AFSCN Command and Control Segment Evolution

Larry K. Whipple, COL. USAF
SPACE SYSTEMS DIVISION

Deborah Moorhead and Roger Fong
THE AEROSPACE CORPORATION

Outline

- OVERVIEW OF AFSCN
- EVOLVING THE COMMAND AND CONTROL SEGMENT
- WORKSTATION INITIATIVES
- ADVANCED SATELLITE WORKSTATION - A PROTOTYPE

Air Force Satellite Control Network (AFSCN)

- WORLDWIDE NETWORK PROVIDING DOD SATELLITE CONTROL CAPABILITY
  - SATELLITE TRACKING AND COMMANDING
  - TELEMETRY DATA PROCESSING
  - COMMUNICATIONS
- NETWORK ELEMENTS:
  - CONSOLIDATED SPACE TEST CENTER (CSTC), ONIZUKA AFB, CA
  - CONSOLIDATED SPACE OPERATIONS CENTER (CSOC), FALCON AFB, CO
  - REMOTE TRACKING STATIONS
  - NETWORK ENGINEERING AND SYSTEM DEVELOPMENT
- SPACE SYSTEMS DIVISION RESPONSIBILITIES:
  - RESEARCH AND DEVELOPMENT MISSIONS
  - NETWORK ENGINEERING AND SYSTEM DEVELOPMENT
- AIR FORCE SPACE COMMAND RESPONSIBILITIES:
  - NETWORK MANAGEMENT
  - OPERATIONAL MISSIONS
- AIR FORCE LOGISTICS COMMAND RESPONSIBILITIES:
  - OPERATIONAL SYSTEMS' SUSTAINING ENGINEERING PROGRAM MANAGEMENT (after Program Management Responsibility Transfer)

Space Missions Support

- AFSCN PROVIDES HEALTH/STATUS AND COMMUNICATIONS SUPPORT TO MOST U.S. AND ALLIED SPACE MISSIONS
  - LAUNCH AND EARLY-ORBIT CHECKOUT
  - ANOMALY ANALYSIS
  - EPHEMERIS MANAGEMENT
  - MANAGEMENT OF STORED VEHICLES AND SELECTIVE ACTIVE VEHICLES
  - SATELLITE "STATE-OF-HEALTH" MONITORING
- DEDICATED SYSTEMS EMPHASIZE PAYLOAD ACTIVITIES
  - PAYLOAD CONFIGURATION
  - VEHICLE MONITORING/POSITIONING

Dedicated Systems Activities

- GPS HAS MASTER CONTROL STATION AND WORLDWIDE GROUND ANTENNA COVERAGE
  - PERFORMS ALL PAYLOAD SYNCHRONIZATION COMPUTATIONS/COMMANDING
  - PERFORMS MOST VEHICLE COVERAGE/LOCATION COMPUTATIONS/COMMANDING
- DSP HAS GLOBAL COVERAGE FROM LARGE PROCESSING STATIONS AND MOBILES
  - PERFORMS ALL PAYLOAD DATA REDUCTION
  - PERFORMS RECONFIGURATION AND STATIONKEEPING FOR MOST OPERATIONAL VEHICLES
- DMSP HAS COMPLETE COMMAND AND CONTROL CAPABILITY, BUT LACKS WORLDWIDE COVERAGE
  - PERFORMS SATELLITE DATA PROCESSING, CONTROL, etc.
  - MISSION DATA SENT ELSEWHERE FOR PROCESSING
  - USES "BENT-PIPE" MISSION DATA ROUTING THROUGH AFSCN ANTENNAS

Dedicated Systems Activities

- DSCS HAS FIXED/MOBILE PAYLOAD CONTROL ASSETS
  - SATELLITE CONFIGURATION CONTROL ELEMENTS PERFORM PAYLOAD RECONFIGURATIONS
- SKYNET HAS COMPLETE CAPABILITY FOR ON-ORBIT OPERATIONS AT UNITED KINGDOM CONTROL CENTER
  - AFSCN ONLY PROVIDES BACKUP COVERAGE AFTER LAUNCH
- MILSTAR WILL HAVE FIXED AND MOBILE MISSION ELEMENT CONTROL SYSTEMS

Outline

- OVERVIEW OF AFSCN
- EVOLVING THE COMMAND AND CONTROL SEGMENT
- WORKSTATION INITIATIVES
- ADVANCED SATELLITE WORKSTATION - A PROTOTYPE

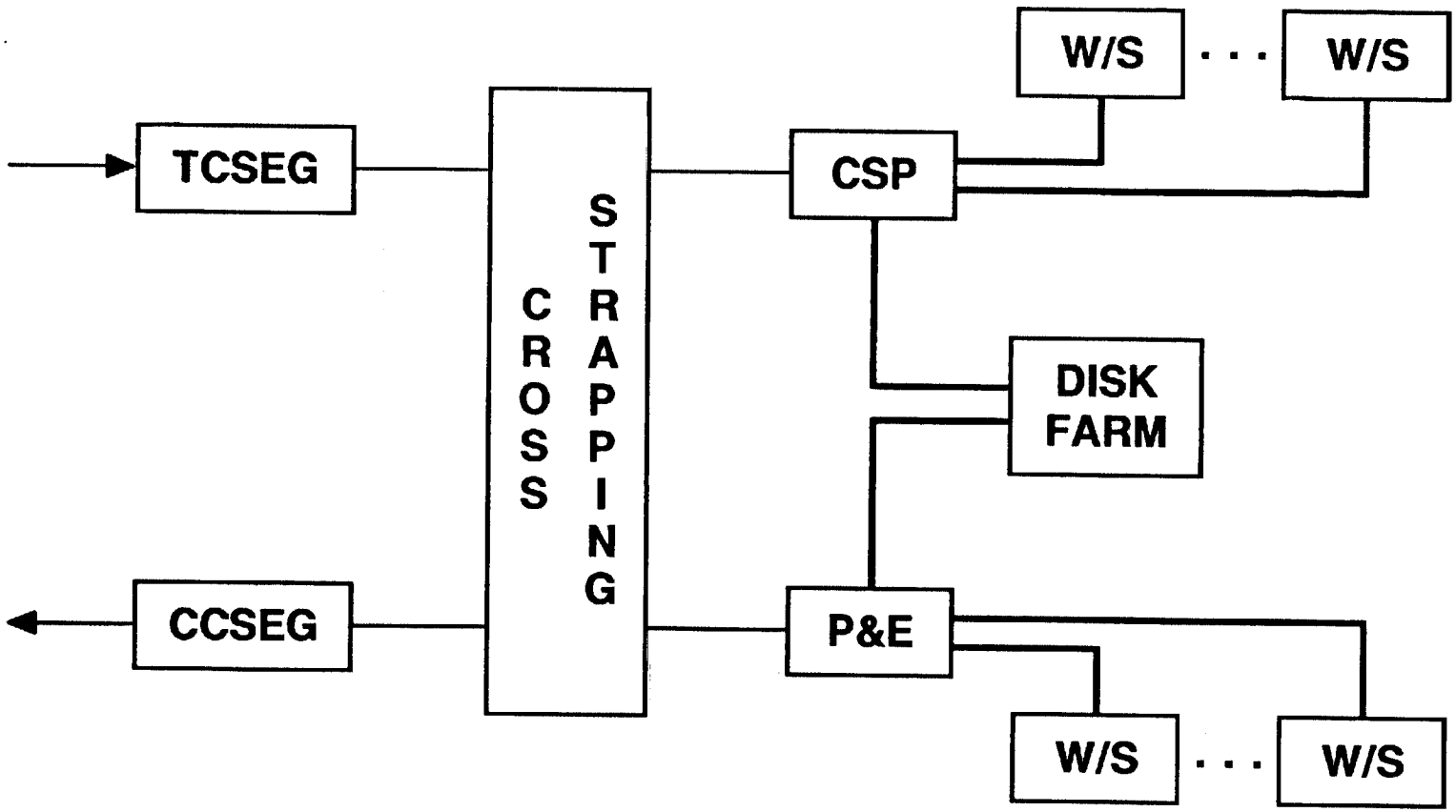
Evolving the CCS

- DRIVEN BY NEW REQUIREMENTS AND PROJECTED AFSCN GROWTH
- SYSTEM MUST REMAIN OPERATIONAL WHILE BEING CHANGED
- PREPARE FOR NORMALIZED SPACE OPERATIONS SUPPORT
- TAKE ADVANTAGE OF TECHNOLOGY ADVANCES
- ENSURE COMPATIBILITY ACROSS NETWORK
- CHOSE OPEN ARCHITECTURE, MULTIVENDOR APPROACH

