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:	PAYOFFS:
• 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	• 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:	**RECOMMENDED ACTIONS:**
• 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	• 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:	PAYOFFS:
• HIGHER TEMPERATURE FLEXIBLE INSULATIONS (FELTS, QUILTS, WOVEN BLANKETS)	• FLEXIBLE INSULATIONS/STRUCTURES ARE USEFUL FOR ALL ENTRY SYSTEMS/STRUCTURES
BACKGROUND & RELATED FACTORS:	**RECOMMENDED ACTIONS:**
• 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	• 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:

- WATER BASED COMPOSITE THERMAL PROTECTION SYSTEM AND STRUCTURE

PAYOFFS:

- ELIMINATES COSTLY ASSEMBLY AND DEPLOYMENT TECHNIQUES
- DEMONSTRATION REQUIRED BEFORE SEI ARCHITECTURE FINALIZED TO TAKE ADVANTAGE OF WEIGHT AND COST SAVINGS

BACKGROUND & RELATED FACTORS:

- 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

RECOMMENDED ACTIONS:

- 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:

- NDT/NDE/SMART MATERIALS
  - DESIGN SHOULD ALLOW FOR SELF-ANALYSIS OF MATERIAL USING NDT/NDE OR SMART INSTRUMENTATION WITHIN (OR ATTACHED TO) THE MATERIAL

PAYOFFS:

- LOWER LIFE CYCLE COSTS
- INCREASED FUNDING REQUIRED TO INCLUDE ADDITIONAL TESTING AND EQUIPMENT DEVELOPMENT.

BACKGROUND & RELATED FACTORS:

- 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

RECOMMENDED ACTIONS:

- 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:
- DEFINE AND UPGRADE FACILITY CAPABILITIES FOR TPS TESTING

PAYOFFS:
- 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:
- 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

RECOMMENDED ACTIONS:
- 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:
- 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

PAYOFFS:
- 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:
- 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

RECOMMENDED ACTIONS:
- ESTABLISH WORKING RELATIONSHIP BETWEEN CFD, CSM, AND COMPUTATIONAL MATEIRALS 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