ONBOARD SYSTEM HEALTH ASSESSMENT

TOM BARRY/ JSC

HARRY CUNNINGHAM
LOCKHEED ESC
HOUSTON,TEXAS

OUTLINE

BACKGROUND

SCOPE

PURPOSE

CHALLENGES/ISSUES

WHAT DO WE NEED?

DEFINITION OF PROBLEM

HOW DO WE GET THERE?

RECOMMENDATIONS

SLIDE 1

SUCCESS OF THE SPACE STATION PROGRAM WILL BE MEASURED BY HOW WELL IT ADDRESSES THE BASIC REQUIREMENTS FOR:
1) MAINTAINING THE ORBITING SPACE STATION FREEDOM FULLY OPERATIONAL FOR ITS PROJECTED LIFE OF THIRTY YEARS
2) THE COST-EFFECTIVE EXECUTION OF THE OVERALL SPACE STATION PROGRAM.
THE DEGREE OF SUCCESS WILL DEPEND ON HOW EFFICIENTLY WE ALLOCATE, USE, AND MAINTAIN ONORBIT SYSTEMS AND RESOURCES AND HOW SUCCESSFULLY WE AVOID WASTE OF RESOURCES, TIME, AND DOLLARS. WE CAN'T RISK HAVING COMPLEX ONBOARD SYSTEMS IN AN UNCERTAIN STATE OF HEALTH AT ANY TIME THEY MAY BE NEEDED. NEITHER CAN WE AFFORD TO PROVIDE TWENTY FOUR HOUR PER DAY GROUND BASED SURVEILLANCE OF THE HEALTH OF ONBOARD SYSTEMS FOR THIRTY YEARS. THE ACCUMULATED DOLLAR COST FOR MAINTENANCE OF THE NECESSARY SPECIALIZED GROUND BASED FACILITIES AND STAFF FOR THE THIRTY YEARS WOULD BE ENORMOUS.

THE ONLY SOLUTION IS A PROPER BALANCE OF THOROUGH AND COMPLETE ONBOARD TESTING CAPABILITIES WITH SUPPORTING GROUND BASED MONITORING RESOURCES AND ACTIVITIES. THE EFFICIENCY AND EFFECTIVENESS OF THOSE CAPABILITIES AND THAT GROUND BASED SUPPORT WILL DETERMINE THE SUCCESS OF THE OVERALL SPACE STATION PROGRAM .

SLIDE 1

BACKGROUND

BASIC REQUIREMENTS OF THE SPACE STATION FREEDOM (SSF)

- EXPECTED 30 YEAR CONTINUOUS ONORBIT OPERATION OF SYSTEMS

- EFFICIENT ONORBIT UTILIZATION OF SYSTEMS

  - SYSTEM FUNCTIONS MUST BE AVAILABLE FOR USE WHEN NEEDED

  - EFFICIENT ALLOCATION AND USE OF RESOURCES IS MANDATORY

- EFFICIENT BALANCE BETWEEN ONBOARD AND GROUND MONITORING CAPABILITIES

SLIDE 2

ONBOARD SYSTEM HEALTH ASSESSMENT MUST PROVIDE COMPLETE AND THOROUGH TESTING CAPABILITIES ALONG WITH EFFECTIVE ASSOCIATED REDUNDANCY/ FAULT MANAGEMENT. THESE CAPABILITIES MUST BE SUPPLIED FOR ALL FUNCTIONS AND INTEGRATED COMBINATIONS, FROM THE ORU LEVEL TO THE ULTIMATE OVERALL MULTI-SYSTEM END-TO-END SSF CONFIGURATION. THE CAPABILITIES WILL BE SOME COMBINATION OF AUTOMATED REDUNDANCY AND STRING RECONFIGURATION MANAGEMENT, BUILT IN TEST/BUILT IN TEST EQUIPMENT (BIT/BITE) AND DIAGNOSTICS, ALONG WITH A VARIETY OF SPECIALIZED ON ORBIT END-TO- END TESTS. CREW/GROUND MANAGEMENT OF THESE CAPABILITIES AND PERFORMANCES MUST BE DIRECTED TO ENSURE THAT ALL ONBOARD SYSTEMS, THEIR CAPABILITIES AND RESOURCES ARE AVAILABLE AND PROPERLY FUNCTIONAL WHEN THEY ARE NEEDED. THAT MANAGEMENT MUST BE WITH RECOGNITION OF THE FOLLOWING BASIC CONSTRAINTS:

1) HEALTH ASSESSMENT ACTIVITIES MUST NOT CONFLICT OR OTHERWISE INTERFERE WITH CRITICAL FUNCTIONS
2) THEY MUST BE DESIGNED TO AVOID UNREASONABLE DEMANDS FOR CREW PARTICIPATION.
3) THE SYSTEMS AND THEIR ASSESSMENT CAPABILITIES MUST BE DESIGNED FOR THE EASY ACCOMMODATION OF ADDITIONS AND MODIFICATIONS TO THE SSF SYSTEMS AND CONFIGURATION(S).

SLIDE 2

WHAT IS ONBOARD SYSTEM HEALTH ASSESSMENT?

