Composite Structure Engineering Safety Awareness Course

Use of publicly available shared databases – NCAMP/CMH-17/P-17 initiatives

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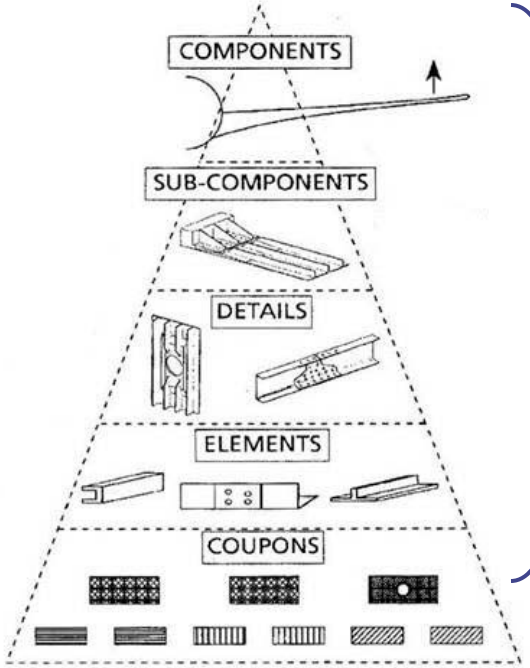
Available Sources of Shared Databases

- For Metals and Fastened Joint Systems
  - Metallic Materials Properties Development & Standardization (MMPDS), formerly MIL-HDBK-5
    - often meet the rigors of the U.S. and foreign governments
- For Composites – standardization is ongoing
  - Composite Materials Handbook 17 (CMH-17), formerly MIL-HDBK-17
    - MIL-HDBK-17 Rev F and earlier datasets: **often require additional substantiating evidence and users have to create (invent?) M&P specifications**
    - CMH-17 Rev G (known as datasets with ***Complete Documentation***): some with FAA-accepted allowables, material suppliers' M&P specifications
      - Equivalent SAE specifications in development through P-17)
    - Upcoming National Center for Advanced Materials Performance (NCAMP): FAA-accepted allowables, NCAMP M&P specifications
      - Equivalent SAE specifications in development through P-17
      - Datasets will be included in CMH-17 Complete Documentation sections

Why Use Shared Databases?

- **reduced time and cost**
- **standardized material property data and specifications**



"Proprietary" at these levels

"Shared" at this level

Evolution of Allowables Process

- MIL-HDBK-17 has a history of developing rigorous statistical approaches for allowables
  - Use of statistics experts
  - Use of simulations, and test cases with real data
  - Recognition that nature of real data can influence choice of math models
- Original MIL-HDBK-17 B30 process (STAT-17 MS Excel Macro)
  - Several possible assumed statistical distributions
  - Able to handle datasets with batch-to-batch variability (i.e. structured data)
  - Handle each environmental condition individually
  - Possible anomalous relations between environmental condition and allowables
- Integration of AGATE methodology (ASAP MS Excel Macro)
  - Recognition that general aviation manufacturers needed to perform smaller test programs
  - Focus on normal distributions
  - Pooling across environmental conditions, resulting in more “stable” statistics
  - Logical relation between environmental condition and allowable

Evolution of Available Data

- CMH-17
  - MIL-HDBK-17 Rev F and earlier (legacy) datasets contain primarily lamina level data (E_1, E_2, G_{12}, nu_{12}, F_1^{tu}, F_2^{tu}, F_1^{cu}, F_1^{cu}, etc.), limited laminate level data, ***proprietary*** material and process specifications (***i.e. you can't get the specs!***)
  - CMH-17 Rev G ***Complete Documentation*** (primarily AGATE datasets) contain lamina and some laminate level data (OHC, OHT, bearing, etc.), fluid sensitivity, and available material and process specifications
  - Upcoming NCAMP datasets contain lamina and some laminate level data, fluid sensitivity, out-time & shelf-life, thermal oxidative stability & thermal cycling (polyimide), all raw data including stress-strain curves, pictures of specimens and test setups, M&P specifications, PCD with user oversight, data generated with FAA/NCAMP oversight, and pedigree information.

Snapshot of Materials Available in CMH-17 Volume 2

CHAPTER 2 CARBON FIBER PROPERTIES

2.1 INTRODUCTION
2.2 COMPLETE DOCUMENTATION
- 2.2.1 Carbon - epoxy prepreg tape
  - 2.2.1.1 T700GC 12k/2510 unidirectional tape
- 2.2.2 Carbon - epoxy prepreg fabric
  - 2.2.2.1 T700SC 12k/2510 plain weave fabric
  - 2.2.2.2 T300 3k/E765 plain weave fabric
  - 2.2.2.3 T300 6k/E765 5-harness satin weave fabric
  - 2.2.2.4 AS4C 3k/HTM45 8-harness satin weave fabric
  - 2.2.2.5 AS4C 3k/HTM45 plain weave fabric
  - 2.2.2.6 HTA 5131 3k/M20 plain weave fabric
- 2.2.3 Carbon - epoxy wet-lay-up fabric
  - 2.2.3.1 HTA 5131 3k/Epocast A/B plain weave fabric

2.3 MIL-HDBK-17 REV F LEGACY DATA
- 2.3.1 Carbon-epoxy prepreg tape
  - 2.3.1.1 T500 12k/976 unidirectional tape
  - 2.3.1.2 HITEX 33 6k/E7K8 unidirectional tape
  - 2.3.1.3 AS4 12k/E7K8 unidirectional tape
  - 2.3.1.4 Celion 12k/E7K8 unidirectional tape
  - 2.3.1.5 AS4 12k/938 unidirectional tape
  - 2.3.1.6 Celion 12k/938 unidirectional tape
  - 2.3.1.7 AS4 12k/3502 unidirectional tape
  - 2.3.1.8 AS4/3501-6 (bleed) unidirectional tape
  - 2.3.1.9 AS4/3501-6 (no bleed) unidirectional tape
  - 2.3.1.1 T300 15k/976 unidirectional tape
  - 2.3.1.11 IM7 12k/8551-7A unidirectional tape
  - 2.3.1.12 IM6 3501-6 unidirectional tape
  - 2.3.1.13 IM7 12k/8552 unidirectional tape
  - 2.3.1.14 IM7 12k/977-2 unidirectional tape
  - 2.3.1.15 AS4 12k/997 unidirectional tape
  - 2.3.1.16 T650-35 12k/976 unidirectional tape
  - 2.3.1.17 IM7 12k/PR 381 unidirectional tape
  - 2.3.1.18 T800HB 12k/3900-2 unidirectional tape
- 2.3.2 Carbon - epoxy prepreg fabric
  - 2.3.2.1 T300 3k/934 plain weave fabric
  - 2.3.2.2 Celion 3000/E7K8 plain weave fabric
  - 2.3.2.3 HITEX 33 6k/E7K8 plain weave fabric
  - 2.3.2.4 AS4 3k/E7K8 plain weave fabric
  - 2.3.2.5 AS4 3k/3501-6 plain weave fabric
  - 2.3.2.6 AS4 3k/3501-6S 5-harness satin weave fabric
  - 2.3.2.7 AS4 6k/3502-6S 5-harness satin weave fabric
  - 2.3.2.8 AS4 3k/3501-6 5-harness satin weave fabric
  - 2.3.2.9 AS4 3k/3501-6 5-harness satin weave fabric
  - 2.3.2.10 T300 3k/977-2 plain weave fabric
  - 2.3.2.11 T300 3k/977-2 8-harness satin weave fabric
  - 2.3.2.12 T650-35 3k/976 plain weave fabric
  - 2.3.2.13 T650-35 3k/976 8-harness satin weave fabric
  - 2.3.2.14 T700S 12k/3900-2 plain weave fabric
- 2.3.3 Carbon - epoxy wet-lay-up fabric
  - 2.3.3.1 T300 3k/EA9396 8-harness satin weave fabric
- 2.3.4 Carbon - epoxy resin-transfer-molded fabric
  - 2.3.4.1 AS4 6k/PR500 5-harness satin weave fabric
  - 2.3.4.2 IM7 6k/PR500 4-harness satin weave fabric
- 2.3.5 Carbon - bismaleimide prepreg tape and fabric
  - 2.3.5.1 T300 3k/F650 unidirectional tape
  - 2.3.5.2 T300 3k/F650 8-harness satin weave fabric
  - 2.3.5.3 T300 3k/F652 8-harness satin weave fabric
  - 2.3.5.4 AS4/5250-3 unidirectional tape
  - 2.3.5.5 T650-35 3k/5250-4 8-harness satin weave fabric
  - 2.3.5.6 T650-35 3k/5250-4 plain weave fabric

