SPACE STATION FREEDOM

SOFTWARE SUPPORT ENVIRONMENT

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This presentation discusses the Space Station Freedom Software Support Environment. After a brief overview of the SSE, the implementation approach and the current and planned functionality are described. The implications and future potential of this common environment for software development and sustaining engineering are also discussed.

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WHAT IS THE SSE?

The Software Support Environment (SSE) is a common software environment for all developers of Space Station Freedom Program (SSFP) "operational software". It consists of software tools, procedures, standards, hardware specifications, and user support services including continuing maintenance and upgrade of the SSE, user help desks, training material and documentation.

The SSE System is an environment consisting of computer hardware, communications networks, the SSE and other elements forming an integrated support system for SSFP software developers.

The SSE provides a common set of tools and methods across all the SSFP facilities involved in software life cycle management, including the Software Production Facilities (SPFs) at the four Work Package Centers and Kennedy Space Center, the SSFP integration facilities (to be established) and the SSE Development Facility (SSEDF).

"Operational software" is currently defined by the SSFP as ALL flight and ground software that either 1) interfaces with on-orbit elements in real time, or 2) is critical to the mission, such as all control center, test and certification software including associated models and simulations, or 3) SSE software.

WHAT IS THE SSE?

- SSE PROVIDES THE COMMON ENVIRONMENT TO BE USED FOR THE LIFE CYCLE MANAGEMENT OF ALL SSFP OPERATIONAL SOFTWARE.

- SSE IS A COLLECTION OF:
  - TOOLS (SOFTWARE)
  - RULES (POLICIES, STANDARDS, PROCEDURES, SOFTWARE PRODUCTION HARDWARE SPECS)
  - SERVICES (DELIVERY OF OI'S, USER SUPPORT, TRAINING, DOCUMENTATION)

- THE SSE SUPPORTS ALL SSFP FACILITIES INVOLVED IN SOFTWARE LIFE CYCLE MANAGEMENT. THESE FACILITIES INCLUDE:
  - WORK PACKAGE AND KSC SOFTWARE PRODUCTION FACILITIES
  - SSFP INTEGRATION FACILITIES
  - THE SSE DEVELOPMENT FACILITY

SSE Supports Program Standards

Since the SSE is the common environment for all SSFP software developers, it provides the mechanisms to enforce program-wide software policies and standards. High-level SSFP software policies are set forth in the Level A Software Management Policies, dated November 11, 1986. Elaboration and expansion on these policies are provided in the Level II Software Policies Document currently in under final review prior to becoming a formally baselined Program document. The SSE will be used to support and enforce use of these policies and standards. Current standards include Ada as the standard programming language, a Common User Interface (CUI) definition, standard content formats for software documentation, and a common software verification approach.

SSE SUPPORTS PROGRAM STANDARDS

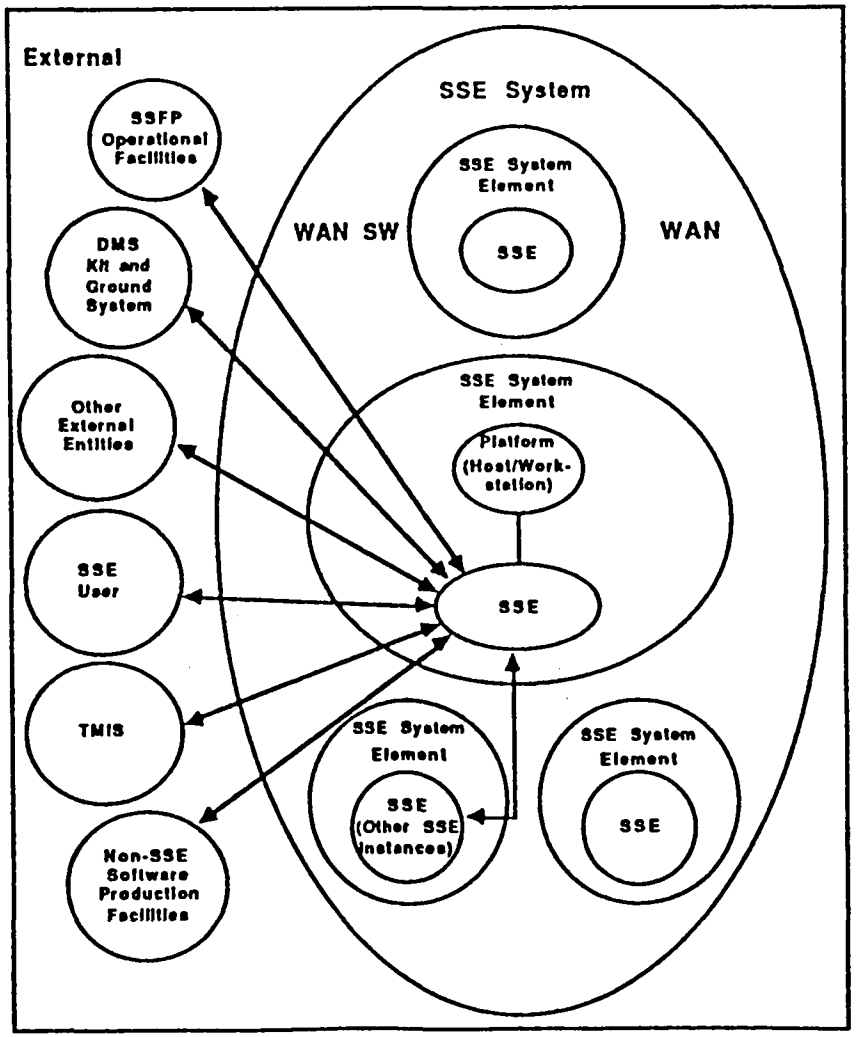
THE SSE SUPPORTS AND PROVIDES MECHANISMS TO ENFORCE PROGRAM-WIDE SOFTWARE POLICIES AND STANDARDS, SUCH AS

