PRESENTATION 2.4

N91-17032

SYSTEM ENGINEERING AND INTEGRATION (SE&I)

SE & I

SYSTEMS ENGINEERING AND INTEGRATION

ED CHEVERS
JOHNSON SPACE CENTER
SAM HALEY
MARSHALL SPACE FLIGHT CENTER

SE&I

- THE INFRASTRUCTURE REQUIRED FOR A SYSTEMS LEVEL APPROACH TO THE DESIGN OF AVIONIC SYSTEMS

- DEFINES THE TOP LEVEL PROCESSES AND METHODOLOGIES REQUIRED TO SUPPORT THE DESIGN, DEVELOPMENT, TEST, AND INTEGRATION OF AVIONIC HARDWARE AND SOFTWARE SYSTEMS

- INCLUDES THE DEVELOPMENT OF GENERIC TOOLS NECESSARY TO SUPPORT ALL PHASES OF DEVELOPMENT FROM CONCEPT TO FLIGHT CERTIFICATION...i.e. MODELS, CONFIGURATION MANAGEMENT, COST ESTIMATION, REAL-TIME SIMULATIONS, PRE-POST TEST DATA PROCESSING AND ANALYSIS, RISK ANALYSIS, AND QUALITY CONTROL

A CHALLENGE TO THE OTHER PANELS

- THIS SYMPOSIUM ADDRESSES THE ISSUE OF TECHNOLOGY ADVANCEMENT FOR PRESENT AND FUTURE SPACE TRANSPORTATION VEHICLES

- MUCH TO DO IN ALL MEETINGS OF THIS TYPE REGARDING TIME REQUIRED TO DEVELOP TECHNOLOGY AND CONCERN THAT SYSTEMS ARE OBSOLETE WHEN FLOWN

BUT

SO WHAT

- CHALLENGE IS TO DEVELOP SYSTEMS WHICH CAN BE EVOLVED AND IMPROVED IN SMALL INCREMENTAL STEPS WHERE EACH INCREMENT:
    - REDUCES PRESENT COST (INCREASES EFFICIENCY)
    - IMPROVES RELIABILITY/CREW SAFETY (IF THERE IS A PROBLEM)
    - DOES NEITHER OF ABOVE BUT SETS THE STAGE FOR A SECOND INCREMENTAL UPGRADE THAT DOES ACCOMPLISH ONE OF THE ABOVE

A CHALLENGE TO THE OTHER PANELS

- ISSUE

1) MAJOR UPGRADES REQUIRE LOSS OF VEHICLE FOR YEARS

2) MAJOR UPGRADES REQUIRE DUAL OPERATION OF OLD AND NEW TECHNOLOGY UNTIL CONFIDENCE ESTABLISHED

3) COST TO CHANGES IN SE&I INFRASTRUCTURE MAY BE MORE THAN "TRADITIONALLY" RECOGNIZED COST OF TECHNOLOGY UPGRADE

WHAT'S BEING DONE TODAY

- RISK ANALYSIS MANAGEMENT
- TOTAL QUALITY MANAGEMENT
- COST ESTIMATION
- COMPUTER AIDED SOFTWARE ENGINEERING
- HARDWARE/SOFTWARE LIFECYCLE METHODOLOGIES
- SYSTEM TESTABILITY
- RAPID PROTOTYPING
- ADVANCED SOFTWARE INTEGRATION
- ADVANCED TRAINING SYSTEMS
- AVIONIC SYSTEM INTEGRATION FACILITIES

WHAT'S REQUIRED IN THE FUTURE

- INTERFACE STANDARDS FOR COMMERCIAL OFF THE SHELF (COTS) PRODUCTS TO AID IN DEVELOPMENT OF INTEGRATED FACILITIES

- ENHANCED AUTOMATED CODE GENERATION SYSTEMS TIGHTLY COUPLED TO SPECIFICATION AND DESIGN DOCUMENTATION

- MODELING TOOLS THAT SUPPORT DATA FLOW ANALYSIS, RUN IN REAL TIME AND GROW WITH THE DESIGN AS IT EVOLVES

- SHARED PROJECT DATA BASES CONSISTING OF TECHNICAL CHARACTERISTICS, COST INFORMATION, MEASUREMENT PARAMETERS, AND REUSABLE SOFTWARE PROGRAMS

SE&I Topics

- Advanced Avionics Development Strategy – Dave Dyer
- Risk Analysis & Management – Ed Smith
- Total Quality Management – Ken Shipe
- Low Cost Avionics – Whitt Brantley
- Cost Estimation & Benefits – Joe Hamaker
- Computer Aided Software Engineering – Carrie Walker
- Computer Systems & Software Safety – Dr. Charles McCay
- System Testability – Tom Barry
- Advanced Avionics Laboratories – Bud Gates
- Rapid Prototyping Systems – Paul Schoen

Avionics Advanced Development Strategy

- Objective
  - Unified Strategy For Avionics Advanced Development To Meet NASA Transportation Needs

- Leverage
  - Maximum Overall Benefit From Limited Funds For Advanced Development

- Approach
  - Systematic Method To Aid Prioritization And Scheduling Of Various Proposed Avionics Technology Developments

- Issues
  - General Acceptance Of Any Systematic Approach Affecting Distribution Of Limited Funds In A Competitive Environment

Risk Analysis & Management

- Objective
  - Improved Capabilities For Identifying And Quantifying Risks Inherent In Avionics Systems Designs
- Leverage
  - Understanding Where To Apply Limited Funds For Best Overall System Improvement
- Approach
  - Development And Demonstration Of New Analytical Tools For Risk Analysis
- Issues
  - Tool Set Portability And Multi-program Implementations

Total Quality Management

- Objective
  - Application Of Variability Reduction Process To The Development Of Avionics Systems
- Leverage
  - Achievement Of Robust Designs, Capable Manufacturing Processes, High Reliability, And Low Cost.
- Approach
  - Development And Applications Of New Techniques For Simultaneous Engineering, Quality Function Deployment, Parameter Design, And Statistical Process Control.
- Issues

LOW COST AVIONICS

- Objective
  - Strategy For Low Cost, Reliable, Low Maintenance Avionics

- Leverage
  - Lowered User Costs Through Implementation Of Appropriate New Technologies, Production Techniques, And Operations

- Approach
  - Evaluate Innovative Ideas And Recent Experience On NASA/Military/Commercial Space Programs

- Issue
  - How To Test New Ideas And How To Deal With The Necessary Cultural Changes To Implement New Ideas

Cost Estimation Benefits Analysis

- Objective
  - Accurate Cost Analysis Of New Proposed Avionic/Software Systems
- Leverage
  - Enables Timely Program Decisions On Avionics System Design Choices Where Cost Is A Major Discriminator
- Approach
  - Investigate Better Metrics For Translating Cost Drivers Into Costs And Develop Associated Tools
- Issues
  - Updating Database, Metrics, And Tools To Be Accurate For Modern/Advanced Avionics Software Systems

Computer Aided Software Engineering

- Objective
  - New Techniques And Toolsets For Computer Aided Software Engineering
- Leverage
  - Makes Definition Development, Verification And Maintenance Of Software Systems More Productive, Robust, Cost Effective, And Adaptable
- Approach
  - Development And Application Of Artificial Intelligence And Structured Analysis Tools.
- Issues
  -

Computer Systems & Software Safety

- Objective
  - Software Systems That Are Safe And Support Mission And Safety Critical Components
- Leverage
  - Assured Probability That System Will Provide Appropriate Protection Against The Effects Of Faults Which Might Endanger Lives, Health, Property, And Environment
- Approach
  - –
- Issues
  - System Cost And Complexity vs. Degree Of Safety

System Testability

- Objective
  - Guidelines And Techniques To Assure Testability Of Avionics Systems

- Leverage
  - Efficient, Low Cost Test And Checkout Operations And Greater Assurance Of System Health

- Approach
  - Development And Application Of Advanced Test/Checkout And Health Status And Monitoring Technology To Avionics Designs For Testability