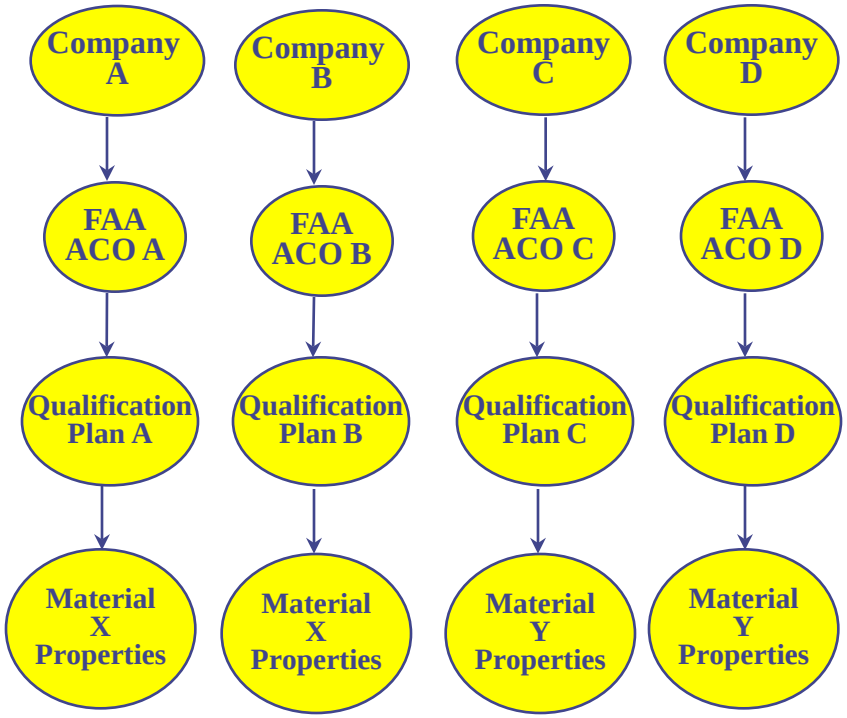
Snapshot of Materials Available in CMH-17 Volume 2

CMH-17 ≠ MMPDS

- CMH-17 shared database approach is unlike MMPDS
- Composites are highly dependent on the ***process***
  - Requires a stable material (like MMPDS)
  - Requires a robust process and proof of the process (unlike MMPDS)
- Even with shared data, composites still require significantly more testing than metals
  - Requires equivalency to show your ability to reproduce the properties (see next slide)
  - Only basic lamina and laminate properties are shared
  - Users often have to perform the additional testing to generate other properties that are not shared

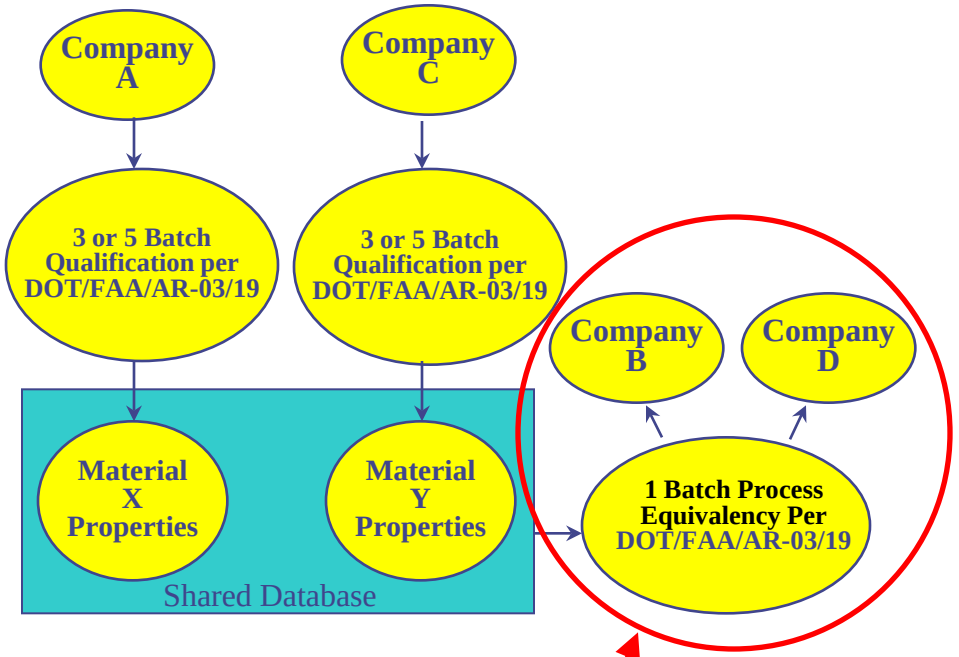
Material Qualification & Equivalency Processes

Traditional Process



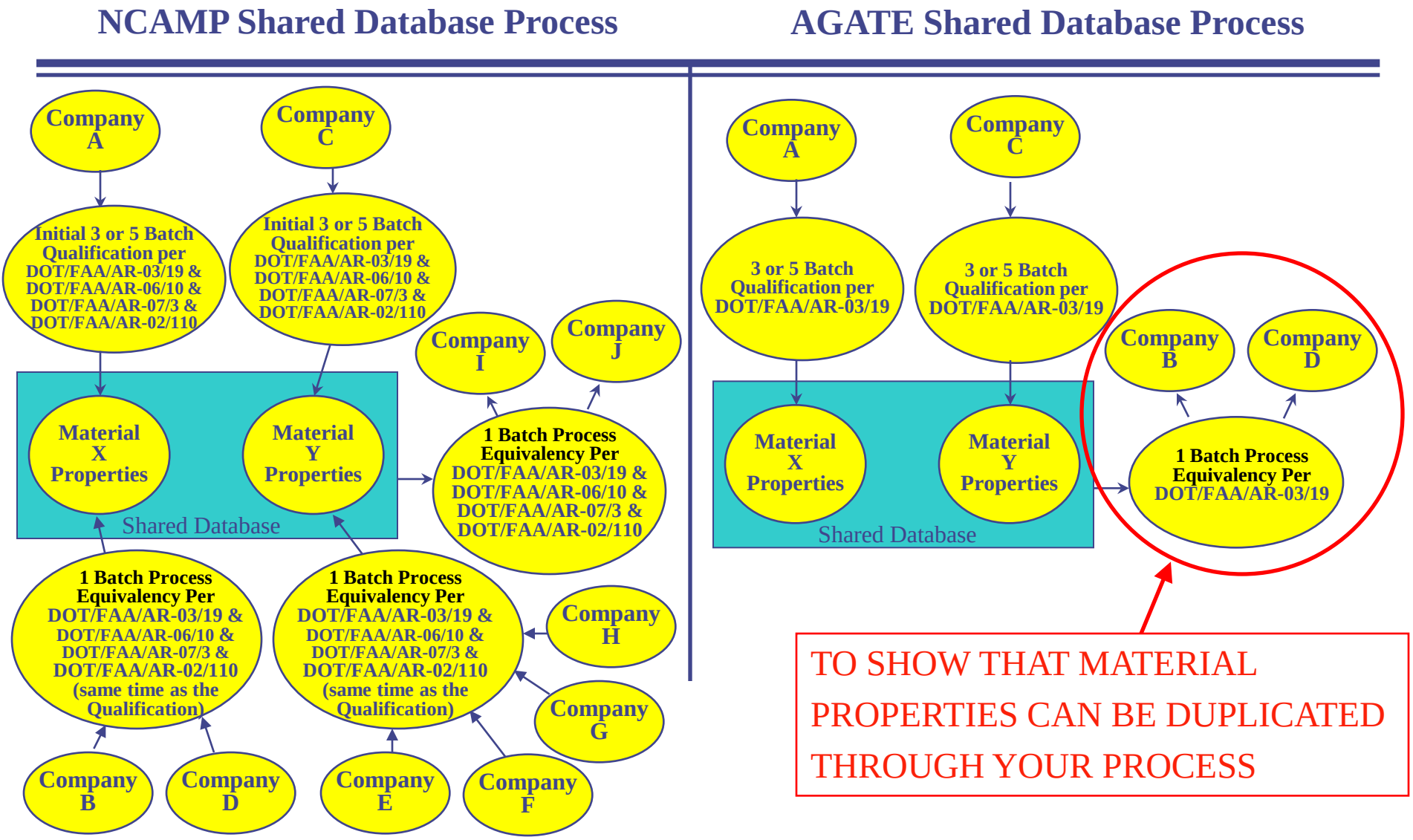
MATERIAL PROPERTIES DO NOT IMPROVE THROUGH MULTIPLE QUALS !

