N93-22097

ENTRY SYSTEMS PANEL

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ENTRY SYSTEMS PANEL

GENERAL FINDINGS:

- **LESSONS LEARNED FROM SHUTTLE:**
  - BRIDGE ESTABLISHED BETWEEN DEVELOPMENT CENTER (JSC), RESEARCH CENTERS (ARC, LARC), AND INDUSTRY (RI, LMSC, CORNING, MANSVILLE, 3M, LTV, UNION CARBIDE, HEXCEL) FOR SHUTTLE TPS
  - NOT ALL TEST RESULTS ADEQUATELY ANALYZED OR, IN HINDSIGHT, COMPLETELY ENCOMPASSING ALL FAILURE MODES.
    - TILE - SIP SEPARATION
    - SHOCK ON OMS POD EFFECTS ON AFRSI
    - OTHER EXAMPLES
  - GAP HEATING EFFECTS FROM GROUND FACILITIES NOT TOTALLY INDICATIVE OF FLIGHT EXPERIENCE
  - NEED TO DESIGN WITH OPERATIONS IN MIND (NOT JUST TO COST) EX: MOISTURE INTRUSION OF GR/EP, MANY OTHER EXAMPLES
  - RSI - DEVELOPED AS POINT DESIGN FOR MANEUVERING ENTRY VEHICLE OF HIGH L/D
  - RSI - 15 YEARS FROM INVENTION TO USE ON FLIGHT HARDWARE

GENERAL FINDINGS (CONT):

- **ENTRY SYSTEMS TECHNOLOGY NOT EASILY DIVORCED FROM SPECIFIC MISSION REQUIREMENTS**
  - PEAK HEATING, DURATION OF HEATING
  - GROUND OR ON-ORBIT ASSEMBLY
  - REUSE REQUIREMENT
- **NEED FAMILY OF TPS FOR VARYING VEHICLE PERFORMANCE REQUIREMENTS**
- SHUTTLE - FRSI, AFRSI, LRSI, HRSI, RCC
- AEROBRAKES MAY NEED ABLATORS OR C-C OR CMC OR RSI OR TBD DEPENDING ON MISSION
- **FLIGHT TESTS ENABLING FOR MANNED AEROBRAKE VEHICLES**
- AEROTHERMODYNAMICS ISSUES
- DEMONSTRATE ON-ORBIT ASSEMBLY/DEPLOYMENT/SERVICING
- **DIFFERENCES FOUND IN GROUND TEST RESULTS**
  - FLIGHT VS ARC JETS
  - JSC VS AMES ARC JETS

GENERAL FINDINGS (CONT):

- **MATERIALS DATA NOT READILY AVAILABLE**
  - NEED DATA BASE THAT IS CERTIFIED, MAINTAINED, ACCESSIBLE
  - NO ORGANIZATION WILLING TO FUND
- **DESIGN PHILOSOPHY MUST CONSIDER GROUND HANDLING OF VEHICLE**
  - ACCESSIBILITY TO EQUIPMENT AND STRUCTURE FOR INSPECTION AND SERVICING
- **U.S. TECHNOLOGY - FOREIGN TECHNOLOGY TRANSFERS BOTH WAYS**
  - U.S. BUYING FRENCH DEVELOPED MATERIAL TECHNOLOGY
    - METALLIC MULTIWALL TPS
      - DEVELOPED IN U.S. 1970's
      - ENHANCED IN GERMANY 1980's
      - ENHANCED CONCEPT CURRENT BASELINE ON PORTIONS OF SDIO SSTO
  - RUSSIANS AND FRENCH USING U.S. DEVELOPED TILE AND BLANKET TECHNOLOGY

ENTRY SYSTEMS PANEL

GENERAL FINDINGS (CONT):

- **BE WARY OF PRELIMINARY LOADS**
- **DON'T SKIP SUB-ASSEMBLY TESTING**
- **DESIGN FOR HANDLING, MAINTENANCE & REPAIR**
- **DON'T ALLOW DEVELOPMENT HISTORY TO VANISH**
  - DOCUMENT DESIGN DRIVERS AND IMPLEMENTATION ISSUES

TPS CRITICAL NEED

- **FLIGHT TESTING**
  - DEMONSTRATE AERO-ASSIST TECHNOLOGIES
  - DEMONSTRATE ON-ORBIT ASSEMBLY/DEPLOYMENT
  - VALIDATE NEW TPS TECHNOLOGIES