- Issues
  - Cost And Complexity Of Testability Features

Advanced Avionics Laboratories

- Objective
  - Modern Multi-use Laboratories As Proving Ground For Advanced Avionics Concepts
- Leverage
  - Timely Demonstration Of New Avionics Technologies And Concepts For Program Acceptability
- Approach
  - Large Reconfigurable Laboratories With Flexibility And Availability For Sharing Between Programs
- Issues
  - Ease Of Reconfigurability To Accommodate Many Diverse And Complex Avionics Systems; And NASA Cultural Changes

RAPID PROTOTYPING SYSTEMS

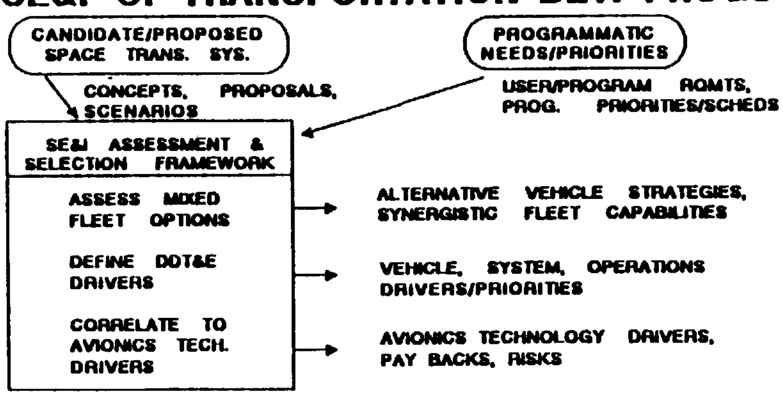
- Objective
  - Rapid Prototyping Tools To Efficiently Integrate Early System And Program Requirements Into Preliminary Designs
- Leverage
  - Provides Early Performance Measures Identifies Resource Bottlenecks, And Supports Trade Studies Of Candidate System Designs
- Approach
  - Develop And Apply Rapid Prototyping Tools To Avionics Preliminary Design And Analysis
- Issue
  - Tool Set Portability And Multi-program Acceptance And Implementation

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING AND INTEGRATION
AVIONICS ADVANCED DEVELOPMENT STRATEGY

NOVEMBER 1989

ADVANCED AVIONICS CONCEPTS

SE&I OF TRANSPORTATION DEV. PROGS



MAJOR OBJECTIVES:

DEVELOP FRAMEWORK FOR ASSESSING AND INTEGRATING AVIONICS ADVANCED TECHNOLOGY DEVELOPMENTS

- PRIORITY AND PHASING OF FUTURE SPACE TRANSPORTATION SYSTEMS
- INTEGRATION ACROSS MULTIPLE PROGRAMS/PROJECTS
- SELECTION/EVALUATION CRITERIA

KEY CONTACTS:

D. DYER/NASA-RESTON
K. COX/JSC

FACILITIES:

MAJOR MILESTONES (1990 - 1995):

O ASSIMILATE RESULTS/STATUS OF VARIOUS SPACE TRANSPORTATION SYSTEM STUDIES (MID TO LATE 90)
- MANNED SPACE TRANSPORTATION
- LUNAR/MARS EXPLORATION INITIATIVE
- CERV, EXT. DURATION ORBITER

O DEVELOP INITIAL FRAMEWORK FOR ASSESSING/PRIORITIZING TECH. NEEDS (MID FY 90)

O APPLY FRAMEWORK (FY 91)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING AND INTEGRATION
AVIONICS ADVANCED DEVELOPMENT STRATEGY

NOVEMBER 1989

TECHNOLOGY ISSUES:

- INTEGRATION OF TRANSPORTATION NEEDS
- STANDARD, PRE-DECLARED CRITERIA FOR ASSESSING:
  - FLEET OPTIONS
  - DESIGN DRIVERS
  - TECHNOLOGY FOCUS
- SYSTEMATIC ASSESSMENT OF SENSITIVITIES OF OPTIONS & CORRESPONDING RISKS (TECH/PROG)

CANDIDATE PROGRAMS:

- MANNED TRANSPORTATION SYSTEMS
  - SHUTTLE EVOLUTION
  - CERV
  - MANNED MARS/LUNAR MISSIONS
- UNMANNED TRANSPORTATION SYS
  - OMV
  - OTV
  - MARS/LUNAR MISSIONS

MAJOR ACCOMPLISHMENTS:

- MRSR PHASE B STUDIES UNDER WAY
- MANNED SPACE TRANSPORTATION STUDY/DEFINITION UNDER WAY
- LUNAR/MARS EXPLORATION INITIATIVE UNDER WAY

SIGNIFICANT MILESTONES:

National Aeronautics and
Space Administration

FREEDOM

Space Transportation Avionics Technology Symposium

Williamsburg, Virginia

Avionics Advanced Development Strategy

D. Dyer, JSC/TDY SSFPO Reston
SE&I Subpanel
November 7-9, 1989

Introduction

- Collected technology needs from individual programs/vehicles
- Bottoms-up collection of proposed advanced development items
- Result is not necessarily a match and usually not affordable

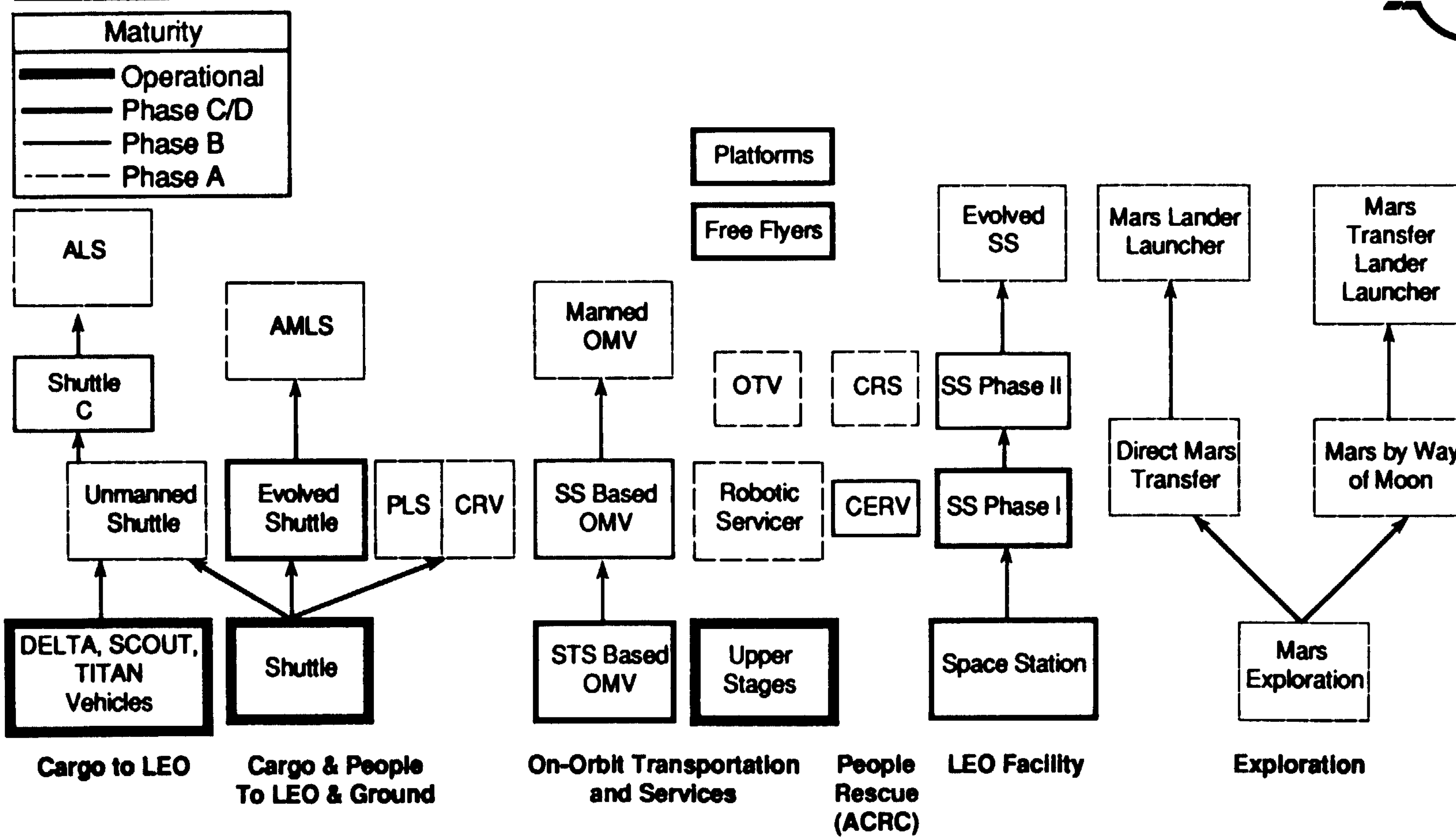
Problem

How to put together an integrated, phased, and affordable advanced development program that links operational, evolving, and developing programs/vehicles as-well-as those in the planning phases?