- **STANDARD PROGRAMMING LANGUAGE (ADA)**
- **COMMON USER INTERFACE STANDARDS**
- **SOFTWARE DOCUMENTATION STANDARDS**
- **COMMON SOFTWARE VERIFICATION APPROACH**

SSE System Context

The SSE System consists of a collection of SSE System Elements in a wide area network (WAN). Each SSE System Element consists of a host platform and a collection of workstations running the SSE software. Each element has several external interfaces which may include SSFP operational facilities, Data Management System (DMS) simulation facilities and ground systems, SSE users (connected either directly or through a communications network), TMIS (the Program Technical and Management Information System) and other software production facilities.

SSE SYSTEM CONTEXT



SSE Hosts and Workstations

Two computer systems are currently supported as SSE host computer architectures: Architecture A is the DEC VAX family with VMS operating system and Architecture B is the larger IBM mainframes with VM. The SSE Development Facility has one of each: a DEC VAX 8820 and an IBM 3090.

There are three workstation types currently approved as SSE workstations: IBM PC/AT Compatible (PS/2 Model 60 running DOS and AT compatible personal computers), Apollo DN 3000 running the DOMAIN operating system, and Macintosh II workstation with Finder as the operating system. Currently, consideration is being given to adding the IBM PS/2 Model 80 as another workstation since the software tools available for this and the Apollo are very similar.

SSE HOSTS AND WORKSTATIONS

- SSE HOST COMPUTER ARCHITECTURES AT DF.
  - DEC VAX 8820 WITH VMS OPERATING SYSTEM
  - IBM 3090 WITH VM
- SSE WORKSTATION TYPES.
  - IBM PS / 2 MODEL 60 AND AT COMPATIBLES
  - APOLLO DN 3000
  - MACINTOSH II
- ADDITIONAL WORKSTATION, IBM PS / 2 MODEL 80 (80386), UNDER CONSIDERATION.

Why does SSF need the SSE?

Software is a high risk area for the Space Station Freedom Program in terms of both safety and cost. The quantity of software developed for this program is expected to far exceed that required for previous space programs including the Shuttle Orbiter. Since there are so many different organizations developing software for the SSFP and they are distributed geographically as well, the potential for problems in the integration and testing phase of the development can be alleviated through the use of common tools and standards provided by the SSE.

Through the common environment used by developers of SSFP software, the life cycle costs can be contained in both the development phase by reducing duplicative efforts and especially in the sustaining engineering phase, when the wide use of a common environment will provide a greater base of skilled support personnel.

The SSE will also provide the means to quickly disseminate improved software tools and to increase software quality as technology improvements emerge.

WHY DOES SPACE STATION FREEDOM NEED THE SSE?

- SOFTWARE IS HIGH RISK FOR THE SSFP IN TERMS OF BOTH SAFETY AND COST.
  - LARGE AMOUNT OF SOFTWARE TO BE DEVELOPED.
  - INTEGRATION AND TESTING ARE MAJOR ISSUES.

- SSE PROVIDES A MEANS TO CONTROL SSFP SOFTWARE LIFE CYCLE COSTS.
  - A SINGLE COMMON IMPLEMENTATION APPROACH.
  - A CONSOLIDATION OF SKILLS FOR SUSTAINING ENGINEERING.

- SSE PROVIDES THE MEANS TO CONTROL SSFP SOFTWARE QUALITY THROUGH COMMON PROGRAM-WIDE STANDARDS AND TOOLS.

Who are the SSE Users?

The SSE user community consists of all persons involved in the life cycle management of SSFP software. This includes software project managers, requirements analysts, software designers, software developers, testers, quality managers, and software configuration control managers. Most of the users will be Work Package contractors. Other SSE users will come from NASA SSFP organizations, Kennedy Space Center and ground support contractors, Space Station Freedom users, and international partners in the SSFP.

The Software Support Environment User's Working Group (SSEUWG) provides the forum for SSE user information exchange and input to the SSE Project. The SSEUWG has representatives from the NASA Centers and organizations involved in the SSFP, the Work Package contractors, the international partners, and potential SSF customers. Meetings are held approximately quarterly. For more information, contact the SSEUWG Chair, Susan Voigt at NASA Langley.

WHO ARE THE SSE USERS?

- SSE USER COMMUNITY ARE DEVELOPERS, TESTERS AND CONFIGURATION MANAGERS OF SSFP SOFTWARE.

- MAJORITY OF USERS ARE WORK PACKAGE CONTRACTORS.

