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**10.3.4 Thermal Protection Systems for All-Weather Reusable
Launch Vehicles by Marc J. Giegerich, McDonnell Douglas
Space Systems Company**



THERMAL PROTECTION SYSTEMS FOR ALL-WEATHER, REUSABLE LAUNCH VEHICLES

**BY
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Thermal Protection System Technology Needs

Support Current and Future Launch, Reentry and Planetary Vehicles

- * **Lightweight, High-performance, Low-maintenance**
- * **Weather resistant (humidity, rain, hail, lightning, etc.)**
- * **High resistance to oxidizing environments (ETO/OTE)**
- * **Ease of Attachment/Removal**
 - **Minimum number of attachment points**
 - **Minimum tooling required**
 - **Minimum down-time impact**
 - **Minimum disturbance to flowfield**
- * **Rugged Construction Method**
 - **Accidental ground-handling damage**
 - **In-flight damage tolerance**
- * **Well-characterized Inspection Methods**
 - **Visual (quick turnaround)**
 - **Non-visual (regular maintenance)**
 - **Non-visual (vehicle overhaul)**

Launch and Entry System Technology Gaps

Long-term, reusable thermal protection materials

- * **Recently developed materials (CMC's, metallics, ceramics, etc.) require ground and flight testing - Requires sharing of risks between Industry, Vendors and Government**
- * **Basic Material Properties which need verification/quantification**
 - **Long-term degradation of thermal, optical and structural properties**
 - **Catalytic reaction rates in high-temperature, low pressure dissociated flow**
 - **Lightning strike damage tolerance**
 - **Acoustic fatigue**
 - **Flutter (including coating behavior)**
 - **Impact resistance (rain, hail, meteorite, etc.)**
- * **Load-Carrying Hot Structures and Control Surfaces**
 - **Fabrication and bonding/attachment of large scale panels**
- * **Lightweight fabrication techniques of ceramic matrix composites**
 - **Rigid construction methods that rival metallics**
 - **Sandwich, fluted core, bi-directional stiffeners, etc.**

Suggested Discussion Topics

On-Orbit Repair Modes/Options

- Vacuum bonding/bandages
- Durability
- Inspection

Attachment Techniques and Issues

- Internal vs. external attachments
- Long-term degradation of attachment hardware
- Composite attachment hardware
- Detachment/reattachment
- Heat-short paths

Ground Handling

- Inspection Requirements and Methods
 - Visual/Non-visual
 - TPS life assessment
- Repairs/Replacements

**10.3.5 Thermal Protection Systems for Aerobrakes
by Stephen S. Tompkins, NASA LaRC**