- SCOPE

  - REDUNDANCY MANAGEMENT AND STRING RECONFIGURATION
  - BIT/BITE/DIAGNOSTICS
  - END-TO-END ONORBIT CHECKOUT
  - CREW/GROUND MANAGEMENT

- PURPOSE

  ENSURE THAT EACH ONBOARD SYSTEM IS AVAILABLE AND FUNCTIONS PROPERLY WHEN NEEDED

SLIDE 3

THE CHALLENGE : TO KEEP ALL ONBOARD SYSTEMS OPERATIONAL FOR THE FULL TERM OF THE PROJECTED THIRTY YEAR LIFETIME SUBJECT TO THE FOLLOWING UNIQUE AND UNUSUAL CONDITIONS AND CONSTRAINTS:

(1) THE INITIAL FULL ASSEMBLY OF THE SPACE STATION FREEDOM (SSF) WILL ONLY OCCUR ONORBIT AND WILL PROVIDE THE FIRST OPPORTUNITY TO CONDUCT AN END-TO-END TEST OF ITS FULLY INTEGRATED COMPLEX OF SYSTEMS OR TO TEST ITS SYSTEMS IN THE REAL OPERATIONAL AND FLIGHT ENVIRONMENT. ALL SUBSEQUENT REPLACEMENTS, ADDITIONS AND UPGRADES MUST ALSO OCCUR ONLY ONORBIT. THERE WILL BE NO "BACK TO THE GROUND " FOR CONFIRMATION OF THEIR PROPER INCORPORATION OR THAT THEY FUNCTION PROPERLY. THAT CAN ONLY BE BY WAY OF ONBOARD TESTING

(2) THE CREW MUST BE CONTINUALLY ASSURED THAT EVERYTHING IS FUNCTIONING PROPERLY AND THAT ALL SYSTEM RESOURCES ARE OR WILL BE AVAILABLE WHEN NEEDED. OTHERWISE, THEY WILL BE SUBJECT TO WORRY ABOUT THE STATUS OF THEIR EQUIPMENT WHICH WILL IMPACT THEIR EFFICIENCY.

(3) ONORBIT HEALTH ASSESSMENT MUST BE ACCOMPLISHED WITH MINIMAL IMPACT ON NORMAL OPERATIONS, ONLY REASONABLE DEMAND FOR CREW PARTICIPATION AND WITHOUT INTERFERENCE TO CRITICAL FUNCTIONS OR IMPORTANT ONGOING ACTIVITIES.

(4) A THIRTY YEAR LIFE OF GROWTH AND CHANGE MUST BE ANTICIPATED. THAT GROWTH WILL INCLUDE UPGRADES AND ADDITIONS TO INCREASE EFFICIENCY, CAPACITY AND SCOPE OF CAPABILITIES. PROVEN NEW TECHNOLOGY WILL BE INCORPORATED INTO THE SSF AS IT BECOMES AVAILABLE.

SLIDE 3

CHALLENGES AND ISSUES

ACCOMPLISHING, WITH MINIMAL IMPACT ON NORMAL OPERATIONS AN REASONABLE DEMANDS FOR CREW PARTICIPATION, THE FOLLOWING:

- MAINTAIN ONBOARD SYSTEMS OPERATIONAL FOR 30-YEAR SSF LIFETIME
- NO RETURN TO GROUND FOR MAINTENANCE OR OVERHAUL
- REPLACEMENTS, ADDITIONS, AND UPGRADES ONORBIT ONLY
- ONBOARD CAPABILITY TO ASSURE CREW THAT SYSTEMS ARE FUNCTIONING PROPERLY AND SYSTEM RESOURCES ARE AVAILABLE AS NEEDED
- ACCOMMODATE CONTINUED SYSTEM GROWTH AND FREQUENT CHANGES IN STATION CONFIGURATION AND SOFTWARE

SLIDE 4

THE PROBLEM OF ARRIVING AT THE NECESSARY LEVEL OF HEALTH ASSESSMENT CAPABILITY IS MULTI-FACETED. THE FOLLOWING ARE SOME OF THE PROGRAMMATIC ISSUES.

(1) CURRENT FUNDING AND SCHEDULE CONSTRAINTS PREVENT EARLY IMPLEMENTATION AND USE OF THE "IDEAL SSF ONBOARD HEALTH ASSESSMENT SYSTEM". SOME CAPABILITIES REQUIRED FOR THAT "IDEAL" SYSTEM ARE BEING DEFERRED TO GROUND MONITORING WHILE OTHERS ARE CURRENTLY CONSIDERED ONLY POTENTIALS FOR GROWTH.

(2) R/D OF APPLICABLE TECHNOLOGIES IS FOCUSED ON PROBLEMS SIGNIFICANTLY DIFFERENT FROM THOSE OF THE SSF. THEY GENERALLY FAIL TO RECOGNIZE PROPERTIES THAT ARE UNIQUE TO THE SSF PROGRAM, SUCH AS ITS THIRTY YEAR STAY IN ORBIT WITHOUT RETURN TO EARTH, ITS COMMITMENT TO TECHNOLOGICAL GROWTH AND ITS CHANGEABLE TIME CRITICALITY.

(3) THERE HAS BEEN AND STILL IS, THE PROBLEM OF GETTING EXPERTISE OF OTHER NASA RESEARCH CENTERS TO BEAR ON THE THE FULLY INTEGRATED MULTI-SYSTEM SSF HEALTH ASSESSMENT PROBLEM. TO THIS POINT THEIR TENDENCY HAS BEEN TO FOCUS ONLY ON WORK PACKAGE OR SYSTEM RESPONSIBILITIES.

SLIDE 4

DEFINITION OF PROBLEM

PROGRAMMATICS

- CURRENT FUNDING/SCHEDULE CONSTRAINTS PREVENT DESIGN/DEVELOPMENT OF AN IDEAL SYSTEM.

  - CURRENT SSF ONBOARD SYSTEM HEALTH ASSESSMENT IS LIMITED, (LESS THAN IDEAL).

  - SOME CAPABILITIES HAVE BEEN DEFERRED TO GROUND MONITORING.

- TECHNOLOGY DEVELOPMENT - IS ISOLATED FROM REAL WORLD SYSTEM LIMITATIONS AND IS NOT FOCUSED ON THIS PROBLEM.

- UNIQUE PROBLEM - ie 30 YEARS OF OPERATION WITH REPAIR SHOP LOCATED THOUSANDS OF MILES AWAY.

- DIFFICULTY IN GETTING EXPERTISE OF OTHER NASA RESEARCH CENTERS TO BEAR ON THE PROBLEM.