NASA
National Aeronautics and Space Administration

Scope of Transportation Needs and Maturities

FREEDOM



Scope

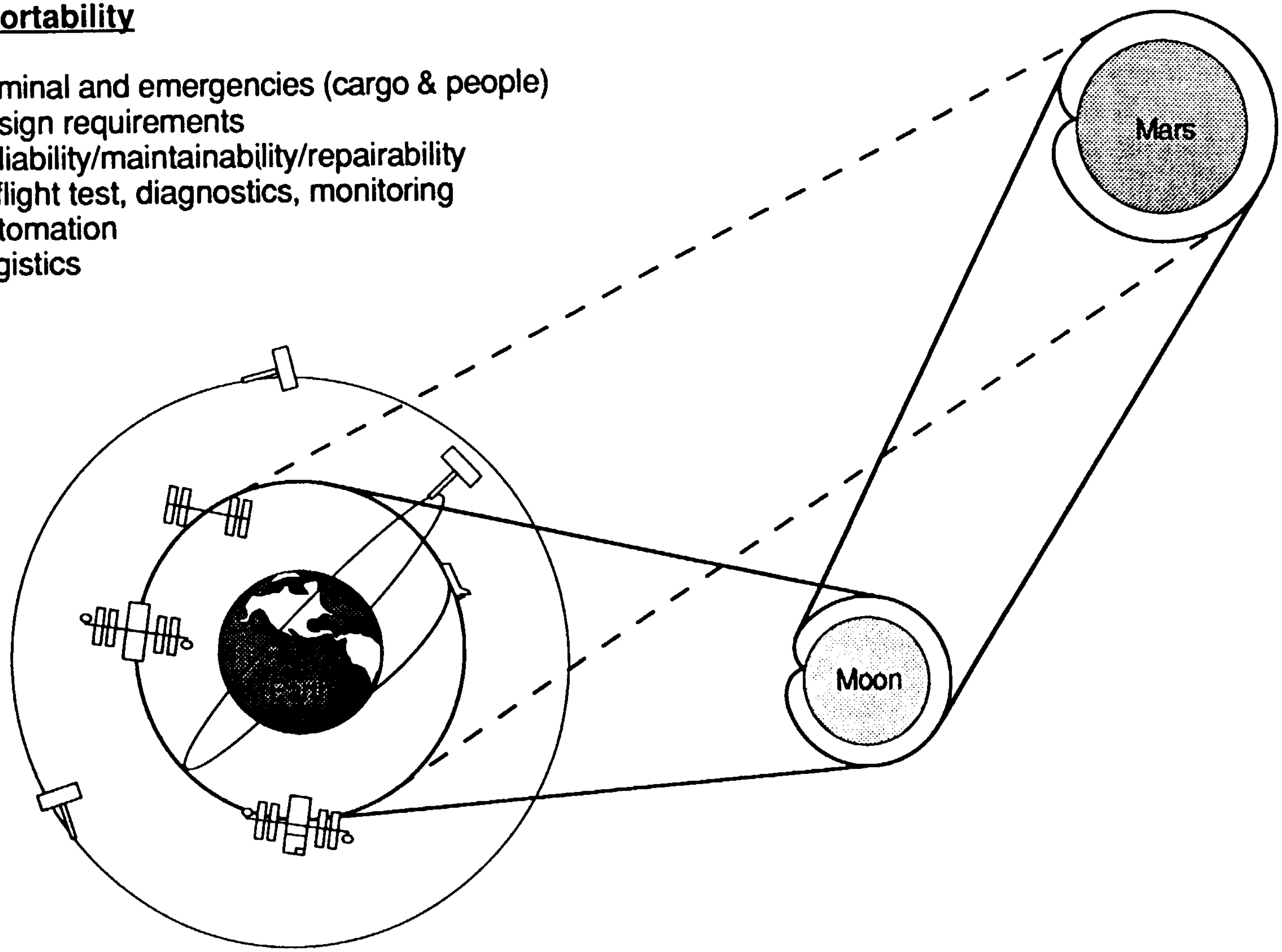
NASA
National Aeronautics and Space Administration

Mixed Fleets Operations

FREEDOM

Supportability

- Nominal and emergencies (cargo & people)
- Design requirements
- Reliability/maintainability/repairability
- In-flight test, diagnostics, monitoring
- Automation
- Logistics



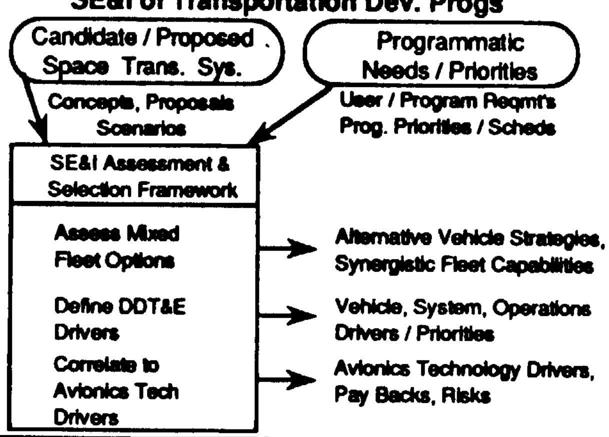
NASA
National Aeronautics and Space Administration

Space Transportation Avionics Technology Symposium
Systems Engineering and Integration
Avionics Advanced Development Strategy

November 1989

FREEDOM

Advanced Avionics Concepts



Major Objectives

Develop framework for assessing and integrating avionics advanced technology developments

- Priority and phasing of future space transportation systems
- Integration across multiple programs/projects
- Selection/Evaluation criteria

Key Contacts:

D. Dyer/NASA–Reston
K. Cox/JSC

Facilities:

Major Milestones (1990 – 1995)

- **Assimilate results/status of various transportation systems studies (Mid to late 90)**
  - Manned Space transportation
  - Lunar/Mars exploration initiative
  - Cerv, ext. duration orbiter
- **Develop initial framework for assessing/prioritizing tech. needs (mid FY 90)**
- **Apply framework (FY 91)**

NASA
National Aeronautics and Space Administration

Space Transportation Avionics Technology Symposium
Systems Engineering and Integration
Avionics Advanced Development Strategy

November 1989

FREEDOM

Technology Issues

- **Integration of transportation needs**
- **Standard, pre-declared criteria for assessing:**
  - Fleet options
  - Design drivers
  - Technology focus
- **Systematic assessment of sensitivities of options & corresponding risks (Tech/Prog)**

Candidate Programs

- **Manned transportation systems**
  - Shuttle evolution
  - CERV
  - Manned Mars/Lunar Missions
- **Unmanned transportation Sys**
  - OMV
  - OTV
  - Mars/Lunar Missions

Major Accomplishments

- **MRSR Phase B studies under way**
- **Manned space transportation study/definition under way**
- **Lunar/Mars exploration initiative under way**

Significant Milestones

NASA
National Aeronautics and Space Administration

Key Steps to Strategy Development

FREEDOM

- Identify and establish candidate/proposed space transportation system concepts, proposals, and scenarios
- Identify programmatic needs and priorities (user/program requirements, program priorities/schedules)
- Assess mixed fleet operations to determine alternative vehicle strategies and synergistic fleet capabilities
- Define DDT&E drivers and priorities (vehicle, system, operations)
- Correlate to avionics technology drivers, define paybacks and risks
- Establish selection/evaluation criteria

