NCAMP Progress and Plans

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Advanced General Aviation Transport Experiments (AGATE)

GOAL: To revitalize U.S. general aviation through development and deployment of advanced technologies in support of retrofit markets and a general aviation transportation system

1995-2002
WHAT WAS AGATE?

- Design & Manufacturing
- Integrated Flight Systems
- Propulsion Sensors & Controls
- Training Systems Technologies
- Air & Ground Infrastructure
- Ice Protection Systems
- Materials Working Group
Overall goal of AGATE effort - SHARED DATABASES

Existing Process

<table>
<thead>
<tr>
<th>Company A</th>
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<tbody>
<tr>
<td>FAA ACO A</td>
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</tr>
<tr>
<td>Material X Certified</td>
<td>Material Y Certified</td>
<td>Material Z Certified</td>
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<tr>
<td>Design Allowable Material X</td>
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AGATE Process

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<tr>
<td>Common Material Need</td>
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<tr>
<td>Qualification with Process Specifications</td>
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<td>Process Equivalency</td>
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Common Database
ACCOMPLISHMENTS

- Composite Material Qualification and Equivalency Methodology Standardized for Prepreg Composite Material Systems
- Focused towards “low-cost” composite material systems
- Approved by the FAA for use on Part 23 aircraft composite applications
- MIL-HDBK-17 interaction at all levels
AGATE plans were ....

- **Multi-Vendor Qualification**
  - airframe design based upon a combination of material vendors (minimum B-basis criteria)

- **"DESIRE EFFECT"**
  - vendor will not have a "monopoly" with respect to a particular aircraft model
  - airframer may switch suppliers based upon price, supply schedule, etc.
  - "price competition" among vendors
Policy for Base Composite Material Qualification, Shared Databases, and Acceptance Criteria

• Objective: To establish policy for those composite databases that can be shared by OEM & product users in development, certification, and maintenance
  - Standardized material control, with the associated base material properties and M&P specifications
  - Covers levels of “building block” testing that are not product design and manufacturing specific

• Three-step approach
  1. Multi-batch material qualification to generate the database & set specs.
  2. Equivalency (“mini-qualification”) to sample and show you process the material to fall within the database population and, if desired, update specs. per your specific use of material as allowed within guidelines
  3. Apply database to your product and continuously control the material
What is Meant By Material Equivalency?

Material Equivalency will be used in the current context to describe the sampling process for a subset of testing used to confirm equivalent mechanical, physical and chemical properties for a particular material or one undergoing minor changes.

This is not to be confused with the qualification process needed for 2nd source, alternate or replacement materials (defined by Material Interchangeability).
Summary

Material Qualification and Equivalency

- Base **material qualification** provides a representative database of key material properties and characteristics for use in design and subsequent quality control (repeatable raw material production)
  - A multi-batch database, yielding specific acceptance criteria for specifications
- Raw composite material is significantly advanced in fabricating the OEM product and a **material equivalency** (sampling or mini-qual.) exercise is required to use the qualification database in certification
  - Material equivalency testing and development of final OEM specifications should be considered more than “tick-marks” on the certification schedule
    - Crucial to establish a strong working relationship between the OEM & supplier
    - Production efficiency and the associated costs to make a product will also be directly related to key characteristics of the “green” composite material; hence, the OEM and material supplier should work together in product development to identify what process controls are needed

* FAA involvement (conformity, test plan review, and data approval)
Timeline of Activity

1995
• AGATE started with GA industry’s desire to share databases and standardize procedures used in material characterization

1998
• First AGATE document release – MIL-17 presentation

1998 - 2002
• AGATE databases produced
• MIL-17 engagement and revision of qualification and equivalency guidelines (3 revisions) – statistical procedures

2000
• FAA Small Airplane Directorate policy memorandum (Policy Statement Number ACE-00-23.613-01; Volume 65, Number 114)

2002

2003
• FAA updated release of qualification and equivalency guidelines DOT/FAA/AR-03/19 (5th revision)

2004
• FAA prepreg Fabric and Liquid Resin Injection Specification Guidelines

2005
• NCAMP initiative announced
What is NCAMP?

• **National Center for Advanced Materials Performance (NCAMP)**

• A NASA funded center located at the National Institute for Aviation Research, on the campus of Wichita State University

• An extension of the AGATE Materials Working Group
  - To take the AGATE Shared Database approach to the next level
NCAMP Initiatives

- Creating a Shared Database Program for Traditional Materials
- Providing Statistical Materials Management and Control
- Accelerating Advanced Materials Usage
- Develop a Materials Scaling & Building Block Approach
- Applying Advanced Materials Processing Technology into a Shared Database
NCAMP Organizational Structure

**Executive Governing Board**
(Larry Ilcewicz, Tia Benson Tolle, Steven Claus, Dana Granville, Tom Freeman)

**Senior Advisory Composites Committee (SACC)**

**Technology Advisory Board**
(material suppliers, lower tier suppliers)

**Industry Advisory Board**
(Industry, Tier One Suppliers) 
{Selected}

**Performance Review Team**
{Selected Experts}
The Approach - Completing the M&P Puzzle

**Material Properties**
NCAMP (FAA Accepted) Basis Values → CMH-17 vol. 2

**Material Specification**
NCAMP Material Specifications → SAE AMS XXXX/XX

**Material & Process Limitation Information**
NCAMP/UBC Process Maps → User Process Specs

**Material Design Guidance**
NCAMP Recommendations → User Design Manual
Collaborating Partners

• CMH-17: Technical resource & data depository
• ASTM D30: Develop/Revise Test Method Standards
• SAE P-17: Develop AMS Material Specification
• PRI, Nadcap & QPL: Develop Audit Criteria for Material Suppliers
Material Qualification Processes