ENTRY SYSTEMS PANEL

ENTRY SYSTEMS QUAD CHARTS

TECHNOLOGY ITEMS

1. TOUGHENED CERAMIC TPS
2. ADVANCED C-C's
3. FLEXIBLE TPS
4. METALLIC TPS
5. LIGHTWEIGHT ABLATORS
6. JOINTS, FASTENERS, SEAMS, etc...
7. TPS/STRUCTURAL INTEGRATION
8. TPS/SYSTEM RESOURCE INTEGRATION
9. INSPECTION, NDE, AND SMART MATERIALS
10. SIMPLIFIED CERT/RE-CERT
11. ENVIRONMENTAL COMPATIBILITY
12. ON-ORBIT ACTIVITIES
13. TEST FACILITIES
14. NEW MODELING CODES (INTERDISCIPLINARY)

ENTRY SYSTEMS PANEL

ISSUES/TECHNOLOGY REQUIREMENTS

DESCRIPTION: • DEVELOP DURABLE, REUSABLE SURFACE INSULATION WITH HIGHER STRENGTH AND TEMPERATURE CAPABILITY	**PAYOFFS:** • PROVIDES MORE DURABLE, LIGHTER WEIGHT, MORE REFRACTORY RSI
BACKGROUND & RELATED FACTORS: • PRESENT RSI MATERIALS WERE DESIGNED WITH MINIMAL IMPACT RESISTANCE. • HIGHER STRENGTH RSI ENHANCES DIRECT BOND CAPABILITY • TOUGH NEW COATINGS AND/OR SURFACE TREATMENTS WILL ENHANCE DURABILITY • ADVANCED FIBERS PROVIDE MORE REFRACTORY RSI	**RECOMMENDED ACTIONS:** • INITIATE A PROGRAM TO IDENTIFY AND DEVELOP TOUGHENED COATINGS AND ADVANCED FIBERS • PERFORM MATERIAL CHARACTERIZATION TESTS ON THE NEW RSI MATERIALS • PERFORM THERMAL RESPONSE AND ARC PLASMA TESTS ON PROMISING CONCEPTS • PERFORM TPS SYSTEMS TESTS THAT LEAD TO ACCEPTANCE FOR USE ON THE EMERGING STS VEHICLES

ENTRY SYSTEMS PANEL

ISSUES/TECHNOLOGY REQUIREMENTS

DESCRIPTION:

- THIN, STRUCTURAL, OXIDATION-RESISTANT CARBON-CARBON (ORCC) COMPOSITES FOR TPS AND STRUCTURAL APPLICATIONS
  - LOW WEIGHT
  - DURABLE/REUSABLE
  - LOW MAINTENANCE AND REPAIR
  - TAILORED FOR SERVICE ENVIRONMENTS

PAYOFFS:

- LIGHTWEIGHT, PASSIVE THERMAL PROTECTION FOR PROJECTED NASA PLANETARY MISSIONS
- FABRICATION FACILITIES:
  - LIMITED COATING CAPABILITY, BUT CAN BE EXPANDED
  - FACILITY NEEDS DEPENDENT ON PARTICULAR MATERIAL SYSTEM

BACKGROUND & RELATED FACTORS:

- REINFORCED CARBON-CARBON (RCC) SHUTTLE LEADING EDGE AND NOSE CAP HAVE NO FLIGHT ANOMALIES
- HIGHER SPECIFIC STRENGTH OF ACC DEMONSTRATED (UP TO 5X RCC)
- ADVANCED ORCC COMPOSITES BASELINED AS TPS ON NASP X-30
- DESIGN, FABRICABILITY, AND ASSEMBLY OF BUILT-UP STRUCTURE DEMONSTRATED FOR ADVANCED C-C
- MAJOR DEFICIENCY IS LONG-LIFE OXIDATION PROTECTION

RECOMMENDED ACTIONS:

- DEVELOP IMPROVED CONCEPT FOR OXIDATION PROTECTION (COATINGS, INHIBITORS, SEALANTS,GLAZES)
- CONTINUE EFFORTS TO IMPROVE MECHANICAL PROPERTIES
- INCREASE EFFORTS TO ADAPT/DEVELOP EFFECTIVE "ONE-SIDE" NDE TECHNIQUES
- IDENTIFY CRITICAL, LIFE-LIMITING TESTS FOR ADVANCED ORCC MATERIALS
- FULL-SCALE TESTING OF COMPONENTS
- DOCUMENT PROCESS AND DESIGN ALLOWABLES

