTS:	Change Requests/Feedback, Certification to Changes
OUTPUTS:	Updates to TOs, Change Pages, Updates to Software CSDIs
CONTROLS:	CRLCMP, O/S CMP, DOD-STD-2167A, MIL-STD-490A
MECHANISMS:	CCB, SCCSB, AFOTEC, Support Contractor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COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.4
DATE:
REMARKS
NODE: A2
CONTEXT:
Mission Requirements
Deploy System
A21
Using Command
Initial Receipt of System
Change Requests/ Feedback
Certification to Changes
CRLCMP, O/S CMP DoD-STD-2167A MIL-STD-490A
Manage ECS Software
A22
CCB, SCCSB, AFOTEC
Support Contractor
Updates to TOs, Change Pages, Updates to Software CSDIs
NODE:
Level 1 node A2
TITLE:
Deploy & Manage Weapon System Software
NUMBER:

B.2.2.2 Deploy Weapon System Software - Node A21

This node, A21, depicts the primary Using Command activities. During PMRT, the Using Command is responsible for certification efforts. The training activity identifies preparation not only for users of the system but the maintainers as well. The primary activity within this node is the deployment of the system. During this activity the system meets the requirements levied upon it through the mission requirements. When deviations to the mission or deficiencies within the system itself occur, there is a feedback loop. This feedback will be primarily in the form of a Material Improvement Program (MIP), a Materiel Deficiency Report (MDR) or a Software Problem Report (SPR). These requests form the basis of the final series of nodes which identify the software maintenance operation.

Conduct Acceptance Tests - Box A211

INPUTS:	System
OUTPUTS:	Accepted System
CONTROLS:	Applicable TOs
MECHANISMS:	Using Command

Execute System Turnover - Box A212

INPUTS:	Accepted System
OUTPUTS:	Approved Software & SPD
CONTROLS:	Applicable TOs
MECHANISMS:	Using Command

Initiate Training - Box A213

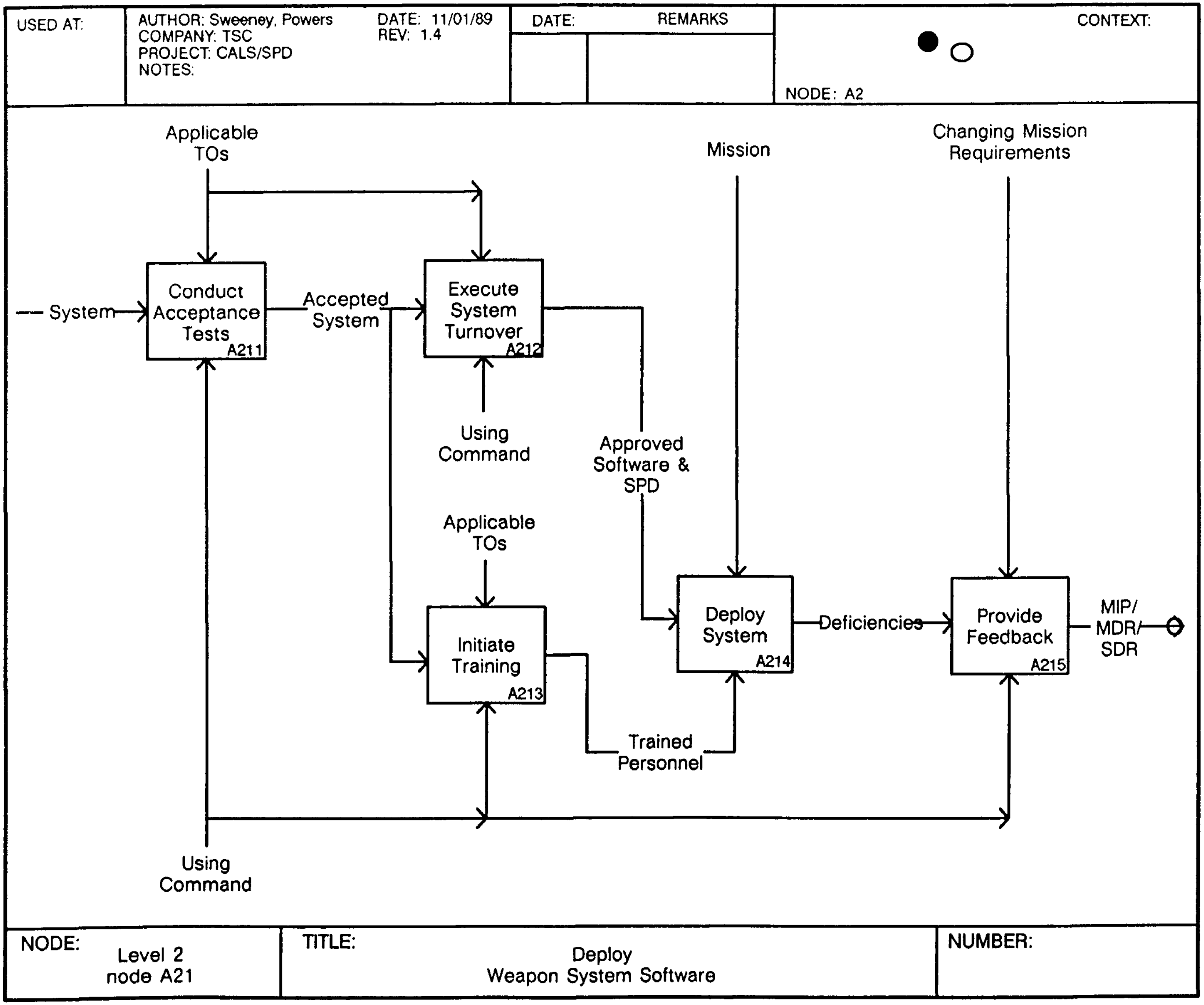
INPUTS:	Accepted System
OUTPUTS:	Trained Personnel
CONTROLS:	Applicable TOs
MECHANISMS:	Using Command

Deploy System - Box A214

INPUTS:	Approved Software & SPD
OUTPUTS:	Deficiencies
CONTROLS:	Mission
MECHANISMS:	Trained Personnel

Provide Feedback - Box A215

INPUTS:	Deficiencies
OUTPUTS:	MIP/MDR/SDR
CONTROLS:	Changing Mission Requirements
MECHANISMS:	Using Command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COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.4
DATE:
REMARKS
CONTEXT:
NODE: A2
Applicable TOs
Mission
Changing Mission Requirements
System
Conduct Acceptance Tests
A211
Accepted System
Execute System Turnover
A212
Using Command
Approved Software & SPD
Applicable TOs
Initiate Training
A213
Deploy System
A214
Deficiencies
Provide Feedback
A215
MIP/ MDR/ SDR
Trained Personnel
Using Command
NODE:
Level 2 node A21
TITLE:
Deploy Weapon System Software
NUMBER:

B.2.2.3 Manage Weapon System Software – Node A22

Node A22 depicts the management of software upon completion of PMRT. The CCB and the SCCSB maintain the integrity of a weapon system's functional configuration, trace changes, and determine the effect of those changes on functionality. The majority of configuration management activity involves the archiving of Post-PMRT SPD including change requests, and updates to information flows and code.