Traditional Process

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<td>Material X Properties</td>
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AGATE Shared Database Process

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<td>Shared Database</td>
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<tr>
<td>1 Batch Process Equivalency Per DOT/FAA/AR-03/19</td>
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Material Qualification Processes

NCAMP Shared Database Process

- Company A
  - Initial 3 or 5 Batch Qualification per DOT/FAA/AR-03/19 & DOT/FAA/AR-02/109 & DOT/FAA/AR-02/110
  - Material X Properties
  - Material Y Properties
  - Shared Database
  - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19 & DOT/FAA/AR-02/109 & DOT/FAA/AR-02/110
  - Company B
  - Company D
  - Company E
  - Company F

AGATE Shared Database Process

- Company A
  - 3 or 5 Batch Qualification per DOT/FAA/AR-03/19
  - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19 & DOT/FAA/AR-02/109 & DOT/FAA/AR-02/110
  - Material X Properties
  - Material Y Properties
  - Shared Database
  - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19 & DOT/FAA/AR-02/109 & DOT/FAA/AR-02/110
  - Company B
  - Company D

Add CTD and ETD to equivalency
Materials Selected for CY 2006

• Cytec Cycom 5215, 1st Most Popular Industrial Choice
  – T40-800 Unitape Gr 145 RC 33% (instead of Gr 190 RC 35%)
  – T650 6K 5HS RC 36%
  – T650 3K PW RC 38%

• Cytec Cycom 5250-4, 2nd Most Popular Industrial Choice
  – T650 Unitape Gr 145 RC 32% (instead of T40-800 Gr 190 RC 35%)
  – T650 6K 5HS RC 35%
  – T650 3K PW RC 36%

• Hexcel 8552, 3rd Most Popular Industrial Choice
  – AS4 tape at 190 gsm 35% RC, CPT approx. 7.4 mils
  – IM7 tape at 190 gsm 35% RC, CPT approx. 7.3 mils
  – AS4 plain weave fabric at 193 gsm 38% RC, CPT approx. 7.95 mils

• ACG MTM 45-1 - AGATE Legacy Material / Air Force Collaboration
  – G30-500 193 gsm 3K plain weave fabric 36% RC
  – G30-500 145 gsm uni 32% RC
  – 6781 S-2 glass 35% RC

• Toray 2510 - AGATE Legacy Material (involves minor additions to the existing database only)
Benefits of Fabricating the Test Panels

- If fabricating 3-batch qualification panels,
  - the data, basis values, and allowables may be used in certified aircrafts\(^{(1)}\)
- If fabricating 1-batch equivalency panels,
  - the data, basis values, and allowables may be used in certified aircrafts if equivalency is demonstrated\(^{(1)}\). Refer to MIL-HDBK-17 rev F section 8.4.1. or DOT/FAA/AR-03/19 section 6.0.
- **Testing costs fully funded by the government through NASA NCAMP for a limited time only (i.e. concurrent with initial qualification programs only)**
- **Prepreg cost paid by the material suppliers for a limited time only (i.e. concurrent with initial qualification programs only)**
- You will only need to fabricate about 18-21 panels per resin system per product form
  - Panel fabrication cost includes prepreg cutting and layup labor, some bagging materials, cure cycle, FAA conformity (if needed), and postage to send the cured panels to NCAMP only
- You will learn about composite material shared-database approach

\(^{(1)}\) Subject to approval by certification agency
OLD APPROACH  [Finite Project]

Develop Material → Qualify Material → Quality Control (pass/fail)

CONTEMPORARY APPROACH  [Continuous Project]

Develop Material

Characterize Material → Qualify Material → Quality Control (pass/fail)

Property Database, Specifications → Continuous Quality Improvement

Evaluate Material Changes

Periodic Property Testing → Monitor Material, SPC
NCAMP Goals: Monitor Material Stability

- Material A
- Material B
- Material C

Material Stability

- Material Introduction
- Trial Batches
- Initial Production Batches
- Sustained Operation Batches

NEW PROCESS

- Material Selection
- Material Properties
- Element Properties
- Component Properties
- Full Scale Testing

OLD PROCESS

- Design is complete before material properties are stable.
- Material properties are stable before design starts.

Time
Material Property Monitoring

- Partnering with material suppliers and aircraft companies to monitor material property variations over time

Control Charts

- Everything varies at least a little bit. So how do you tell when you are just experiencing normal variation versus when something out of the ordinary is occurring? Control charts were designed to make that distinction.
- As long as all points lie inside the upper and lower control limits, the variation is presumed to be normal or a common cause variation. When a data point falls outside those limits, it’s time to look for a reason for the variation.
- Two-sided monitoring for all properties including strength.
Areas of Development
(Research topics designed to enhance NCAMP database)

- Material LEF development (ongoing through collaboration with a FAA-funded research project)
- Aging of prepreg research (ongoing through collaboration with University of British Columbia, Toray Composites America, Avpro, and Ames Lab at Iowa State University)
- Countersink & filled hole effects (proposed)
- Sandwich cocure effects (proposed)
- Absolute vs gage vacuum effects (proposed)
- Upper & lower processing envelop effects (proposed)
- Effects of defects (proposed)
- Viscoelasticity as a method of process control (proposed)
Questions, Comments, Suggestions?

• If you have any other suggestions for NCAMP, please contact Yeow Ng at 316-978-5212 or yeow.ng@wichita.edu