Requirements Summary

- **Interested in all environments**
- **Monitoring requirements depend on investigation and orbit**
- **Environmental factors:**
  - Spectral radiation data:
    - **Solar wind**
    - **Plasma**
    - **Low energy electrons and protons**
    - **High energy electrons and protons**
    - **Ultraviolet (UV)**
    - **Vacuum UV (VUV)**
    - **Soft X-rays**
  - Atomic oxygen
- **All missions benefit from better materials information**
  - NASA, commercial, military, other government

Materials Technology Breakout: Prioritized List

1. Ground-to-Space Correlation for Materials Degradation
2. Slow Crack Growth in Polymeric Films
3. Embrittlement of Polymers (Surface/Bulk)
4. Molecular Contamination
5. Variable Optical Property Materials
6. Performance Characterization of Coatings and Films in Space
7. Atomic Oxygen/UV Radiation Synergistic Effects
8. Role of Oxygen Ions in On-Orbit Erosion (Atomic oxygen versus O+)
9. Long-Term Charging Effects on Materials
10. Composite Materials

Technology #1: Ground-to-Space Correlation for Materials Degradation

- **Justification for Requirement:**
  - Ground tests often do not simulate the degradation that occurs in materials in the space environment
  - Need flight data to correlate to ground test data
- **Correlative environment measurement requirements:**
  - Spectral radiation data:
    - **Low energy electrons and protons**
    - **High energy electrons and protons**
    - **Solar wind**
    - **Plasma**
    - **Ultraviolet, vacuum ultraviolet, soft X-rays**
  - Atomic oxygen
- **Environments of Interest: All environments**

Technology #2: Slow Crack Growth in Polymeric Films

- **Issues: The effects of the following on slow crack growth in polymeric films need to be quantified:**
  - Threshold dose or load
  - Dose rate effects
  - Temperature effects (dwell and soak)
  - Load effects
- **Possible experiment techniques:**
  - Micro-Electro-Mechanical Systems (MEMS) for monitoring of materials' properties
  - Photodetectors
- **Correlative environment measurement requirements:**
  - Monitoring is experiment/environment dependent
  - Spectral radiation data: low energy electron and proton, high energy electron and proton, solar wind, plasma, UV, VUV, soft X-rays
  - Atomic oxygen
- **Environments of interest: All environments**

Technology #3: Embrittlement of Polymers (Surface/Bulk)

- **Contributions of the following effects to the embrittlement of polymers needs to be quantified:**
  - Ultraviolet (UV), vacuum UV (VUV), electrons and protons, other radiation?
  - Synergistic effect with atomic oxygen (AO): flux rate effects
  - Radiation dose rate effects
  - Temperature effects
  - Load effects
- **Correlative environment measurement requirements:**
  - Depends upon experiment/environment
  - Spectral radiation data: low energy electron and proton, high energy electron and proton, solar wind, plasma, UV, VUV, soft X-rays
  - AO
- **Environments of Interest: All environments**

Technology #4: Molecular Contamination

- **Issues/possible experiment investigation requirements:**
  - Electrostatic Return
  - Photopolymerization/ fixing
  - AO scrubbing (removal) versus fixing
  - Temperature effects
  - Contamination source identification techniques
  - Effects of voltage bias on contamination rates and species
- **Correlative environment measurement requirements:**
  - Ultraviolet (UV), vacuum UV (VUV), atomic oxygen, pressure
- **Environments of interest: All environments**
  - Dose in <10 eV range

Technology #5: Variable Optical Property Materials

- **Issue: Interactions with space environment (verify performance in space environment) for:**
  - Thermochromics
  - Electrochromics
  - Photochromics
  - Micro-Electro-Mechanical louvers
- **Correlative environment measurement requirements:**
  - Obscuration due to contamination
  - Atomic oxygen
  - Ultraviolet/vacuum ultraviolet
  - Total dose
- **Environments of interest: All environments**

Technology #6: Performance Characterization of Coatings and Films in Space

- **Issue: Need for flight qualification of coatings and films such as:**
  - Atomic oxygen (AO)-durable materials (i.e., POSS)
    - **Flexible AO protective coatings**
    - **Paintable/spray-on AO durable coatings**
    - **Conductive AO durable coating (ITO replacement)**
  - Metal durability (vapor deposited coatings)
  - Conductive coatings
- **Correlative environment measurement requirements:**
  - Depends upon the investigation
- **Environments of interest: LEO/GEO environments**

Technology #7: Atomic Oxygen (AO)/Ultraviolet (UV) Radiation Synergistic Effects

- **Issue: What are the variations in the synergistic effects of AO and UV on materials due to:**
  - Solar cycle variations
  - Dose rate effects
  - AO "scrubbing" off (removal of) UV embrittlement
  - Temperature effects
- **Correlative environment measurement requirements:**
  - AO
  - Spectral UV and vacuum UV
  - Total dose
- **Environments of interest: LEO environment**

Technology #8: Role of Oxygen Ions in On-Orbit Erosion: Atomic Oxygen (AO) Versus Positively Charged Oxygen (O+)

- **Issue: Characterize the role of oxygen ions in on-orbit materials' erosion including:**
  - Low erosion yield materials
  - Potential solar cycle variations
  - Flux rate effects
  - Temperature effects
- **Correlative environment measurement requirements:**
  - AO and O+
  - Spectral ultraviolet (UV) and vacuum UV
  - Total dose
- **Environments of interest: LEO environment**

Technology #9: Long-Term Charging Effects on Materials

- **Issue: What are the long-term charging effects on materials including:**
  - Thin Film Materials Effects: mechanical and optical properties
  - Flux Rate Effects on Property Changes
- **Correlative environment measurement requirements are experiment/environment dependent:**
  - Spectral radiation data (low energy electron and proton, high energy electron and proton, solar wind, plasma, UV, VUV, soft X-rays) AO
- **Environments of interest: All environments**

Technology #10: Composite Materials

- **Issue: Performance characterization of composite materials:**
  - Strength/Stiffness on-orbit
    - **Synergistic effects with radiation/thermal cycling or thermal dwell**
  - Radiation Shielding Integrated Composites
    - **Importance increases with miniaturization and need for ultra lightweight**
- **Correlative environment measurement requirements:**
  - Atomic oxygen
  - Total dose
- **Environments of interest: All environments**