AGATE Shared Database Process



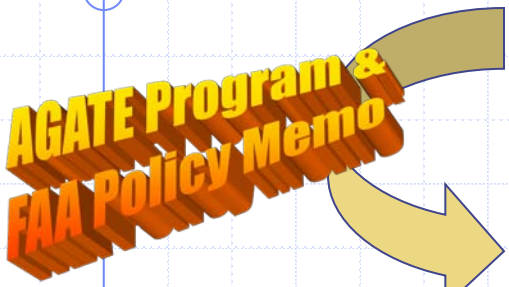
TO SHOW THAT MATERIAL PROPERTIES CAN BE DUPLICATED THROUGH YOUR PROCESS

Material Qualification & Equivalency Processes



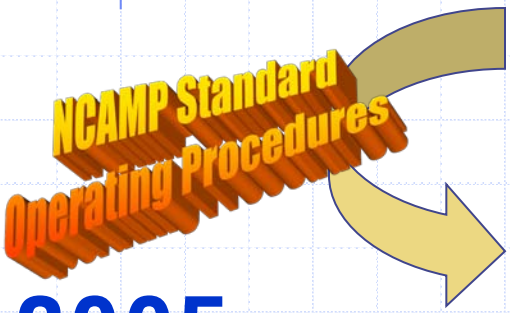
PAST
(Inefficient)

OEMs QUALIFY THEIR OWN MATERIALS
- same materials are qualified by different OEMs
- heavy workload on the FAA
- material properties not usable by others
- many years delay in data submission to CMH-17 (if ever) with no M&P spec



1996-2005

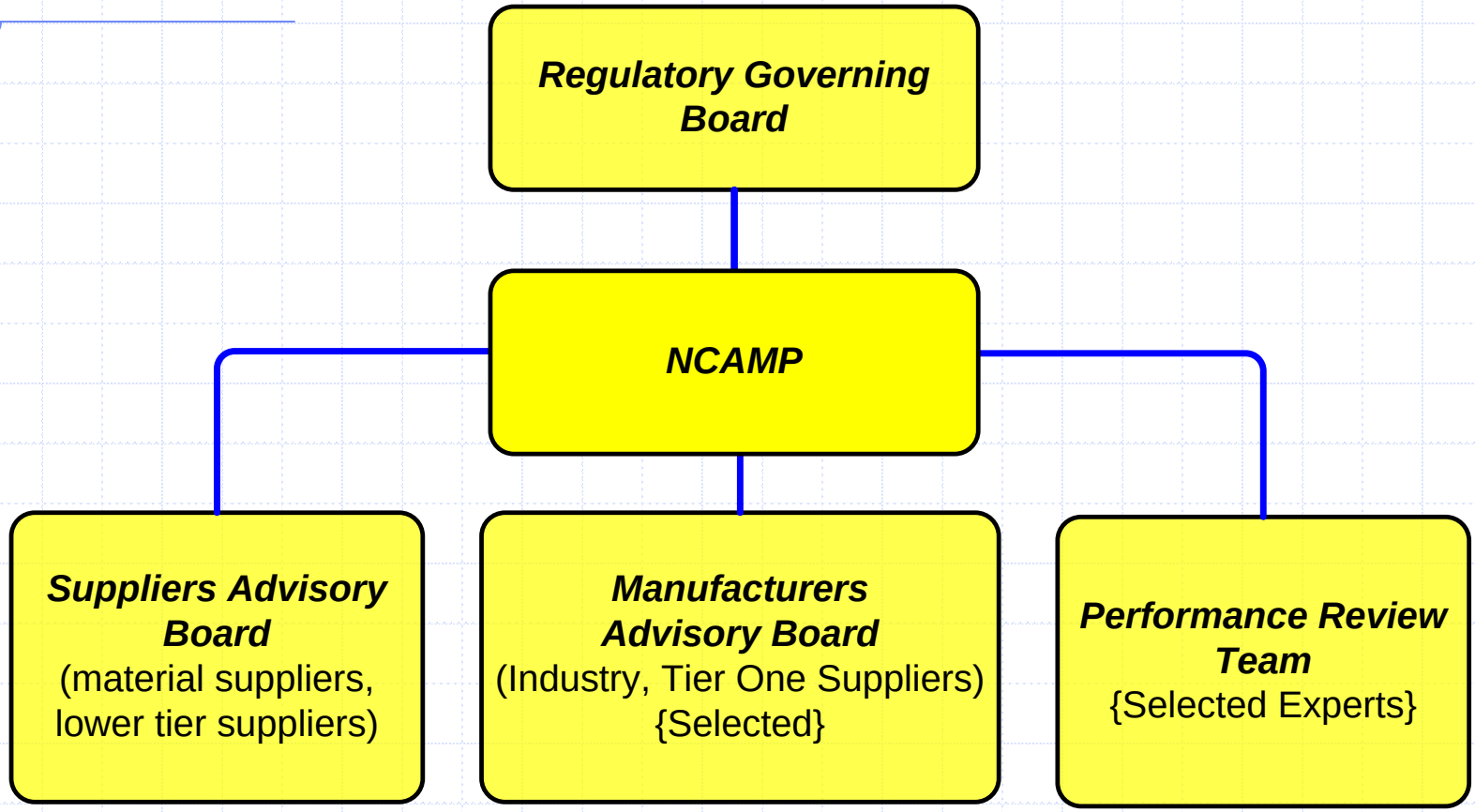
AGATE SHARED DATABASE APPROACH
- Primarily applied to General Aviation Products
- FAA accepting the role of CMH-17 and SAE
- each material is qualified one time only
- reduced workload on the FAA (but still higher than for metals)
- FAA-accepted shared material property databases



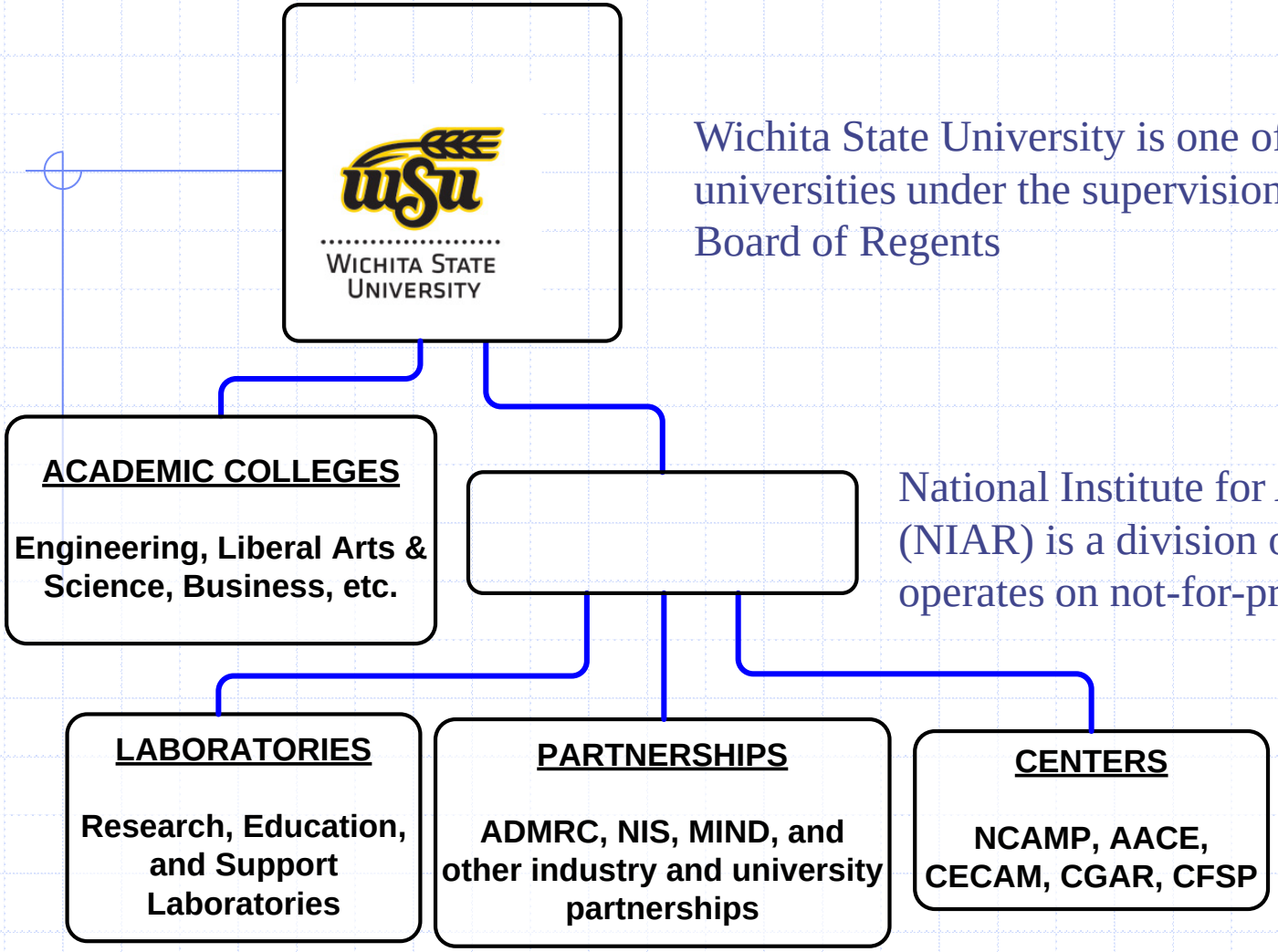
2005-FUTURE

In cooperation with CMH-17, NCAMP seeks to expand use of shared database
- FAA-accepted shared material property databases
- industry self regulate with minimal FAA oversight
  - supervised and reviewed by OEMs (similar to the “PAST”)
  - facilitated by CMH-17/SAE/NCAMP
- each material is qualified one time only
- no delay in availability of data to CMH-17

NCAMP Organizational Structure



Harmonization with CMH-17 is ongoing



Wichita State University is one of several universities under the supervision of Kansas Board of Regents

National Institute for Aviation Research (NIAR) is a division of WSU which operates on not-for-profit basis

NCAMP is a center within NIAR which operates independently of other centers, partnerships, and laboratories.