DESCRIPTION:

- HIGHER TEMPERATURE FLEXIBLE INSULATIONS (FELTS, QUILTS, WOVEN BLANKETS)

PAYOFFS:

- FLEXIBLE INSULATIONS/STRUCTURES ARE USEFUL FOR ALL ENTRY SYSTEMS/STRUCTURES

BACKGROUND & RELATED FACTORS:

- FLEXIBLE INSULATIONS OFFER EXCELLENT BENEFITS
- LOW WEIGHT
- MINIMUM CERTIFICATION INVESTMENT REQUIRED
- LOWER LIFE CYCLE COSTS
- NO ATTACHMENT HARDWARE
- CURRENTLY AVAILABLE (USED) FLEXIBLE INSULATIONS ARE TEMPERATURE LIMITED
  - FRSI 700° F
  - AFRSI 1500° F
- AVAILABLE ADVANCED HIGH TEMPERATURE FIBERS CAN SIGNIFICANTLY INCREASE TEMPERATURE CAPABILITY

RECOMMENDED ACTIONS:

- DEVELOP AND EVALUATE INORGANIC/ORGANIC YARNS, FABRICS, FELTS AND BLENDS
- IMPROVE LOW COST FABRICATION METHODS
- DEVELOP FLEXIBLE CERAMIC COATINGS HAVING:
  - HIGH TEMPERATURE RESISTANCE
  - HIGH EMISSIVITY
  - MOISTURE RESISTANCE
  - AERODYNAMIC/VIBROACOUSTIC STABILITY
- DEVELOP HIGH TEMPERATURE, FLEXIBLE ADHESIVES TO TAKE ADVANTAGE OF WARM (HIGH TEMPERATURE COMPOSITE) STRUCTURES

ENTRY SYSTEMS PANEL

ISSUES/TECHNOLOGY REQUIREMENTS

DESCRIPTION: • METALLIC TPS MATERIAL & INTEGRATION DEVELOPMENT AND VALIDATION	**PAYOFF/RESOURCES:** • LIGHTWEIGHT, DURABLE TPS FOR EXTENDED WEATHER ENVIRONMENTS
BACKGROUND & RELATED FACTORS: • METALLICS OFFER POTENTIAL FOR MORE FLEXIBILITY IN WEATHER ENVIRONMENTS - CURRENT TPS MATERIALS LIMIT FLIGHT THROUGH WEATHER ENVIRONMENTS - METALLICS CAN WITHSTAND LIGHTNING STRIKES - METALLICS OFFER HIGH MECHANICAL STRENGTH • METALLIC-TPS IS MECHANICALLY ATTACHED WITH BACK-FACE CLIPS - CERAMIC TILES MUST BE ADHESIVELY BONDED - NOT EASILY DETACHED/REPLACED - SUBJECT TO DEBONDING - IMPAIRS INSPECTION OF STRUCTURE • METALLIC TPS IS WEIGHT-COMPATIBLE WITH CERAMICS & CMC TPS TECHNOLOGY	**RECOMMENDED ACTIONS:** • DETERMINE HIGH-TEMPERATURE STRENGTH & THERMAL PROPERTIES (STATIC TEST) • TEST IMPACT RESISTANCE IN PARTICLE IMPINGEMENT TEST FACILITY - CONFIRM/DETERMINE MINIMUM GAGE TOLERANCE/REQUIREMENT • DEVELOPMENT OF LOW CATALYCITY, HIGH EMISSIVITY, COMPATIBLE COATINGS • DETERMINE OXIDATION & CORROSION RESISTANCE • TEST THERMAL PERFORMANCE AS INTEGRATED TPS PANEL (WITH INSULATION) - ACOUSTIC TOLERANCE - EFFECTIVE CONDUCTIVITY - HOT GAS FLOW PREVENTION EFFECTIVENESS

