



SPACE ASSEMBLED ENTRY SYSTEMS	Structures and Mechanics Division	
	Donald M. Curry	September, 1991

**SPACE ASSEMBLED ENTRY SYSTEMS
CERTIFICATION**

Donald M. Curry

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ISSUE:

- **HOW DO YOU SAY YOU'RE "GOOD FOR GO" IF YOU SPACE ASSEMBLE AN ENTRY VEHICLE?**

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APPROACH:

- **SHUTTLE ORBITER THERMAL PROTECTION CERTIFICATION**
- **SHUTTLE THERMAL PROTECTION SYSTEM FLIGHT EXPERIENCE**
- **SPACE ASSEMBLED ENTRY SYSTEM CERTIFICATION**

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- ORBITER TPS CERTIFICATION PROCESS
 - TESTS
 - THERMAL PERFORMANCE
 - AERODYNAMIC FLOW
 - ACOUSTIC FATIGUE
 - STRENGTH INTEGRITY
 - MATERIAL PROPERTIES
 - ANALYSIS
 - NATURAL ENVIRONMENTS
 - INDUCED ENVIRONMENTS
 - MISCELLANEOUS
 - SIMILARITY
 - COMMIT-TO-FLIGHT

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ORBITER TPS ENVIRONMENTS FOR CERTIFICATION

Natural Environments

Temperature - Atmospheric
 Thermal - Vacuum
 (Solar Radiation - Thermal)
 Pressure
 Fungus
 Meteoroids
 Humidity
 Lightning
 Ozone
 Rain
 Salt Spray
 Sand/Dust
 Solar Radiation - Nuclear
 Wind

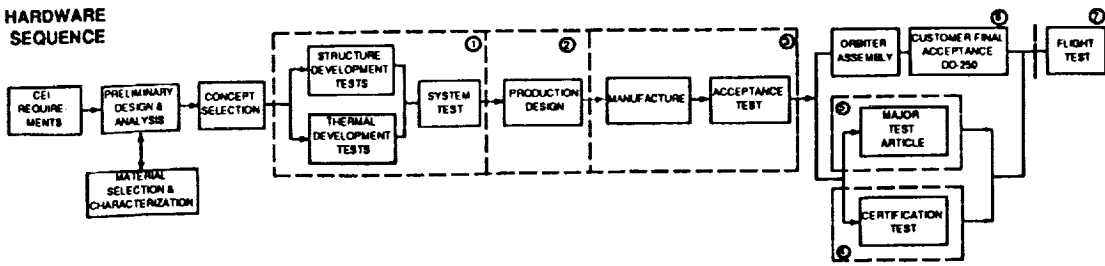
Induced Environments

Temperature
 Ascent Heating
 On-Orbit and Entry Heating
 Pressure
 Acoustics
 Shock
 Random Vibration
 Structural Loads
 Limit and Ultimate
 Acceleration

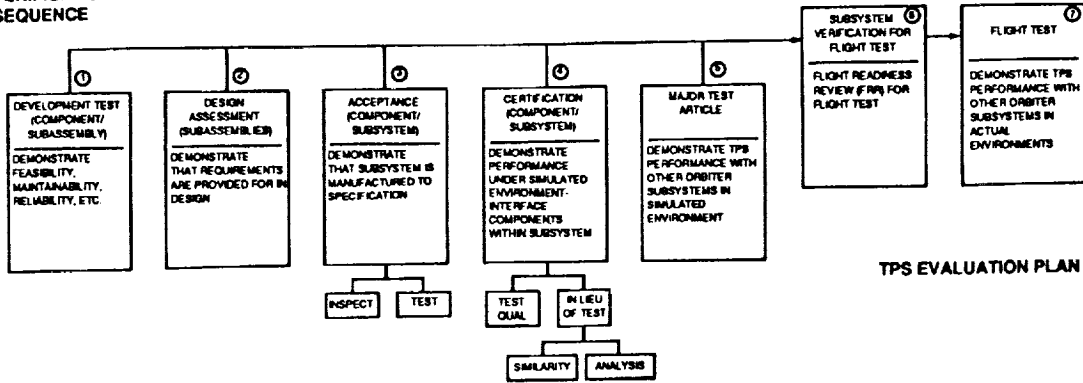
Miscellaneous Environments

Life - Full and Limited
 Fluid Compatibility

HARDWARE SEQUENCE



VERIFICATION SEQUENCE



TPS EVALUATION PLAN

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- SHUTTLE TPS FLIGHT EXPERIENCE
 - IMPACT DAMAGE
 - GAP FILLER DAMAGE
 - WINDOW CONTAMINATION