Not-For-Profit Business Model

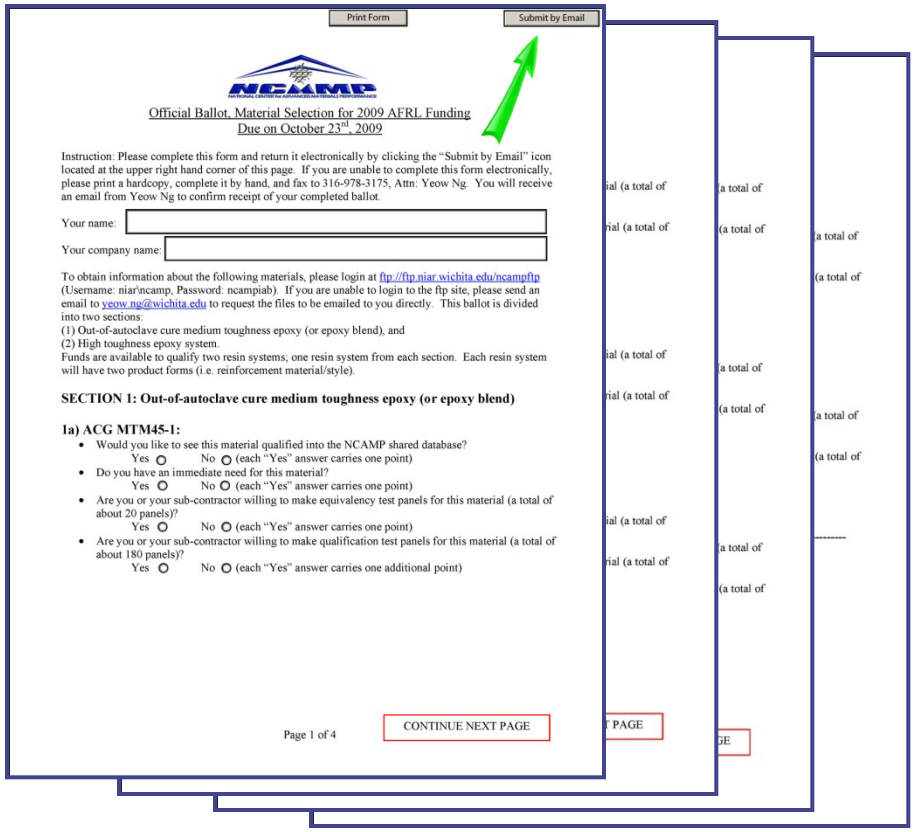
- Utilizing federal and commercial funding to build procedures to generate industry-shared composite material property databases and specifications
- Self-sufficiency
  - 15 year history of generating and maintaining industry-shared composite material property databases
  - Continual transition from federally-funded to industry-funded
- Sources of Revenue
  - Primarily from services rendered
  - No annual membership fee
  - No fee to access data or specifications
- NCAMP staff are not limited to industry-shared material property database and specification work; may perform proprietary work for industry and research projects for government


Piper
Freedom of flight
Cessna
A Textron Company
BOMBARDIER
Diamond AIRCRAFT
TohoTenax
AIRBUS
MAGELLAN
AEROSPACE CORPORATION
BRISTOL AEROSPACE LIMITED
COMTEK
Advanced Structures
Beechcraft
Jawker
HEXCEL
TOYOTA
eurocopter
THE NORDAM GROUP
victrex
STORK Fokker
Gurit
J.D. Lincoln Inc.
The Leader In Composite Material Technology
Gulfstream
ALBANY
Engineered Composites
EADS
LOCKHEED MARTIN
We never forget who we're working for™
ATK
ATK SPACE SYSTEMS
FEDERAL AVIATION ADMINISTRATION
Pratt & Whitney
A United Technologies Company
GKN AEROSPACE
EMBRAER
Ticona
Performance Driven Solutions™
nelcote™
CYTEC
Technology ahead of its time™
BURNHAM
COMPOSITES
BOEING
GENERAL DYNAMICS
Armament and Technical Products
SUBARU
SPIRIT
AEROSYSTEMS
Fuji Heavy Industries
Advanced Composites Group
'TORAY'
AAR
aarcorp.com
CMH-17
COMPOSITE MATERIALS HANDBOOK
NCAMP
AIR FORCE RESEARCH LABORATORY
CIRRUS
Bell Helicopter
A Textron Company
MAVERICK CORPORATION
Henkel
A Brand like a Friend
NEWPORT
ADHESIVES and COMPOSITES, Inc.
SAE International
NORTHROP GRUMMAN
IAI
ISRAEL AIRCRAFT INDUSTRIES
GE
Aviation
Nadcap
GOODRICH
United Technologies
MITSUBISHI HEAVY INDUSTRIES, LTD.
Honeywell
TENCATE
materials that make a difference
SCALED COMPOSITES
Liberty
AEROSPACE
kaneka
Kawasaki
Kawasaki Heavy Industries
NAVAIR
Vought
Aircraft Industries, Inc.
northwest
composites
centre
GENERAL ATOMICS
AND AFFILIATED COMPANIES
Epic
Sikorsky
A United Technologies Company
KAI
Lewcott
JAXA
Japan Aerospace Exploration Agency
Rocky Mountain Composites
ASTM
INTERNATIONAL
Standards Worldwide
B/E
AEROSPACE

Material Selection Process for Government Co-funded Programs

(when the government agencies do not specify the material)

1. Government/NCAMP may define categories of materials or processes
2. Material suppliers propose materials for inclusion in ballot
3. NCAMP creates the official ballot; government approval of the ballot is required
4. Material users (OEM/Tier-1) vote for the most desirable material
5. NCAMP counts the votes; government approval of the result is required



Print Form | Submit by Email

Official Ballot, Material Selection for 2009 AFRL Funding
Due on October 23rd, 2009

Instruction: Please complete this form and return it electronically by clicking the "Submit by Email" icon located at the upper right hand corner of this page. If you are unable to complete this form electronically, please print a hardcopy, complete it by hand, and fax to 316-978-3175, Attn: Yeow Ng. You will receive an email from Yeow Ng to confirm receipt of your completed ballot.

Your name:

Your company name:

To obtain information about the following materials, please login at ftp://ftp.niar.wichita.edu/ncampftp (Username: niar\ncamp, Password: ncampiab). If you are unable to login to the ftp site, please send an email to yeow.ng@wichita.edu to request the files to be emailed to you directly. This ballot is divided into two sections:
(1) Out-of-autoclave cure medium toughness epoxy (or epoxy blend), and
(2) High toughness epoxy system.
Funds are available to qualify two resin systems; one resin system from each section. Each resin system will have two product forms (i.e. reinforcement material/style).