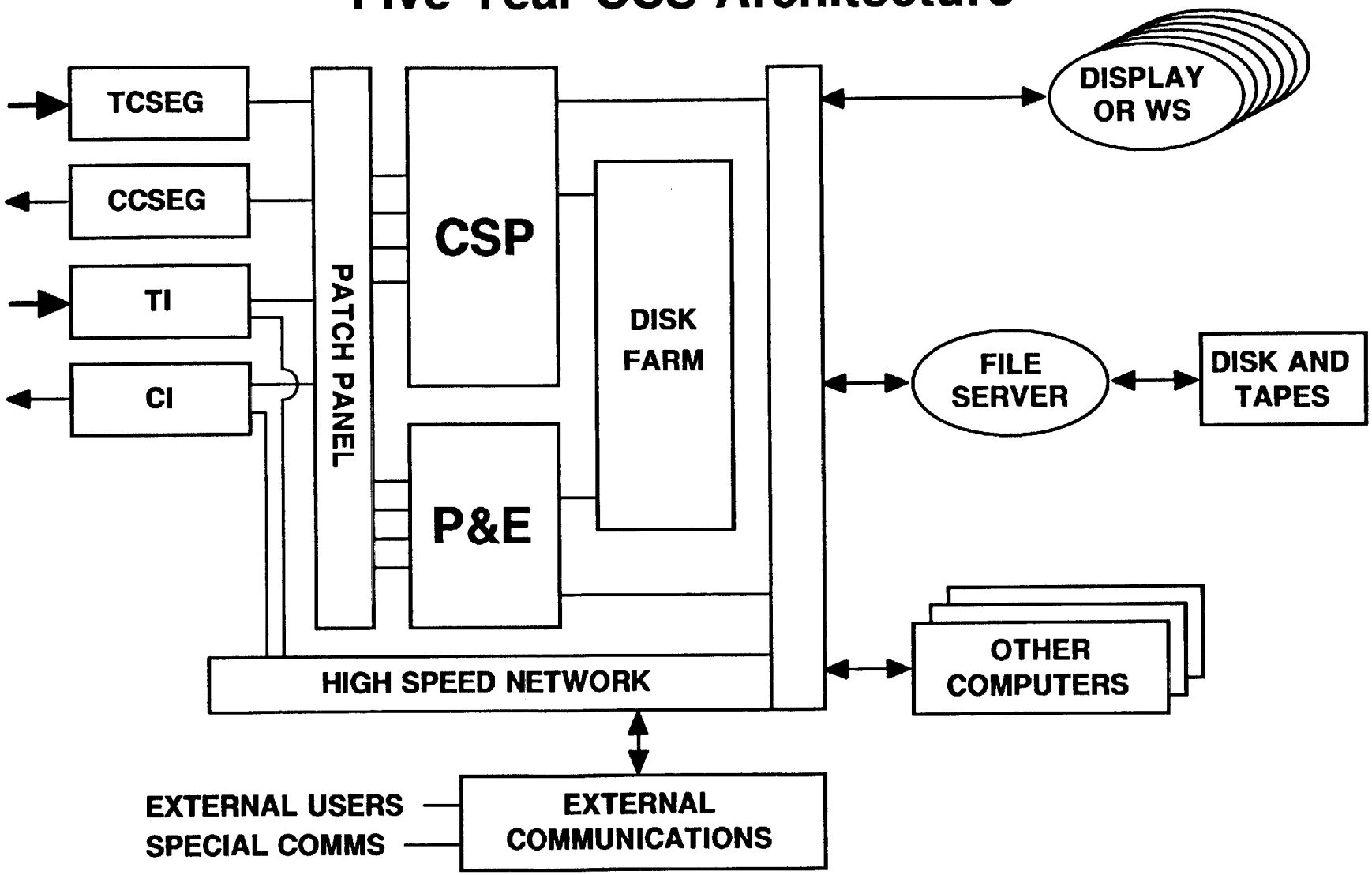
Approach

- IDENTIFY TRANSITIONAL AND FUTURE ARCHITECTURE OBJECTIVES
- PROVIDE FOR EXPECTED REQUIREMENTS AND TECHNOLOGY ADVANCES
- DEVELOP GUIDELINES FOR THE EVOLUTION OF THE CCS ARCHITECTURE
  - USE STANDARDS AND AVOID PROPRIETARY SOLUTIONS
  - ADDRESS CCS TRANSITION ISSUES