Execute PMRT – Box A221

INPUTS:	Contract Deliverables
OUTPUTS:	Initial Configuration
CONTROLS:	AFR 800-4, PMRT Plan
MECHANISMS:	SPO, SPM, Using Command, PMRT Working Group

Initiate Configuration Management Support – Box A222

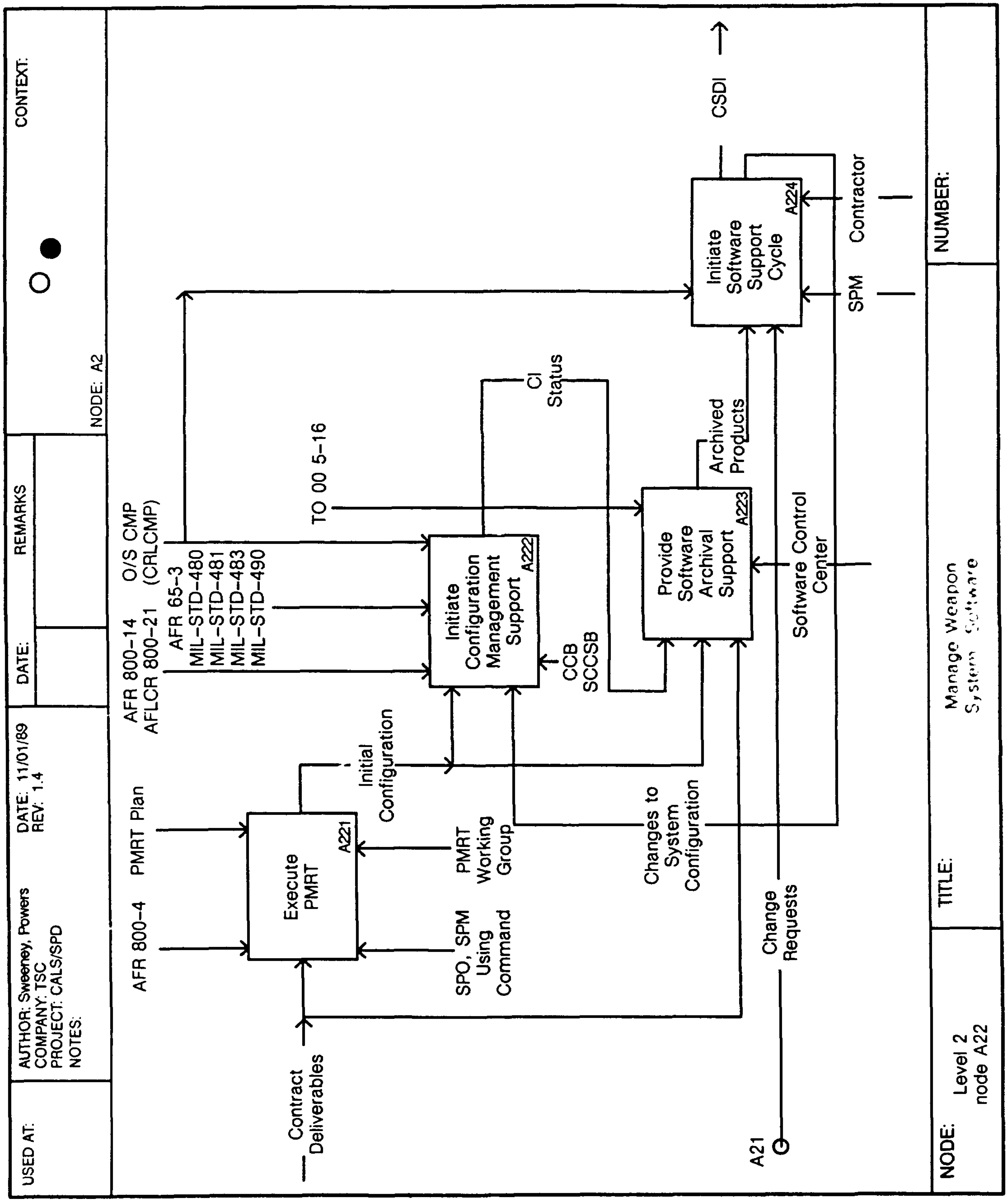
INPUTS:	Changes to System Configuration, Initial Configuration
OUTPUTS:	CI Status
CONTROLS:	AFR 800–14, AFLCR 800–21, AFR 65–3, MIL–STD–480, MIL–STD–481, MIL–STD–483, MIL–STD–490, O/S CMP or CRLCMP
MECHANISMS:	CCB, SCCSB

Provide Software Archival Support – Box A223

INPUTS:	CI Status, Initial Configuration, Contract Deliverables
OUTPUTS:	Archived Products
CONTROLS:	TO–00–5–16
MECHANISMS:	Software Control Center

Initiate Software Support Cycle – Box A224

INPUTS:	Archived Products, Change Requests (A21)
OUTPUTS:	CDSI, Changes to System Configuration
CONTROLS:	O/S CMP (CRLCMP)
MECHANISMS:	SPM, Contractor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COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.4
DATE:
REMARKS
NODE: A2
CONTEXT:
AFR 800-4
PMRT Plan
Execute PMRT
A221
SPO, SPM Using Command
PMRT Working Group
Contract Deliverables
Initial Configuration
AFR 800-14
AFLCR 800-21
AFR 65-3
MIL-STD-480
MIL-STD-481
MIL-STD-483
MIL-STD-490
O/S CMP
(CRLCMP)
Initiate Configuration Management Support
A222
CCB
SCCSB
Changes to System Configuration
TO 00 5-16
CI Status
Provide Software Archival Support
A223
Software Control Center
Archived Products
Change Requests
A21
Initiate Software Support Cycle
A224
SPM
Contractor
CSDI
NODE:
Level 2
node A22
TITLE:
Manage Weapon System Software
NUMBER:

B.2.2.4 Execute PMRT - Node A221

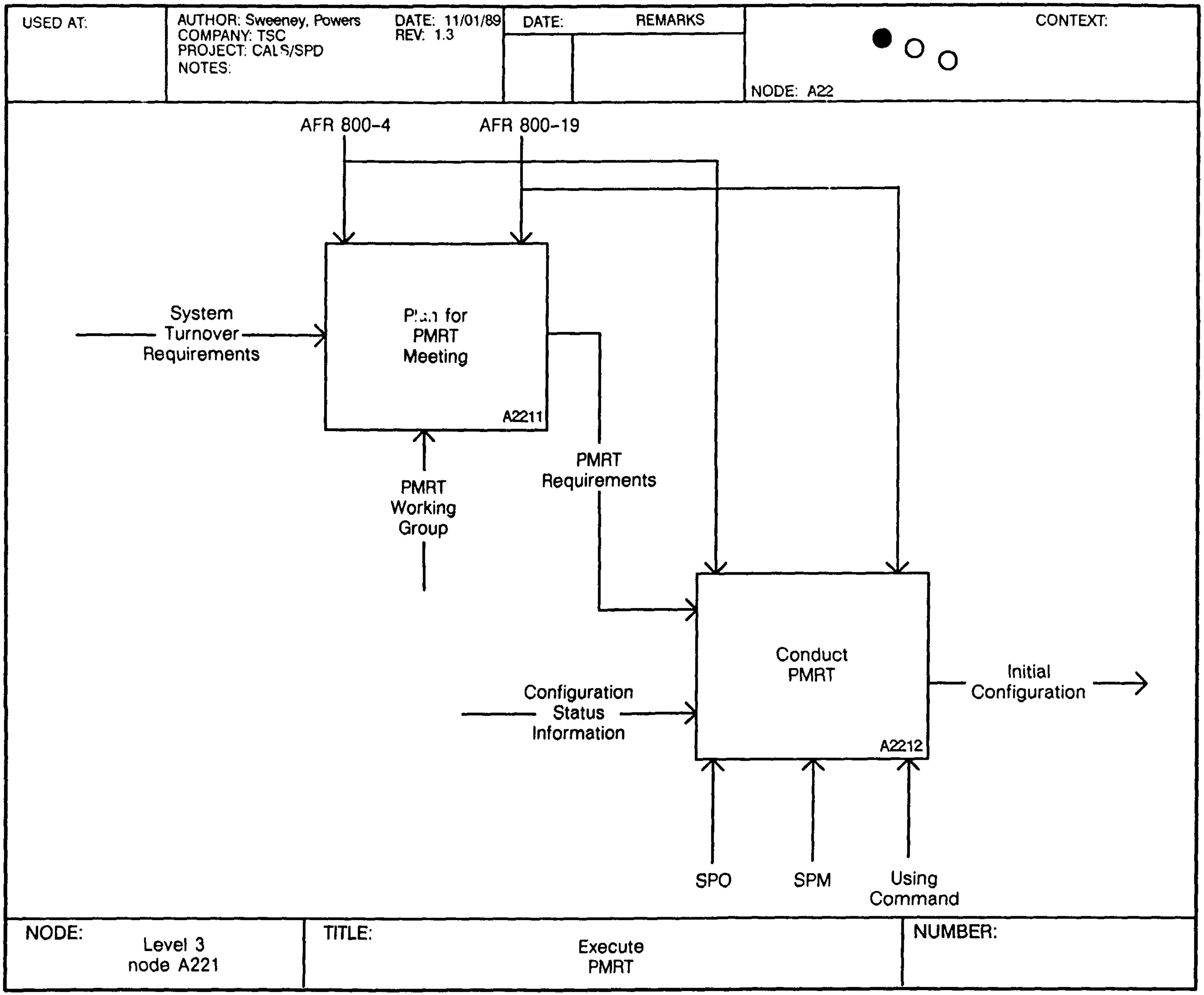
PMRT takes place upon completion of the production stage. The PMRT Working Group, made up primarily of SPO, Using Command, SPM and Contractor members, works to ensure that the software and system meet their functional requirements and that adequate support data and products are delivered. Upon completion of PMRT, responsibility for the software and its support is transferred from Developing Command to the Supporting Command.

Plan for PMRT Meeting - Box A2211

INPUTS:	System Turnover Requirements
OUTPUTS:	PMRT Requirements
CONTROLS:	AFR 800-4, AFR 800-19
MECHANISMS:	PMRT Working Group

Conduct PMRT - Box A2212

INPUTS:	PMRT Requirements, Configuration Status Information
OUTPUTS:	Initial Configuration
CONTROLS:	AFR 800-4, AFR 800-19
MECHANISMS:	SPO, SPM, Using Command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COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.3
DATE:
REMARKS
CONTEXT:
NODE: A22
AFR 800-4
AFR 800-19
System Turnover Requirements
Plan for PMRT Meeting
A2211
PMRT Working Group
PMRT Requirements
Conduct PMRT
A2212
Configuration Status Information
Initial Configuration
SPO
SPM
Using Command
NODE:
Level 3 node A221
TITLE:
Execute PMRT
NUMBER:

B.2.2.5 Initiate Configuration Management - Node A222

Configuration Management is the process by which the CCB and the SCCSB maintain the desired functionality of software. The process involves the development of the baselines that make up configurations. The configuration regulates updates to software and associated products as a result of user change requests, and system audits to ensure that it is meeting CSCI requirements delineated out in its baseline documents.