SECTION 1: Out-of-autoclave cure medium toughness epoxy (or epoxy blend)

1a) ACG MTM45-1:

- Would you like to see this material qualified into the NCAMP shared database?
  Yes ○ No ○ (each "Yes" answer carries one point)
- Do you have an immediate need for this material?
  Yes ○ No ○ (each "Yes" answer carries one point)
- Are you or your sub-contractor willing to make equivalency test panels for this material (a total of about 20 panels)?
  Yes ○ No ○ (each "Yes" answer carries one point)
- Are you or your sub-contractor willing to make qualification test panels for this material (a total of about 180 panels)?
  Yes ○ No ○ (each "Yes" answer carries one additional point)

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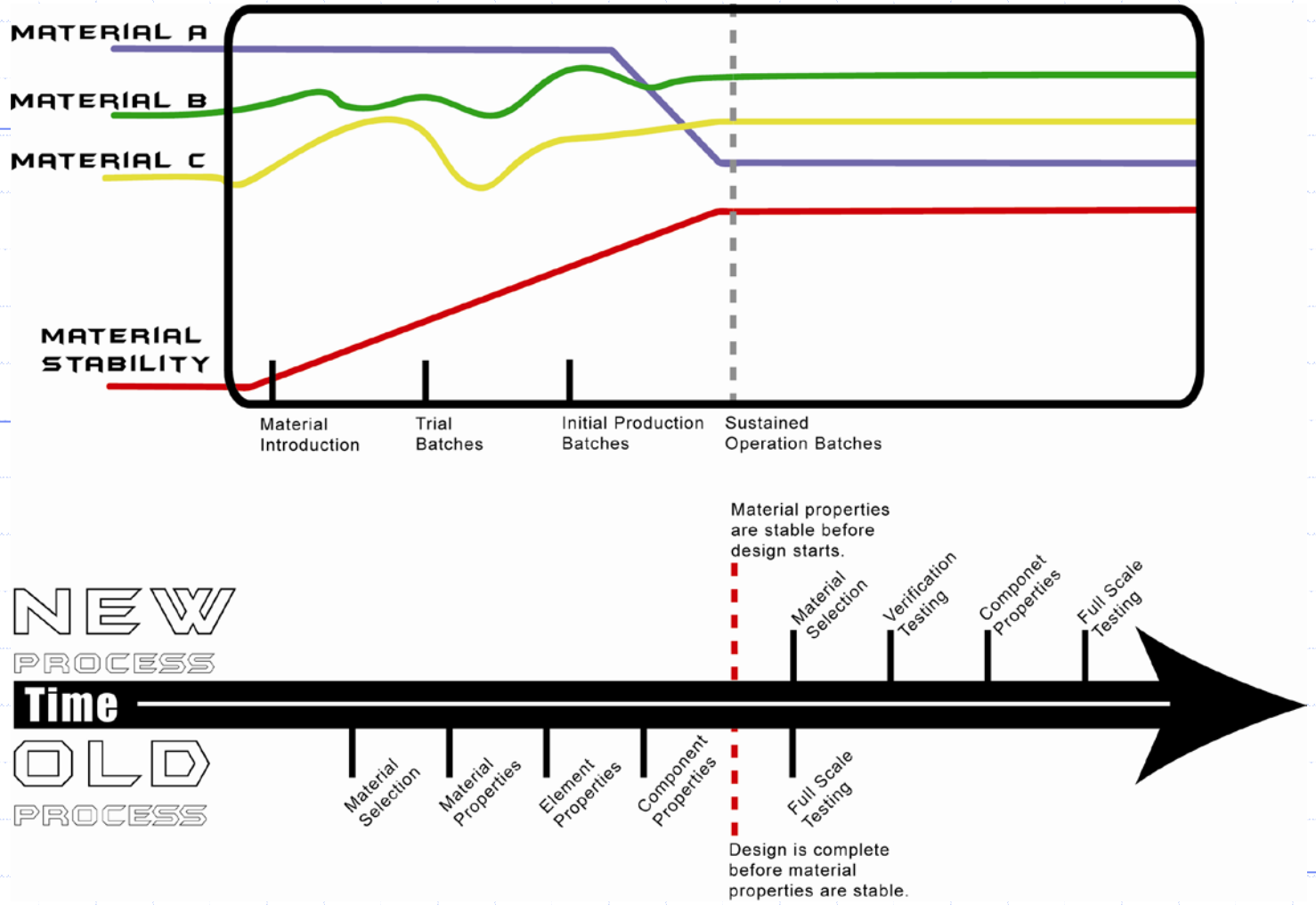
Qualify Matured Materials Only



Material qualification and property data acquisition should be independent of aircraft certification program

Who Contributes What?
(in government co-funded programs)

- Material suppliers provide materials
- Aircraft companies generally provide labor to fabricate and inspect panels
  - May fulfill *coupon* level building block requirement
- FAA/NCAMP provides oversight and creates pedigree through inspection verification and test witnessing
  - No guarantee on any program application; subject to approval by certification agency on case-by-case basis
- NASA/DoD provide funding for coordination and material testing (limited time only)

Material Qualification Programs
(Government Co-Funded)

- NASA Funded Cytec Cycom 5215
  - T40-800 12K Unitape Gr 145 RC 33%
  - 6K 5HS fabric with T650-36% RC, CPT approx. 14.9 mils
  - 3K70PW fabric with T650-38% RC, CPT approx. 8.0 mils
- NASA Funded Cytec Cycom 5250-5
  - T650 6K Unitape Gr 145 RC 32%
  - 6K 5HS fabric with T650-35% RC, CPT approx. 14.6 mils
  - 3K70PW fabric with T650-36% RC, CPT approx. 7.8 mils
- NASA Funded Hexcel 8552
  - AS4 12K tape at 190 gsm 35% RC, CPT approx. 7.4 mils
  - IM7 12K 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
- NASA Funded ACG MTM 45-1
  - G30-500 193 gsm 3K plain weave fabric 36% RC
  - HTS 5631 12K 145 gsm uni 32% RC
  - 6781 S-2 glass 35% RC
- AFRL Funded Renegade MVK-14 FreeForm Polyimide Qualification
  - T650 3K 8HS 370 gsm Fabric 36% Resin Content
- AFRL Funded Cytec 5320-1 (2 product forms)
  - T650 3K PW at 193 gsm, 36% RC
  - T650 Tape at 145 gsm, 33% RC
- AFRL Funded Cytec 5276-1 (2 product forms)

Benefits

- To Material Suppliers
  - Publication of key material properties
  - Non-proprietary industry material and process specifications
- To Material Users
  - Availability of published material properties suitable for:
    - Material selection
    - Initial sizing of structure
    - With minimal internal testing may be used as part of product certification
  - To get access to draft reports/specifications, contact kmarlett@niar.wichita.edu
- To Government
  - Reduced workload by leveraging industry experts
  - Reduced cost by eliminating multiple/redundant programs

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 NASA/DoD, 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)**
- In 1-batch equivalency process, you will only need to fabricate about 18 panels per resin system per product form
  - Panel fabrication cost includes prepreg cutting and layup labor, some bagging materials, cure cycle, DAR conformity, and postage to send the cured panels to NCAMP only
- You have access to the data
- You will learn about composite material shared-database approach

(1) Subject to approval by certification agency

Companies that are fabricating test panels (participating in quals & process equivalency)

1. Gulfstream Aerospace
2. AdamWorks
3. Albany Engineered Composites
4. ATK Space Systems (UT & OH)
5. Boeing Commercial Airplane
6. Boeing Helicopters
7. Scaled Composites
8. Goodrich Aerostructures
9. Bombardier Aerospace (Canada)
10. AAR Composites
11. Cirrus Design Corporation
12. Hawker Beechcraft
13. Spirit AeroSystems, Inc. (KS & OK)
14. Cessna Aircraft Company
15. Canyon Composites, Inc.
16. Bell Helicopter Textron, Inc.
17. General Dynamics ATP
18. Northrop Grumman Corporation
19. Israel Aircraft Industries, Ltd. (Israel)
20. General Atomics Aeronautical Systems, Inc.
21. Lockheed Martin Aero
22. Comtek Advanced Structures (Canada)
23. Burnham Composite Structures
24. Quickstep
25. Radius Engineering
26. Canyon Composites, Inc.
27. Advanced Composites Technologies
28. Composites Horizons Inc
29. BAE Systems Composite Structures Inc.
30. GE Aviation
31. Pratt & Whitney
32. Embraer (Brazil)
33. Korea Aerospace Industries (Korea)

100% Industry Funded Programs

- Tencate TC250 (265ºF oven cure)
  - HTS40 F13 150gsm/TC250 uni-directional prepreg
  - 12 k HTS40 F13 SFP OSI (193 gsm)/TC250 prepreg
- Newport NCT4708 (265ºF oven cure)
  - NCT4708 MR60H 300gsm Tape
  - NCT4708 MR40 150gsm Tape
- Nelcote E-752 (350ºF oven cure)
  - 193 gsm 3k PW G30-500 E752 Fabric
  - 145 gsm AS7 E752 Unidirectional Tape

How To Get Your Material Qualified with NCAMP?