Baseline CCS Architecture

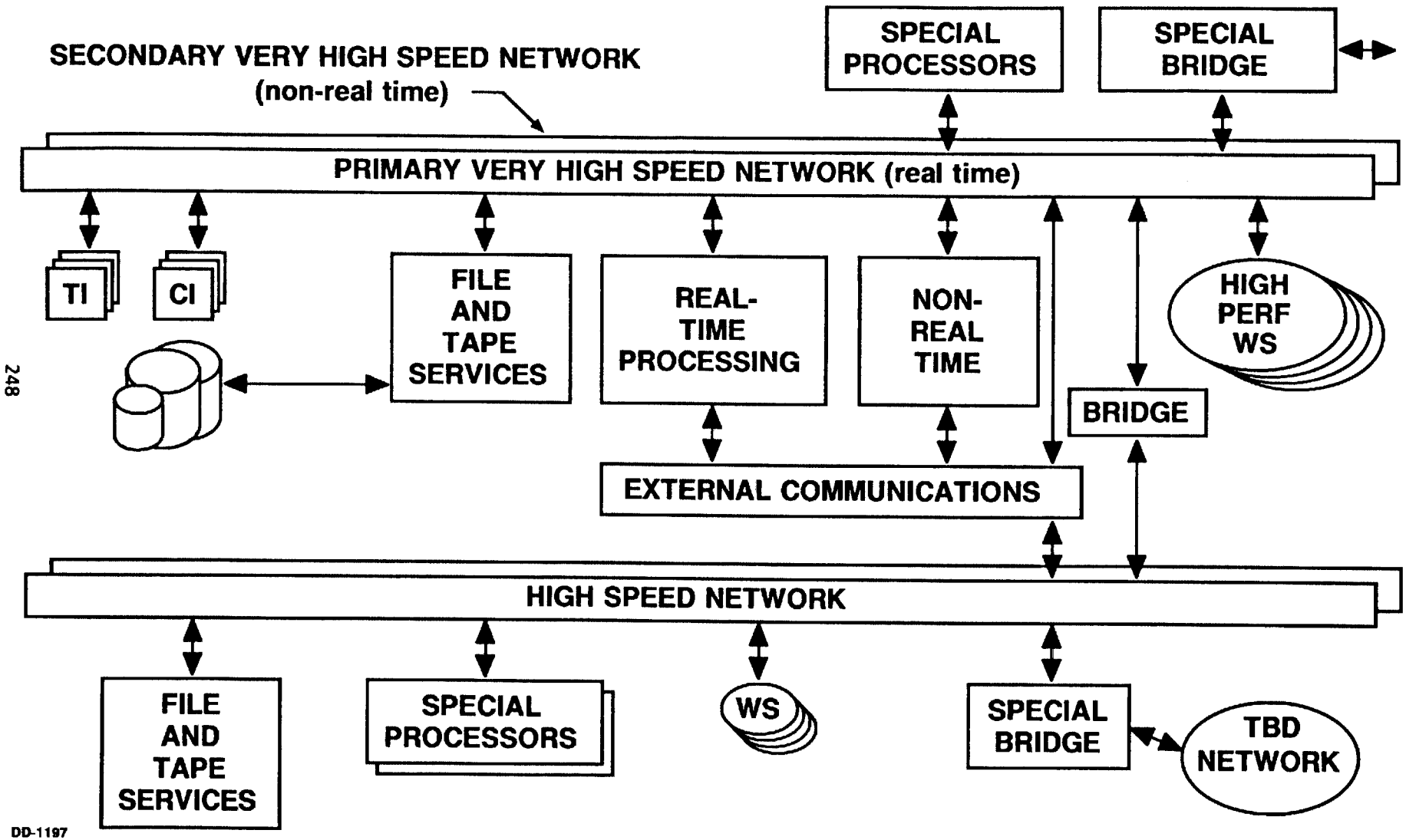


Five-Year CCS Architecture



DD-1196

Ten-Year CCS Architecture

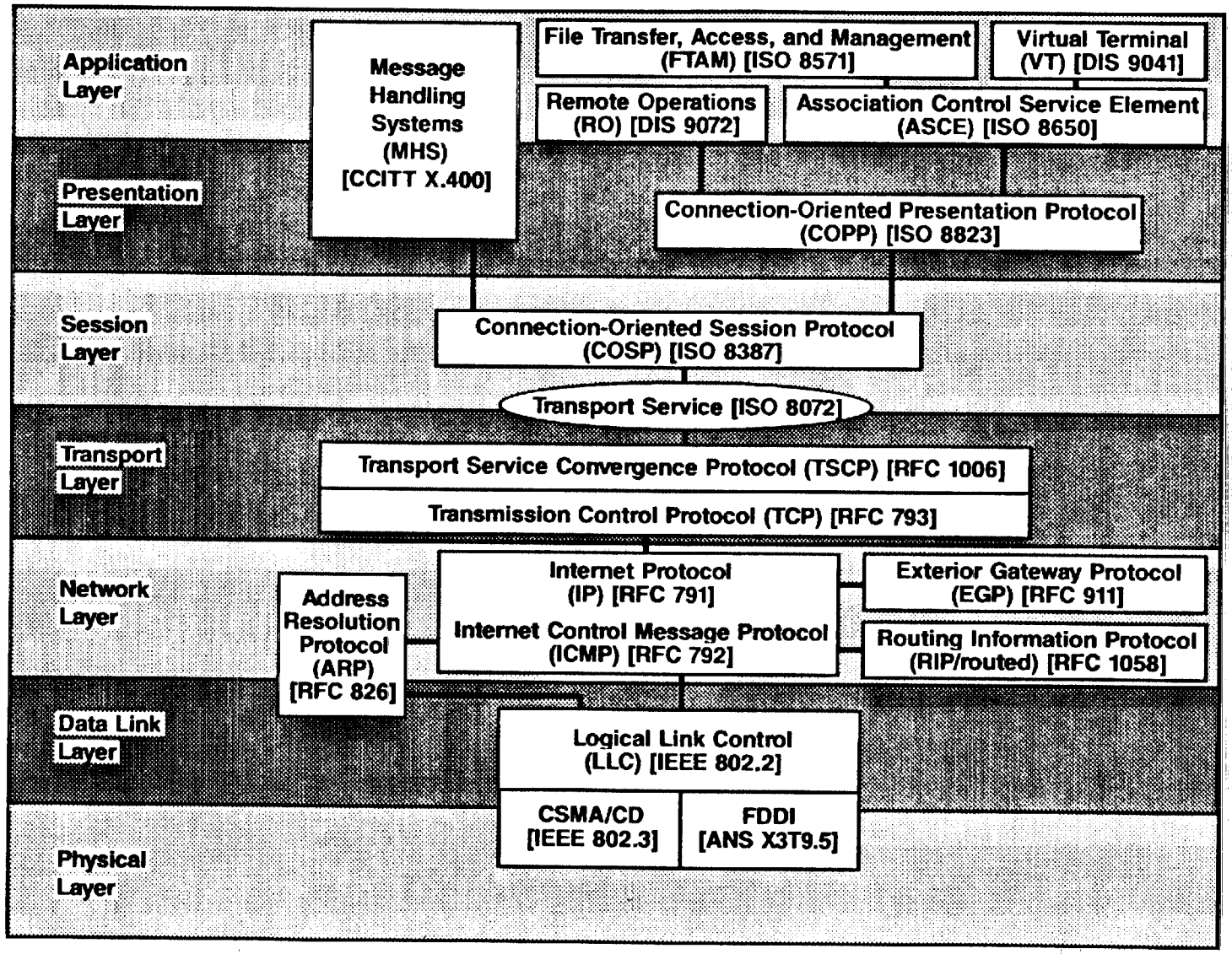


DD-1197

"Guidelines for the Evolution of the CCS Architecture" Recommendations

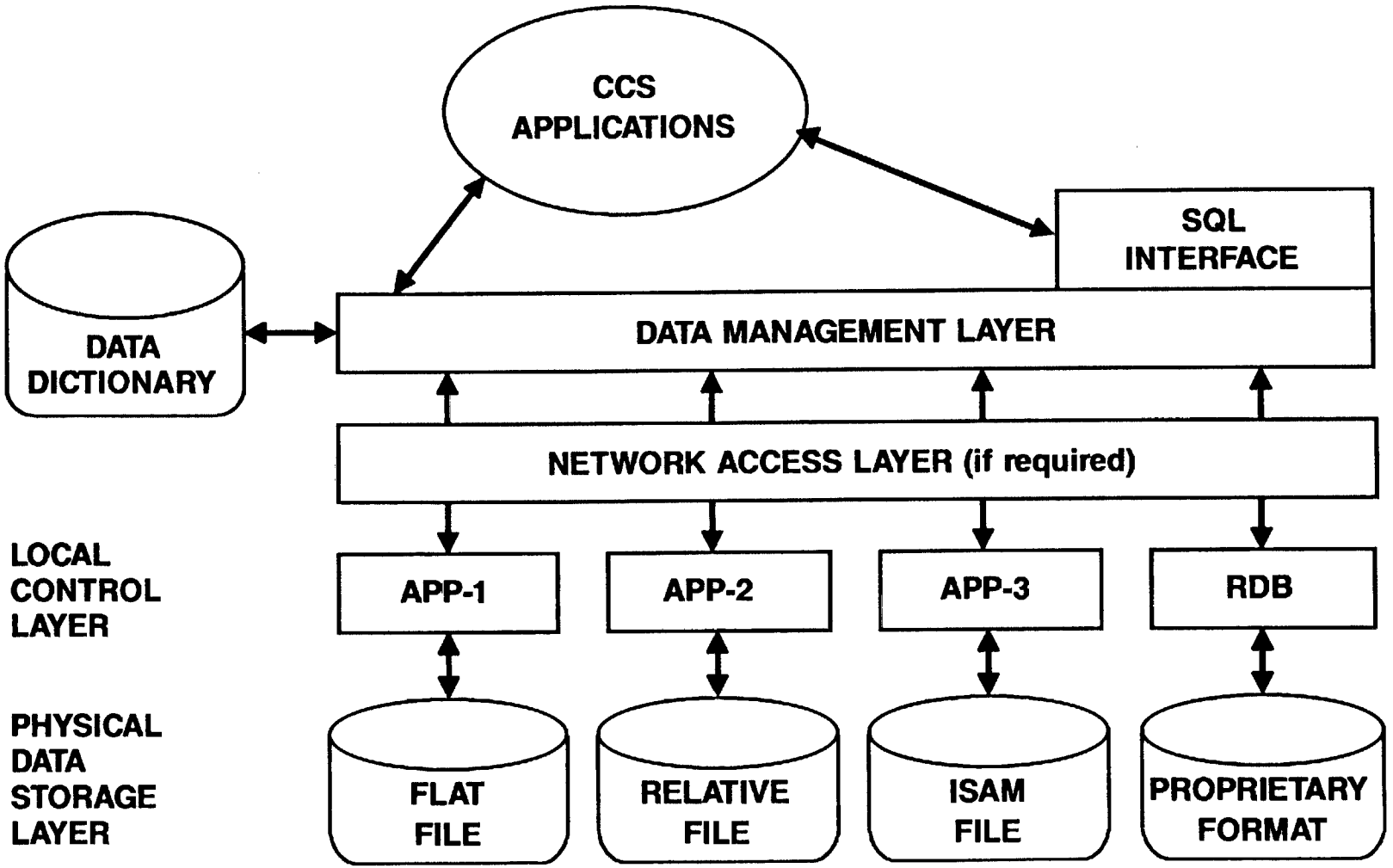
- NETWORKS
  - 5-YEAR: TCP/IP-OSI
  - 10-YEAR: U.S. GOSIP
- OPERATING SYSTEM
  - 5- AND 10-YEAR: POSIX (FIPS-151)
- LANGUAGE
  - 5-YEAR: NEW CODE IN ADA, JOVIAL CODE REMAINS ON CURRENT HOSTS
  - 10-YEAR: ALL MAJOR CCS FUNCTIONS IN ADA
- EQUIPMENT INTERFACES
  - 5-YEAR: SCSI, EISA, VME BUS, MULTIBUS II, VENDOR-SPECIFIC
  - 10-YEAR: FUTUREBUS+, HPPI, VENDOR-SPECIFIC

Transition Phase Protocol Architecture



DD-1194

Recommendations (Cont'd)



A FEDERATED DATABASE ARCHITECTURE

Recommendations (Cont'd)

- WORKSTATIONS
  - BIT-MAPPED DISPLAYS
  - POINTING DEVICE FOR POINT-AND-SELECT INTERACTION
  - 32-BIT MICROPROCESSOR WITH 16-MBYTES MEMORY
  - X-TERMINALS MAY BE COST-EFFECTIVE IN SOME CONFIGURATIONS
  - 5-YEAR: WORKSTATIONS IN ALL AREAS
  - 10-YEAR: FULL COMPLEMENT OF WORKSTATIONS
- USER INTERFACE
  - X-WINDOW SYSTEM
  - MOTIF EMERGING AS INDUSTRY CHOICE
  - 5-YEAR: MOST IMPORTANT FORM FRAMES REPLACED BY WINDOWS
  - 10-YEAR: ALL INTERACTIONS VIA WINDOWS

Recommendations (Cont'd)

- FILE MANAGEMENT
  - COMPUTER GRAPHIC METAFILE (MIL-M-28003, FIPS 128) FOR EXTENSIVE GRAPHIC INFORMATION
  - STANDARD GENERALIZED MARKUP LANGUAGE (MIL-M-28001, ISO 8879) FOR DOCUMENT PREPARATION
  - POSTSCRIPT FOR EXTENSIVE PRINTING OF TEXT AND GRAPHICS
  - FILE DIRECTORIES HAVE HIERARCHICAL STRUCTURE
  - 5-YEAR: TRANSITION TO THESE STANDARDS FOLLOWS THE INTRODUCTION OF WORKSTATIONS, OPERATING SYSTEMS
  - 10-YEAR: COMPLETE TRANSITION EXPECTED

Areas of Other Recommendations

- SECONDARY STORAGE
  - DISKS, TAPE
  - CONSIDER OPTICAL STORAGE IN FUTURE
- COMPUTE ENGINES
  - ASSESS FOR APPLICATION REQUIREMENTS
  - INTERFACES CONSISTENT WITH OTHER GUIDELINES
- "CASE" TOOLS
  - STANDARDIZE COMPUTER-AIDED SOFTWARE ENGINEERING (CASE) TOOL SET
  - HOST ON APPROVED DEVELOPMENT SYSTEMS
  - EASIER APPLICATION TO ADD DEVELOPMENTS
- SECURITY
  - SYSTEM HIGH OPERATION
  - AS TECHNOLOGY AVAILABLE, TRANSITION TO MULTILEVEL SECURITY

Outline

- OVERVIEW OF AFSCN
- EVOLVING THE COMMAND AND CONTROL SEGMENT
- WORKSTATION INITIATIVES
- ADVANCED SATELLITE WORKSTATION - A PROTOTYPE

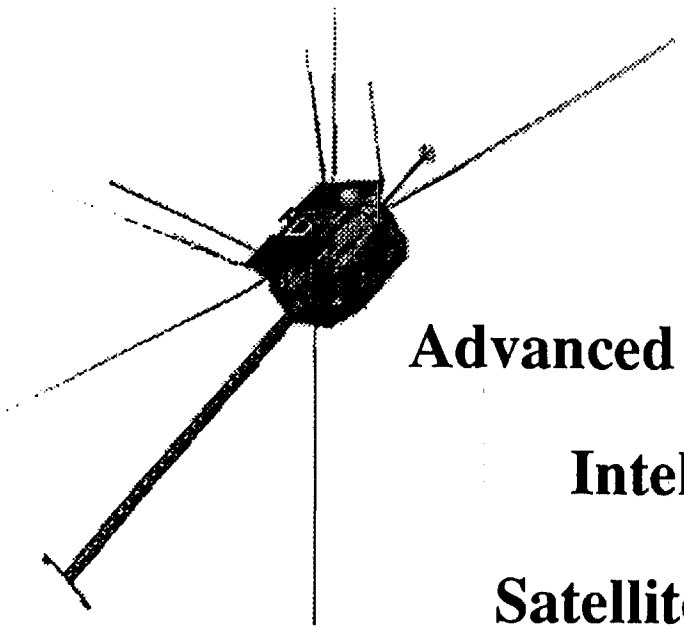
Workstation Initiatives

- REQUIREMENTS GROWING FOR SUPPORT OF MORE COMPLEX AND GREATER NUMBER OF SATELLITES
- INVESTIGATE OPERATIONS FOR POTENTIAL APPLICATIONS OF AUTOMATION
- ASSESS STATE-OF-THE-ART COMPUTER PROCESSING, USER INTERFACES, EXPERT SYSTEMS, AUTOMATED SUPPORT AND ANALYSIS TOOLS
- COORDINATE TECHNICAL STUDIES, PROTOTYPE DEVELOPMENT, AND IMPLEMENTATION OF TECHNOLOGIES AMONG VARIOUS PROGRAMS (e.g., SSD/CW, SSD/SDE, SSD/XR, Phillips Labs)
- ASSURE COMPLIANCE WITH "GUIDELINES FOR THE EVOLUTION OF CCS ARCHITECTURE" AND APPLICABLE STANDARDS

Outline

- OVERVIEW OF AFSCN
- EVOLVING THE COMMAND AND CONTROL SEGMENT
- WORKSTATION INITIATIVES
- ADVANCED SATELLITE WORKSTATION - A PROTOTYPE

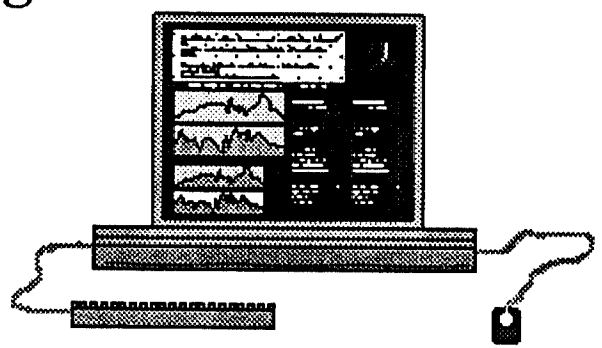
The Aerospace Corporation



Advanced Satellite Workstation (ASW):