- OTHER SSE USERS WILL INCLUDE:
  - NASA SSFP ORGANIZATIONS
  - KSC AND NON-PRIME CONTRACTORS
  - SPACE STATION FREEDOM USERS
  - INTERNATIONAL PARTNERS (STANDARD)

- SSEUWG IS THE USER FORUM FOR USER INFORMATION EXCHANGE AND INPUT TO THE SSE PROJECT.

SSE Implementation Approach

The SSE is being developed by Lockheed Missiles and Space Company, Inc. (LMSC) under contract to NASA. The development team is located in Houston, TX near the NASA Johnson Space Center. Subcontractors with LMSC are PRC, SAIC and Ford Aerospace. The six-year contract started on July 10, 1987.

The SSE is being developed incrementally. The first SSE system was delivered to the Government, called the Interim SSE, on September 10, 1987. Operational Increments (OIs) have been delivered periodically to increase the functionality of the SSE. The SSEDF has been recently upgraded to OI 3.2. This system will be delivered to the user Software Production Facilities (SPFs) beginning in mid-February. Future OIs are planned for release about every 5 months.

SSE IMPLEMENTATION APPROACH

- SINGLE CONTRACTOR FOR SSE DEVELOPMENT.

- CONTACT AWARDED TO LOCKHEED MISSILES AND SPACE COMPANY, INC., HOUSTON, TX.
  - CONTRACT START DATE (CSD) - JULY 10, 1987.

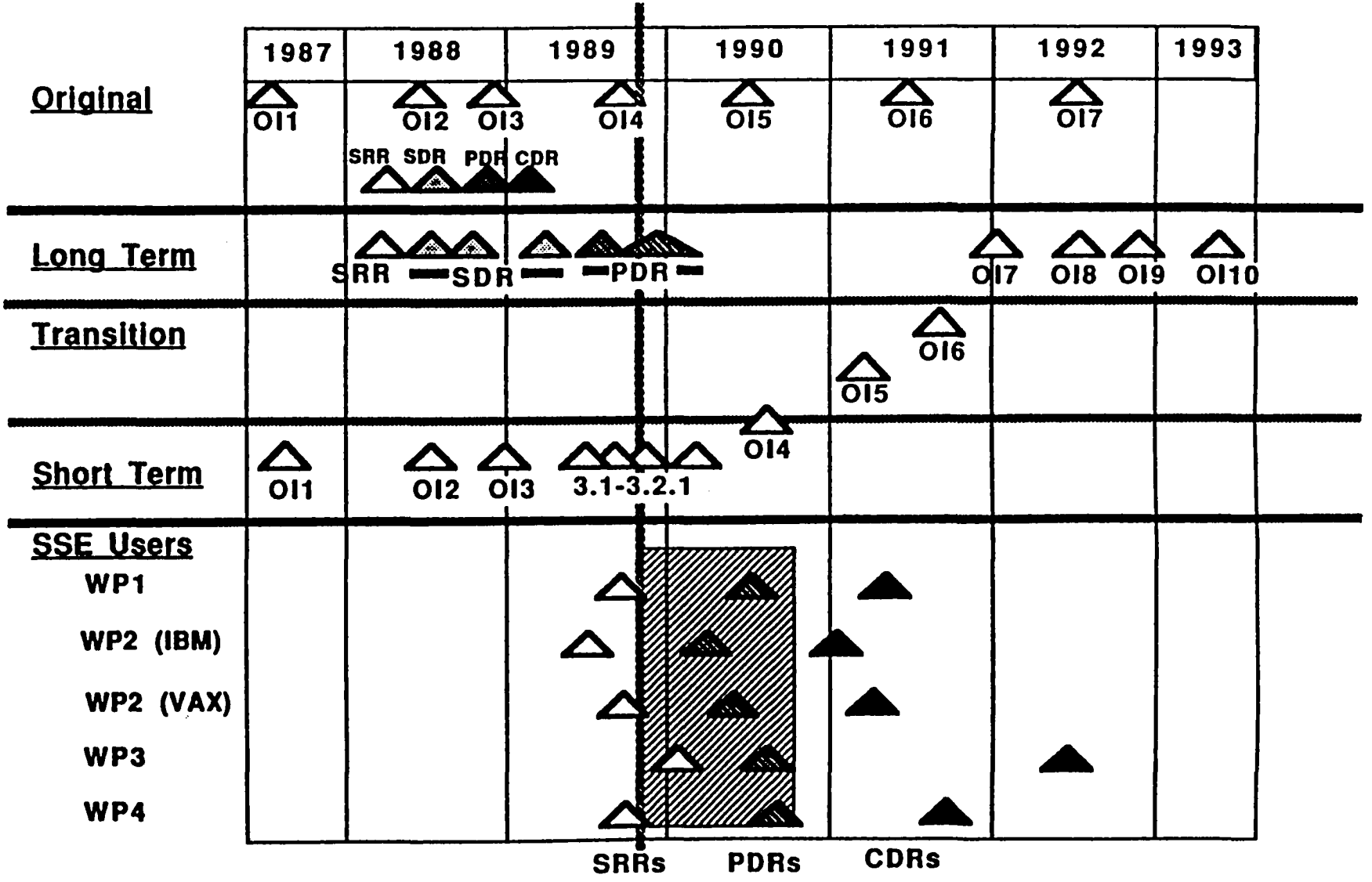
- INCREMENTAL DEVELOPMENT.
  - INTERIM SSE SYSTEM (OPERATIONAL INCREMENT 1.0) DELIVERED SEPTEMBER 10, 1987.
  - CURRENTLY SSE SYSTEM AT OI 3.2.
  - FUTURE OI'S TO BE DELIVERED EVERY 5 MONTHS.