SLIDE 5

UNDER THE CURRENT SSF DEVELOPMENT PLAN THE ONBOARD HEALTH ASSESSMENT REQUIREMENTS WILL DEPEND ON THE STATE OF SSF DEVELOPMENT. THE REQUIRED ASSESSMENT CAPABILITIES WILL GROW FROM BARE MINIMUM FOR PMC (PERMANENTLY MANNED CONFIGURATION) TO THOSE FOR A SUBSTANTIAL SYSTEM WITH A FAIR AMOUNT OF AUTOMATION AT AC (ASSEMBLY COMPLETE). FROM AC FORWARD (MATURITY AND GROWTH), THE REQUIREMENT WILL BE TO GROW ONBOARD HEALTH ASSESSMENT CAPABILITIES IN SCOPE EFFICIENCY AND AUTOMATION, ADOPTING NEW APPLICABLE TECHNOLOGY AS IT BECOMES AVAILABLE. THE DIFFERENCES IN THE REQUIREMENTS FOR THE THREE STATES OF DEVELOPMENT ARE SIGNIFICANT AND DESERVE DEEPER CONSIDERATION. LET'S LOOK AT EACH IN TURN.

NOTE: THE DIFFERENCES BETWEEN PMC AND AC ARE MADE OBVIOUS IN THE REQUIREMENTS DOCUMENT JSC 31000. ITS STATEMENTS OF REQUIREMENTS ARE ACCOMPANIED BY DESIGNATIONS AS TO WHETHER THEY ARE TO BE ENFORCED AT PMC OR AC.

SLIDE 5

SSF HEALTH ASSESSMENT REQUIREMENTS

- REQUIREMENTS DIFFER DEPENDING ON STATE OF SSF DEVELOPMENT
  - SOME REQUIREMENTS HAVE BEEN DEFERRED FROM PMC (PERMANENTLY MANNED CONFIGURATION) TO AC (ASSEMBLY COMPLETE)
  - MANUAL/ GROUND FOR PMC
  - AUTOMATIC/ONBOARD WITH GROUND SUPPORT FOR AC
- STATES OF SSF DEVELOPMENT
  - PMC
  - AC
  - MATURITY/GROWTH

SLIDE 6

UNDER THE CURRENT SSF DEVELOPMENT PLAN, AT PMC ONLY A BARE MINIMUM OF ONBOARD HEALTH ASSESSMENT ASSOCIATED CAPABILITIES WILL BE AVAILABLE. THE ONLY ASSOCIATED AUTOMATION IS THE FAULT DETECTION,ISOLATION AND RECOVERY (FDIR) PROVIDED FOR CRITICALITY 1 (CREW SAFETY CRITICAL) FUNCTIONS. FOR THOSE, THE FDIR IS TO THE ORU LEVEL AND REDUNDANCY SWITCHOVERS ARE AUTOMATIC. ASIDE FROM THAT, THE ONLY ONBOARD ACTIVITIES ASSOCIATED WITH HEALTH ASSESSMENT AND MAINTENANCE IS THE ACQUISITION OF DIAGNOSTIC DATA, THEIR TRANSFER TO THE GROUND FOR ANALYSIS AND ASSESSMENT AND CREW INITIATED CORRECTIVE ACTIONS DIRECTED FROM THE GROUND. THE PRIMARY CONTROL FOR THOSE ACTIVITIES IS FROM THE GROUND BASED OPERATIONS MANAGEMENT GROUND APPLICATION (OMGA) WITH CREW SUPPORT. THE DATA ACQUIRED ONBOARD AND ISSUED TO THE GROUND ARE DIAGNOSTIC DATA DERIVED FROM INSTALLED BIT/BITE ALONG WITH DMS, REDUNDANCY AND CONFIGURATION STATUS DATA. THE OUTSTANDING FEATURE OF THIS METHODOLOGY IS THE GROUND BASED TIER 1 CONTROL.

SLIDE 6

PMC

- MINIMAL REQUIREMENTS

  - FAULT DETECTION/ISOLATION TO ORU FOR CRITICALITY 1 FUNCTIONS ONLY

  - AUTOMATED RM FOR CRITICALITY 1 (SAFETY CRITICALS) ONLY

- PRIMARY CONTROL FROM GROUND (OMGA) WITH CREW SUPPORT

  - ASSOCIATED CREW ACTIVITY IN RESPONSE TO GROUND DIRECTION

- METHODOLOGY

  - DIAGNOSTICS COLLECTED ONORBIT VIA BIT/BITE AND TRANSMITTED TO GROUND FOR ANALYSIS AND FAULT DIAGNOSIS (JSC 31000 Par. 3.1.19.3)

  - CREW/GROUND DIRECTED RECONFIGURATIONS TO REDUNDANT FUNCTIONS (NOT AUTOMATIC) (JSC 31000 Par. 3.1.8.7.1)

  - CONFIGURATION AND REDUNDANCY STATUS DATA ARE SENT TO THE GROUND (SIGNIFICANT OMA FUNCTIONALITY DEFERRED TO OMGA FOR PMC)

SLIDE 7

AT AC THE PRIMARY (TIER 1) CONTROL SHIFTS FROM THE OMGA TO THE ONORBIT OMA (OPERATIONS MANAGEMENT APPLICATION) , WITH OMGA AND CREW IN SUPPORTING ROLES. SYSTEM AND INTRA-SYSTEM CONTROL WILL BE BY LOWER TIER (SYSTEM) MANAGEMENT. ALSO AT AC, THERE WILL BE THE CAPABILITY FOR FAULT DETECTION/ISOLATION TO THE ORU LEVEL, WITH REDUNDANCY AND AUTOMATED REDUNDANCY MANAGEMENT EXPANDED TO COVER ALL SAFETY AND MISSION CRITICAL FUNCTIONS. THE INITIAL AC HEALTH MONITORING AND MAINTENANCE CAPABILITIES WILL BE THOSE FOR SATISFACTION OF BASELINE OPERATIONAL SSF REQUIREMENTS. THEY WILL INCLUDE FULLY AUTOMATED FDIR FOR HIGH LEVELS OF CRITICALITY (CREW SAFETY AND MISSION) AND BIT/BITE CAPABLE OF FAULT DETECTION/ISOLATION TO THE ORU/ORU INTERFACE LEVEL. DMS WILL BE PROVIDED WITH AUTOMATED FDIR AND RM AND CONFIGURATION STATUS MONITORING AND LOGGING WILL BE AUTOMATED. PRIOR TO THIS, DMS ONLY SUPPLIED DIAGNOSTICS, STATUS AND CONFIGURATION DATA. THESE WILL BE THE PROPERTIES AND FEATURES OF THE BASELINE OPERATIONAL SSF HEALTH ASSESSMENT SYSTEM.