Intelligent Decision Support for Satellite Planning and Operations

Roger B. Fong



Background

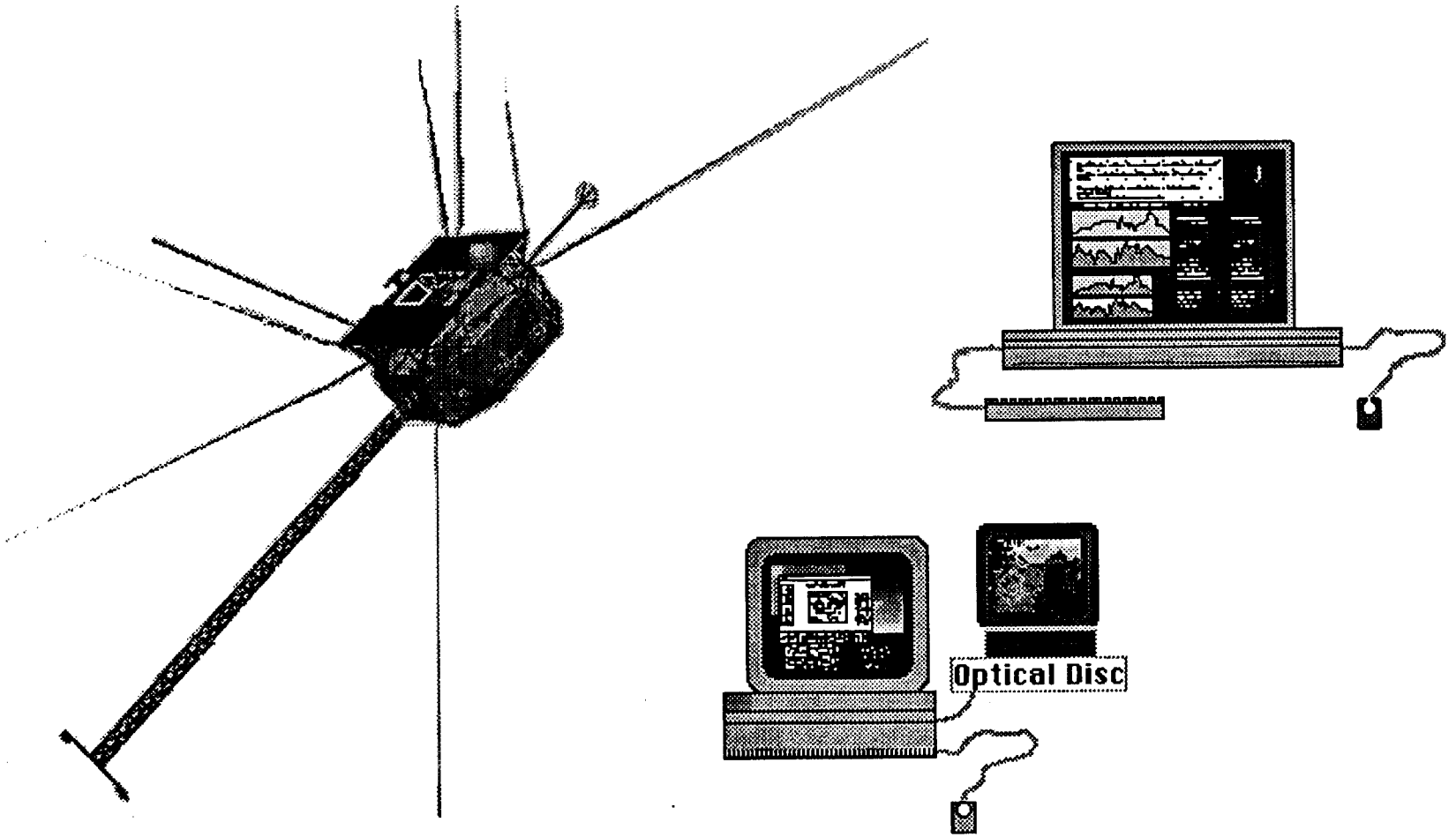
- Satellites are increasing in numbers, complexity
  - Size of constellations
  - Number, sophistication of onboard processors
  - Level of autonomy
  - Data rates
- Normalization of Space
  - Less expertise onsite at ground stations
  - Drive towards more efficient operations
- Emerging information technologies can increase operator/analyst effectiveness

ASW-DSE Purpose & Scope

Demonstration and application of advanced information technologies for satellite support activities.

- **Planning & Scheduling Tools**
- **Expert Systems**
- **Telemetry Processing and Display Systems**
- **Hypermedia and Multimedia Systems**
- **Modeling and Visualization**
- **Artificial Neural Networks and Fuzzy Logic**

Advanced Satellite Workstation Decision Support Environment



ASW History at Aerospace

- **1985:**

  Expert systems for satellite anomaly diagnosis

  (DSCS III)

  - **Symbolics Lisp processors**

- **1986:**

  Satellite Architecture Browser/Expert Systems (GPS)

  - **Symbolics Lisp processors**
  - **Expert systems, graphical telemetry stripcharts, hierarchical satellite schematics**

ASW History at Aerospace

(Continued)

- 1987:

  Hypermedia Information System

  - Macintosh, Laser Disk Player
  - Online Documentation: text, high-resolution satellite photographs, video, engineering schematics, animation

- 1988-90:

  Integrated ASW Architecture (CRRES)

  - Networked Sun/Macintosh
  - Useable, deployed prototype (Consolidated Space Test Center) (operator feedback, lessons learned)

Fundamental Lesson of Early Efforts

A broad-based, integrated decision support environment provides the greatest leverage for operator support

Such an integrated environment should combine expert systems, graphical telemetry displays, planning and modeling tools, and multimedia documentation to provide automated, transparent access to information

ASW/CRRES Prototype Goals

Investigate/Demonstrate value of advanced, workstation based technologies as a basis for future procurement and operational use

- **Assess usefulness, proper role for a number of advanced technologies:**
  - **Planning and scheduling tools**
  - **User-configurable telemetry processing and displays**
  - **Expert systems**
  - **Hypermedia/Multimedia**
  - **(modeling and visualization)**
  - **(heuristic reasoning)**

ASW/CRRES Prototype Goals

(Continued)

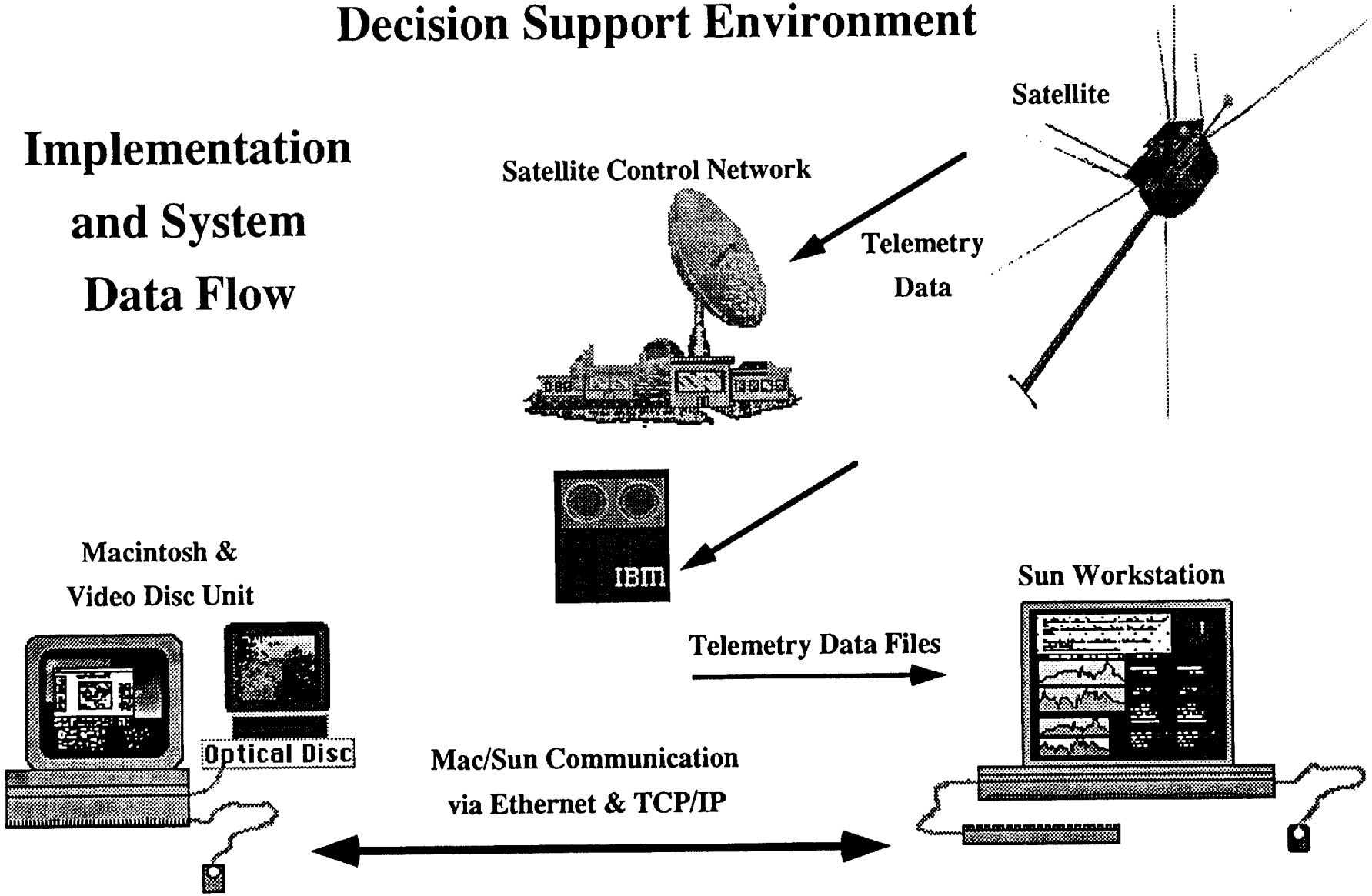
- Design, assess an environment providing full integration of these technologies
  - Expert system control of displays
  - Automatic "cueing" of operator to situation-relevant documentation

- Deployment in ops environment for evaluation, feedback

- Prototype as a basis for requirements definition, cost/schedule planning for future procurements