Generate Configuration Identification - Box A2221

INPUTS:	Software Development Library/File
OUTPUTS:	CM Data, Relationship
CONTROLS:	O/S CMP (CRLCMP)
MECHANISMS:	CCB

Provide CM Control - Box A2222

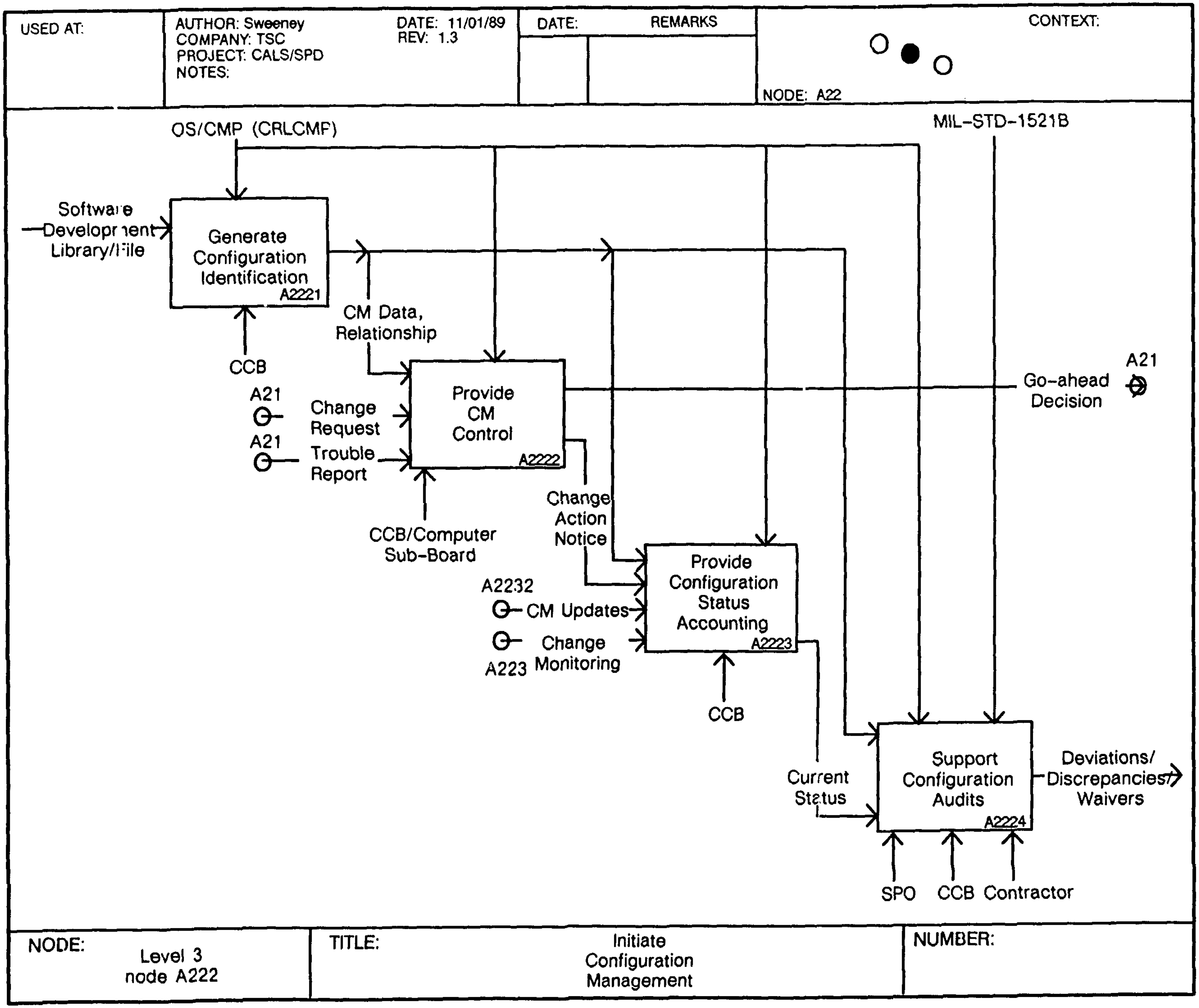
INPUTS:	CM Data, Relationship, Change Request (A21), Trouble Report (A21)
OUTPUTS:	Go-ahead Decision (A21), Change Action
CONTROLS:	O/S CMP (CRLCMP)
MECHANISMS:	CCB/Computer Sub-Board

Provide Configuration Status Accounting - Box A2223

INPUTS:	Change Action Notice, CM Updates (2232), Change Monitoring (A223) CM Data, Relationship
OUTPUTS:	Current Status
CONTROLS:	O/S CMP (CRLCMP)
MECHANISMS:	CCB

Support Configuration Audits - Box A2224

INPUTS:	CM Data, Relationship, Current Status
OUTPUTS:	Deviations/Discrepancies/Waivers
CONTROLS:	O/S CMP (CRLCMP), MIL-STD-1521B
MECHANISMS:	SPO, CCB, Contractor


USED AT:
AUTHOR: Sweeney
COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.3
DATE:
REMARKS
CONTEXT:
NODE: A22
OS/CMP (CRLCMF)
MIL-STD-1521B
Software Developr ıent Library/File
Generate Configuration Identification
A2221
CCB
CM Data, Relationship
A21
Change Request
A21
Trouble Report
Provide CM Control
A2222
CCB/Computer Sub-Board
Go-ahead Decision
A21
Change Action Notice
A2232
CM Updates
Change Monitoring
A223
Provide Configuration Status Accounting
A2223
CCB
Current Status
Support Configuration Audits
A2224
Deviations/ Discrepancies/ Waivers
SPO
CCB
Contractor
NODE:
Level 3
node A222
TITLE:
Initiate Configuration Management
NUMBER:

B.2.2.6 Institute Software Support Cycle – Node A223

Node A223, Institute Software Support Cycle, identifies the activities associated with supplying the weapon system with software support. This process is representative of the "block change cycle." The block change cycle is the process whereby a group or "block" of changes are planned for deployment at the same time.

The first activity initiates the change process. The change is usually in the form of an improvement to the system or a record of a deficiency. A system impact analysis and a mission impact analysis are required prior to determining whether the change can be made.

The software development cycle mirrors the development cycle used during the FSD phase. Upon completion of test and certification, the TO or Time Compliant Technical Order (TCTO) must be developed. Once that is completed, the Software Control Center administers the distribution of the kit.