DESCRIPTION: • DEVELOP ADVANCED, LOW DENSITY, HIGH TEMPERATURE ABLATIVE TPS FOR ADVANCED EARTH AND PLANETARY ENTRY SPACECRAFT APPLICATIONS	**PAYOFFS:** • ENABLING TECHNOLOGY FOR RADIATION EQUILIBRIUM TEMPERATURE ABOVE 3000°F
BACKGROUND & RELATED FACTORS: • ABLATIVE TPS SUCCESSFULLY USED FOR MANNED VEHICLES. NO DEVELOPMENT SINCE APOLLO/VIKING. • ABLATOR TPS THERMAL PERFORMANCE PREDICTABLE • LIGHTWEIGHT TPS REQUIRED TO MAXIMIZE PAYLOAD WEIGHT AND DECREASE COST • UNEXPECTED THERMAL EXCURSIONS NOT CRITICAL • AEROASSIST AND DIRECT ENTRIES FOR LUNAR AND PLANETARY MISSIONS REQUIRE HIGH TEMPERATURE TPS	**RECOMMENDED ACTIONS:** • DEVELOP NEW, ADVANCED LOW DENSITY ABLATION MATERIALS • IDENTIFY AND CHARACTERIZE ADVANCED ABLATION MATERIALS • DESIGN, FABRICATE ABLATIVE TPS • CHARACTERIZE THERMAL PERFORMANCE OF SUB-SCALE TPS PANEL IN ARC JET SIMULATION OF ENTRY ENVIRONMENT • UPDATE AND VERIFY ANALYTICAL MODELS • MODIFY ARC JET FACILITIES TO TEST LARGE TPS PANEL

ENTRY SYSTEMS PANEL
ISSUES/TECHNOLOGY REQUIREMENTS

DESCRIPTION:

- DEVELOPMENT OF SPECIAL TPS COMPONENTS:
  - JOINTS
  - FASTENERS
  - SEAMS
  - NOSETIP & LEADING EDGES

PAYOFFS:

- ENABLING TECHNOLOGY FOR SPACE-ASSEMBLED TPS
- REDUCE COST AND SCHEDULE IMPACTS ON FUTURE PROGRAMS

BACKGROUND & RELATED FACTORS:

- SPECIAL TPS COMPONENTS HAVE HAD COST AND SCHEDULE IMPACTS ON EXISTING SYSTEMS:
  - SEAMS, JOINTS, FASTENERS, ATTACHMENTS, MOVING SURFACES AND ADHESIVES ARE CRITICAL INTERFACES IN ALL TPS DESIGNS
  - VERY HIGH HEATING REGIONS SUCH AS NOSE TIPS AND LEADING EDGES REQUIRE SPECIAL DESIGN CONSIDERATIONS INCLUDING POSSIBLE USE OF HEAT PIPES

RECOMMENDED ACTIONS:

- DESIGN, FABRICATE, AND TEST ADVANCED SPECIAL TPS COMPONENTS
- MODIFY FACILITIES FOR TESTING THESE TPS COMPONENTS

DESCRIPTION:

- LIGHTWEIGHT, INSULATING CERAMIC MATRIX COMPOSITES (CMC):
  - WARM STRUCTURE (BACKFACE TEMP 600°F) WHICH CONSISTS OF CONTINUOUS FIBER REINFORCED FACESHEETS WITH A REUSABLE SURFACE INSULATION CORE HARD BONDED TO A LOAD BEARING POLYIMIDE/GRAPHITE OR BMI SUBSTRATE
  - HOT STRUCTURE (SANDWICH STRUCTURE), CONSISTS OF CONTINUOUS FIBER REINFORCED CMC FACESHEETS DIRECTLY BONDED TO AN RSI CORE. THIS CMC SANDWICH IS A LIGHTWEIGHT STRUCTURE FOR LOAD BEARING HOT STRUCTURE

PAYOFFS:

- LIGHTWEIGHT, PASSIVE THERMAL PROTECTION FOR PROJECTED NASA SPACE FLIGHT MISSIONS
- DAMAGE TOLERANT SURFACES
- HIGH OXIDATION RESISTANCE

BACKGROUND & RELATED FACTORS:

- THE BASELINE GLASS COATED RSI MATERIALS ARE FRAGILE, HAVE MINIMAL STRENGTH, AND ARE LIMITED TO 2500° F USE TEMPERATURE
- THE BASELINE RSI & RCC SYSTEMS REQUIRE LABOR INTENSIVE INSTALLATION PROCEDURES

RECOMMENDED ACTIONS:

- IDENTIFY AND DEVELOP FUNCTIONALLY GRADIENT CORE MATERIALS THAT ARE COMPATIBLE WITH EXISTING CMC FACESHEETS
- DEVELOP PROCESSING METHODS TO COMBINE CMC FACESHEETS WITH LOW DENSITY CORES
- PERFORM OVEN SOAK, THERMAL RESPONSE AND ARC JET SCREENING TESTS TO DETERMINE CONCEPT FEASIBILITY
- PERFORM MATERIAL CHARACTERIZATION TESTS ON THE PROMISING NEW LIGHTWEIGHT CMC STRUCTURES
- PERFORM THERMAL AND STRUCTURAL ANALYSIS OF THE CMC USING THE BASELINE DATA

ENTRY SYSTEMS PANEL
ISSUES/TECHNOLOGY REQUIREMENTS

DESCRIPTION:	PAYOFFS:
• WATER BASED COMPOSITE THERMAL PROTECTION SYSTEM AND STRUCTURE	• ELIMINATES COSTLY ASSEMBLY AND DEPLOYMENT TECHNIQUES • DEMONSTRATION REQUIRED BEFORE SEI ARCHITECTURE FINALIZED TO TAKE ADVANTAGE OF WEIGHT AND COST SAVINGS
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• WEIGHT AND COST OF PAYLOAD-TO-ORBIT KEY TO SEI FEASIBILITY • SYNERGISTIC USE OF ON-BOARD RESOURCES MINIMIZES WEIGHT TO ORBIT, I.E. WATERBASED POLYMER OR ICE MATRIX COMPOSITES UTILIZES RESOURCES NOW CONSIDERED EXPENDABLE • DEPLOYMENT AND RIGIDIZATION MINIMIZES MANPOWER AND ENERGY FOR ON-ORBIT FABRICATION OF AEROBRAKE STRUCTURES • WATER BASED SYSTEMS NONTOXIC	• PERFORM STUDIES OF WATER BASED POLYMER/ICE MATRIX COMPOSITES: PROPERTIES, PROCESSES, FABRICATION OF COMPOSITE DESIGN • FABRICATE AND TEST REPRESENTATIVE CONCEPTS • DEMONSTRATE ON SHUTTLE OR SPACE STATION FOR DEPLOYMENT AND RIGIDIZATION ON ORBIT

DESCRIPTION:	PAYOFFS:
• NDT/NDE/SMART MATERIALS - DESIGN SHOULD ALLOW FOR SELF-ANALYSIS OF MATERIAL USING NDT/NDE OR SMART INSTRUMENTATION WITHIN (OR ATTACHED TO) THE MATERIAL	• LOWER LIFE CYCLE COSTS • INCREASED FUNDING REQUIRED TO INCLUDE ADDITIONAL TESTING AND EQUIPMENT DEVELOPMENT.
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• UNKNOWN AMOUNT OF OXIDATION/DAMAGE IN RCC • SUSPECT RSI BOND CONDITION REQUIRES REMOVAL AND REPLACEMENT • CURRENT NDE/BOND VERIFICATION LIMITED BY SCHEDULE/FUNDING • NDE/TECHNIQUES REQUIRED TO PREVENT UNNECCESSARY REMOVAL AND REPLACEMENT • ON-ORBIT INSPECTION IMPRACTICAL	• DEVELOP NDT/NDE DURING ORIGINAL DESIGN/MANUFACTURE (BASELINE NEW INSTALLATION) • DESIGN FAILURE INDICATORS INTO MATERIAL • PERFORM TESTING TO VERIFY NDE/NDT/INDICATORS PERFORMANCE IN DETECTION.

ENTRY SYSTEMS PANEL

ISSUES/TECHNOLOGY REQUIREMENTS

DESCRIPTION:	PAYOFFS:
• REDUCE COMPLEXITY OF TPS CERTIFICATION/RECERTIFICATION	• TPS MODIFICATION AND DESIGN RELATED UPGRADES • TECHNOLOGY APPLICATION TO BOTH PRESENT, AS WELL AS FUTURE SPACECRAFT DESIGNS
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• PRESENT METHOD OF INCORPORATING DESIGN CHANGES COSTLY AND TIME CONSUMING • OEX PROVIDED MEANS TO CERTIFY WITHOUT EXTENSIVE CERTIFICATION • CERTIFICATION BY SIMILARITY • PRESENT DRAWING CHANGES REQUIRED TREEING INTO TOTAL PACKAGE	• USE MODELING FOR ANALYSIS • USE OEX DEVELOPED TECHNIQUES FOR CERTIFYING NEW MATERIALS • CHANGE DOCUMENTATION BY ALLOWING CHANGES AT SUB-LEVELS • USE SIMILARITY IN NON-CRITICAL AREAS • STANDARDIZE RECERTIFICATION REQUIREMENTS (I.E., MISSION REQUIREMENTS)