  For example:

  - Timing requirements
  - Flight testing requirements
  - Greatest payback across programs

NASA
National Aeronautics and Space Administration

Examples of Across Program Functional Types

FREEDOM

INFLIGHT MAINTAINABILITY FOR LONG DURATION MISSIONS

- NSTS - To Support Extended Duration On-orbit (EDO)
- SSF - External and internal maintenance and logistics
- CERV - Long-term dormant avionics with quick activation
- Mars Transfers - To support functional availability and redundancy

INFLIGHT CREW TRAINING

- NSTS - To support landings after an EDO
- SSF - To support Phase II and growth station operations
- Mars - To support landings after long transfer times

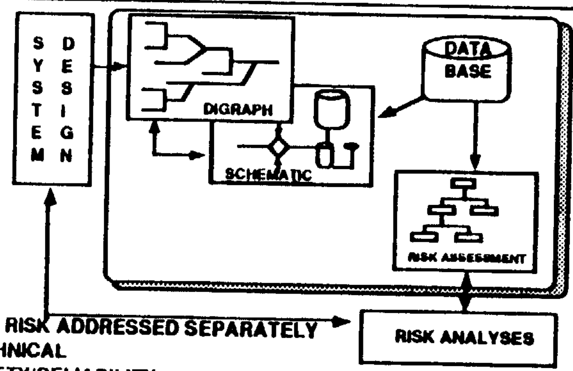
AUTOMATIC RENDEZVOUS AND DOCKING

- NSTS - Unmanned flights
- SSF - To support man tended free flyer return to station
  - To support OMV/platform return to station
  - To support unmanned resupply
- OMV - To support approaches to orbiter, platforms, and satellites
- Mars - To support Mars sample return mission

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SE & I
RISK ANALYSIS & MGT

NOVEMBER 1989

SYSTEMS RISK ASSESSMENT/ANALYSIS METHODOLOGY:



PRESENTLY, RISK ADDRESSED SEPARATELY
- TECHNICAL
- SAFETY/RELIABILITY

PRESENT APPROACH PROHIBITIVE
- SYSTEM COMPLEXITY
- EXTENDED EVOLUTIONARY LIFECYCLE

MAJOR OBJECTIVES:

- COMBINE RISK METHODOLOGY
- COST-EFFECTIVE APPROACH
  - UNDERSTAND SYSTEM IN FAILURE SPACE
  - DESIGN KNOWLEDGE CAPTURE
  - SUPPORT
    - DESIGN DECISIONS
    - TEST OPERATIONS
    - FLIGHT OPERATIONS
    - TRAINING
  - PROVIDE CAPABILITY TO DEFINE AND ASSESS RISK
    - INPUT FOR QRA
    - INPUT FOR APPROPRIATE COMPONENT/UNIT ANALYSES

KEY CONTACTS:

- JT EDGE/NASA-JSC/EH3
  - PROTOTYPE TOOLS
- W. GEISSLER/LESC
  - PROTOTYPE TOOLS
- I. SACKS/R & D ASSOC.
  - DIGRAPH MATRIX ANALYSIS
- R. ROBITALLE/ROCKWELL-DNY
  - SHUTTLE CRITICAL FUNCT. AUDIT
- G. HENNING/LESC
  - FAILURE-SPACE MODELING
- J. WELLS/LLNL
  - RISK ANALYSIS TECHNIQUES
- B. BUCHBINDER/NASA HQS/Q
  - NASA RISK ANALYSIS POINT-OF-CONTACT

MAJOR MILESTONES:

- PROCESS REQUIREMENTS DEFINITION
  - 1 - 6/90
- TOOL PROTOTYPING
  - 7/90 - 8/91
- METHODOLOGY VALIDATION/DEMO
  - 9/91

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SE & I
RISK ANALYSIS & MGT

TECHNOLOGY ISSUES:

- UNDERSTANDING USER NEEDS AND EVOLVING METHODOLOGY
- METHODOLOGY ACCEPTANCE BY USERS
- TOOL PORTABILITY/FLEXIBILITY ACROSS COMPUTER SYSTEMS
- ANALYSIS TOOL INTEGRATION INTO MAJOR PROGRAM TOOLSETS
- EASE OF APPLICATIONS DEVELOPMENT AND OPERATIONS
- MODEL VALIDATION
- PROGRAM ACCEPTANCE OF IMPLEMENTATION AND MAINTENANCE COSTS

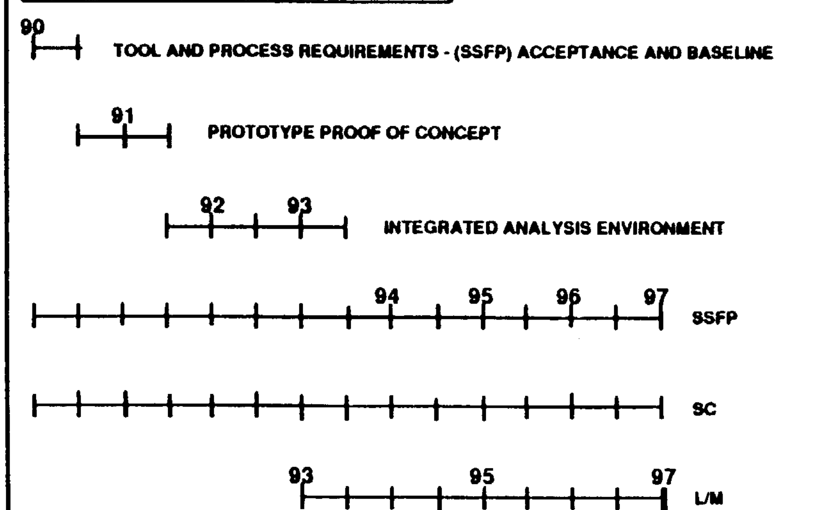
CANDIDATE PROGRAMS:

- SSFP (JT EDGE)
- LUNAR/MARS EXPLORATION
- SUPERCONDUCTING SUPERCOLLIDER (H. E. SMITH)
- NSTS (R. ROBITAILLE (SCFA))
- ASSURED CREW RETURN VEHICLE

MAJOR ACCOMPLISHMENTS:

- SHUTTLE CRITICAL FUNCTION AUDIT (SCFA)
    - DIGRAPH MODELING/TOOL DEVELOPMENT
- FIRM PROCESSOR
    - FAILURE ANALYSIS ALGORITHM-BETA TEST
- DMA WITH GRAPHICS INTERFACE
    - FAILURE ANALYSIS TOOL WITH GRAPHICS I/O
- FAILURE ENVIRONMENT ANALYSIS TOOL (FEAT)
    - FAILURE ANALYSIS TOOL WITH GRAPHIC I/O-BETA TEST
- SHUTTLE CONFIGURATION ANALYSIS PROGRAM (SCAP)
    - OPERATIONAL FAILURE ANALYSIS

SIGNIFICANT MILESTONES:



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SE&I
TOTAL QUALITY MANAGEMENT

NOVEMBER 1989

CONCEPTS:

- CUSTOMER SATISFACTION
- CONSTANCY OF PURPOSE
- CONTINUOUS IMPROVEMENT
- PARTICIPATIVE MANAGEMENT
- PEOPLE EMPOWERMENT / INVOLVMENT
- CONCURRENT ENGINEERING
- UNIVERSAL QUALITY MEASURES
- EDUCATION AND TRAINING

MAJOR OBJECTIVES:

1 YR — SHORT RANGE

- NATIONAL AWARENESS & COMMITMENT

3 YRS. — MID RANGE

- ESTABLISH AS A WAY OF LIFE

3-7 YRS — LONG RANGE

- USA PRODUCTS BENCHMARKED AS WORLD CLASS

KEY CONTACTS:

- K. SHIPE/ MARTIN MARIETTA ASTRONAUTICS
  (303) 971-9522
- R. SAPP / LOCKHEED
  (818) 712-2000
- M. LOFTON / MDAC-MDSSC
  (714)896-2621
- F. DOHERTY / OASD(P&L)
  (202) 695 -7915

MAJOR MILESTONES (1988-95)

- PROPOSED RULES FIRST ENTERED IN FEDERAL REGISTER, VOL. 54, NO. 137 WEDNESDAY, JULY 19, 1989
- PROPOSED AMENDMENT
  TITLE 32, SUBCHAPTER M, CHAPTER I ADD TQM TO PART 281 (TBD)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SE & I
TOTAL QUALITY MANAGEMENT

NOVEMBER 1989

TECHNOLOGY ISSUES:

- CONCURRENT ENGINEERING
- QUALITY FUNCTIONAL DEPLOYMENT
- QUALITY BY EXPERIMENTAL DESIGN
- UNIVERSAL QUALITY LANGUAGE (THE SIGMA)
- OPTIMIZATION OF PRODUCT PARAMETERS TO PROCESS CAPABILITIES
- STATISTICAL PROCESS CONTROL
- INTEGRATE R & M ANALYSIS INTO CAE
- MONETARY LOSS FUNCTION
- CALS INITIATIVES

CANDIDATE PROGRAMS:

- SPACE STATION (NASA)
- ADVANCED LAUNCH SYSTEMS (DOD & NASA)
- PROPOSED- EXTERNAL TANKS AS SPACEPORTS
- EXISTING ELV DESIGNS- TITAN , ATLAS, DELTA, SCOUT (DOD & NASA)
- FLIGHT TELEROBOTIC SERVICER (NASA)
- ZENITH STAR (DOD/SDIO)
- ALL NEW ACQUISITIONS AFTER "TBD" DATE (ALL USA AGENCIES)

MAJOR ACCOMPLISHMENTS :

- TQM RECORDED IN NATIONAL REGISTER - JULY, 1989
- FIRST NATIONAL TOTAL QUALITY MGMT. SYMPOSIUM (AIAA/ADPA/NSIA), NOV. 1989
- OVER 25 MAJOR COMPANIES HAVE BUILT THEIR "CASE FOR CHANGE" & BEGUN ISSUING INTERNAL TQM GUIDELINES - 1989

SIGNIFICANT MILESTONES:

- FIRST NASA EXCELLENCE AWARD - 1986
- MALCOLM BALDRIGE QUALITY AWARD - 1988
- NASA ESTABLISHED NINE UNIVERSITY ENGINEERING RESEARCH CENTERS - 1988
- DOD RELEASED TQM GUIDE, FINAL DRAFT, DOD 5000.51G, AUG. 1989

SPACE TRANSPORATION AVIONICS TECHNOLOGY SYMPOSIUM
SE&I
LOW COST AVIONICS

NOVEMBER 1989

LOW COST AVIONICS CONCEPTS

With:
- Consolidated Subsystems, Reduced Boxes
- Lower Levels of Distributed/Embedded Processing
- Hardware Improved Rather Than Software Redundancy Mgt.
- Software Standardization (ADA)

MAJOR OBJECTIVES

- Have Modern Low Cost Avionics Systems in Lab Demo Before Project øC/D
- Designed For Low Cost Operations
  - Ground
  - Space Based
- Designed For Continuous Change/Upgrade
- Multi-Project Applicability
- Product improvement Continually in Progress
- Commonality of Systems Across Agencies

KEY CONTACTS:

LaRC - C. Meissner, F. Pitts

MSFC - W. Clubb, W. Brantley

JSC - T. Barry, T. Moore

LaRC - H. Wimmer

WDRC - J. Stanley, R. Bortner

BAC - D. Johnson

GD - J. Karas

MMC - R. Gates

MDAC - E. Whitehead

Facilities
- MSFC Avionics Productivity Center
- JSC Avionics Eng. Lab
- Prime Contractor Labs

MAJOR MILESTONES (1990-1995):

- Developed System Lab Demos ('92-'93)
- Shuttle C Avionics ('94-'95)
- Shuttle Upgrade (95)
- ALS Avionics ('98)
- CERV, PLS ('95-98)
- TRANSER/Excursion Vehicles ('95)

SPACE TRANSPORATION AVIONICS TECHNOLOGY SYMPOSIUM
SE&I
LOW COST AVIONICS

NOVEMBER 1989

TECHNOLOGY ISSUES:

- Architectures to optimize HW/SW Integration
- Standardization of Modules/Interfaces/Back planes
- On-Board Checkout/BIT
- Assemblies with Internal Redundancy of Critical Functions
- Utilize Very Large Scale Integration on a Chip
- Improve Software Generation/Verification Techniques

CANDIDATE PROGRAMS:

- All Existing & Advanced Space Transportation Systems

MAJOR ACCOMPLISHMENTS:

- TITAN IV/ Centaur Upgrades

SIGNIFICANT MILESTONES

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

SE&I

COST ESTIMATION & BENEFITS

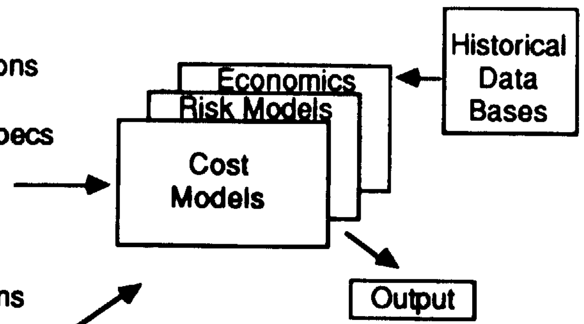
November 1989

Cost Estimation & Benefits Analysis

Input

Hardware Descriptions
- Weights
- Functional Specs
- Quantities
- Heritage
- Complexity

Software Descriptions
- Functions
- KSLOCS
- Heritage
- Complexity



- Life Cycle Costs
- Sensitivities
- Confidence Levels
- Discounted Benefits

Major Objectives

- More Accurate Cost Estimates At All Phases Of Definition
- Improved Differentiation Between Competing Concepts
- Better Quantification Of Cost Drivers
- Better Metrics To Translate Cost Drivers Into Cost
- Improved Measurement Of Cost Sensitivities To Key Design And Performance Variables
- Better Quantification Of Risk / Confidence Of Estimates
- Improved Quantification / Display / Communications Of Cost Versus Benefits To Management
- Decrease Reliance On Subjective Judgements
- Wedding Of CAD / CAM / CIM / COST
- Parametric Cost / Schedule / System Performance Trades

Key Contacts

- Ed Dean / LaRC
- Ernie Fridge / JSC
- Joe Hamaker / MSFC

Major Milestones (1990 - 1995)

- JSC Software Model (1988 IOC)
- JSC AMCM Hardware Model (1989 IOC)
- LaRC AMCM & GE Price Research (1987 - ∞)
- MSFC NASCOM Model (1990 IOC)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

SE&I

COST ESTIMATION AND BENFITS ANALYSIS

November 1989

Technology Issues

- Realtime Collection / Analysis / Understanding Of The Data Base
- Development Of Accurate Hardware And Software Metrics
- Development Of User Friendly, Standardized Cost Models And Expert System
- Estimate Of New Technology / Languages Costs
- Accurate Software Sizing

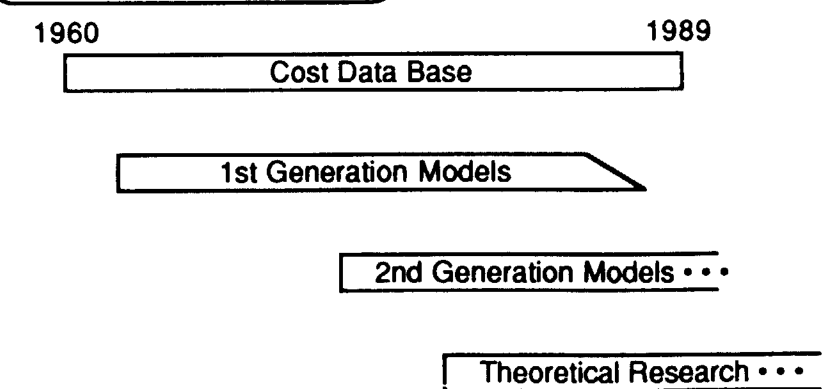
Candidate Programs

- Shuttle-C
- Advanced Launch System
- Next Manned Transportation System
- Shuttle Improvements
- Space Station Freedom
- Lunar / Mars Initiative
- All Other New Start Candidates