Status and Challenges

The SSE Project Schedule has undergone some replanning in the last year. The original plan called for completion of the SDR in mid 1988, but achieving a requirements specification that was satisfactory to the user community and the SSFP took considerably longer than expected Subsequent review points have also slipped. The original approach called for a replacement system at OI 4.0, but under the revised plan, the interim SSE system is gradually being refined and will transition to the new SSE architecture by OI 7.0. Meanwhile, the five SPFs have been installed and are operational at Work Package contractor sites. These contractors have software reviews (PDRs and CDRs) that require support from the SSE, and these are also depicted on the schedule.

STATUS AND CHALLENGES

SSE PROJECT SCHEDULE



SSE Implementation Status

Software Production Facilities (SPFs) are installed at five Work Package contractor sites: Work Package 1 - Boeing, Huntsville, AL; Work Package 2 - McDonnell Douglas, Huntington Beach, CA and IBM, Houston, TX; Work Package 3 - General Electric, King of Prussia, PA; and Work Package 4 - Rocketdyne, Canoga Park, CA. An additional SPF is planned for support at Kennedy Space Center at Harris Corporation, Rockledge, FL.

The SSE Operational Increment (version) 3.1 is installed on the five operational SPFs. OI 3.2 has already been installed at the SSEDF and will be installed in the SPFs beginning in February. The next OI will be OI 4.0, ready for installation in the fall 1990.

SSE IMPLEMENTATION STATUS

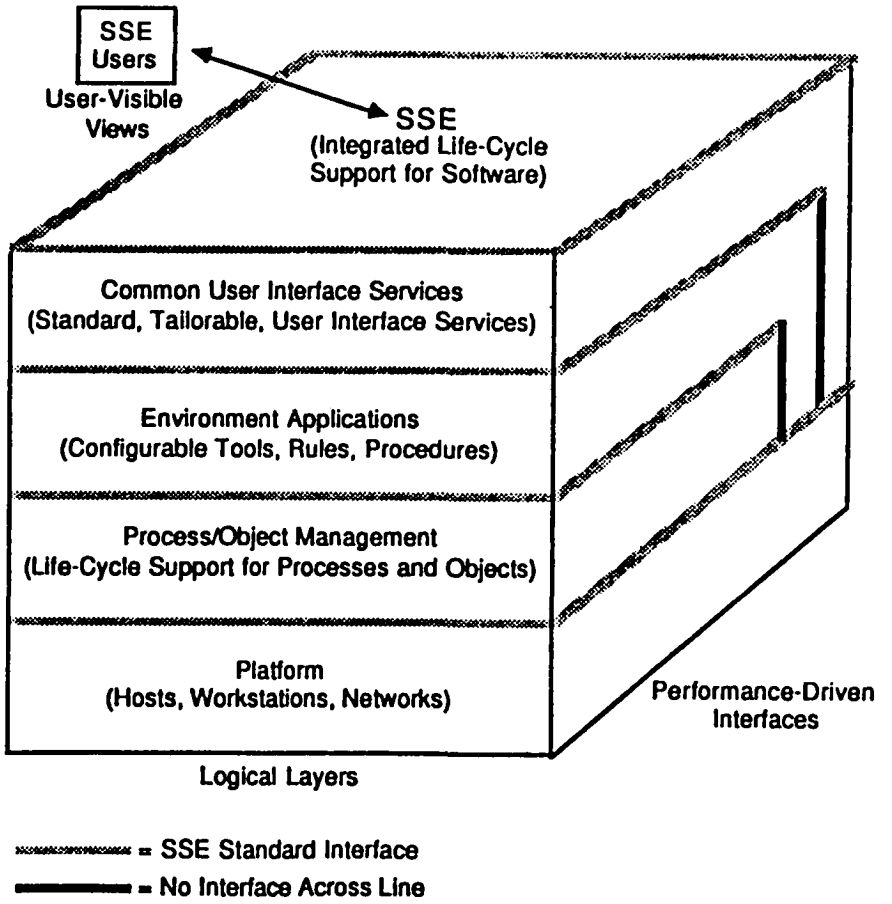
- SOFTWARE PRODUCTION FACILITIES AT 5 SSFP CONTRACTOR SITES.
  - ROCKETDYNE - CANOGA PARK, CA.
  - McDONNELL DOUGLAS - HUNTINGTON BEACH, CA.
  - BOEING - HUNTSVILLE, AL.
  - IBM - HOUSTON, TX.
  - GENERAL ELECTRIC - KING OF PRUSSIA, PA.
- SSE SOFTWARE PRODUCTION FACILITY PLANNED FOR HARRIS CORPORATION, ROCKLEDGE, FL.
- SSE CAPABILITIES IN PLACE.
  - 0I 3.1 IS INSTALLED AT THE 5 SPFs.
  - OI 3.2 INSTALLATION WILL BEGIN AT SPFs IN FEBRUARY 1990.
  - OI 4.0 SCHEDULED FOR FALL 1990.