Initiate Change Processing – Box A2231

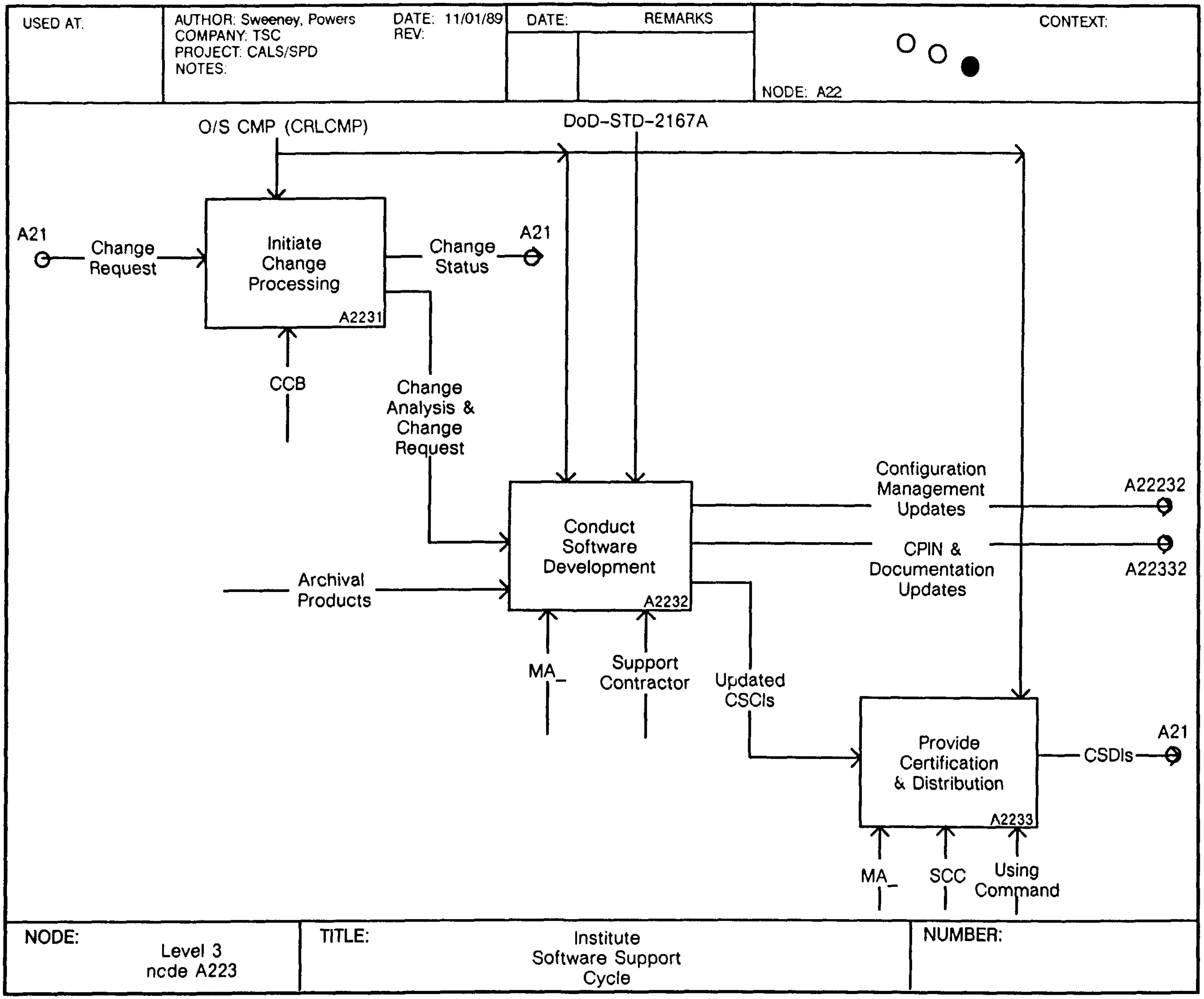
INPUTS:	Change Request (A21)
OUTPUTS:	Change Status (A21), Change Analysis & Change Request
CONTROLS:	O/S CMP (CRLCMP)
MECHANISMS:	CCB

Conduct Software Development – Box A2232

INPUTS:	Change Analysis & Change Request, Archival Products
OUTPUTS:	Configuration Management Updates (A22232), CPIN & Documentation Updates (A22332), Updated CSCIs
CONTROLS:	O/S CMP (CRLCMP), DOD-STD-2167A
MECHANISMS:	MA_, Support Contractor

Provide Certification & Distribution – Box A2233

INPUTS:	Updated CSCIs
OUTPUTS:	CSDIs (A21)
CONTROLS:	O/S CMP (CRLCMP)
MECHANISMS:	MA_, SCC, Using Command


USED AT:
AUTHOR: Sweeney, Powers
COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV:
DATE:
REMARKS
CONTEXT:
NODE: A22
O/S CMP (CRLCMP)
DoD-STD-2167A
A21
Change Request
Initiate Change Processing
A2231
Change Status
A21
CCB
Change Analysis & Change Request
Conduct Software Development
A2232
Archival Products
MA_
Support Contractor
Updated CSCIs
Configuration Management Updates
A22232
CPIN & Documentation Updates
A22332
Provide Certification & Distribution
A2233
CSDIs
A21
MA_
SCC
Using Command
NODE:
Level 3
ncde A223
TITLE:
Institute Software Support Cycle
NUMBER:

B.2.2.7 Initiate Change Processing - Node A2231

Node A2231 describes the first major activity in the software support cycle. It includes the screening of the request, development of a determination of impact, and a decision to either implement or defer the change. The technical analysis includes an assessment of those CPINs which have been impacted.

Initiate Change Request Screening - Box A22311

INPUTS:	Change Request (A21)
OUTPUTS:	Rejection Notice (to Initiator) (A21), Screened Requests
CONTROLS:	AFR 800-14, Screening Parameters
MECHANISMS:	SCCSB

Perform System Impact Analysis - Box A22312

INPUTS:	Screened Requests
OUTPUTS:	Potential Trade Offs to Relevant Systems
CONTROLS:	System Specification, AFR 800-14
MECHANISMS:	SCCSB

Perform Mission Impact Analysis - Box A22313

INPUTS:	Mission Requirements
OUTPUTS:	Potential Tradeoffs to Relevant Systems
CONTROLS:	AFR 800-14, Screened Requests
MECHANISMS:	SCCSB

Perform Technical Analysis - Box A22314

INPUTS:	Potential Tradeoffs to Relevant Systems
OUTPUTS:	Suggested Changes/Technique
CONTROLS:	AFR 800-14
MECHANISMS:	SCCSB