SLIDE 7

AC

- SATISFIES BASELINE OPERATIONAL REQUIREMENTS

  - FAULT DETECTION/ISOLATION TO THE ORU/ORU'S INTERFACING SYSTEM / SOFTWARE (JSC 31000 PAR. 3.1.8.3.1)

  - EXPANDED REDUNDANCY AND AUTOMATED RM FOR SAFETY AND MISSION CRITICAL FUNCTIONS - EXPANDED ROLE OF BIT/BITE (INTRA/INTER-SYSTEM TESTING)

- PRIMARY GLOBAL CONTROL IS OMS (OMA) WITH OMGA/CREW SUPPORT

  - LOWER TIER CONTROL FOR INTER/INTRA SYSTEM

- METHODOLOGY

  - AUTOMATED FDIR FOR HIGH LEVELS OF CRITICALITY

  - BIT/BITE FOR FAULT DETECTION/ISOLATION TO ORU/ORU INTERFACE

  - CAPABILITY FOR ON-DEMAND AUTOMATED STATUS CHECKS

  - DMS PROVIDED WITH AUTOMATED FDIR (JSC 31000, PAR. 3.3.2.6.2)

  - AUTOMATED CONFIGURATION/ RM STATUS MONITORING/LOGGING

SLIDE 6/7

SUMMARY OF THE DIFFERENCES

Reference Par. (page(s))	PMC Requirement	AC Requirement
3.1.5.4 (3-10/11)	Onboard/ground operations sequencing override capability	Design for autonomous operations for a TBD period with sequencing override capability
3.1.8.3.5 (3-17)	automatic FDIR for criticality 1 only RM/RM status to crew/ground	automatic RM with status to ground, crew and other automated applications
3.1.8.7.2 (3-25)	automatic RM reconfiguration for safety criticals only - others are manual (crew/ground)	Onorbit automation for elimination of need for realtime continuous monitoring by SSMB ground personnel
3.1.24.2.2 (3-86/87)	overall control by OMGA with crew support	control by OMA with crew/ground support
3.1.24.3.4.8 (3-9)	Primary recovery mode for station wide functional failures is manual/ground process with limited automation	Primary recovery mode is automatic with manual support
3.3.2.2.1.2 (3-134)	Single DMS network (core)	Double DMS network (core/payload)
3.3.2.3.1.2.8 (3-167 thru 3-169)	Fault Detection and reconfiguration by OMA	Fault management and reconfiguration by OMA
3.3.2.3 (3-154 thru 3-190)	Primary control by OMGA	Primary control by OMA

* NOTE - List of some of the major differences.

SLIDE 8

SUBSEQUENT TO AC, THE REQUIREMENT WILL BE FOR A CONTINUAL EFFORT TO IMPROVE THE ONBOARD HEALTH ASSESSMENT CAPABILITIES. THAT EFFORT SHOULD BE DIRECTED TO ACHIEVE TOTAL RELIABILITY, COMPLETE END-TO-END SSF COVERAGE AND TOTAL AUTONOMY OF HEALTH ASSESSMENT. THE ULTIMATE GOAL SHOULD BE TO PROVIDE AN ONBOARD HEALTH ASSESSMENT AND MAINTENANCE SYSTEM HAVING ALL THESE PROPERTIES THAT WILL FUNCTION WITH MINIMUM DEMAND FOR CREW ATTENTION. THIS GOAL SHOULD BE KEPT IN MIND THROUGHOUT THE LONG OPERATIONAL LIFE OF THE SSF. AS APPLICABLE NEW METHODOLOGIES ARE DEVELOPED AND TECHNOLOGIES ARISE, THEY SHOULD BE INCORPORATED INTO THE ONBOARD SYSTEMS TO ENHANCE THE HEALTH ASSESSMENT AND MAINTENANCE CAPABILITIES. THIS SHOULD BE AN ONGOING ACTIVITY, SINCE THAT CAPABILITIES EVOLUTION PROCESS WILL PROVIDE DEFINITION FOR USE IN OTHER PROGRAMS INVOLVING COMPLEX SYSTEMS WITH LONG OPERATIONAL LIFES.

SLIDE 8

MATURITY/GROWTH

- REQUIREMENT IS FOR CONTINUAL ENHANCEMENTS AIMED AT:
  - INCREASED RELIABILITY
  - INCREASED COVERAGE
  - LESSENING DEMANDS ON CREW
  - INCREASE OF SSF AUTONOMY
  - END-TO END AUTOMATION OF HEALTH SURVEILLANCE AND MAINTENANCE (IDEALIZED GOAL)

- METHODOLOGY(IES)???