SSE Architecture

The architecture for the eventual SSE is a layered one, with very well defined interfaces between the layers, so that it can evolve over the 30 year life time of the Space Station Freedom. The Common User Interface layer is the external view the user will have. It will be based on industry standards such as X-windows and OSF/MOTIF. the software tools that support the users are called "environment applications" and these may be commercial off the shelf (COTS) products or specially tailored tools and procedures. Below that layer is the Process/Object Management layer which contains the mechanisms to provide life cycle support for both software development processes and the objects (specs, designs, code, test procedures, test data, etc.). The lowest layer is the host and workstation platform operating systems on which the SSE system must run.

SSE ARCHITECTURE

SSE ARCHITECTURAL MODEL (LONG-TERM)

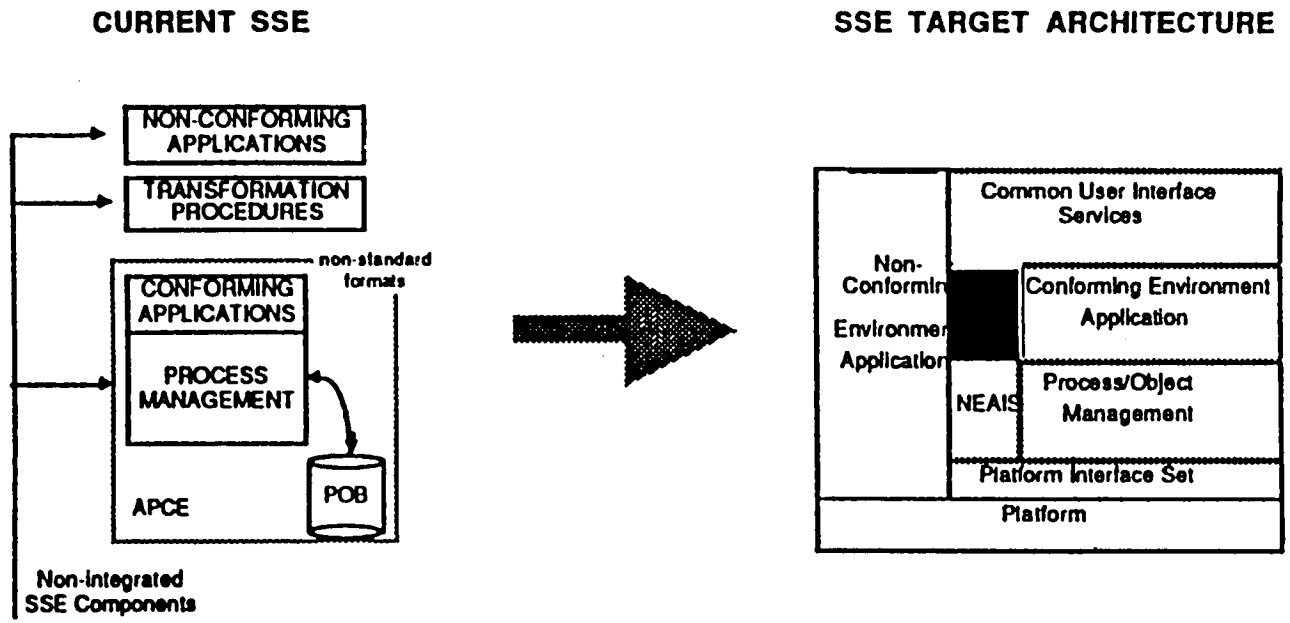


SSE Transition Plan

The SSE Project replan includes a transition phase during which the SSE will evolve from the current collection of proprietary and COTS software to a target architecture which contains the four layers of the final architecture, but also permits "non-conforming environmental applications" which are COTS that require direct user interface and cannot be handled through the common user interface services. The SSE Architectural Design Document (contract document requirements list item number 58) describes the architecture in more detail.