Assign Change Implementation & Track - Box A22315

INPUTS:	Potential Trade Offs to Relevant Systems, Suggested Changes/ Technique
OUTPUTS:	Change "Go-Ahead" Notice (A223), Impact Analysis Reports (A223)
CONTROLS:	AFR 800-14
MECHANISMS:	SCCSB

USED AT:

AUTHOR: Sweeney. Powers
COMPANY: TSC
PROJECT: CALS/SPD
NOTES:

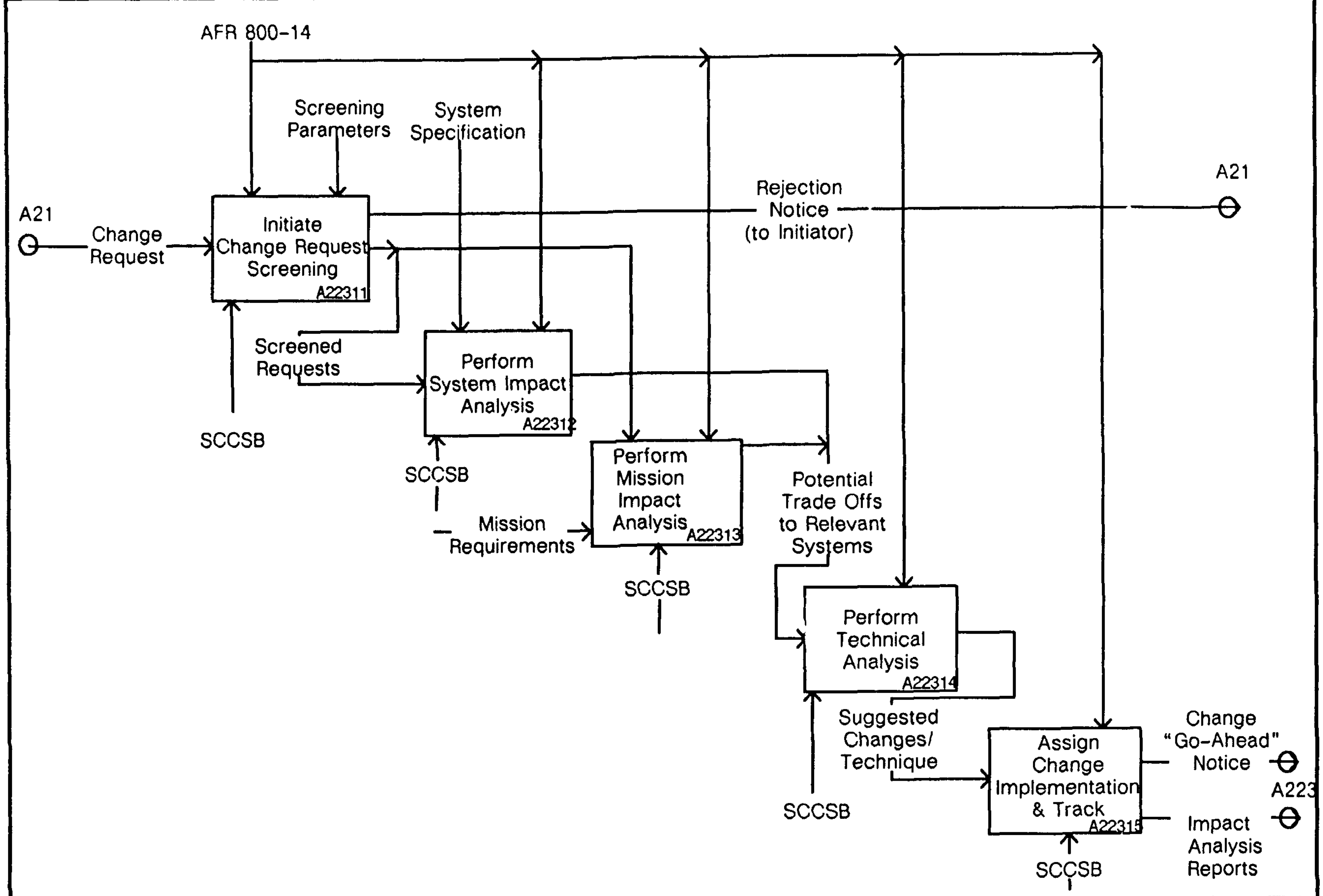
DATE: 11/01/89
REV:

DATE:

REMARKS

CONTEXT:

NODE: A223



NODE: Level 4 node A2231

TITLE: Initiate Change Processing

NUMBER:

B.2.2.8 Conduct Software Development – Node A2232

Node A2232 details the activities during the software development cycle. This process was described earlier in Node A123.

Perform Requirements Analysis – Box A22321

INPUTS:	Change Request, Impact Analysis Reports, Change Implementation Status, Go Ahead Notice (A2231)
OUTPUTS:	SRS
CONTROLS:	SPM, DOD-STD-2167A, DOD-STD-2168, Initial Design Parameters
MECHANISMS:	Contractor

Generate Preliminary Design – Box A22322

INPUTS:	SRS
OUTPUTS:	Preliminary Design
CONTROLS:	DOD-STD-2167A, DOD-STD-2168
MECHANISMS:	Contractor

Generate Detailed Design – Box A22323

INPUTS:	Preliminary Design
OUTPUTS:	Detailed Design
CONTROLS:	DOD-STD-2167A, DOD-STD-2168
MECHANISMS:	Contractor

Code & Unit Test – Box A22324

INPUTS:	Detailed Design
OUTPUTS:	CSUs
CONTROLS:	DOD-STD-2167A, DOD-STD-2168
MECHANISMS:	Contractor