DESCRIPTION:	PAYOFFS:
• WEATHERPROOFING TPS AGAINST TERRESTRIAL ENVIRONMENT	• MISSION FLEXIBILITY IN WEATHER ENVIRONMENTS • REDUCED LIFE CYCLE COSTS
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• RAIN, TAPWATER ABSORPTION INCREASES LAUNCH WEIGHT, CAUSES FREEZE DAMAGE TO TPS • HAIL, ICE IMPACTS ERODE TPS - LOSS OF INTEGRITY • PROTECTION (EITHER FACILITY AND/OR MATERIAL) PRESERVES INTEGRITY OF TPS DURING UNWANTED ENVIRONMENTS • COMPATIBILITY OF OPERATING ENVIRONMENT (E.G., FUELS, VAPORS, ETC.)	• DEVELOP REUSABLE COATING/SYSTEM IMPERMEABLE TO IMPACT DAMAGE/WATER INTRUSION/REENTRY THERMAL ENVIRONMENT • DEVELOP SEALS, FLOW PATHS TO PRECLUDE ABSORPTION OF MOISTURE IN INTERNAL INSULATION • ASSESS REAL THREAT TO EACH ELEMENT • FACILITY DESIGN TO ACCOMMODATE ENVIRONMENT

ENTRY SYSTEMS PANEL
ISSUES/TECHNOLOGY REQUIREMENTS

DESCRIPTION:	PAYOFFS:
• DETERMINE LONG TERM SPACE EXPOSURE EFFECTS ON TPS FOR INTERPLANETARY VEHICLES	• ENABLING TECHNOLOGY FOR PLANETARY ENTRY TPS
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• ATOMIC OXYGEN (AO) AFFECTS POLYMER MATERIALS AND COATINGS • LONG TERM ENVIRONMENTAL DURABILITY UNKNOWN • RADIATION MAY DEGRADE MATERIALS, COATINGS, FILMS • MATERIALS, COATINGS, FILM PROPERTIES MUST REMAIN PREDICTABLE OVER LONG TERM • PARTICLE IMPACT CAN DAMAGE TPS	• DETERMINE LONG TERM EFFECTS OF VACUUM, AO, DEBRIS/DUST IMPACT, RADIATION • DETERMINE COMPATIBILITY WITH OTHER SPACECRAFT SYSTEM MATERIALS/FUELS • DEVELOP PROTECTIVE SYSTEMS AND EVALUATE TPS PERFORMANCE

DESCRIPTION:	PAYOFFS:
• DEVELOP ON-ORBIT DEPLOYMENT ASSEMBLY/SERVICING TECHNIQUES	• ENABLING TECHNOLOGY IS REQUIRED FOR VERIFICATION AND CERTIFICATION OF SPACE ASSEMBLED AND/OR DEPLOYED HARDWARE SYSTEMS. • REQUIRED 3-5 YEARS PRIOR TO SEI MISSIONS (LUNAR MISSION-2002, MARS MISSION -2020)
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• NO LAUNCH SYSTEMS AVAILABLE FOR DELIVERING GROUND ASSEMBLED LARGE TPS STRUCTURES TO ORBIT	• DEVELOP FLIGHT TEST PLAN AND ASSOCIATED ENTRY SYSTEM HARDWARE FOR DEMONSTRATION OF ON-ORBIT OPERATIONS OF ENTRY HARDWARE SYSTEMS WHICH MAY INCLUDE: - DEPLOYMENT OF ENTRY SYSTEM STRUCTURE - ASSEMBLY OF ENTRY SYSTEM STRUCTURAL COMPONENTS