SSE TRANSITION PLAN

SSE SOFTWARE ARCHITECTURE



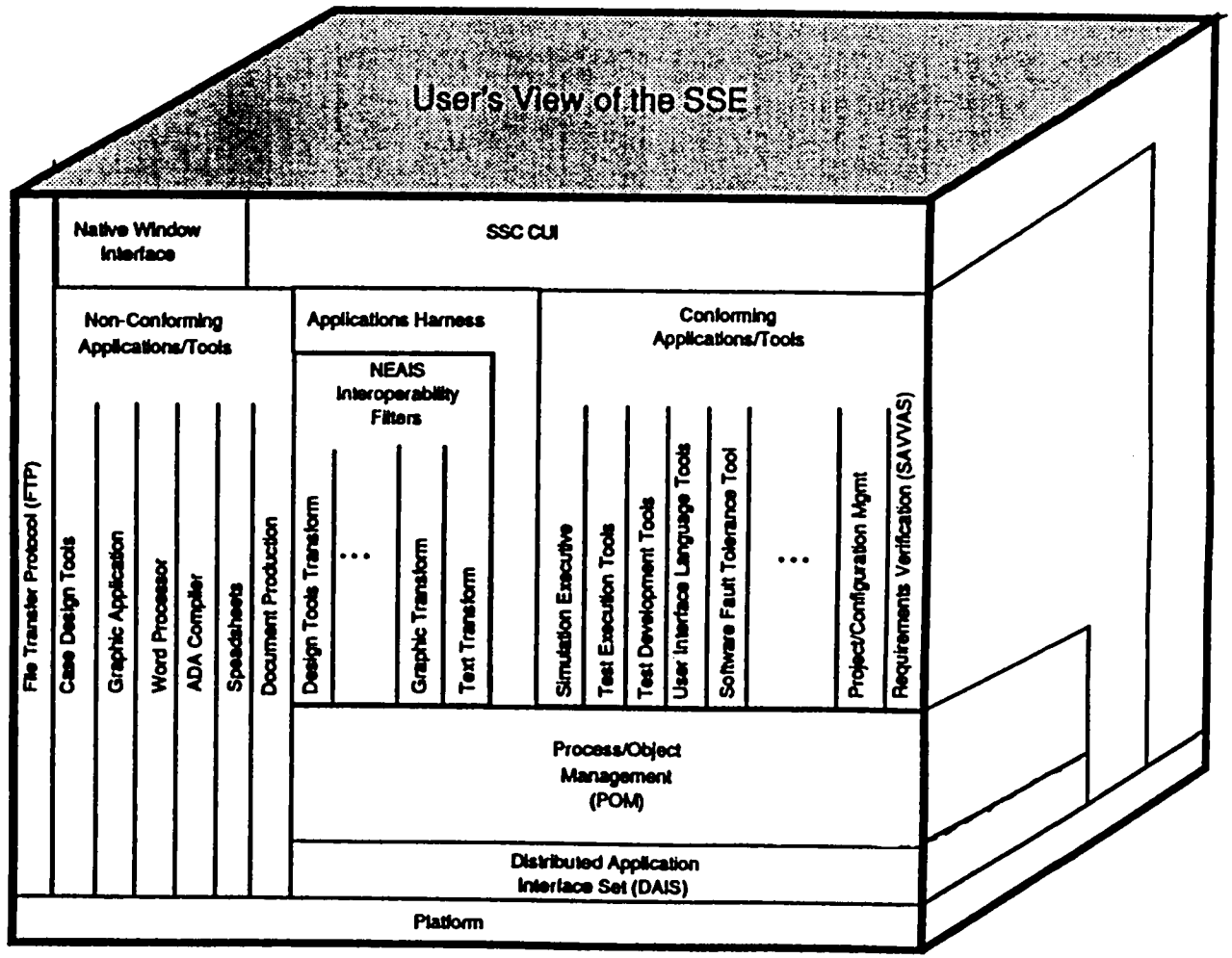
- DURING THE TRANSITION PERIOD SPANNING FROM OI 4 THROUGH OI 6 THE CURRENT SSE WILL EVOLVE FROM A COLLECTION OF PROPRIETARY AND COTS SOFTWARE CAPABILITIES TO THE NEAR TERM GOAL ARCHITECTURE DEFINED IN THE SSE ARCHITECTURAL DESIGN DOCUMENT (DRLI 58)

SSE Transition Plan/Cube Model OI 5.0

This is a detail from the SSE Architectural Design document showing the elements of SSE OI 5.0, with several non-conforming tools, many of which reside on the SSE workstations, and some conforming applications/tools which are being developed specifically by the SSE Project. Major elements of the Process Object Manager will also be complete by OI 5.0.

SSE TRANSITION PLAN

CUBE MODEL OF THE SSE OI 5.0



SSE Functionality

The SSE provides support for software development in Ada. If the SSFP authorizes additional standard languages, the SSE will be expanded to support them as well.

The SSE Ruleset provides the software standards, guidelines, and procedures to support software acquisition, integration, verification and maintenance. It provides support to enforce the software policies and standards established by the SSFP.

The SSE Toolset provides the tools necessary to acquire, integrate and deliver SSFP operational software during all life cycle phases. The tools encompass the following functional areas: SSE process management; software management support; software production; flight software integration, test and verification; data reconfiguration, training, and library (object) management. The SSE also provides services such as delivery and configuration management of the SSE software itself, user support, training, and documentation.

SSE FUNCTIONALITY

- SSE SUPPORTS SOFTWARE DEVELOPED IN ADA.

- SSE RULESET PROVIDES SOFTWARE STANDARDS, GUIDELINES AND PROCEDURES.

- SSE TOOLSET PROVIDES ALL SOFTWARE TOOLS NECESSARY TO ACQUIRE, INTEGRATE AND DELIVER SSFP OPERATIONAL SOFTWARE. SSE TOOLS ENCOMPASS THE FOLLOWING FUNCTIONAL AREAS:

  - SSE PROCESS MANAGEMENT
  - SOFTWARE MANAGEMENT SUPPORT
  - SOFTWARE PRODUCTION
  - FLIGHT SOFTWARE INTEGRATION, TEST AND VERIFICATION
  - DATA RECONFIGURATION
  - TRAINING
  - LIBRARY (OBJECT) MANAGEMENT