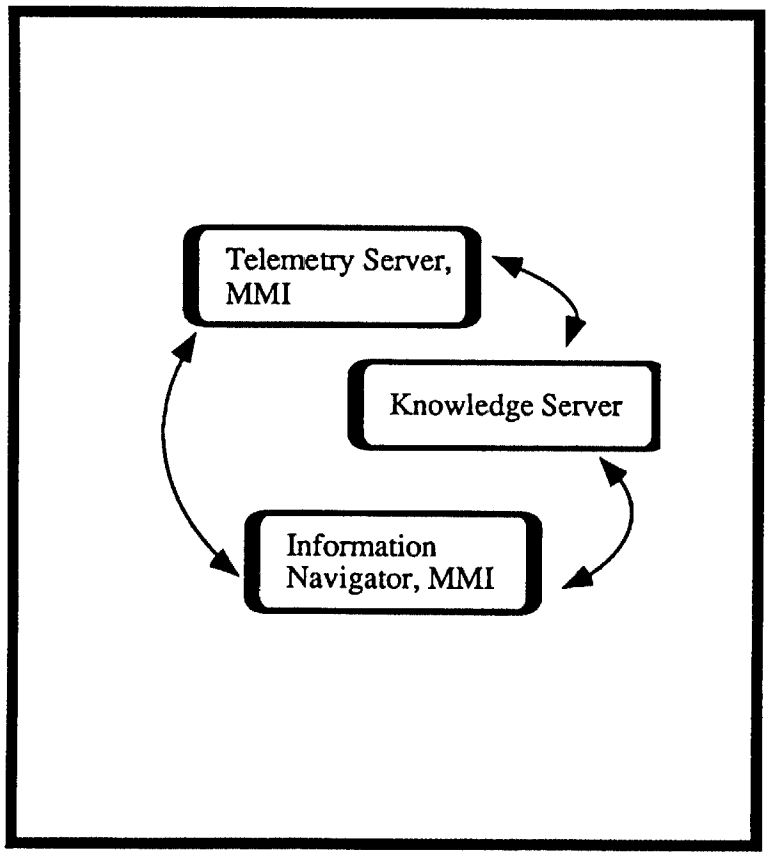
Decision Support Environment

Implementation and System Data Flow

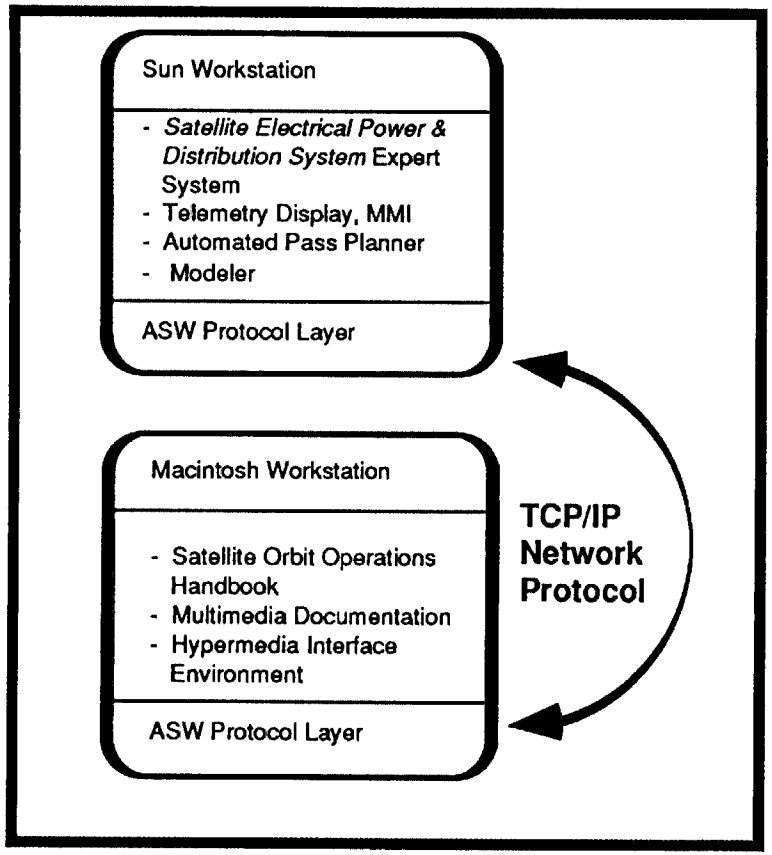


ASW Functional Architecture

Architecture Components

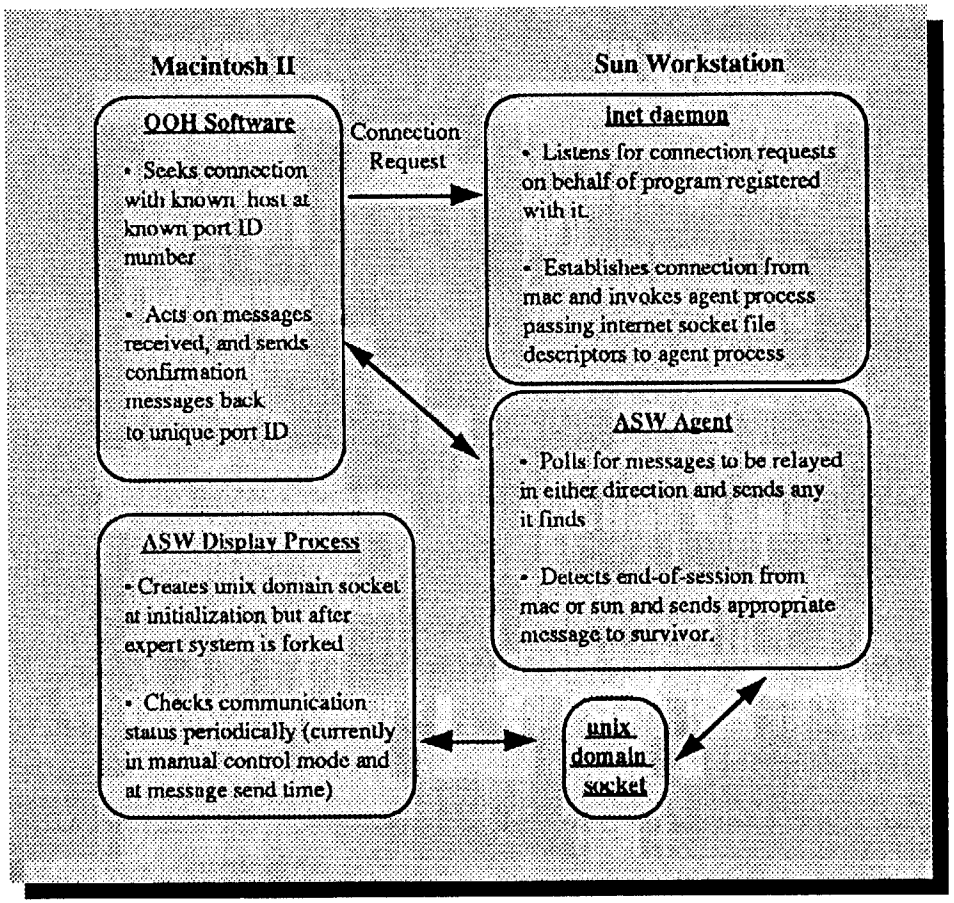


Application Distribution



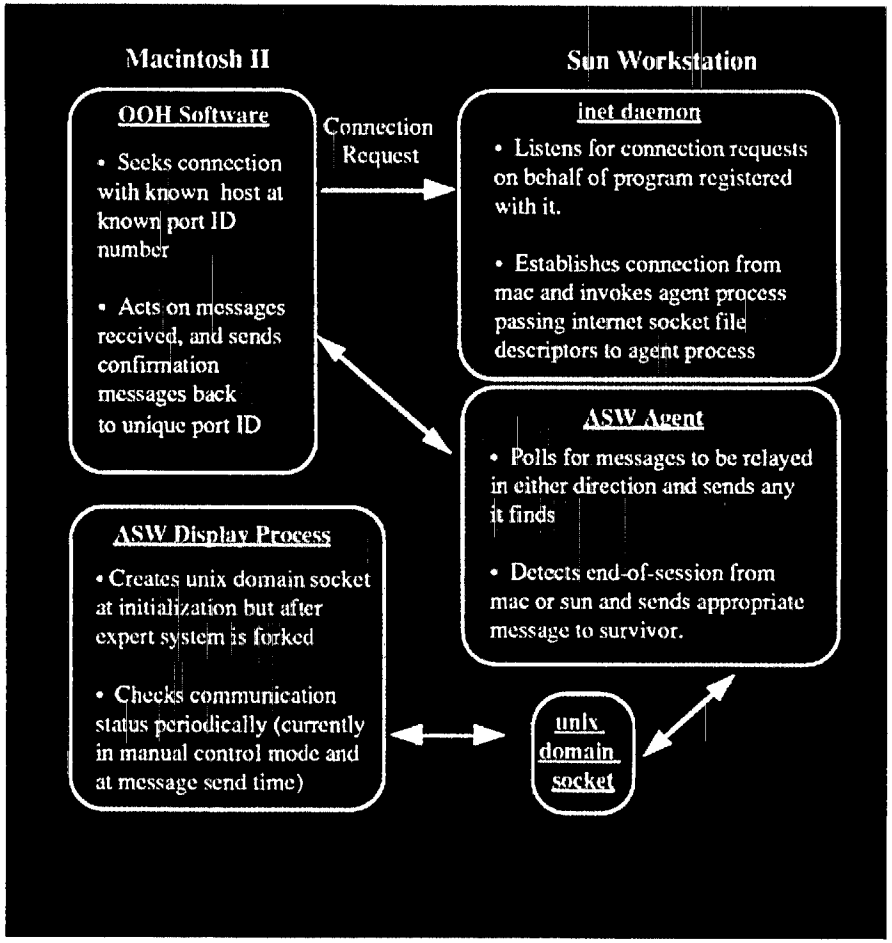
ASW-DSE Communications Architecture

- Object-Oriented Message System
- Built on top of TCP/IP Network Services
- UNIX-Workstation is the Message Manager
- Hypermedia Workstation Controls Video System Peripherals in Response to Messages