Major Accomplishments

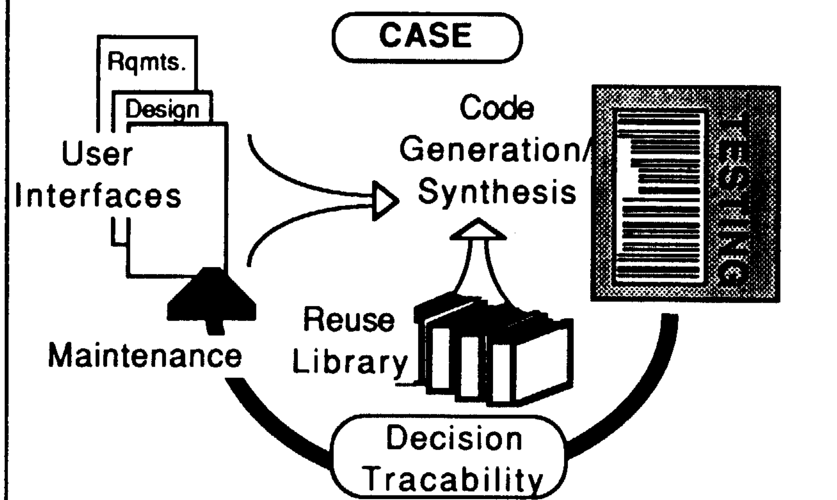
- 30 Years Of Data
- Many 1st Generation Models (1965 - 1985)
- A Few 2nd Generation Models (JSC Software Model, JSC AMCM, MSFC NASCOM, GE Price)
- Initiative Of Theoretical Research Within The Field Of Cost Analysis

Significant Milestones



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING & INTEGRATION
COMPUTER-AIDED SOFTWARE ENGINEERING

NOVEMBER 1989



MAJOR OBJECTIVES:

- Rapid Software Development
- Reduced Development/Maintenance Costs
- Flexible Mission Services
- Increased Software Reliability
- Reusability
- Evolvability

KEY CONTACTS:

C. Walker/LaRC
G. Raines/JSC

MAJOR MILESTONES (1990-1995):

- Identify appropriate state-of-the-art systems (commercial or government furnished) to provide the design surface. (1990)
- Provide code generation for various architectures (hide arch. from sw developer.) (1992)
- Automate code testing. (1993)
- Integrate knowledge-based reusable software system into CASE environment. (1994)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING & INTEGRATION
COMPUTER-AIDED SOFTWARE ENGINEERING

NOVEMBER 1989

TECHNOLOGY ISSUES:

- Defining software requirements clearly and unambiguously.
- Translating specification to code easily and correctly.
- Testing code for reliability.
- Maintaining code effectively.
- Managing projects efficiently.
- Applying automated methods to real-time, fault-tolerant software.
- Adapting technology to large, complex projects.

CANDIDATE PROGRAMS:

SSF
DoD
Shuttle
ELVs
ALS

MAJOR ACCOMPLISHMENTS:

- Integration of automated development techniques with knowledge-based reusable software system.

- Integration of automated development techniques with decision-tracking system.

CURRENT TECHNOLOGY:

- Slow manual code generation.
  (7-8 lines/day - flight software)

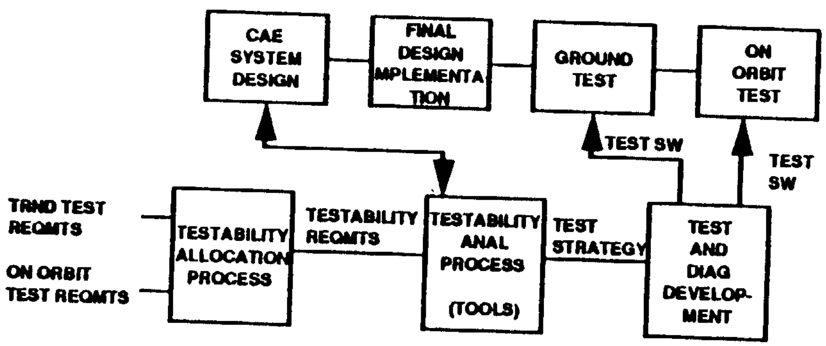
- Inefficient manual code maintenance.

- Independent handling of project design, coding, testing, maintenance, and management.

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SE & I
SYSTEM TESTABILITY

NOVEMBER 1989

ADVANCED CONCEPTS:



MAJOR OBJECTIVES:

- OPTIMIZE TESTABILITY DESIGN PROCESS
- OPTIMIZE SYSTEM SUPPORTABILITY/AVAILABILITY
- PROVIDE ANALYTICAL TOOLS TO DEVELOP TEST STRATEGIES
- OPTIMIZATION OF FD/FI DESIGN
- MINIMIZE WEIGHT AND POWER OF BITE
- TESTABILITY PROCESS/TOOLS NOW MATURE
    - WIDELY USED BY DoD
    - NEED TO GET PROCESS/TOOLS INTO NASA MAINSTREAM

KEY CONTACTS:

B. ROSENBERG - HARRIS CORP
B. KELLEY - HARRIS CORP
W. KEINER - NAVY SURFACE WEAPON CENTER
J. T. EDGE - NASA JSC
R. CACERAS - MDC
H. MORROW - IBM
M. BATTAGLIA - NASA RESTON
D. LANDWEIR - IBM
J. KLION - ROME AIR DEV. CENTER
A. STANLEY - ROCKWELL AUTONETICS
J. BUCCHE - GRUMMAN
E. FREDDOLINO - ROCKWELL, DOWNEY

MAJOR MILESTONES 1990-1995

- SPACE STATION TESTABILITY PROCESS/TOOLS IN PLACE PRIOR TO PDR
- TESTABILITY PROCESS BEING USED ON LHX/ATF 1991
- APPLY TOOLS TO SHUTTLE UPGRADES 1991
- PROOF OF CONCEPT ON NASA SYSTEM 1990
- IMPROVE TESTABILITY PROCESS/TOOLS WITH TECHNOLOGY DEVELOPED BY AI/EXPERT SYSTEMS TECHNICAL DISCIPLINES

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

SE & I

SYSTEM TESTABILITY

NOVEMBER 1989

ISSUES:

- TIMELY ACCEPTANCE BY SYSTEM DEVELOPERS
- LACK OF NASA APPLICATION/PROOF OF CONCEPT
- HOW MUCH TESTABILITY IS ENOUGH
- QUANTITATIVE RELATIONSHIP OF TESTABILITY AND AVAILABILITY
- NON UNIFORMITY OF CAE TO TESTABILITY TOOLS INTERFACES
- TOOL USER FRIENDLINESS

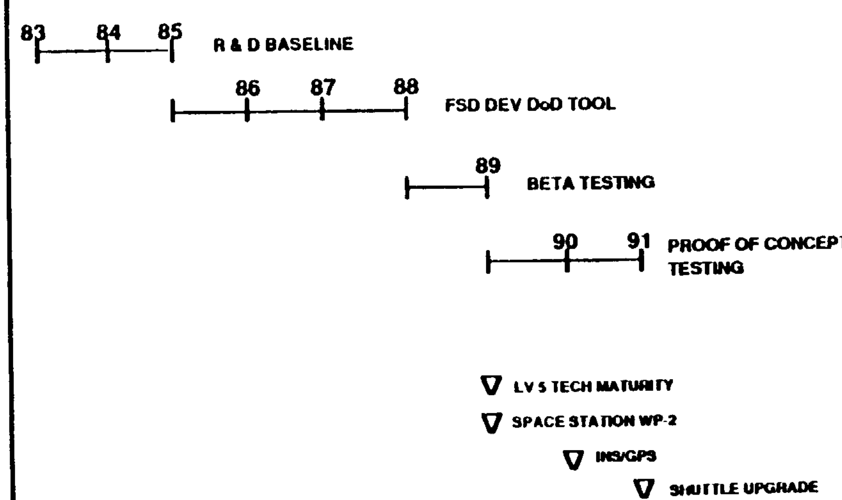
CANDIDATE PROGRAMS

- SPACE STATION - UNDERWAY
- CERV - CRITICAL FACTOR FOR VEHICLE CHECK-OUT/ AVAILABILITY
- SHUTTLE-C - REDUCE LAUNCH CHECK-OUT COST
- ALS - REDUCE LAUNCH CHECK-OUT COST
- SDI
- LUNAR MARS EXPLORATON - VISABILITY INTO SYSTEM AVAILABILITY