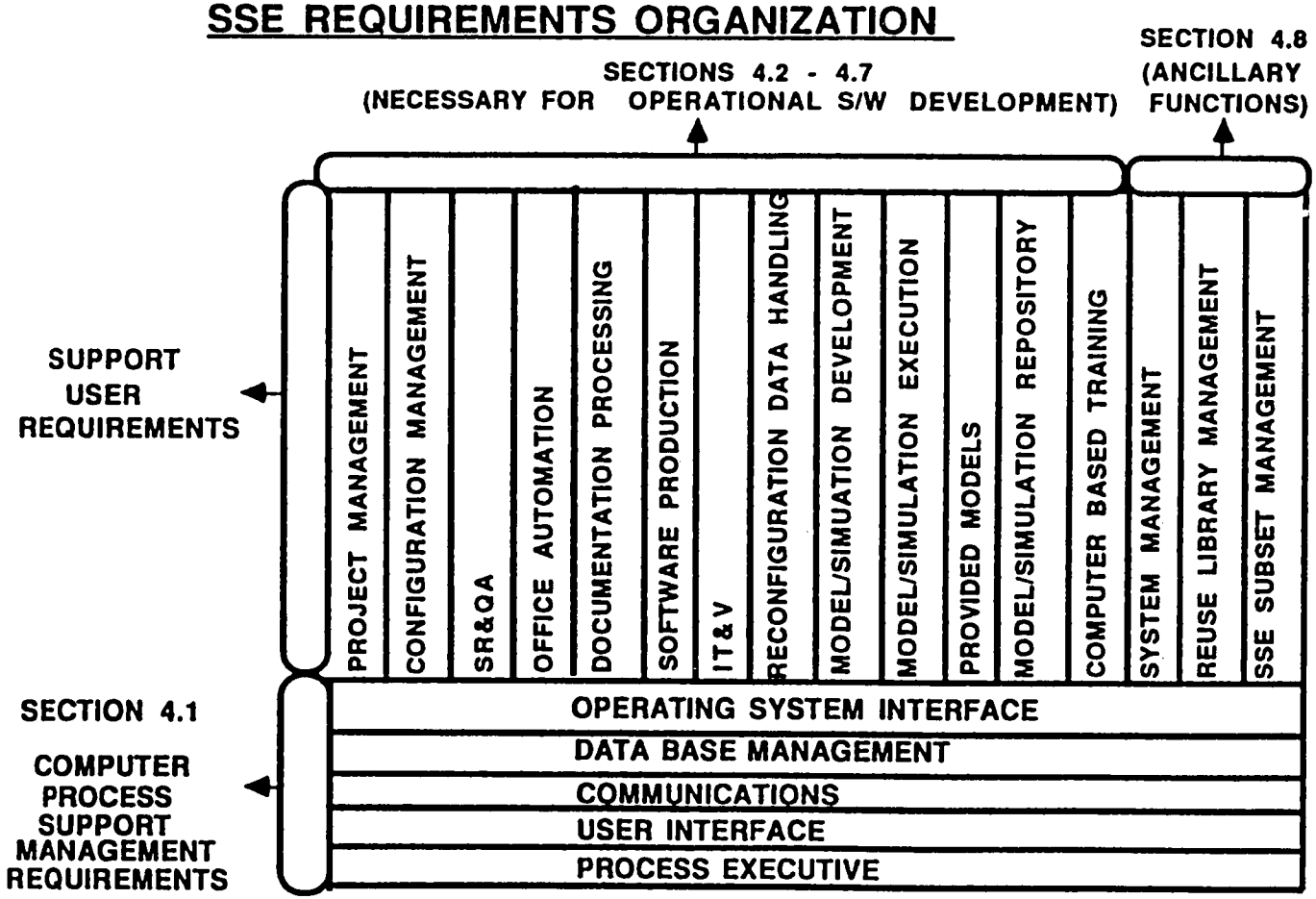
- SSE SERVICES ENABLE SSE USAGE FOR SSFP.

SSE Requirements Specification

The SSE functional and detailed requirements have been documented in the project documents DRLI 16 and 72. This chart indicates the various categories of requirements and how they are organized in the SSE Requirements Specification Document (DRLI 72) Some requirements specifically support user activities and others are computer process support requirements.