SLIDE 9

REASONABLE SATISFACTION OF THE SSF HEALTH ASSESSMENT REQUIREMENTS AT PMC, AC, AND BEYOND CAN BE ENSURED THROUGH EARLY RECOGNITION OF BASIC NEEDS IN SYSTEM DESIGN.
THAT DESIGN MUST BE DIRECTED TOWARD EFFECTIVE USE OF THE CREW. IT MUST PROVIDE AN EFFICIENT AND RELIABLE ONBOARD SYSTEM HEALTH ASSESSMENT/ MAINTENANCE CAPABILITY TO ENSURE CONTINUAL CREW CONFIDENCE IN THEIR EQUIPMENT. EXERCISE OF THAT CAPABILITY MUST BE WITHOUT ADVERSE IMPACT ON NORMAL OPERATIONS OR THE DEMAND FOR THE UNREASONABLE USE OF ONORBIT RESOURCES. DEVELOPMENT OF PROPER DESIGN/ METHODOLOGY REQUIRES COMPLETE AND CLEAR DEFINITION OF THE OVERALL HEALTH ASSESSMENT PROBLEM AND ITS REQUIREMENTS AT PMC, AC AND BEYOND. A PLENTIFUL SUPPLY OF HOOKS AND SCARS WILL BE REQUIRED FOR ITS PROGRESSIVE IMPLEMENTATION. THIS IS A TOUGH DESIGN PROBLEM THAT DEMANDS A WIDESPREAD COOPERATIVE ATTACK FOR PROPER SOLUTION. WE NEED BETTER COOPERATION BETWEEN THE VARIOUS NASA CENTERS AND WE NEED TO INVOLVE ACADEMIA AND INDUSTRY RESEARCH. THE POTENTIAL FOR THE DEVELOPMENT OF TRANSFERRABLE NEW TECHNOLOGY ALONG WITH THE CHALLENGE PRESENTED BY THE PROBLEM SHOULD BE ATTRACTIVE INDUCEMENTS FOR THE PARTICIPATION OF THOSE NON-NASA GROUPS.

SLIDE 9

HOW DO WE GET THERE ?

- EARLY RECOGNITION OF THE BASIC NEEDS
  - MOST EFFECTIVE USE OF CREW
  - MOST EFFECTIVE USE OF ONORBIT TIME/RESOURCES
  - MORE COMPLETE AND CLEAR DEFINITION OF THE PROBLEM
  - PLENTIFUL SUPPLY OF HOOKS AND SCARS
- WIDESPREAD ATTACK OF THE PROBLEM
  - COOPERATIVE ATTACK- NASA CENTER-TO-CENTER, ACADEMIA AND INDUSTRY R/D EFFORTS
  - SIGNIFICANT VIA POTENTIAL FOR TECHNOLOGY TRANSFER TO OTHER PROGRAMS
  - TECHNOLOGICAL ADVANCES AND NEW TECHNOLOGY

SLIDE 10

THE FOLLOWING ARE RECOMMENDED FOR THE ATTACK OF THE SSF HEALTH ASSESSMENT AND MAINTENANCE PROBLEM

(1) ADOPT AND ENFORCE THE POLICY OF "DESIGN TO TEST". THIS APPROACH HAS PROVEN MOST EFFECTIVE FOR THE DEVELOPMENT OF TESTING AND HEALTH ASSESSMENT CAPABILITIES FOR LARGE AND COMPLEX SYSTEMS.

(2) MAKE CERTAIN THAT THE BASIC DESIGN OF THE SSF SYSTEMS INCORPORATES A PROPER AND PLENTIFUL SUPPLY OF SOFTWARE "HOOKS" AND HARDWARE "SCARS" TO ACCOMMODATE FUTURE GROWTH AND EXPANSION OF HEALTH ASSESSMENT TECHNOLOGY AND CAPABILITIES.

(3) STIMULATE INTEREST IN THE PROBLEM THROUGHOUT ALL NASA CENTERS AND NON-NASA RESEARCH ORGANIZATIONS.

(4) APPLY APPROPRIATE NEW TECHNOLOGIES TO SOLVE THE PROBLEM AND MAINTAIN FLEXIBILITY IN THEIR SELECTION. ENTERTAIN OUTGROWTHS OF PROVEN DEVELOPMENTS. AND THE PROSPECT OF COMBINING THE BEST FEATURES OF VARIOUS TECHNOLOGIES. AVOID A METHODOLOGY THAT LEADS TO "LOCK IN" TO A GIVEN TECHNOLOGY AND ADOPT ONE THAT IS ADAPTABLE TO GROWTH AND CHANGE.

SLIDE 10

RECOMMENDATIONS

- PROMOTE AND ENFORCE DESIGN/DEVELOPMENT REQUIREMENT FOR :
  - DESIGN TO TEST
  - INCORPORATION OF HOOKS/SCARS TO ACCOMMODATE EXPANDED CAPABILITIES/TECHNOLOGICAL GROWTH
- EXPAND ARENA OF PROBLEM RECOGNITION
  - ALL NASA CENTERS
  - ACADEMIC RESEARCHERS AND RESEARCH ORGANIZATIONS
  - INDUSTRIAL RESEARCH CENTERS/ORGANIZATIONS
- APPLY APPROPRIATE NEW TECHNOLOGIES TO OUR PROBLEM
  - OUTGROWTHS OF PROVEN DEVELOPMENTS
  - TECHNOLOGY COMBINATIONS (ASSEMBLIES OF BEST FEATURES)

SLIDE 11

FOR THE OPERATIONAL SSF WE NEED THE CONTINUAL ONBOARD CAPACITY TO ENSURE CREW AND MISSION SAFETY, OPERATIONAL READINESS AND SUFFICIENT PERFORMANCE RESERVES TO COPE WITH ANY UNFORESEEN EMERGENCY THROUGHOUT THE ONORBIT LIFE OF THE SSF. WE NEED A COMPLETE AND RELIABLE ABILITY TO EFFECTIVELY COPE WITH ANY FAULT OR FAILURE. WE NEED THE ONORBIT ABILITY TO VERIFY THAT ALL REPAIRS, REPLACEMENTS, UPGRADES AND ADDITIONS INTRODUCED TO THE OPERATIONAL SSF ARE PROPER AND CORRECT. WE NEED THE ONORBIT ABILITY TO CONDUCT THE TESTING NECESSARY TO ESTABLISH FULL CONFIDENCE IN THE EQUIPMENT AT ANY TIME. WE NEED THE ONORBIT ABILITY TO BE ASSURED THAT THAT ONBOARD TESTABILITY IS RELIABLE AND EFFICIENT.