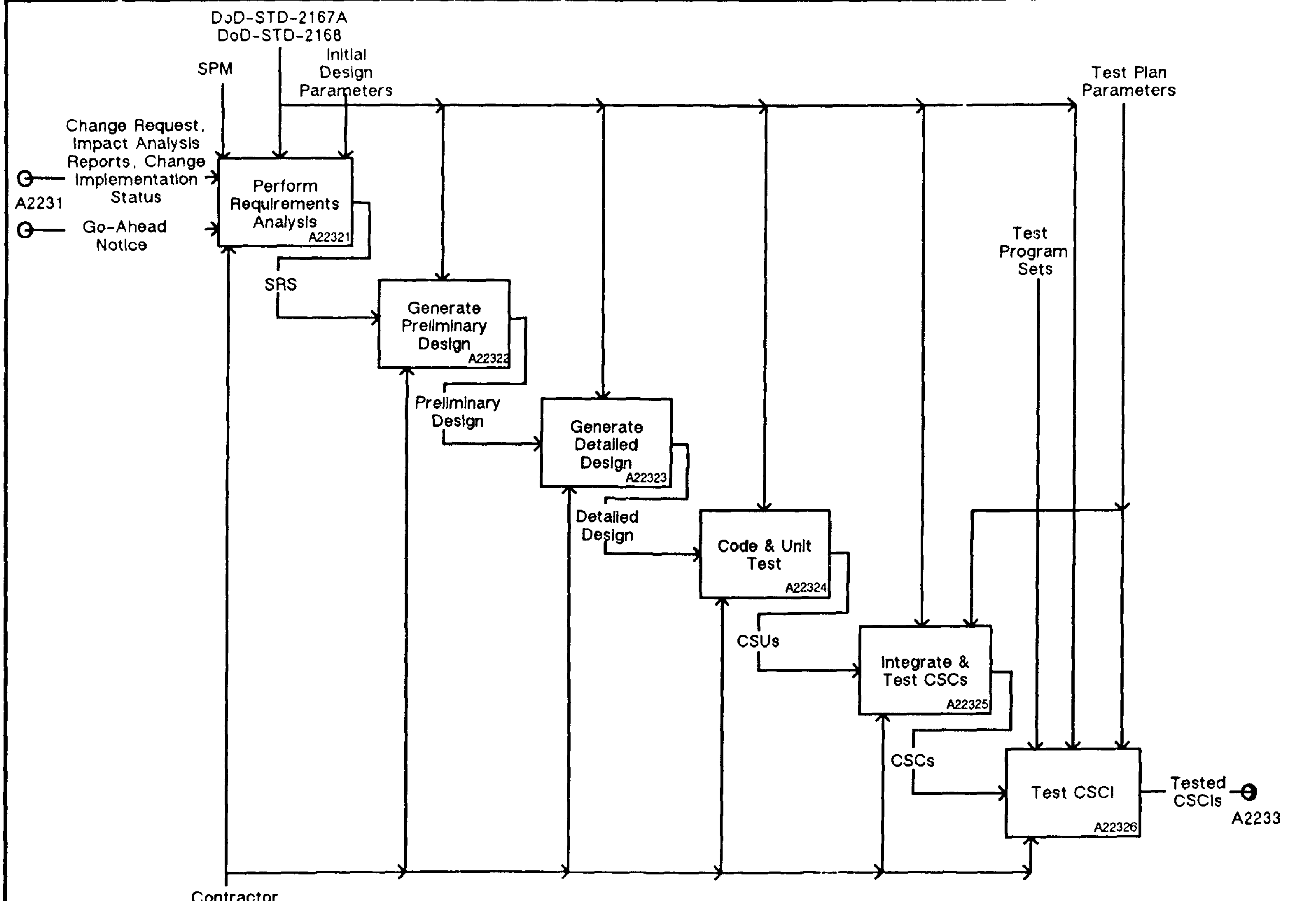
Integrate & Test CSCs – Box A22325

INPUTS:	CSUs
OUTPUTS:	CSCs
CONTROLS:	DOD-STD-2167A, DOD-STD-2168, Test Plan Parameters
MECHANISMS:	Contractor

Test CSCI – Box A22326

INPUTS:	CSCs
OUTPUTS:	Tested CSCIs (A2233)
CONTROLS:	DOD-STD-2167A, DOD-STD-2168, Test Program Sets, Test Plan Parameters
MECHANISMS:	Contractor

USED AT:	AUTHOR: Sweeney, Powers COMPANY: TSC PROJECT: CALS/SPD NOTES:	DATE: 11/01/89 REV: 1.5	DATE:	REMARKS	CONTEXT: NODE: A223



NODE: Level 4 node A2232	TITLE:	NUMBER:

B.2.2.9 Provide Certification and Distribution – Node A2233

Node A2233 identifies the final steps in the block change cycle. These activities include the integration and test of the software, updating manuals, generating the necessary technical orders, and coordinating the distribution through the SCC.

Conduct System Integration and Test – Box A22331

INPUTS:	Tested CSCIs (A2232)
OUTPUTS:	Validated CSCIs
CONTROLS:	CRLCMP, O/S CMP
MECHANISMS:	MAS/SPM/SCC

Update Documentation & CPINs– Box A22332

INPUTS:	Tested CSCIs, CPIN & Documentation Updates (A2232)
OUTPUTS:	Change Pages, etc.
CONTROLS:	CRLCMP, O/S CMP
MECHANISMS:	MAS/SPM/SCC