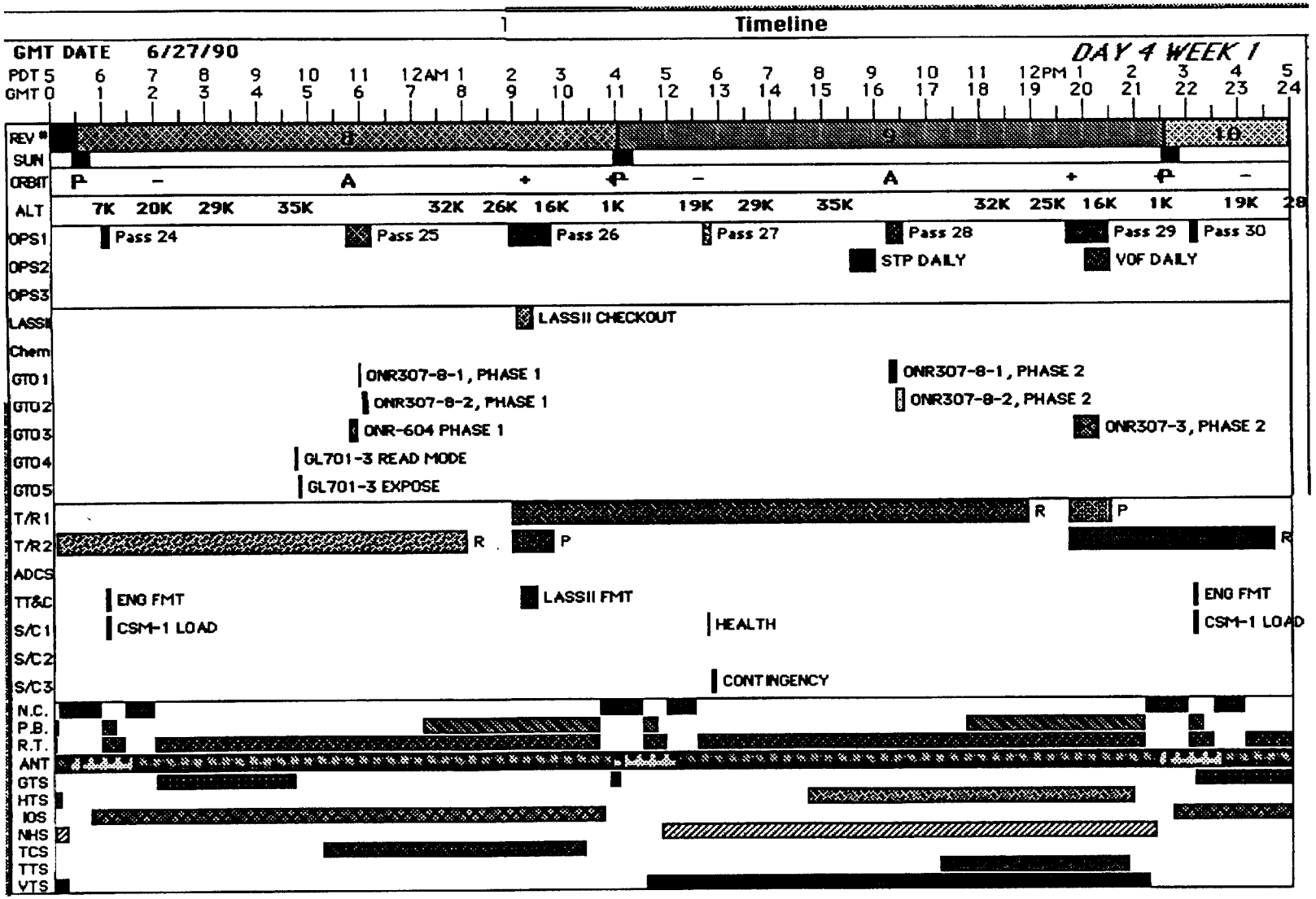


ASW-DSE Communications Architecture

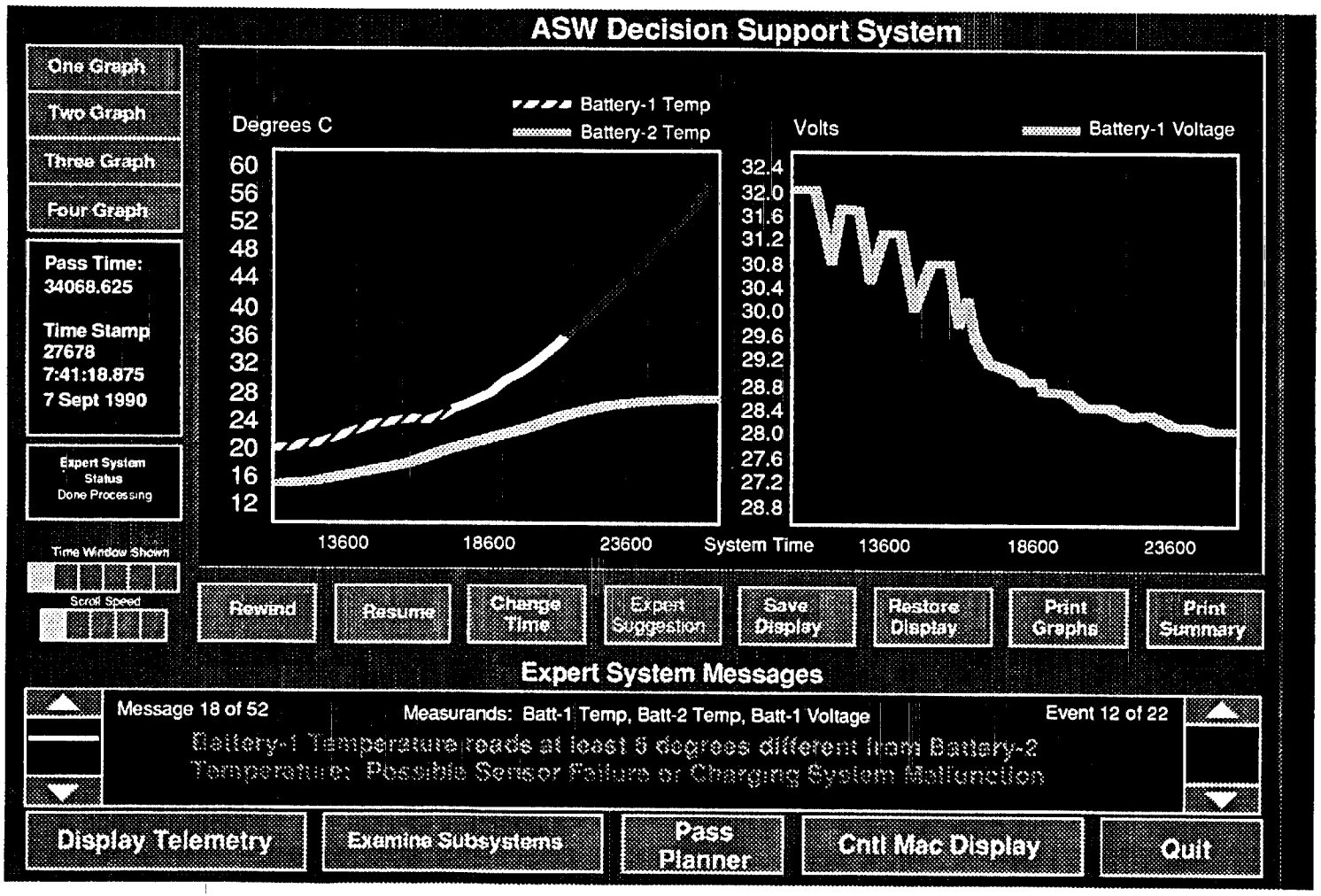
- **Object-Oriented Message System**
- **Built on top of TCP/IP Network Services**
- **UNIX-Workstation is the Message Manager**
- **Hypermedia Workstation Controls Video System Peripherals in Response to Messages**



