Fall 2007 AMTAS Brainstorming Session:
Multifunctionality & Nanotechnology

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The Boeing Company

A Center of Excellence AMTAS Advanced Materials in Transport Aircraft Structures

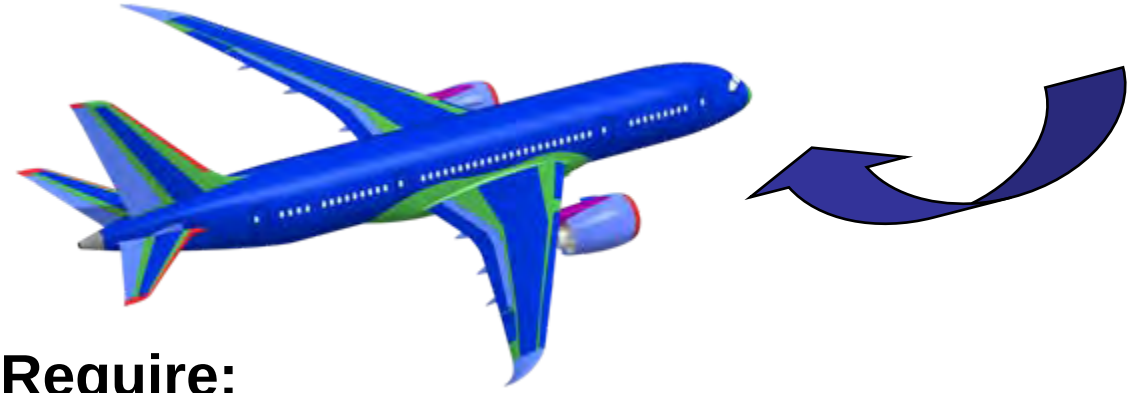
Goals

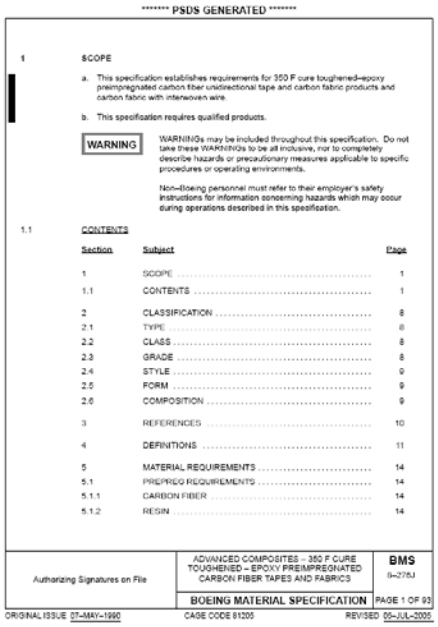
- Increased Safety
- Environmentally Friendly
- Risk/Variability Reduction
- Reduced Emissions/Noise
- Higher Performance/Robustness
- Increased Payload/Range/Speed
- Maintenance-Free/Ease of Repair
- Lower Operating/Maintenance Costs

Multifunctional Materials & Structures

MF - Getting more from the material:

Replacing a multitude of materials with multifunctional materials in engineered applications can reduce costs of qualifications, certifications and inventory.





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1 SCOPE

a. This specification establishes requirements for 350 F cure toughened-epoxy preimpregnated carbon fiber unidirectional tape and carbon fabric products and carbon fabric with interwoven wire.

b. This specification requires qualified products.

WARNING — WARNINGs may be included throughout this specification. Do not take these WARNINGs to be all inclusive, nor to completely describe hazards or precautionary measures applicable to specific procedures or operating environments.

Non-Boeing personnel must refer to their employer's safety instructions for information concerning hazards which may occur during operations described in this specification.

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Authorizing Signatures on File | ADVANCED COMPOSITES – 350 F CURE TOUGHENED – EPOXY PREIMPREGNATED CARBON FIBER TAPES AND FABRICS | BMS 9-276J

BOEING MATERIAL SPECIFICATION | PAGE 1 OF 93

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Will Require:

Multifunctional design, optimization, and analysis tools
Multifunctional manufacturing and assembly
Multifunctional repair, maintenance
Multifunctional certification

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Multifunctional Materials & Structures – TIG Examples

- Electrically Conductive Glass Fiber Composites
  - Reduced metallics inside the fuselage for CRN purposes
  - Corrosion isolators plies can also serve as sensing layers
  - Anti-static (ESD)
- Structural Energy Sources
  - Batteries, fuel cells, capacitors..
- Multifunctional Coatings
  - Electrical & thermal conductivity, corrosion protection, adhesive bonding, self-cleaning, ice-phobic, anti-microbial, ...
- Multifunctional Sensors
  - Detect moisture, impact, temperature…
- Electrically, Thermally Conductive, and Acoustic Damping Structure
  - Eliminate auxiliary systems
- Multifunctional Foam to reduce density and perform other functions
- Multifunctional layered film for impact, conductivity, transparency

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Multifunctional Materials & Structures

- **Increasing Emphasis on Multifunctional Materials for the Future**
  - Structural integration of electronic devices
  - Combination of load-carrying capabilities with functional requirements (e.g. thermal, power)
  - Adaptive, sensory and active materials
  - Revolutionary concept of “autonomic” structures which sense, diagnose and respond for adjustment
  - Hybridization of materials and lay-up for complex requirements

B. L. (“Les”) Lee, AFOSR @ ASC 2007

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Other Nanotechnologies

- Nano enhanced high temp materials allow engines to run hotter, improve efficiency, increase thrust-to-weight ratio
- Ice-phobic coatings using POSS
- CNT repair patches for aluminum corrosion (updated version of old Boron composite repairs for metal
- More durable paint
- Sensors for fire, biological, chemical threats
- NIST Nanocable project – plastic electrical wire
- Nano film damping of turbulent flow induced vibrations

- Nano energized fuel catalysts for greater efficiency/reduced pollution
- Thermoelectric technology have a large range of applications to capitalize on waste heat and thermal gradients (MURI conference).
- Nanoscale piezoelectric material technology for vibration energy harvesting.
- Non-electrically conductive thermal interface material improvements for electronic cooling
- Non-thermally conductive, but electrically conductive interface material for TE applications.

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The Key to success will be in choosing the right team members