SLIDE 11

WHAT DO WE NEED?

- ABILITY TO ISOLATE FAULTS AND FAILURES TO AN ORU - 100%.
- ABILITY TO ISOLATE FAULTS & FAILURES TO THE CARD OR SRU (FOR CERTAIN CARDS ie EDP)- 90%.
- ABILITY TO RECOVER FROM ALL FAULTS (TRANSIENTS OR PERMANENT).
- ABILITY TO WORK AROUND FAILURES.
- ABILITY TO ENSURE THAT S/W UPGRADES & CHANGES ARE INSTALLED PROPERLY AND PERFORM AS EXPECTED.
- ABILITY TO CONFIGURE SYSTEM FOR TESTING DURING GROUND OPERATION OR "ON DEMAND".
- ABILITY TO VERIFY SYSTEM/STATION CONFIGURATION/RECONFIGURATION & MODING AT ANY TIME.
- ABILITY TO DO TEST RESULTS PREPROCESSING ONBOARD TO REDUCE TELEMETRY/GROUND SUPPORT BURDEN.
- NEW DESIGNS UTILIZE/TESTABILITY TOOLS DURING DESIGN/DEVELOPMENT PHASE TO ENSURE ONORBIT TEST EFFICIENCY.

SLIDE 12

CONSIDERING THE SCOPE OF THE PROBLEM, THERE APPEARS TO BE NO EXISTING TECHNOLOGY THAT, TAKEN ALONE, CAN SATISFY ALL OUR REQUIREMENTS. THE PRIME CANDIDATES, AUTOMATED KNOWLEDGE BASED AND EXPERT DIAGNOSTIC SYSTEMS, APPEAR INADEQUATE AT THEIR CURRENT LEVEL OF DEVELOPMENT. THIS IS ALSO TRUE FOR TH CONVENTIONAL BIT/BITE. ONE PROBLEM WITH THESE IS THAT THE FOCUS OF THEIR DEVELOPMENTS TO THIS TIME HAS HAVE BEEN GENERALLY LIMITED TO LOW LEVELS OF ARCHITECTURE (REPLACEABLE UNITS AND SUBSYSTEMS). A SECOND PROBLEM IS THAT MOST HAVE BEEN DESIGNED TO PROVIDE DIAGNOSTICS FOR AFTER- THE- FACT, IN-SHOP USE. OUR REQUIREMENT IS FOR THE ADDRESS OF FULL AND INTERSYSTEM FAULT/FAILURE MANAGEMENT ONORBIT. THE DEMAND IS FOR NEW TECHNOLOGY THAT, PERHAPS BUILDS ON THESE EXISTING ONES, BUT THAT HAS ADDED SCOPE AND CAPABILITIES. THE INCORPORATION OF ONBOARD SOFTWARE SIMULATIONS AND MODELS INTO KNOWLEDGE BASED EXPERT SYSTEMS APPEARS TO BE ONE ATTRACTIVE POSSIBILITY. DESIGN TO TEST OF SYSTEMS (SYSTEM LEVEL BIT/BITE AND DIAGNOSTICS) IS A SECOND. FINALLY, WHAT ABOUT AN ONBOARD COMPUTER DEDICATED TO SYSTEM/INTER-SYSTEM TESTING ?

SLIDE 12

FOOD FOR THOUGHT

- POTENTIAL TECHNOLOGY

  - ONBOARD USE OF SOFTWARE SIMULATIONS AND MODELS

  - EXPERT SYSTEMS

  - KNOWLEDGE BASED AUTOMATED SYSTEMS

    - RULE BASED

    - MODEL BASED

    - OTHERS

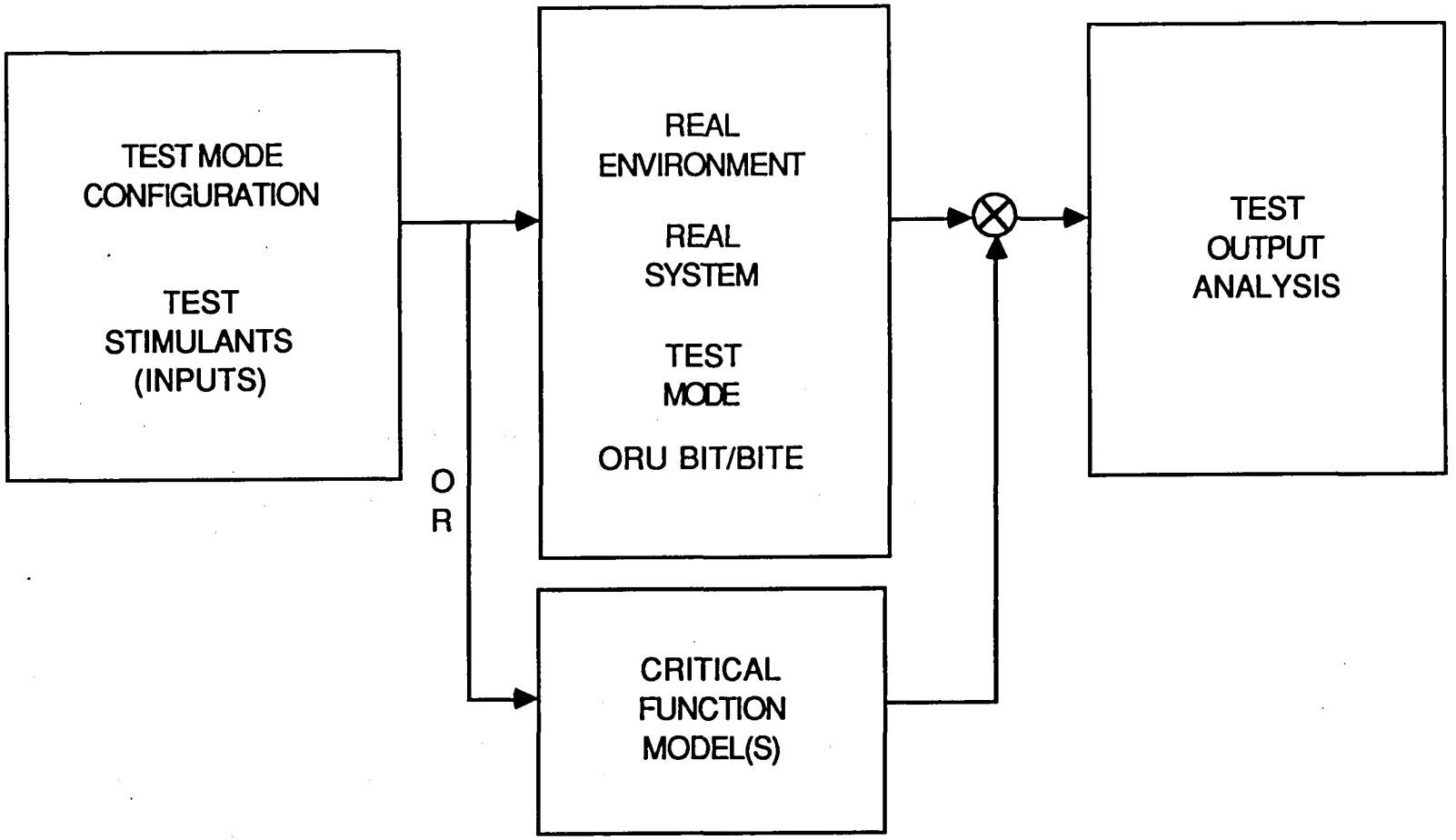
  - SYSTEM LEVEL BIT/BITE/DIAGNOSTIC DESIGN