- NCAMP has developed material specifications and basic allowables as part of government research projects
  - NCAMP is in fact a natural progression from the AGATE experimental project
  - Some materials were selected based on specific project interests
  - Other materials were selected through NCAMP material selection process; a highly competitive process due to limited funding
- Suppliers not directly tied to government project may contact NCAMP directly for support
  - NCAMP services are charged at not-for-profit hourly rate; travel at actual cost basis
  - Specifications developed following NCAMP procedures will be recognized as being acceptable to the FAA
  - Provides suppliers a path for having accepted material allowables published in CMH-17

Typical method to introduce new material system

- Suppliers interested in obtaining assistance in developing recognized material specifications and initial set of material allowables should contact NCAMP at yeow.ng@wichita.edu
- NCAMP will provide the following services to suppliers:
  - Develop M&P specifications and test plans from industry/government-reviewed ***standardized templates***
  - Assist suppliers to create PCDs using NCAMP guides
  - Work with suppliers to obtain appropriate data (not limited to NIAR test labs)
  - Ensure that NCAMP process is followed; independent inspection verification by NCAMP AIR and independent test witnessing by NCAMP AER
  - Ensure that all stakeholders are involved throughout the process, in accordance with NCAMP SOP
  - Create test reports with data and material allowables

Material Types Supported

- Currently standardized templates are available for thermoset prepreg materials
- Standardize templates for other material types need to be developed
  - NCAMP is constantly gauging industry & government interests in
    - Liquid injection molding (RTM, VARTM, etc.), compression molding, fiber placement, etc.
    - Braids, chopped fiber, slit-tape, non-crimp fabrics, and other novel textile forms/preforms
    - Thermoplastic prepreg
  - **Standardized templates** are created through a rigorous process
    - Thorough understanding of M&P and structural issues is a prerequisite; mature, stable, and robust M&P only; may need to hire subject matter experts
    - Active OEM/Tier-1/user/supplier participation is required
    - Interface with regulatory agencies is required
    - May be a lengthy and expensive process, depending on the M&P

NCAMP SOP: Uses and Limitations

- Each material qualification and material property data acquisition program uses unique sets of test plan and material & process specifications. Since composite material properties are dependent on the raw material (e.g. prepreg) properties as well as the composite fabrication process, material users should use the same material & process specifications. Deviation from the original material specification may change the composite material properties and render the material property data and allowables invalid. The material specification along with its process control document (PCD) may be revised over time so material users should use the same material specification and participate in material/PCD change management activities. However, minor deviation from the original process specification is quite common, especially in fabricating complex aerospace parts, but the deviation must be justified by analysis and/or test, as required by certifying agency.

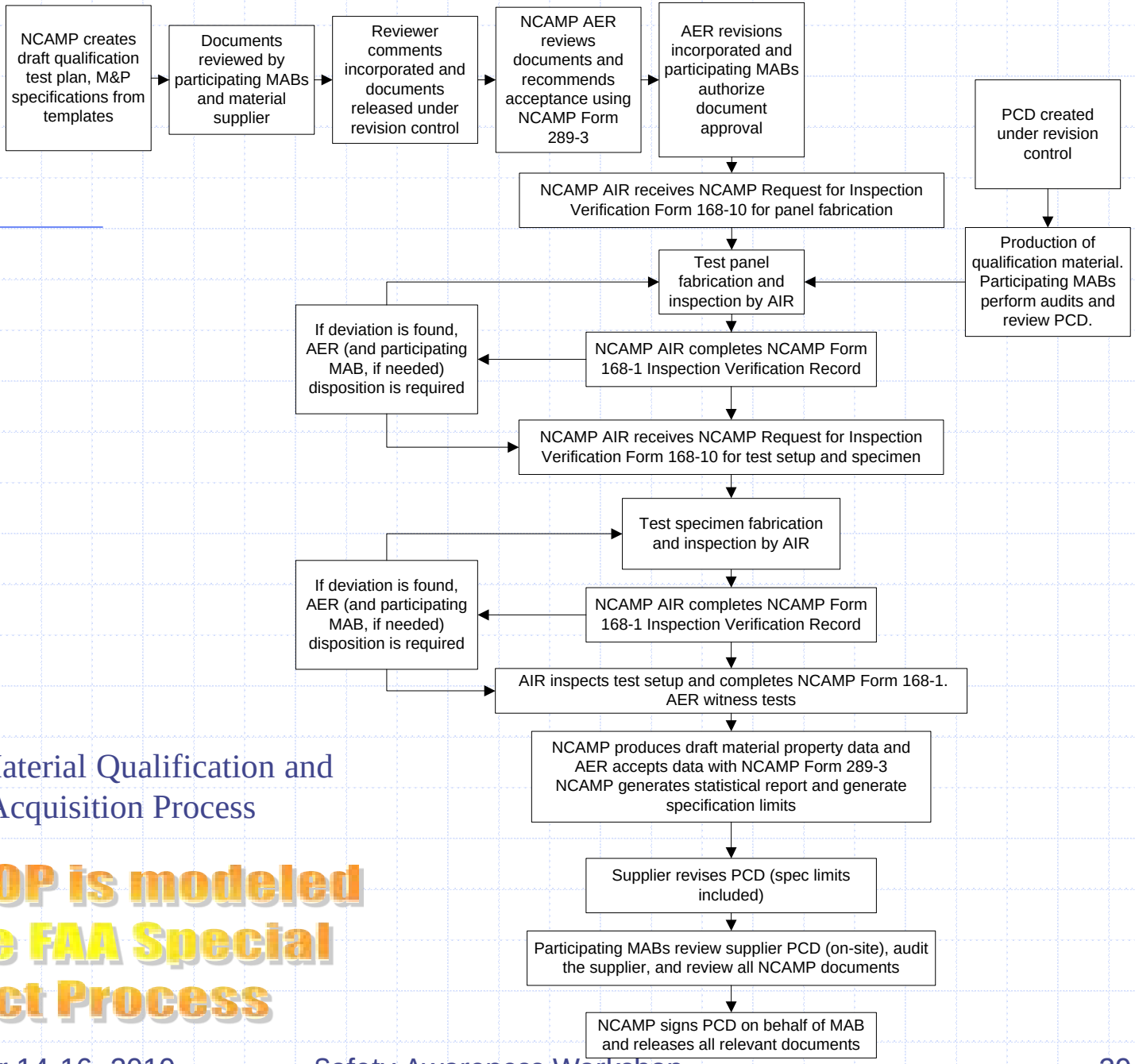
- The use of NCAMP material and process specifications do not guarantee material or structural performance. Material users must institute required quality control including, but not limited to, performing regular purchaser quality control tests, performing periodic equivalency/additional testing, participating in material change management activities, conducting statistical process control, and conducting regular supplier audits in order to properly utilize NCAMP design data.

- NCAMP does not guarantee that all the data necessary to design and certify a composite structure is provided by the data defined within the NCAMP database. The applicability of NCAMP material property data, material allowables, and specifications must be evaluated on case-by-case basis by aircraft companies and certifying agencies. Each user of the data must conduct validation tests as described by the NCAMP procedures to verify that the data is applicable to the materials and processes being used. NCAMP assumes no liability whatsoever, expressed or implied, related to the use of the material property data, material allowables, and specifications.

Scope of NCAMP SOP

- Material Qualification and Property Data Acquisition Process
- Equivalency Process for Part Fabricators
- Maintenance of Existing Shared Material Properties Database
- Provide processes to assure quality of data being provided

NCAMP and CMH-17 will work to publish these guidance in Vol. 1 of CMH-17



Flowchart of Material Qualification and Property Data Acquisition Process

NCAMP SOP is modeled after the FAA Special Project Process

AER Recommends Acceptance of Test Plan, Material Specification, and Process Specification

NCAMP FORM 289-3 ENGINEERING ACCEPTANCE (03-09)

National Center for Advanced Materials Performance

NCAMP FORM 289-3 ENGINEERING ACCEPTANCE

1. DATE: 9/30/2009

IDENTIFICATION

2. NCAMP PROJECT NO.	3. SUBMITTER OF DATA OR DOCUMENT
NPN090901	Yeow Ng

LIST OF DATA

4. IDENTIFICATION	5. TITLE
Material Specification: NMS 141, Rev -, 9/28/09	High Temperature Polyimide Composite Prepregs
NMS 141/2, Rev -, 9/28/09	High Temperature Polyimide Composite Prepreg, Type 36, Class 2, Grade 376, Style 3K-135-8HS
Process Specification: NPS 81141, Rev -, 9/28/09	Fabrication of NMS 141 Qualification, Equivalency, and Acceptance Test Panels
Qualification Test Plan: NTP 1412Q1 Rev -, 9/30/09	negade

6. PURPOSE OF DATA OR
Material property da

7. COMMENTS

8. ACCEPTANCE

I (We)

- ☒ Recommend acceptance of these documents (note: AER cannot accept test plans)
- ☐ Accept these data (or documents containing data)
- ☐ Reject these data or documents

9. SIGNATURE(S) OF AER(S)	AER NAMES	AER NUMBERS(S)
[redacted]	Ed Hooper	EH1

Page 1 of 1

AER will check this box to recommend acceptance of test plans and specifications (after reviewing them)

INSTRUCTION GUIDE FOR NCAMP FORM 289-3 ENGINEERING ACCEPTANCE

PURPOSE

This form should be submitted by AER to NCAMP under the following circumstances:

1. For the purposes of showing that the AER has reviewed documents such as material specification, process specification, and test plans and is recommending acceptance of the documents for a given test program. Note: AER cannot accept test plans; AER can only recommend acceptance of test plans.