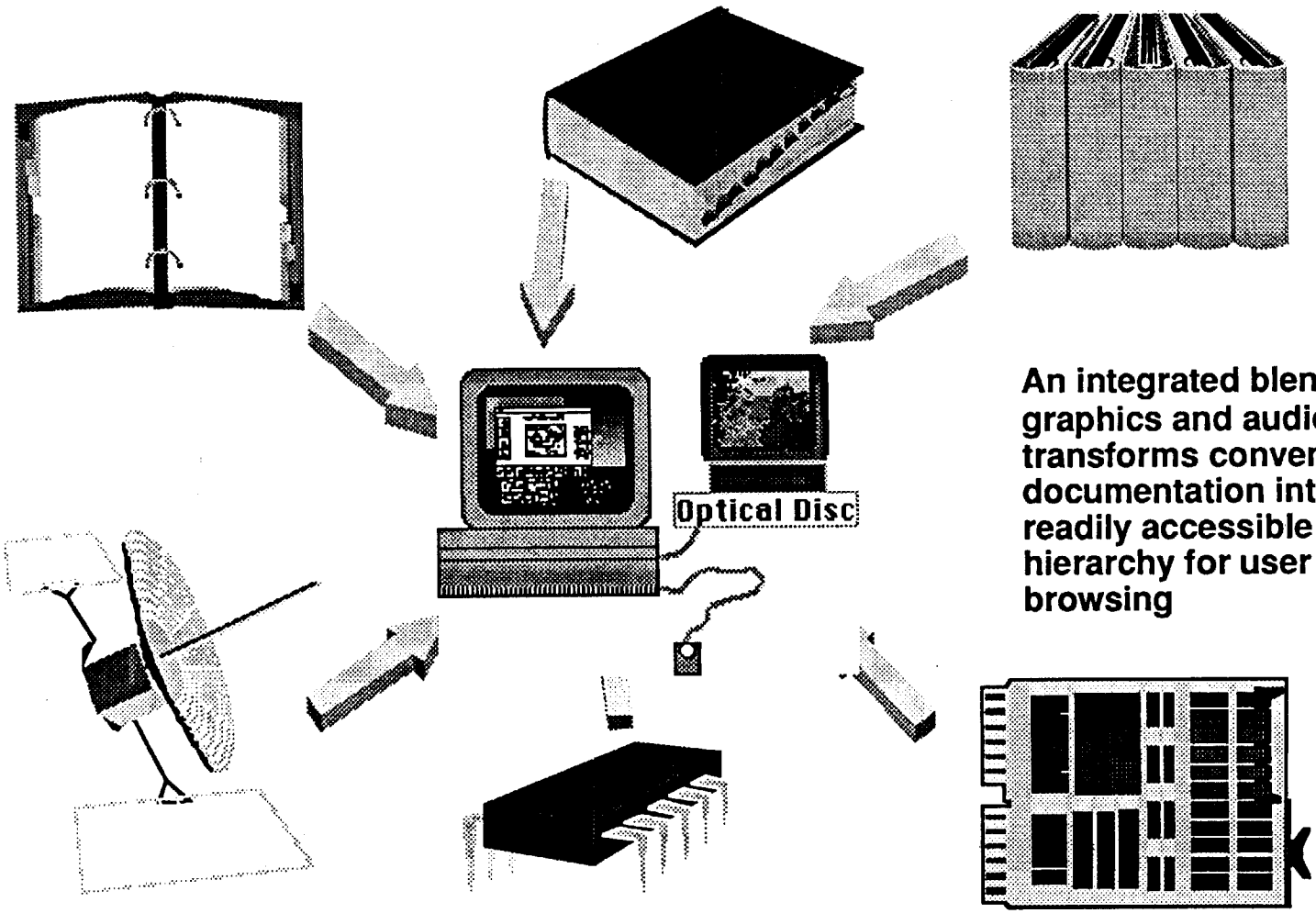
ASW-DSE Timeliner



Advanced Satellite Workstation Telemetry Analysis

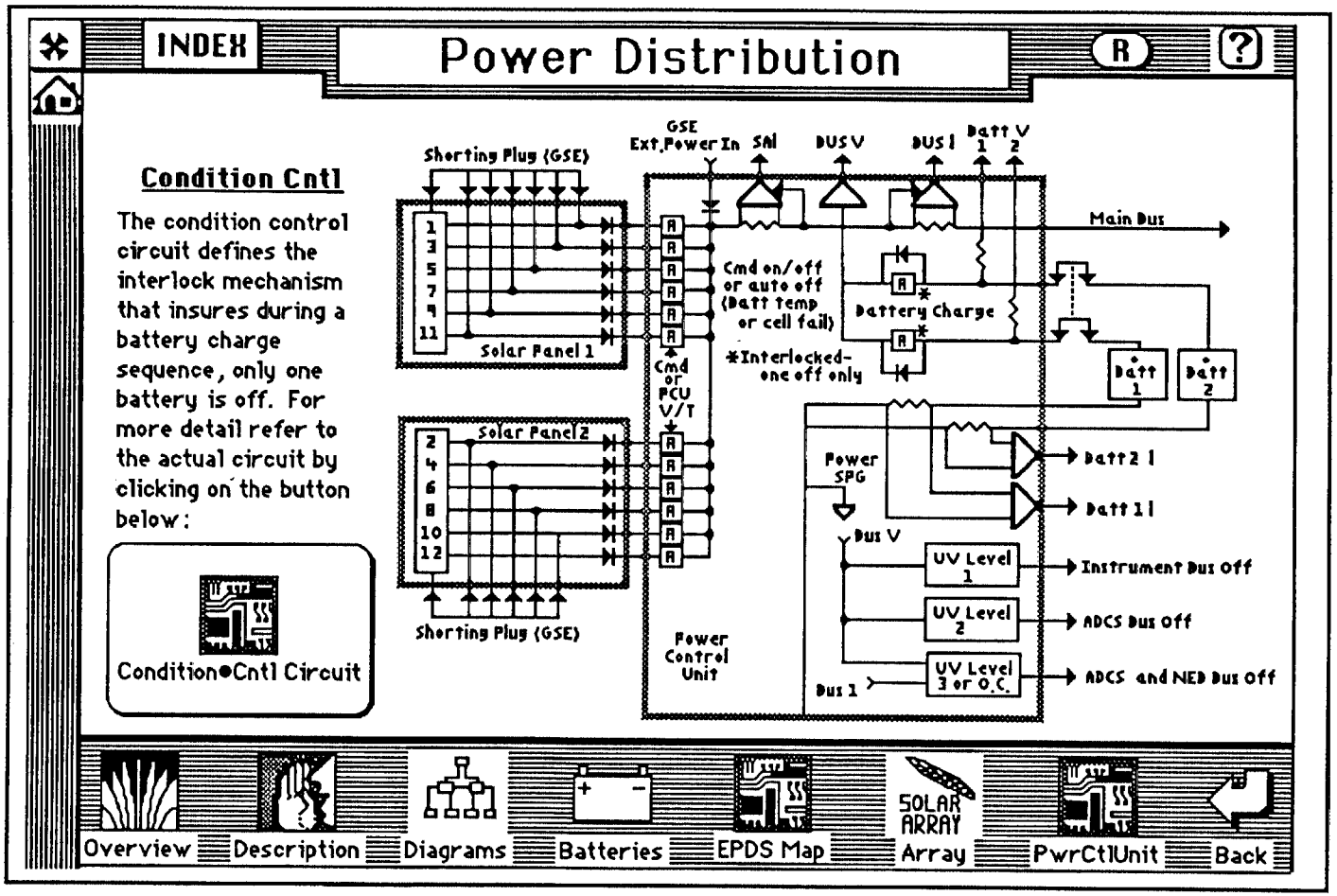


Multimedia Information Systems

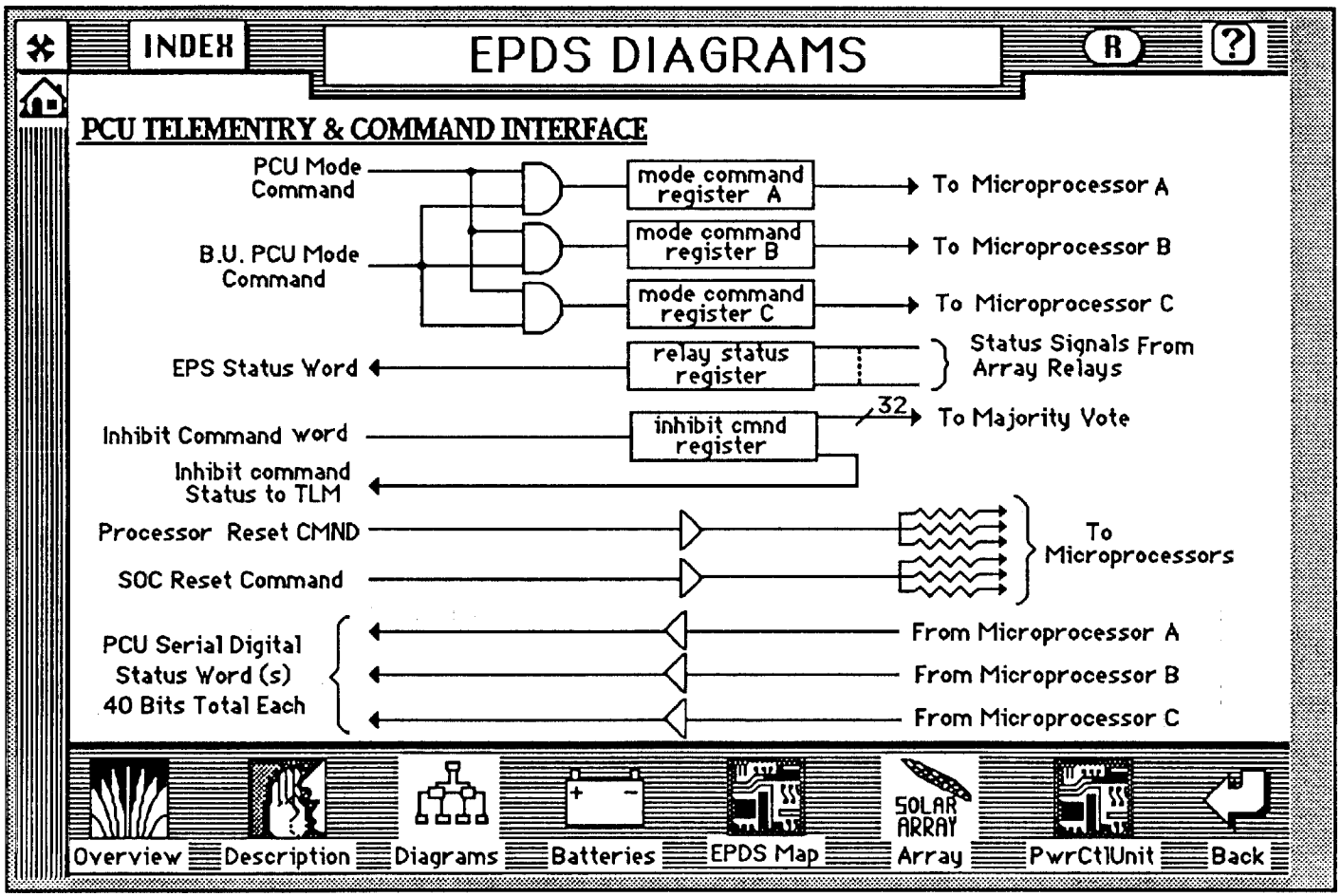


An integrated blend of text graphics and audio that transforms conventional documentation into a readily accessible hierarchy for user browsing

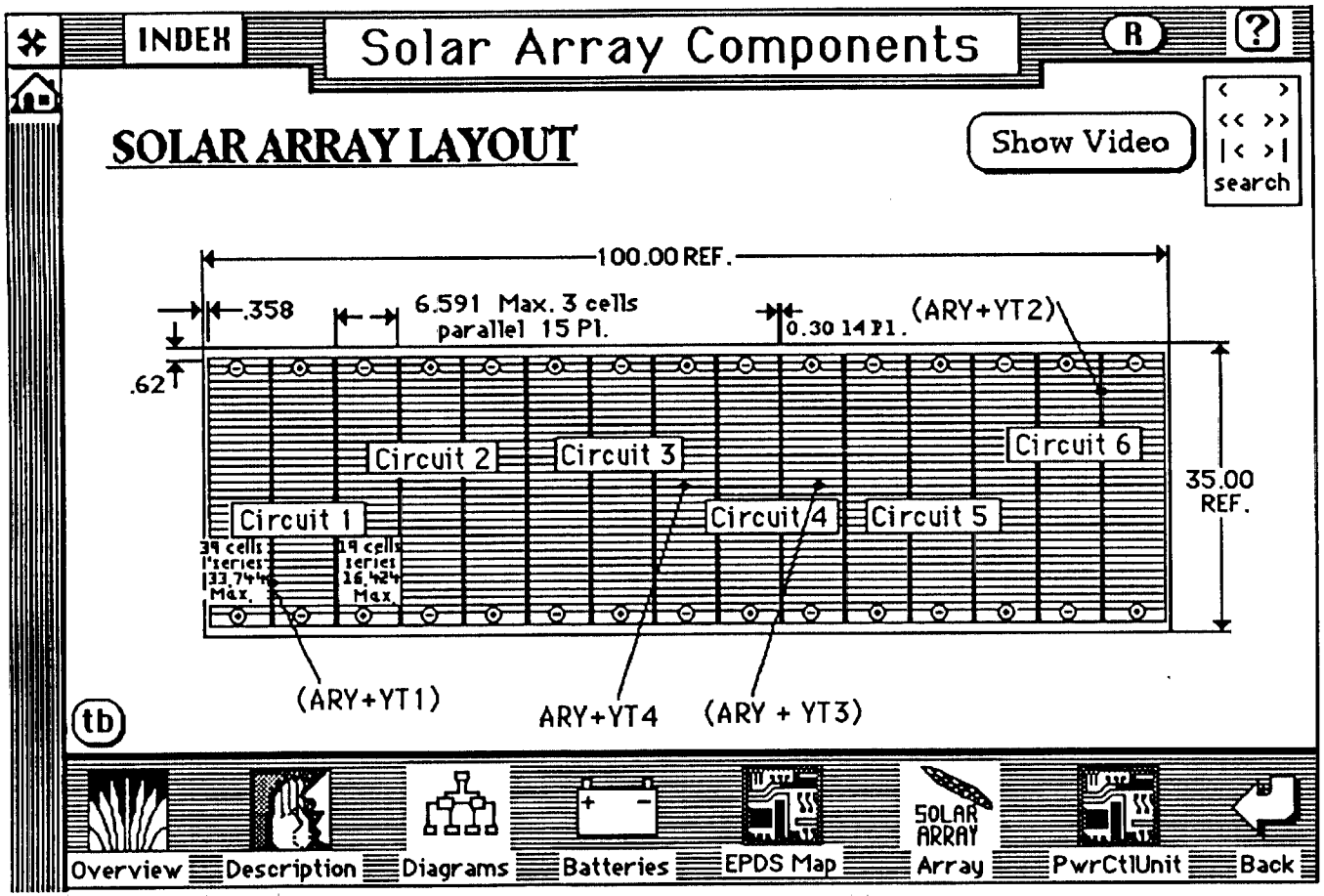
ASW-DSE Hypermedia System User Interface