  - NEED FOR DEDICATED ONBOARD TEST COMPUTER?

SLIDE 13

LET ME EXPAND A BIT ON THE NOTION OF INCORPORATING MODELS AND SIMULATIONS INTO KNOWLEDGE BASED SYSTEMS. WHY IS THAT POSSIBILITY SO ATTRACTIVE ? FIRST THEY WILL BE READILY AVAILABLE (DEVELOPED, AND GROWN TO MATURITY IN THE GROUND BASED IT&V PROGRAM). SECONDLY THEIR ONBOARD USE IS DEMANDED TO BYPASS CRITICAL FUNCTIONS DURING INTEGRATED TESTING. FINALLY, A GREAT DEAL OF DESIGN KNOWLEDGE IS NATURALLY EMBEDDED IN THOSE MODELS AND THEY CAN BE EFFECTIVELY EMPLOYED TO GROW KNOWLEDGE THROUGH THEIR USE TO PROVIDE STANDARDS FOR PERFORMANCE COMPARISONS.

SLIDE 13

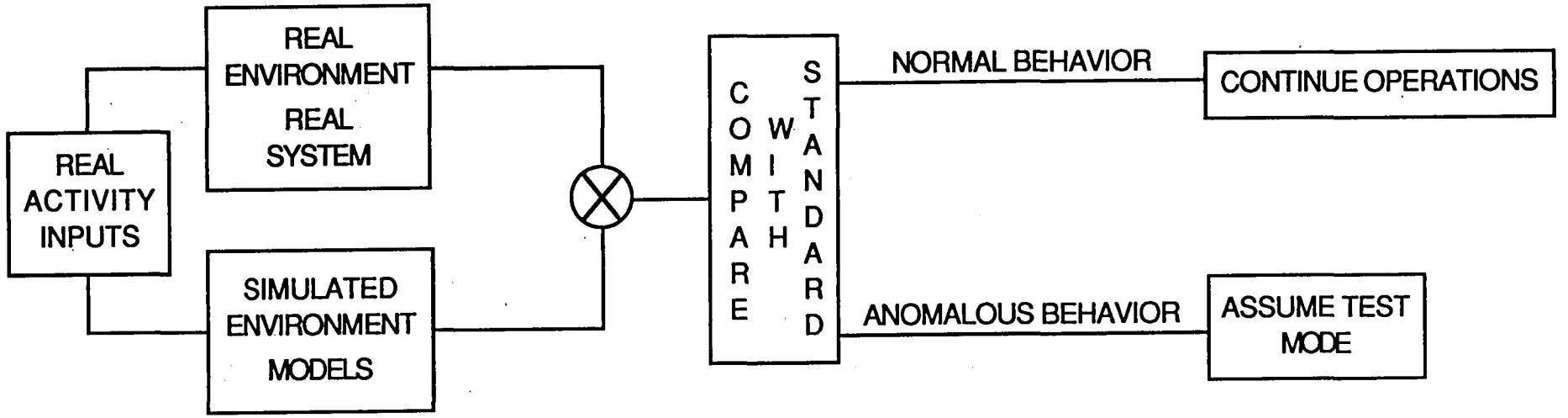


NON INTERFERENCE TESTING

SLIDE 14

CRITERIA FOR THE MEASUREMENT OF PERFORMANCE AND BEHAVIOR FOR FUNCTIONAL SYSTEMS AND COMPLEXES OF SYSTEMS WILL BE DIFFICULT, IF AT ALL POSSIBLE, TO DESCRIBE COMPLETELY AND ACCURATELY IN THE SYMBOLIC FORM REQUIRED BY CONVENTIONAL KNOWLEDGE BASES. THIS IS TO SUGGEST THAT SOFTWARE SIMULATIONS AND MODELS CAN BE EFFECTIVELY USED FOR THAT PURPOSE. THEY CAN BE EMPLOYED IN PARALLEL WITH REAL SYSTEM OPERATIONS TO PROVIDE STANDARDS FOR PERFORMANCE COMPARISONS. THOSE STANDARDS MAY BE OF IDEAL PERFORMANCE FOR THE MONITORING OF SYSTEM PERFORMANCE OR MAY BE SPECIALIZED FOR TESTING CONDUCTED TO ACQUIRE DIAGNOSTICS SHOULD THAT PERFORMANCE PROVE TO BE OUT OF TOLERANCE. SUCH USES WILL YIELD VALUABLE KNOWLEDGE REGARDING SYSTEM PERFORMANCE CHARACTERISTICS AND TRENDS. THEY MAY ALSO BE EMPLOYED FOR "WHAT IF" STUDIES TO EXPAND KNOWLEDGE REGARDING SYSTEM PERFORMANCE AND BEHAVIOR. FOR EXAMPLE, THEY MAY BE MANIPULATED TO SIMULATE SOME FAULT, FAILURE OR OFF NOMINAL CONDITION TO ESTABLISH SYSTEM HEALTH EVALUATION CRITERIA.