MAJOR ACCOMPLISHMENTS:

- BETA TEST (10 SITES) OF DoD TESTABILITY TOOL COMPLETED (1989)
- INDUSTRY BRIEFED ON DoD TESTABILITY OBJECTIVES (1988)
- MIL SPEC 2165 TESTABILITY SPEC INVOKED ON ALL NEW DoD FSD PROGRAMS (1985)

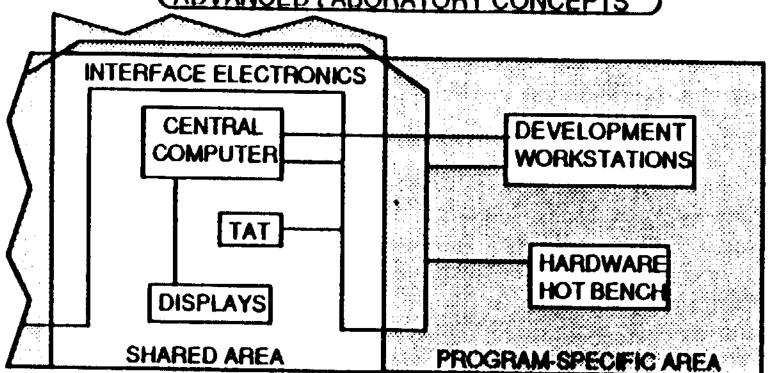
SIGNIFICANT MILESTONES:



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING AND INTEGRATION
ADVANCED AVIONICS LABORATORIES

NOVEMBER 1989

ADVANCED LABORATORY CONCEPTS



SHARED AREA
- IMU Cal, test, and eval
- HWIL Simulation
- Data acquisition, logging, and display

PROGRAM-SPECIFIC AREA
- Software development
- Subsystem development and simulation
- "Hot Bench"

MAJOR OBJECTIVES

- Provide a proving ground for advanced avionics concepts (Fault Tolerance, AGN&C, advanced sensors, integrated VHM)
- Reduce development and V&V costs via:
  - common hardware and facilities
  - commonality of software models and database structures
  - reduced manpower requirements for operational support
  - more efficient operations
- Provide a common development environment to encourage data sharing between programs
- Provide growth path for adaptation to new technologies

KEY CONTACTS AND FACILITIES

Contacts
Chuck Meissner, Felix Pitts/LaRC
Ken Cox/JSC
Ray Bortner/WRDC
Whit Brantley, Ron White/MSFC
Don Johnson/Boeing
Fred Kuenzel/GD
Crane Simmons/MDAC
Bud Gates/MMAG
Leon Shockley/RIC
Jay Lala/CSDL

Government Facilities
AIRLAB - LaRC
WRDC labs
MSFC labs - APC, SSME lab
JSC labs - SAIL

Contractor Facilities
ELV Labs at MMAG, GD, MDAC
Shuttle labs at RIC
Boeing System Integration Labs
CSDL Labs

MAJOR MILESTONES

- AIPS demos at CSDL - Oct 89
- MPRAS Demos
  - Key Concepts Mar 90
  - Subsystems Jul 91
  - Full Architecture May 92
- Shuttle-C Avionics Lab (MSFC)
  - S/W only capability Aug 90
- ALS Vehicle Avionics Simulation Laboratory (MSFC)
  - IOC Oct 91
  - Operational Aug 93

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING AND INTEGRATION
ADVANCED AVIONICS LABORATORIES

NOVEMBER 1989

TECHNOLOGY ISSUES

- Cultural changes necessary for acceptance of advanced avionics concepts
- Real-time hardware-in-the-loop simulation vs. all software approach
- Common database technology for multiple programs
- Providing easy transition from modeling/analysis environment to HWIL simulations
- Defining hardware and software appropriate for common areas
- Providing standalone as well as integrated testing
- Ease of reconfigurability

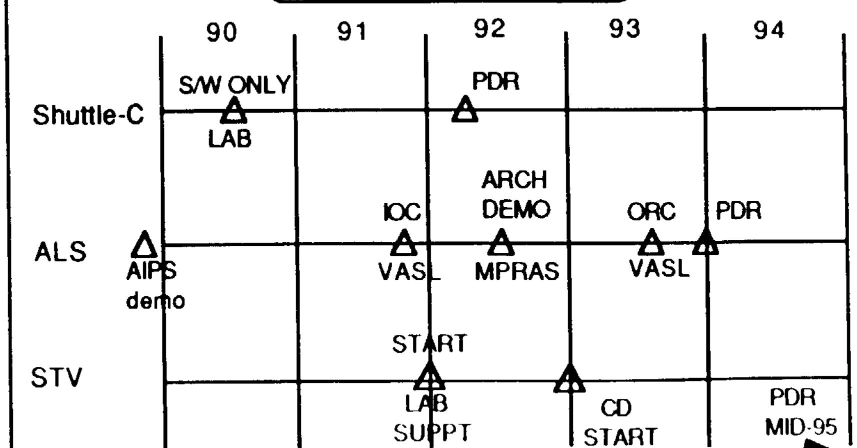
CANDIDATE PROGRAMS

- ALS
- ELV Upgrade Programs
- Shuttle
- Shuttle-C
- NASP
- Advanced upper stages (STV)
- Spacecraft programs (AXAF, others)
- Lunar/Mars Vehicles

MAJOR ACCOMPLISHMENTS

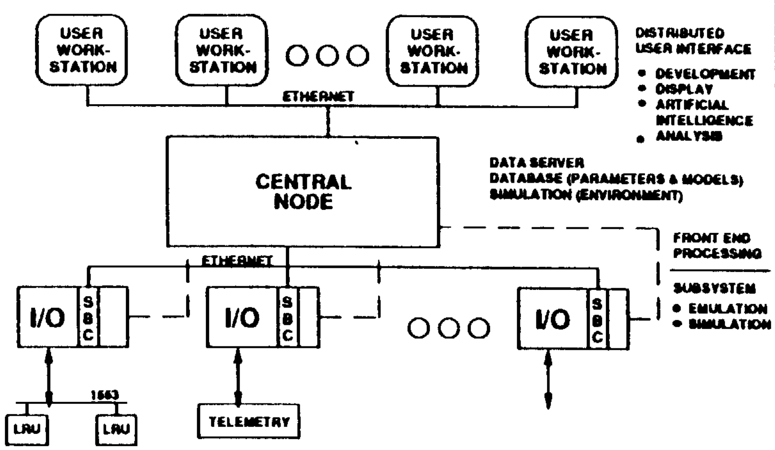
- Test, Evaluation, Integration, and Test Facility at CSDL - Oct 89
  - Supports LaRC-sponsored AIPS Distributed System
- HLCV/MAST Laboratory
  - Preliminary designs completed Feb 89
  - Concept demonstrations performed May-Sep 89

SIGNIFICANT MILESTONES



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SE & I ELEMENTS
RAPID PROTOTYPING SYSTEMS

RAPID PROTOTYPING SYSTEMS



MAJOR OBJECTIVES

- INTEGRATED DESIGN, DEVELOPMENT, TEST AND OPERATIONS
- REDUCTION IN COST - SCHEDULE, MANPOWER, RESOURCES
- TRANSPORTABILITY AND REPEATABILITY OF DATA AND PROCEDURES
- EARLY AVAILABILITY OF ARCHITECTURES FOR EVALUATION AND TRADE STUDIES/
- REUSABILITY OF CODE
- SOFTWARE ADAPTABILITY OF HARDWARE ARCHITECTURES