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**ORBITER TPS FLIGHT EXPERIENCE
IMPACT DAMAGE**

- **STATIC AREAS**
- **DYNAMIC INTERFACES**

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**ORBITER TPS FLIGHT EXPERIENCE
GAP FILLER DAMAGE/TILE SLUMPING**

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**CERTIFICATION OF SPACE ASSEMBLED
ENTRY SYSTEM**

- SCOPING OUT THE ENVIRONMENT
 - TEMPERATURES - SURFACE, STRUCTURES
 - VIBROACOUSTIC/AEROSHOCK
 - AIRLOADS
- HOW THE VEHICLE IS DESIGNED
 - IDENTIFY CRITICAL LOCATIONS
 - TEMPERATURE
 - LOADS
 - MARGINS OF SAFETY
 - MATERIALS DATA BASE
- HOW THE VEHICLE IS BUILT/ASSEMBLED
 - CRITICAL PROCESSING PARAMETERS
 - INSPECTION POINTS/RIGOR
 - ACCEPTANCE CRITERIA
 - REPAIRS/MAINTAINABILITY
- FLIGHT EXPERIENCE
 - LESSONS LEARNED
 - FLIGHT TEST
 - ANOMALY RESOLUTION

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FACTORS THAT INFLUENCE TPS DESIGN

- Maturity*
- Density*
- Aerothermal (Temperature)*
- Strength(Airloads/Vibroacoustic)*
- Outgassing*
- Oxidation Resistance*
- Atomic*
- Diatomic*
- Damage Tolerance/Impact Resistance*
- Repairability*
- Refurbishment*
- Long Term Space Exposure*
- Multi-use*
- Man-rated*
- Size Limits - Fabrication*

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CERTIFICATION - KEY ISSUES

- DESIGN/ASSEMBLY
 - GAP HEATING IN JOINT REGIONS BETWEEN SEGMENTS
 - SEAL PERFORMANCE AT INTERFACES
 - PREVENTION OF HOT GAS/RADIATION LEAKS
 - TPS PENETRATIONS

SUCH DESIGN PROBLEMS ARE NOT REALISTICALLY ASSESSED UNTIL A REQUIREMENT EXISTS TO "FLY THE SYSTEM."

- MATERIALS
 - DAMAGE TOLERANCE/IMPACT RESISTANCE
 - LONG TERM SPACE EXPOSURE

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CERTIFICATION - METHODS

- UTILIZATION OF EXISTING DATA BASE
 - Analytical Methods
 - Ground Test Results
 - Flight Tests
- GROUND-BASED TESTING OF SPACE ASSEMBLED ENTRY SYSTEM CONCEPTS
 - Ability to simulate environment
 - Lack of correlation with actual flight environment
- ANALYTICAL CERTIFICATION
 - Verified models using available flight and ground test data
 - Aeroassist Flight Experiment (AFE) data

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CERTIFICATION - METHODS (cont.)

- **FLIGHT TEST OF A SPACE ASSEMBLED ENTRY SYSTEM**
 - Forces disciplined Design and Fabrication
 - Encourages acceptance of new (revolutionary) concepts
 - Addresses complex problem of mutual interactions within system
 - Acquires vital quantitative data not available through ground test

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SUMMARY

- Significant advances have been made in the design, fabrication, certification and flight tests of entry systems (Mercury through Shuttle Orbiter).
- Shuttle experience has identified some key design and operational issues.
- Space assembled entry system certification/verification
 - Demonstration of advanced technology
 - Attention to vehicle design, fabrication and assembly
 - Flight experience

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ORBITER TPS FLIGHT EXPERIENCE

WINDOW HAZING/CONTAMINATION



10.3.2 Thermal Protection System of the Space Shuttle Orbiter
by F.E. Jones, NASA KSC