2. For the purposes of showing that the AER has witnessed the material testing and is accepting the data for a given test program. Prior to any testing activity, the AER must verify that:
   a. All the specimens have passed inspection verification by an NCAMP AIR; a signed copy of the Inspection Verification Record NCAMP Form 168-1 must show that the specimens have passed such inspection verification.
   b. Appropriate equipment and fixtures are used.
   c. The measuring instruments such as load cell, extensometer, and thermocouple have certified calibrations that are current and valid within the range of interest. Verify that the strain gage indicator(s) has been calibrated using an NIST-traceable calibrator that is current and valid within the range of interest (note: internal shunt calibration alone is inadequate). Since strain gage indicator settings can be altered easily, this verification must be performed for every test setup, taking into account strain gage factor. For modulus measurements, verify that the load cell, extensometer, and strain gage calibration range encompasses the range of interest (typically, 1,000 – 3,000 microstrain for tensile/compressive modulus and 2,000 – 6,000 microstrain for in-plane shear modulus). For strength measurements, verify that the load cell calibration is valid at the expected specimen failure load level. One exception to this requirement is Poisson's ratio measurements where transverse strain range may be below the calibrated range.
   d. For certain tests such as ASTM D3039 that requires system alignment check, verify that the alignment was checked no longer than 30 days ago and that the grips have not been removed/reinstalled in the interim. If in doubt, re-check the system alignment prior to test. Note that most mechanical grips with universal joints will not be able to meet system alignment requirement. Grips with fixed joints are typically required to meet the system alignment requirement. The mating surfaces of the fixed joints must be clean, free of oil, and secure so that the grips will not become misaligned during the tests.

   AERs are typically requested to witness the testing of at least one specimen per test method per test condition per test program. The AER should verify that appropriate failure mode(s) is obtained and that the modulus, Poisson's ratio, and strength values are within expected ranges (where applicable). An AER may elect to witness the testing of more or less specimens at the sole discretion of the AER.

NCAMP Requests for Inspection Verification on Test Panel Fabrication To be conducted by AIR

NCAMP FORM 168-10 (03/09)

National Center for Advanced Materials Performance

1. Project Number: NPN090

3. Request for Inspecti

☒	**Test Panels**	revision.
☐	**Test Setups**	
☐	**Test Specimens**	
☐	**Other (specify)**	

A inspection verification pertaining to the subject is requested for the following:

4. Company or Laboratory Name:	Canyon Composites, Inc.				
5. Address: Street:	1548 N. Gemini Place				
City:	Anaheim	**State:**	CA	**Zip:**	92801
6. Contact Person	Jason Chikami, canyoncomposites@earthlink.net, tel: (714) 991-8181 B. J. Rutkoski, bj@canyoncomposites.com Eric Ehlers, eric.ehlers@canyoncomposites.com				
7. NCAMP Project Manager:	Yeow Ng	**Phone:**	316-978-5212 (office) 316-253-9122 (cell)		
8. NCAMP Project Engineer:	Kristin Marlett	**Phone:**	316-978-3296		

9. AER Name:
Ed Hooper

10. AIR Name:
William Becker

11. NOTE: Please inspect per instructions in item 12 below. Contact program manager Mr. Yeow Ng if you have any question or if there is any deviation/unsat. Provide inspection record and deviations (if any) in NCAMP Form 168-1.

12. Inspection Verification Instructions:

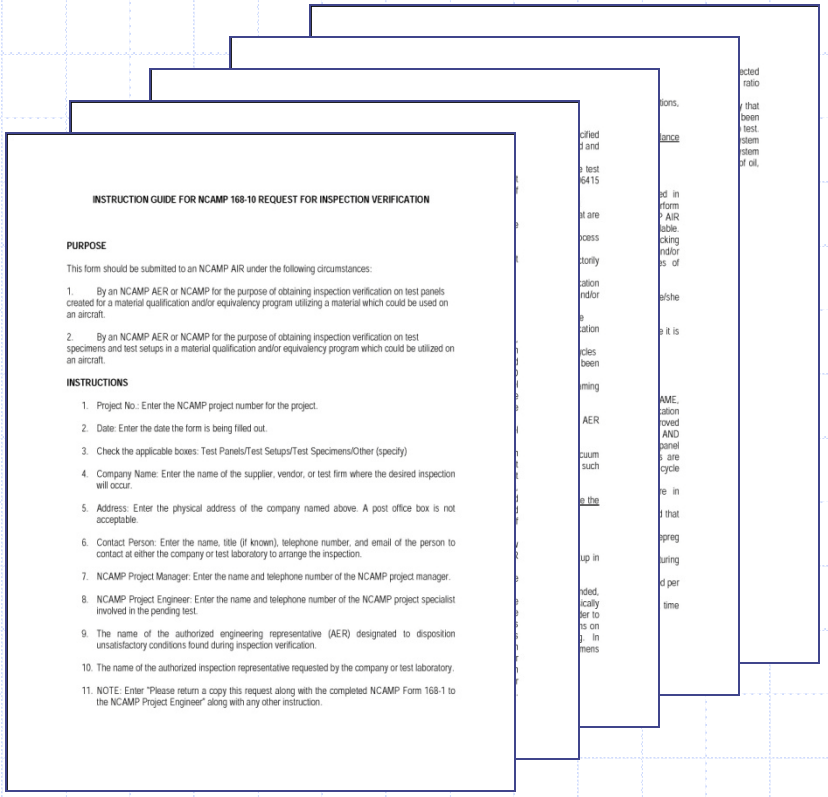
Guidance

i. The checklist below pertains to Polymer Matrix Composite (PMC) test panels fabricated in accordance with the governing process specification. It is understood that for PMC panels to perform as intended, item n. below is very important. It is further understood that to have the NCAMP AIR physically witness the fabrication of all panels would take more time and resource than are available. In order to alleviate this, it is expected that the NCAMP AIR will check to see that the ply stacking sequence on the planning match the test plan and that the job has been bought off by QA and/or Engineering. In addition, the NCAMP AIR should witness selected fabrication processes of representative panels at a frequency of his/her discretion.

ii. It is not the intent of these instructions to limit the NCAMP AIR in performing the inspections he/she feels are necessary.

iii. Where multiple panels are being processed through the same facility in a short period of time it is recognized that some steps could be validated one time and not for each panel.

Page 1 of 2



INSTRUCTION GUIDE FOR NCAMP 168-10 REQUEST FOR INSPECTION VERIFICATION

PURPOSE

This form should be submitted to an NCAMP AIR under the following circumstances:

1. By an NCAMP AER or NCAMP for the purpose of obtaining inspection verification on test panels created for a material qualification and/or equivalency program utilizing a material which could be used on an aircraft.

2. By an NCAMP AER or NCAMP for the purpose of obtaining inspection verification on test specimens and test setups in a material qualification and/or equivalency program which could be utilized on an aircraft.