SLIDE 14

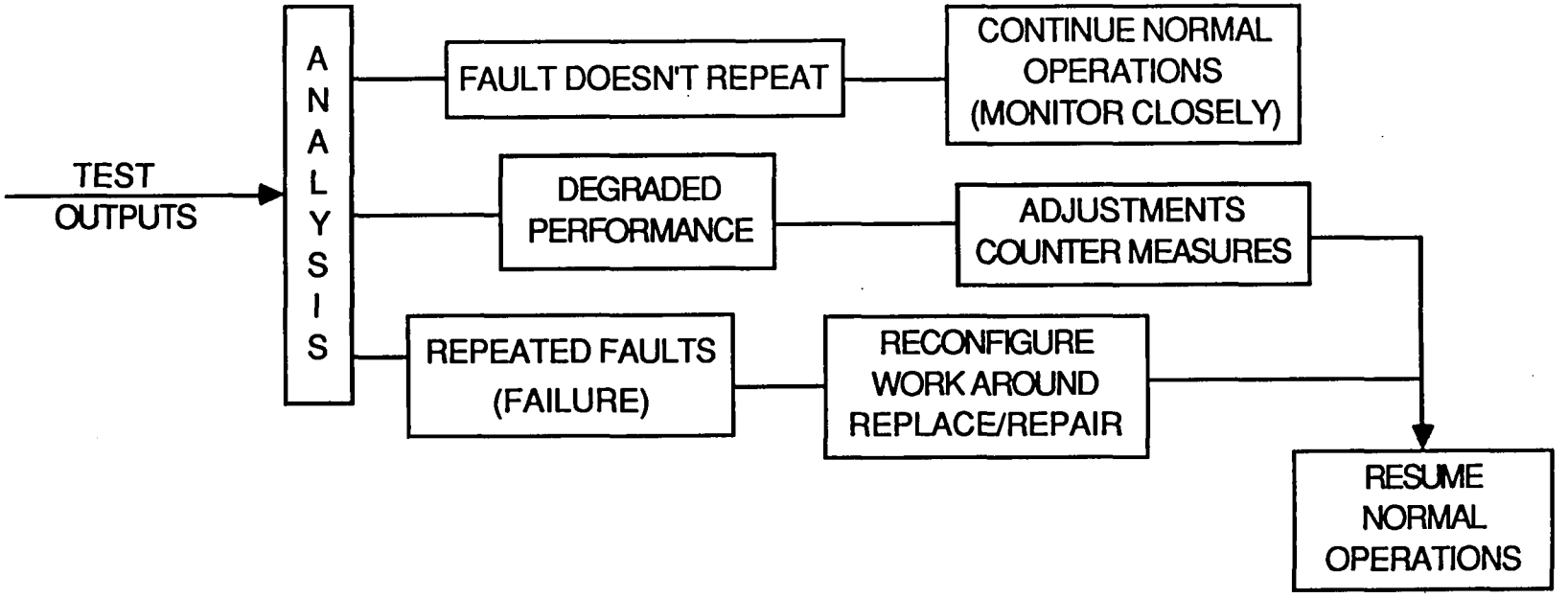


SIMULATION ASSISTED SURVEILLANCE

SLIDE 15

THE ONBOARD CAPABILITIES MUST PROVIDE FOR APPROPRIATE RESPONSES TO ONBOARD TESTING. THESE MUST INCLUDE THE ABILITY TO EFFECTIVELY ANALYZE TEST RESULTS THEN TO TAKE APPROPRIATE ACTION(S). IF THE RESULTS DON'T INDICATE A PROBLEM, NORMAL OPERATIONS ARE MAINTAINED. IF THERE IS AN INDICATED FAULT OR FAILURE ADDITIONAL TESTING MUST BE DONE, FIRST TO RULE OUT "FALSE ALARMS" THEN TO DERIVE A PROPER SET OF DIAGNOSTICS. SHOULD IT BE A FALSE ALARM, NORMAL OPERATIONS ARE RESUMED WITH INCREASED SURVEILLANCE OF THE SUSPECTED TEST SUBJECT OTHERWISE APPROPRIATE CORRECTIVE ACTION(S) ARE TAKEN (RM SWITCHOVER, WORK-AROUND RECONFIGURATION, REPAIR/REPLACEMENT). IF THE TEST RESULTS INDICATE ONLY PERFORMANCE DEGRADATION, NOT FAULT/FAILURE, THEN ACTIONS TO COUNTER THE PERFORMANCE DEGRADATION ARE IN ORDER. THESE MAY BE ADJUSTMENTS OF SYSTEM CONTROLS OR ACTIVITY SCHEDULES OR THEY MAY BE OF A DIFFERENT NATURE, BUT MUST BE DIRECTED AT RESTORING THE NOMINAL PERFORMANCE CAPABILITY. FOLLOWING ANY CORRECTIVE ACTION, IT MUST BE VERIFIED TO BE COMPLETE AND PROPER BEFORE ITS SUBJECT IS RESTORED TO NORMAL OPERATIONS.

SLIDE 15



TEST RESPONSE/POST TEST ACTIVITIES