ENTRY SYSTEMS PANEL

ISSUES/TECHNOLOGY REQUIREMENTS

DESCRIPTION:	PAYOFFS:
• DEFINE AND UPGRADE FACILITY CAPABILITIES FOR TPS TESTING	• PROVIDES RELIABLE THERMAL STRUCTURAL DATA BASE FOR NEW THERMAL PROTECTION SYSTEMS • REQUIRED 10-15 YEARS PRIOR TO SEI MISSIONS (LUNAR MISSION-2002, MARS MISSION-2020)
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• NO NEW ARC-JET FACILITIES IN 20 YEARS • CURRENT ARC-JET FACILITIES NOT ADEQUATE TO TEST LARGE TPS SUBSYSTEMS ELEMENTS AT REPRESENTATIVE CONDITIONS • CURRENT ARC-JET INSTRUMENTATION LIMITED TO INTRUSIVE FLOW MEASUREMENTS	• UPGRADE ARC JET FACILITIES TO: - ACCOMMODATE LARGE SIZE TPS SUBYSTEM ELEMENTS - PROVIDE UNIFORM HIGH QUALITY FLOW - PROVIDE COMBINED RADIATIVE AND CONVECTIVE HEATING - PROVIDE APPROPRIATE PLANETARY GAS COMPOSITIONS (MARS, VENUS, TITAN) • UPGRADE ARC JET FACILITY INSTRUMENTATION TO MEASURE: - TUNNEL FLOW CONDITIONS AND CHEMISTRY USING NON-INTRUSIVE FLOW METHODOLOGY - TEST ARTICLE STRESS/STRAIN AT TEMPERATURE - SURFACE TEMPERATURE DISTRIBUTION - AERO/ACOUSTIC ENVIRONMENT

DESCRIPTION:	PAYOFFS:
• DEVELOPMENT OF INTERDISCIPLINARY MODELING CODES FOR ADVANCED THERMAL PROTECTION MATERIALS AND SYSTEMS WITH CAPABILITY TO HANDLE - MICRO-LEVEL MATERIAL EFFECTS - MATERIALS RESPONSE - TPS/STRUCTURAL RESPONSE - LIFE PREDICTIONS - AEROELASTICITY - DESIGN OPTIMIZATION	• ADVANCED CODE DEVELOPMENT AND VALIDATION IS AN ENABLING ACTIVITY FOR FUTURE VEHICLE DESIGN AND DEVELOPMENT • SUBSTANTIAL INCREASES IN COMPUTATIONAL RESOURCES REQUIRED EARLY IN DEVELOPMENT CYCLE • ADVANCED INSTRUMENTATION AND FACILITY UPGRADES REQUIRED TO GENERATE BENCHMARK DATA • 5-10 YEAR DEVELOPMENT TIME
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• ABLATIVE MODELING CODES ARE 10-20 YEARS OLD • INTERDISCIPLINARY APPROACHES ARE ESSENTIAL FOR VEHICLE MULTI-PARAMETER OPTIMIZATION • COUPLING TO ADVANCED CFD CODES REQUIRED FOR COMPLETE SYSTEM RESPONSE MODELING	• ESTABLISH WORKING RELATIONSHIP BETWEEN CFD, CSM, AND COMPUTATIONAL MATERIALS COMMUNITIES • SUPPORT COMPUTATIONAL RESOURCES AND CODES DEVELOPMENT ACTIVITIES • GENERATE NECESSARY BENCHMARK DATA FOR MULTIDISCIPLINARY CODE VALIDATION

ENTRY SYSTEMS PANEL

TPS IMPROVEMENTS WILL FULFILL FUTURE PROGRAM NEEDS

IMPROVED PERFORMANCE SAFETY/RELIABILITY

HAZARD RISK REDUCED THROUGH IMPACT RESISTANCE & HIGHER TEMPERATURE CAPABILITY

MARGINS INCREASED THROUGH IMPLEMENTATION OF HIGHER STRENGTH MATERIALS

LOWER OPERATING COST

OPERATIONAL COST REDUCED THROUGH IMPROVEMENTS IN TPS THERMAL CAPABILITY & DURABILITY (IMPROVED MAINTAINABILITY)

TURNAROUND TIME DECREASED

INCREASED CAPABILITY/ SUPPORTABILITY

VEHICLE CAPABILITY IMPROVED THROUGH USE OF LIGHTER WEIGHT TPS MATERIALS

FLIGHT PERFORMANCE MARGINS INCREASED BY REDUCING SUSCEPTIBILITY OF TPS TO WEATHER DAMAGE