SSE REQUIREMENTS SPECIFICATION

SSE REQUIREMENTS ORGANIZATION

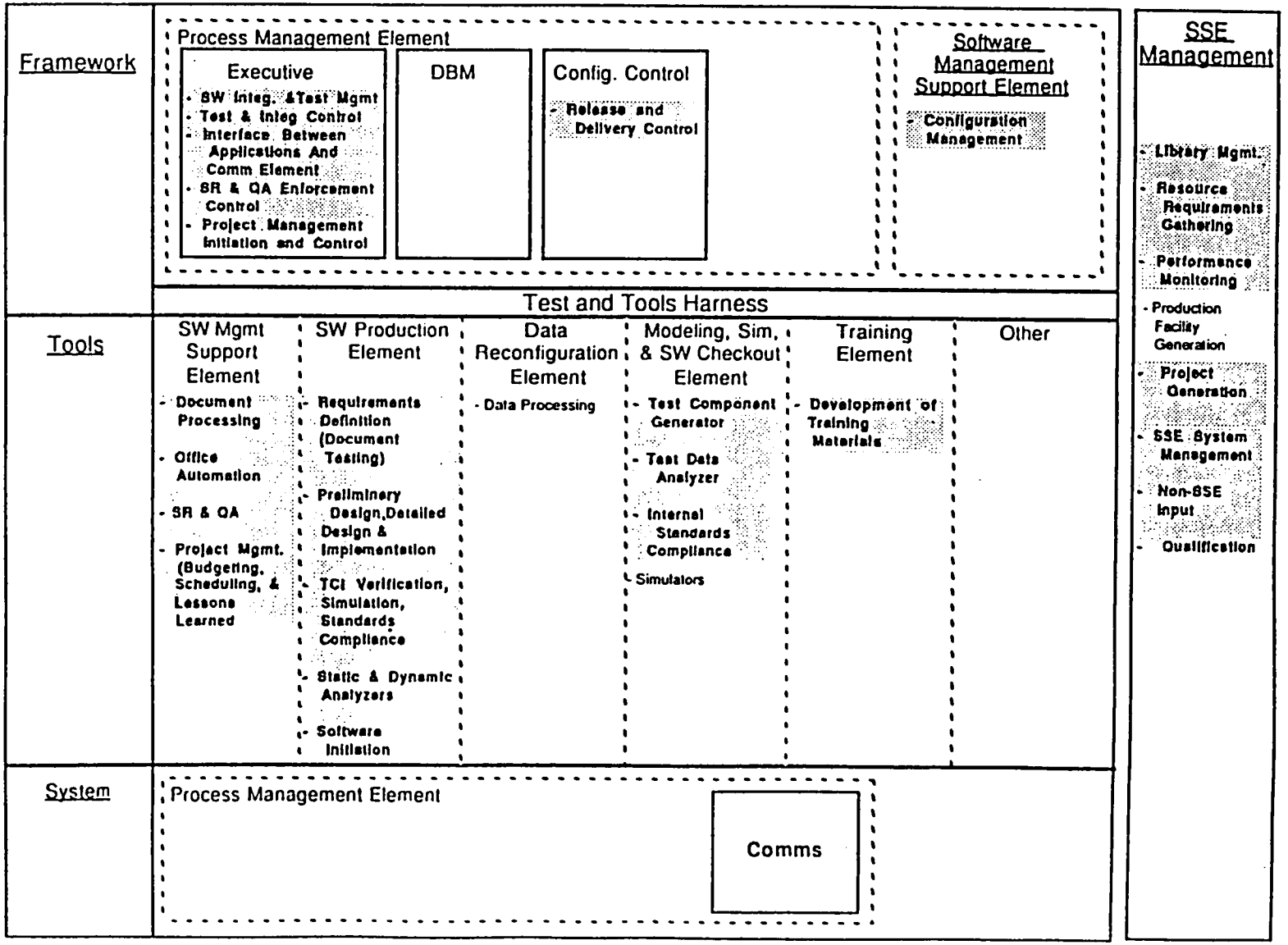


SSE Project Overview/Functional Capabilities

The allocation of the requirements to the SSE architecture is depicted in this diagram which shows various elements in the SSE design and the categories of tools or functional areas contained in each. The SSE architectural design has evolved so that the terms "Framework" and "Test and Tools Harness" have been replaced. The process management element is now part of the Process/Object Management layer, and the tools are called environment applications. The functional capability of the harness is embodied in the interface between the common user interface and the environment applications layers.

SSE PROJECT OVERVIEW

SSE Functional Capabilities



Implications and Future Potential

In the near term, the SSE Project will need to focus its resources on providing support to the most critical needs of the Space Station Freedom development teams. With each OI, the SSE will transition more towards the long term architecture. As the Process Object manager evolves, a more object-oriented approach will be enabled, and the layered architecture will have better defined interfaces. The well-defined interface layers will permit changes within any of the layers without a cascading impact on the entire system.

The primary benefits of the SSE will probably not be evident until the Space Station Freedom is in orbit and the program reaches a sustaining engineering and growth status. Then the disciplined software approach enabled by the SSE will make the continued operation and expansion of the software much more tractable.

The layered architecture of the SSE also provides great potential for migrating new software technologies to the SSE, such as improved requirements analysis tools, expert system design aids, elaborate reuse library support, and formal verification.

IMPLICATIONS AND FUTURE POTENTIAL

- NEAR TERM - SSE PROJECT WILL FOCUS ON SUPPORTING WORK PACKAGE CONTRACTOR DEVELOPMENT EFFORTS

- EVOLUTION TO SSE LAYERED ARCHITECTURE PROVIDES GOOD BASIS FOR CONTINUED GROWTH AND IMPROVEMENT OF SSE CAPABILITIES.

- SUSTAINING ENGINEERING OF SSFP SOFTWARE USING THE SSE RULES AND TOOLS WILL BE MORE TRACTABLE AND COST EFFECTIVE THAN UNDISCIPLINED DEVELOPMENT AND SUPPORT.

- NEW SOFTWARE TECHNOLOGIES CAN MIGRATE TO THE SSE, SUCH AS IMPROVED REQUIREMENTS ANALYSIS TOOLS, EXPERT SYSTEM DESIGN AIDS, ELABORATE REUSE LIBRARY SUPPORT AND FORMAL VERIFICATION.