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	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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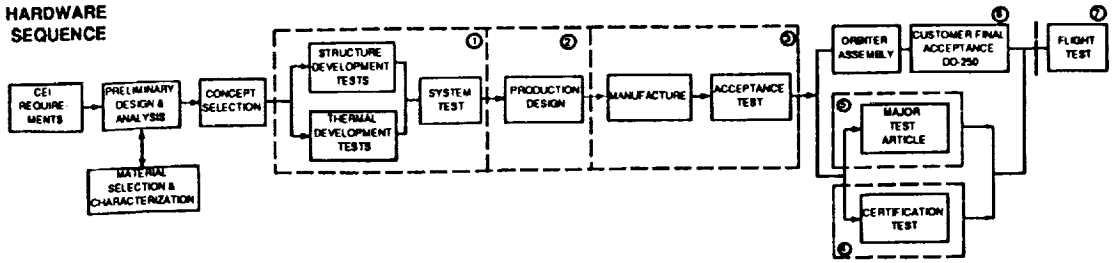
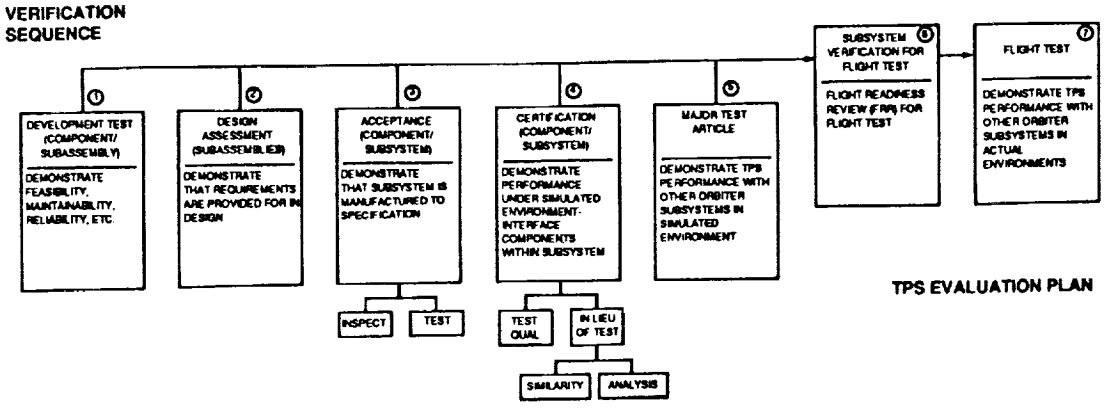
ORBITER TPS ENVIRONMENTS FOR CERTIFICATION

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





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

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

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