KEY CONTACTS

- P. D. SCHOEN - AEROSPACE SIMULATION AND SYSTEMS TEST CENTER
  ROCKWELL DOWNEY
- T.B.D. - HONEYWELL
- D. HUDSON - MARTIN MARIETTA CORPORATION
- D. DEETS - DRYDEN FLIGHT RESEARCH CENTER (DFRC)

FACILITIES

- NASA AND/OR CONTRACTOR FACILITIES, E.G.
- AEROSPACE SIMULATION AND SYSTEMS TEST CENTER (RI/ASSTC)
- SHUTTLE AVIONICS INTEGRATION LABORATORY (NASA/JSC)
- REMOTELY AUGMENTED VEHICLE (RAV) FACILITY (NASA/DFRC)

MAJOR MILESTONES

- OPERATIONAL SYSTEMS –
- GN&C TEST STATION (GTS) RECOMMISSIONING (NASA/JSC)
- ADVANCED AVIONICS TEST BED/SYSTEM (RI/DOWNEY)
- REMOTELY AUGMENTED VEHICLE (RAV) FACILITY (NASA DFRC)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
SE & I ELEMENTS
RAPID PROTOTYPING SYSTEMS

TECHNOLOGY ISSUES

STANDARDIZATION OF PROTOTYPE METHODOLOGY (PROGRAMMATIC)

- DEVELOPMENT OF RAPID PROTOTYPING APPROACH OR METHODOLOGY
- NUMEROUS, CONFLICTING VERSIONS (ANARCHY) OF APPROACHES
- LIFE CYCLE MODELS (THROWAWAY VS END PRODUCT)

DEVELOPMENT OF INTEGRATED TOOLS AND IMPLEMENTATION METHODOLOGY

- DISTRIBUTION OF PROCESSING (DATA FLOW ARCHITECTURE)
- DATA FUSION
- ADAPTIVE RECONFIGURATION
- UTILIZATION OF ARTIFICIAL INTELLIGENCE

CANDIDATE PROGRAMS

SHUTTLE/ORBITER AVIONICS EVOLUTION

ASSURED CREW RETURN VEHICLE

SHUTTLE -C

NATIONAL AEROSPACE PLANE

SPACE STATION

ADVANCED MANNED LAUNCH SYSTEM

LUNAR/MARS

MAJOR ACCOMPLISHMENTS

ESTABLISHMENT OF RAPID PROTOTYPE CAPABILITIES

- ADVANCED AVIONICS TEST BED/SYSTEM (ASSTC)
- GLASS COCKPIT DEVELOPMENT FOR NASP AND SHUTTLE/ORBITER (ASSTC)
- AUTOMATED FLIGHT TEST MANAGEMENT STUDY (AFTMS) - (NASA/DFRC)

TOOLS (EXAMPLES)

- VIRTUAL PROTOTYPING SYSTEM (VAPS)
- DISPLAY BUILDER/EDITIONS (E.G., DATAVIEWS)
- BEHAVIOR MODELING (E.G., CADNETICS)
- EXPERT CONSULTANT FOR AVIONICS SYSTEM TRANSFORMATION EXPLOITATION (ECATE)
- PROTOTYPE SYSTEM DESCRIPTION LANGUAGE (PSDL)

SIGNIFICANT MILESTONES

CENTRALIZATION OF PROTOTYPE METHODOLOGY (PROGRAMMATIC)

- SHUTTLE/ORBITER
- SHUTTLE - C
- NASP
- ALS
- AMLS

DETERMINATION OF APPROACH

- LIFE CYCLE MODEL

STANDARDIZATION OF DEVELOPMENT

- HARDWARE
- SOFTWARE (TOOLS)
- DEVELOPMENT PROCESS

STANDARDIZATION AND IMPROVEMENT OF AI TOOLS AND RESOURCES

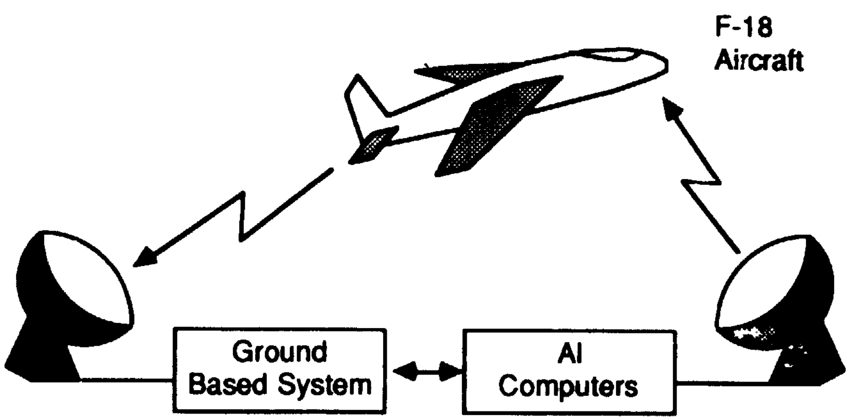
SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

SE & I

RAPID PROTOTYPING SYSTEMS

November 1989

Rapid Prototyping Aero Demonstrations



Major Objectives

- Demonstrate New Technology Concepts In Real-World Environment
- Acceptance By Flight Operations And SR&QA Organizations
- Bring Realism To Paper Studies

Key Contacts

D. Deets/Ames-Dryden
K. Peterson/Ames-Dryden

Facilities

Rapid-Prototyping Flight Research Facility
Integrated Test Facility (IFF)
F-18 Systems Research Aircraft
CV-990 Landing Gear Research Aircraft
B-52 Launch Platform
Western Aeronautical Test Range (WATR)

Major Milestones (1990 - 1995)

• Fiber Optics Engine Sensing (F-15; F-18)	1992
• CV-990 Landing Gear Test Demonstrations	1991-93
• Transparent-Based Cockpit Display Processing (F-18)	1993

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

SE & I

RAPID PROTOTYPING SYSTEMS

November 1989

Technology Issues:

SYSTEMS

- Real-Time Expert Systems
- Retrofit Of New Technology Into Existing Operational Vehicles
- Close Proximity Of Manned And Autonomous Unmanned Vehicles

CULTURE

- Reliance On Automation-Intensive Element In Operational Systems

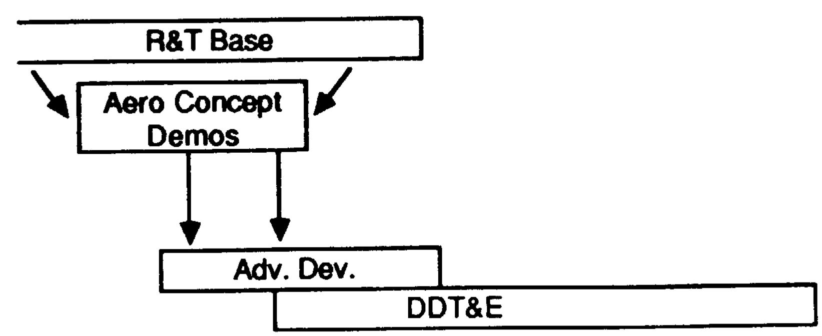
Candidate Programs

- Long-Duration Autonomous Aircraft
- Advanced Space Avionics System Retrofit In F-18 Aircraft
- Flight Planning/Monitoring Automation Demonstration
- Lifting-Body-Type Flight Research

Major Accomplishments

- F8-Digital Fly-By-Wire (1974)
- Real-Time Systems Monitoring (1987)
  - Gain And Phase Margins
  - Simulation - Flight Overlays
- Automated Flight Test Management System Demonstration (ATMS) (1988)

Significant Milestones



PANEL WHITE PAPERS

- OPERATIONAL EFFICIENCY
- FLIGHT ELEMENTS
- PAYLOAD ACCOMMODATIONS
- SYSTEMS ENGINEERING AND INTEGRATION (SE&I)

OPERATIONAL EFFICIENCY