ASW-DSE Hypermedia System User Interface

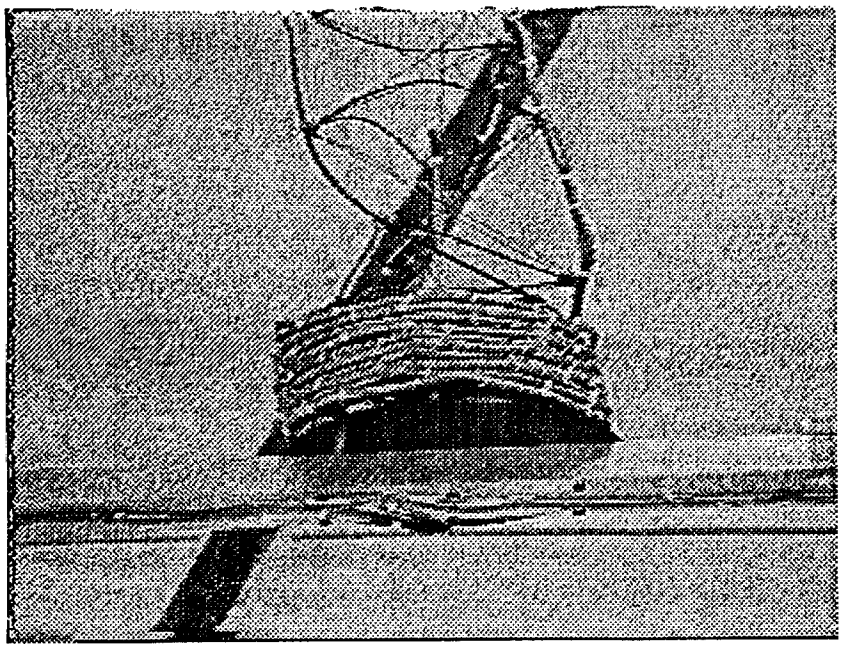


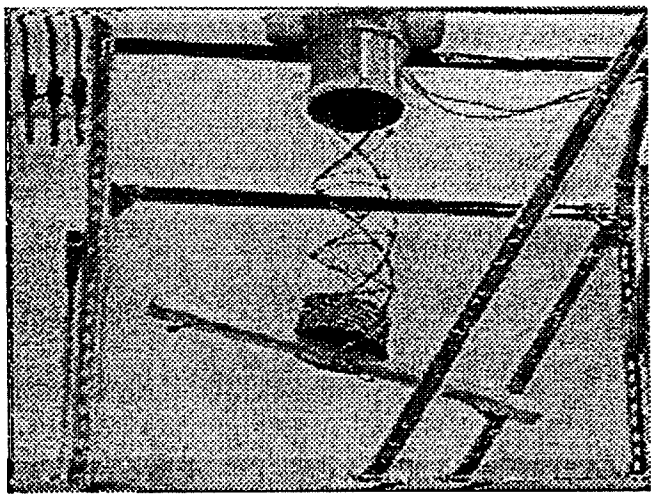
ASW-DSE Hypermedia System User Interface

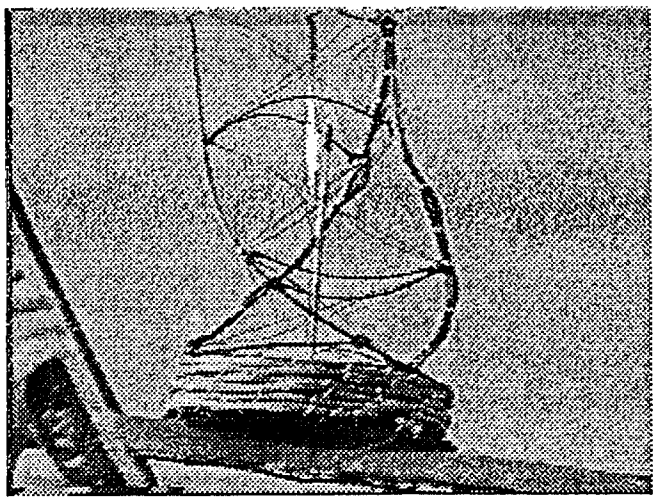


ASW-DSE Hypermedia System User Interface

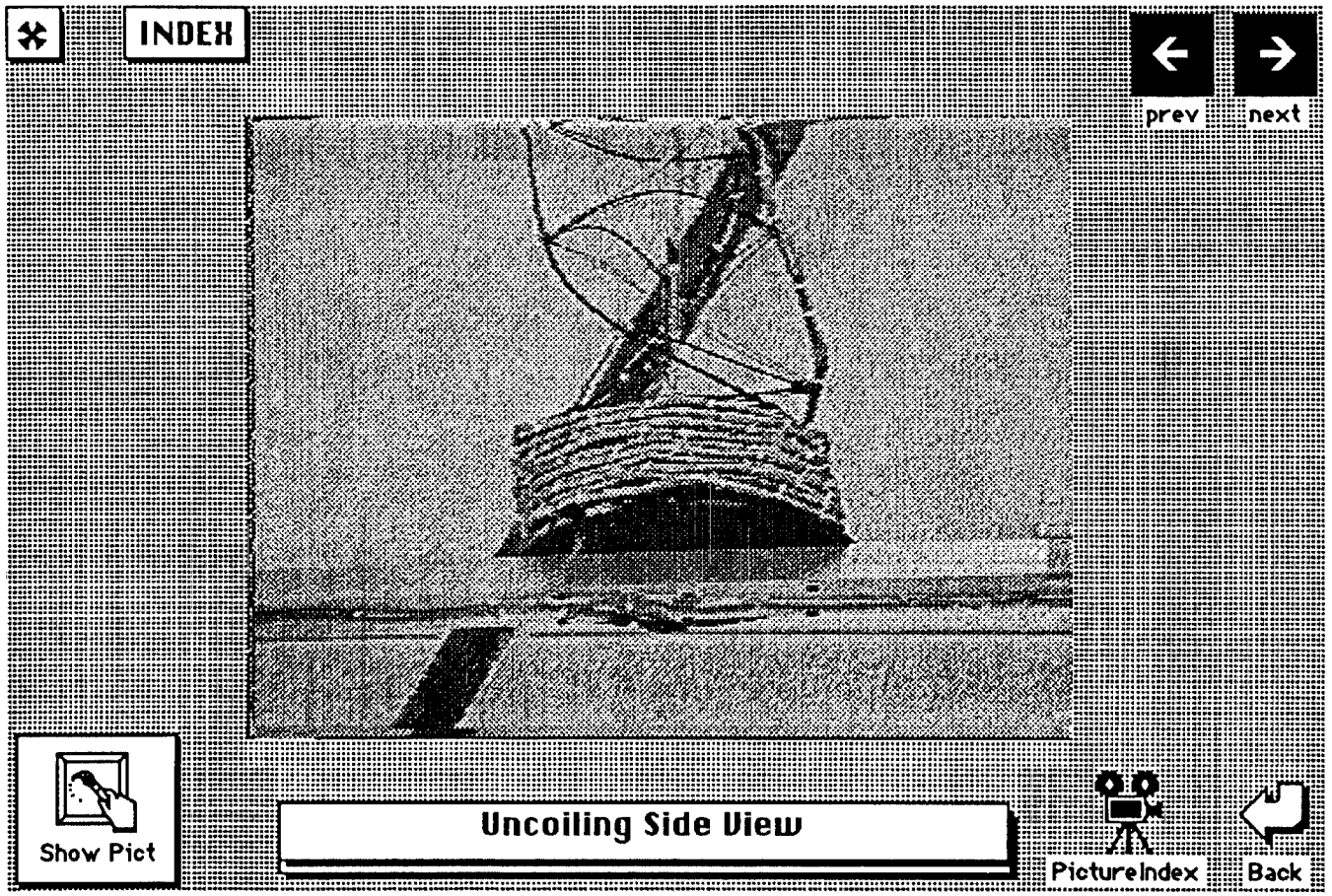
Selected pictures taken from an online video of the magboom deployment sequence







ASW-DSE Hypermedia System User Interface



Current/Future Developments

- Advanced prototype for UHF/Follow-on Satellite
  - Integration of telemetry front-end server
  - Mature prototype based on early lessons, feedback from operators

- New research/development
  - Intelligent information access
  - Data visualization
  - Heuristic and approximate reasoning

Summary

- Prototype development and deployment has been a useful approach
  - Concurrent engineering in practice
  - Many lessons learned
  - Will help to ensure the success of future system evolution

- Advanced workstation technology can provide major operational enhancements if used appropriately
  - Operator feedback is essential
  - Effective decision support is an integration of many technologies

- We are only beginning to tap the potential of rich information environments with sophisticated access techniques, data visualization, and automated reasoning