Reproduction & Publishing – Box A22333

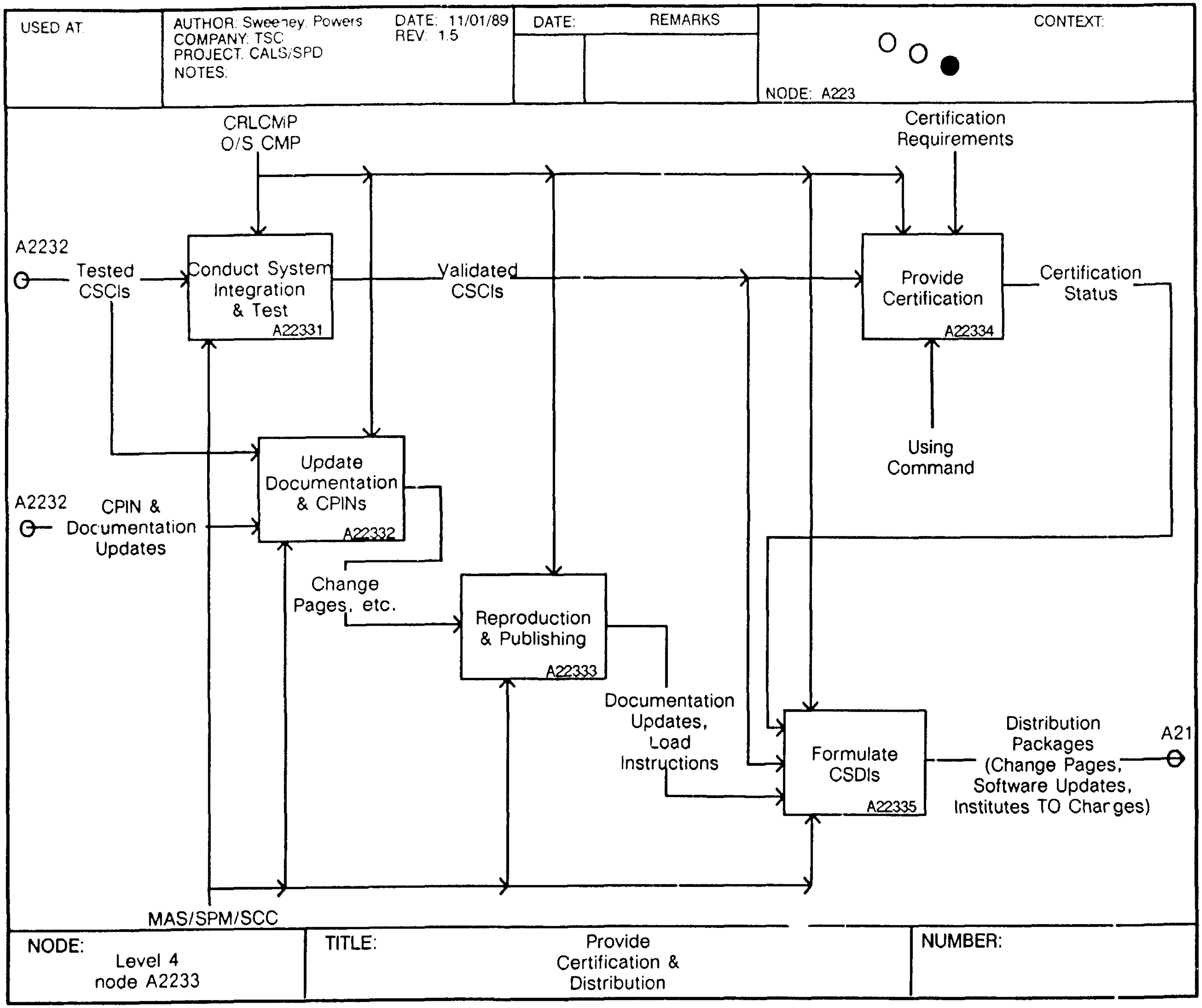
INPUTS:	Change Pages, etc.
OUTPUTS:	Documentation Updates, Load Instructions
CONTROLS:	CRLCMP, O/S CMP
MECHANISMS:	MAS/SPM/SCC

Provide Certification – Box A22334

INPUTS:	Validated CSCIs
OUTPUTS:	Certification Status
CONTROLS:	CRLCMP, O/S CMP, Certification Requirements
MECHANISMS:	Using Command

Formulate CSDIs – Box A22335

INPUTS:	Certification Status, Validated CSCIs, Documentation Updates, Load Instructions
OUTPUTS:	Distribution Packages (Change Pages, Software Updates, Institutes TO Changes) (A21)
CONTROLS:	CRLCMP, O/S CMP
MECHANISMS:	MAS/SPM/SCC


USED AT:
AUTHOR: Sweeney, Powers
COMPANY: TSC
PROJECT: CALS/SPD
NOTES:
DATE: 11/01/89
REV: 1.5
DATE:
REMARKS
CONTEXT:
NODE: A223
CRLCMP
O/S CMP
Certification
Requirements
A2232
Tested
CSCIs
Conduct System
Integration
& Test
A22331
Validated
CSCIs
Provide
Certification
A22334
Certification
Status
Using
Command
Update
Documentation
& CPINs
A22332
A2232
CPIN &
Documentation
Updates
Change
Pages, etc.
Reproduction
& Publishing
A22333
Documentation
Updates,
Load
Instructions
Formulate
CSDIs
A22335
Distribution
Packages
(Change Pages,
Software Updates,
Institutes TO Charges)
A21
MAS/SPM/SCC
NODE:
Level 4
node A2233
TITLE:
Provide
Certification &
Distribution
NUMBER:

APPENDIX C: BIBLIOGRAPHY

BIBLIOGRAPHY

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APPENDIX D: POINTS OF CONTACT

POINTS OF CONTACT BY COMMAND

AFLC						AFSC					
HQAFLC	OC/ALC	OO/ALC	SA/ALC	SM/ALC	WR/ALC	HQAFSC	ALD	BSD	ESD	TEST	ASD
MMDBS	MMEC	CRE	SMSP	CRE	MAITBC	ENRP	ERC	ACD	AV	AFFTC	WRDC
MMEC	MMECE	MAS	MAS	DET25	MMEC	ENXC		AL	MET	6510thTW	
	MMUDC	MASAA	MASQI	. MMFM	MMDETD			MSLT	PLE		
		MASAC	MASTC	. MMFR					PL		
		MASMC	MASOF	. MMG					RADC		
		MMARTC	MAWSE	MABER					SR		
		MMECA	MM-4	MAIEPD					TC		
		MMEO	MMEC	MAIPCA							
		MMEOB	MMECS	MAIPCE							
		MMETI	MMECD	MANE							
		MMGR	XPS	MANELC							
		MMICE		MANPBP							
		MMIYD		MASAA							
		MMMA		MASAF							
		MMSA		MASAG							
		MMSHRN		MASBA							
		SCSP		MASOF							
				MASQI							
				MASSDA							
				MASSLB							
				MASTC							
				MAWSE							
				MM-4							
				MMBCE							
				MME							
				MMEC							
				MMECN							
				MMEOF							
				MMFMM							
				MMGR							
				MMKR							
				MMKRB							
				MMMA							
				MMQB							
				MMSRD							
				MMTM							
				MMTR							
				QL							
				XPS							

POINTS OF CONTACT BY COMMAND CONT'D

AFCC	AFSPACECOM	ATC	ESC	MAC	SAC	TAC	CONTRACTORS
SSC	LKW LKWS LKY SWSC	LGM TTDR	AFEWC	DO LG LGME SC SX XP XRE XRHE XRS	DO LGY SCZ XRHE XRHV XRRR XRRX	LGMA LGS LGQS LGX LGXA SCX	ACCESS RESEARCH TECHNOLOGY ATI GENERAL MOTORS INTERLEAF INTERMETRICS LOGICON MENTOR GRAPHICS SOFTWARE ENGINEERING INSTITUTE TRW

The above organizations are the points of contact within the Air Force and Industry that were contacted as part of this effort through site visits, personal, and/or telephone contacts.

END