INSTRUCTIONS

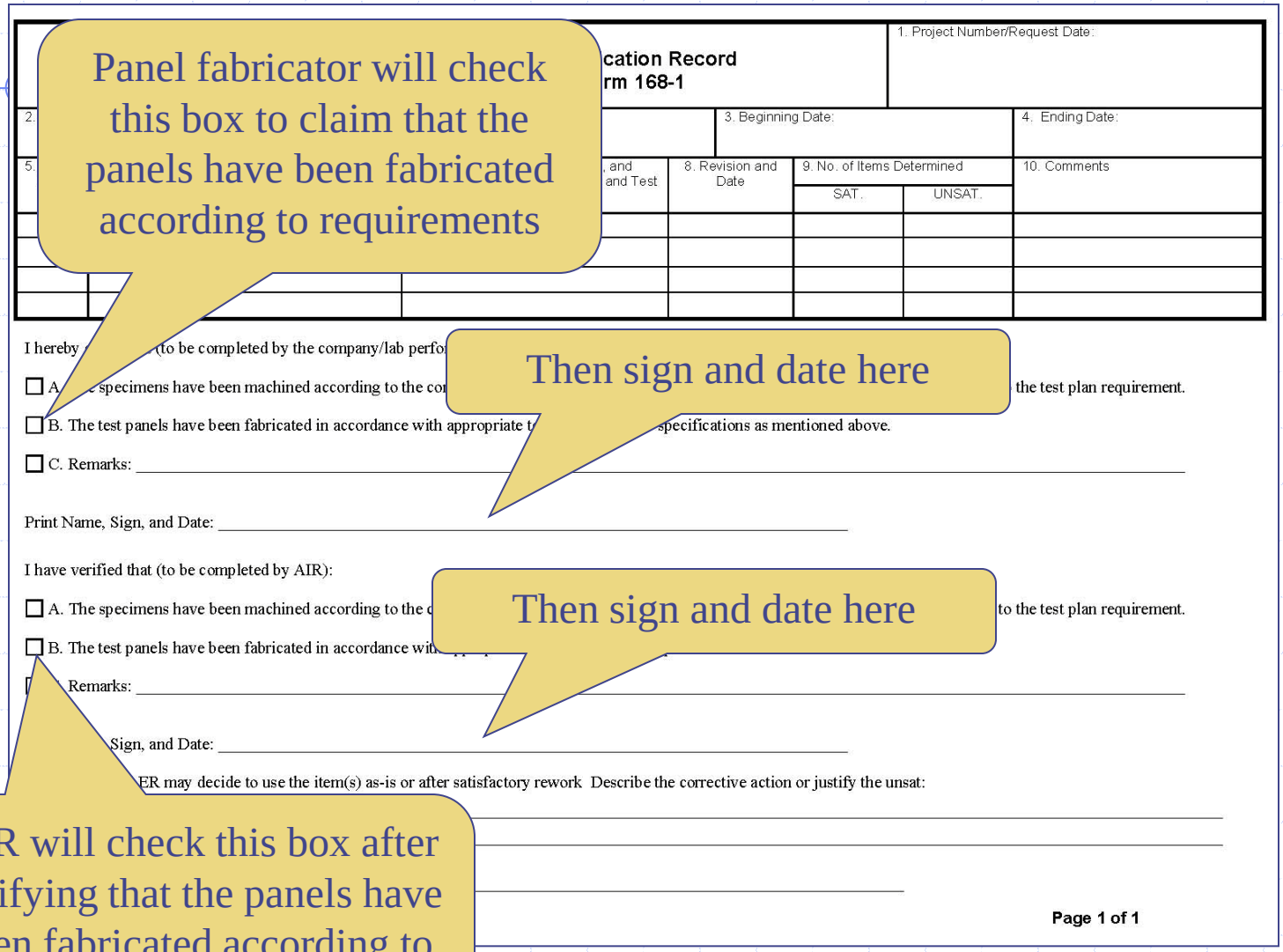
1. Project No.: Enter the NCAMP project number for the project.
2. Date: Enter the date the form is being filled out.
3. Check the applicable boxes: Test Panels/Test Setups/Test Specimens/Other (specify)
4. Company Name: Enter the name of the supplier, vendor, or test firm where the desired inspection will occur.
5. Address: Enter the physical address of the company named above. A post office box is not acceptable.
6. Contact Person: Enter the name, title (if known), telephone number, and email of the person to contact at either the company or test laboratory to arrange the inspection.
7. NCAMP Project Manager: Enter the name and telephone number of the NCAMP project manager.
8. NCAMP Project Engineer: Enter the name and telephone number of the NCAMP project specialist involved in the pending test.
9. The name of the authorized engineering representative (AER) designated to disposition unsatisfactory conditions found during inspection verification.
10. The name of the authorized inspection representative requested by the company or test laboratory.
11. NOTE: Enter "Please return a copy this request along with the completed NCAMP Form 168-1 to the NCAMP Project Engineer" along with any other instruction.

12. Inspection Verification Instructions (continued from previous page):

Checklist

a. This inspection will be in accordance with test plan NTP 1412Q1 Rev – dated 9/29/09 or later NCAMP-approved revision, material specification NMS 141/2 Rev – dated 9/28/09 or later NCAMP-approved revision, and process specification NPS 81141 Rev – dated 9/28/09 or later NCAMP-approved revision. Appendix 2 of the test plan provides the panel names, stacking sequences, and panel sizes. Some deviations in panel names are allowed to accurately reflect the actual fabrication process used (for example, cure cycle numbers may have C1, C2, C3, C4, etc.)
b. Verify Controlled Contamination areas is in accordance with governing specification
c. Verify personnel qualification as applicable.
d. Verify that the measuring instruments such as temperature, pressure, and vacuum transducers are calibrated. These instruments may be located on larger equipment such as an autoclave or oven.
e. Verify material used to build panel matches that identified in approved test plan and that there is traceability of material to panel
f. Check to see that all required tests have been done for each batch of prepreg material used and that results are within acceptance spec limits
g. Check to see that the certificate of conformance from the vendor shows the material lot/batch number(s) that match those in the prepreg roll(s).
h. Check to see that temperature recorders (on material storage freezers) are maintained per governing specification
i. Check to see that all materials used are within their storage temperature and out time limits (if available).
j. Check to see that frozen materials are protected in sealed bags, have followed specified handling procedures to avoid condensation before use, and that the bags are resealed and water tight before refreezing.
k. Verify that the tool used matches that required to produce the part specified in the test plan. All the tools should be flat except for interlaminar tension test per ASTM D6415 which requires a curved tool.
l. Verify that the tool surface quality is acceptable (i.e. smooth and able to hold vacuum)
m. Verify that thermocouple placement is in accordance with the governing process specification guidelines
n. Review plan for ply lay up and orientation and verify operations completed satisfactorily and accepted by their internal Quality Assurance and/or Engineering. If not verified satisfactorily, please verify by yourself as follows: Verify that ply orientation, lay-up, and stacking sequence are per test plan (on representative panels only because it may be too time consuming to inspect every panel). Note that ply orientation may not be easily inspected after the panels have been cured. Panels that are warped may have wrong/unsymmetrical layup.
o. Verify that vacuum bagging meets the requirements of the governing process specification and verify operations completed satisfactorily and accepted by Quality Assurance and/or Engineering.
p. Verify Cure Time/Temperature/Pressure meet the governing process specification requirements
q. Verify that the panels for each batch were cured in a minimum of two separate cure cycles
r. Verify inspection requirements called for in the governing process specification and test plan have been accomplished satisfactorily
s. Inspect the panels to verify panels meets the test plan dimensional and naming requirements specified in Appendix 2 of the test plan. Minor deviations from the test plan, particularly the codes for panel, cure cycle, and batch numbers, may be intentional in order to accurately define the actual numbers used in the fabrication process.
t. Review and verify Quality Assurance and/or Engineering has accepted the panels
u. Review any MRA/MRB documents for engineering acceptance, including NCAMP AER concurrence when necessary.

Inspection Verification Record: Test Panels



cation Record
rm 168-1

1. Project Number/Request Date:

2.	3. Beginning Date:	4. Ending Date:

5.	, and and Test	8. Revision and Date	9. No. of Items Determined		10. Comments
			SAT.	UNSAT.	

I hereby (to be completed by the company/lab perfo

☐ A. specimens have been machined according to the co the test plan requirement.

☐ B. The test panels have been fabricated in accordance with appropriate t specifications as mentioned above.

☐ C. Remarks: _____

Print Name, Sign, and Date: _____

I have verified that (to be completed by AIR):

☐ A. The specimens have been machined according to the c to the test plan requirement.

☐ B. The test panels have been fabricated in accordance wit

☐ Remarks: _____

Sign, and Date: _____

ER may decide to use the item(s) as-is or after satisfactory rework Describe the corrective action or justify the unsat:

_____

_____

_____

Page 1 of 1

Panel fabricator will check this box to claim that the panels have been fabricated according to requirements

Then sign and date here

Then sign and date here

AIR will check this box after verifying that the panels have been fabricated according to requirements

NCAMP Requests for Inspection Verification on Test Specimens To be conducted by AIR

NCAM

National C
Materia

1. Project Number: NPM		2. Date: 7/12/10
3. Request for Insp		on:
☐	Test	
☒	Test Specimens	Inspection verification on test specimens at NIAR Composites Laboratory for NTP 1412Q1 Renegade Materials MVK-14 Polyimide FreeForm™ T650 3K 8HS fabric 36% RC (see section 12 below for more details)
☐	Other (specify)	

A inspection verification pertaining to the subject is requested for the following:

4. Company or Laboratory Name:	NIAR Composites Laboratory, Wichita State University				
5. Address: Street:	1845 Fairmount Ave				
City:	Wichita	State:	KS	Zip:	67260-0093
6. Contact Person at Company or Laboratory:	Errick Robles, tel: 316-978-6717				
7. NCAMP Project Manager:	Yeow Ng	Phone:	316-978-5212		
8. Project Engineer:	Jonathan Lusk Kristin Marlett	Phone:	316-978-7443 316-978-3296		

9. AER Name: Ed Hooper

10. AIR Name: Bill Stovall and/or Ted Hazen

11. NOTE: Please return a copy this request along with the completed NCAMP Form 168-1 to the NCAMP Project Engineer.

12. Inspection Verification Instructions:

Guidance

i. The checklist below pertains to Polymer Matrix Composite (PMC) test specimens in accordance with the governing test plan.

ii. For specimen inspection verification, it is understood that for the specimens to perform as intended, item c below is very important. It is further understood that to have the NCAMP AIR physically measure all specimen dimensions would take more time and resource than are available. In order to alleviate this, it is expected that the NCAMP AIR will check to see that the specimen dimensions on planning match the test plan and that the job has been bought off by QA and/or Engineering. In addition, the NCAMP AIR should physically measure selected dimensions of representative specimens at a frequency of his/her discretion.

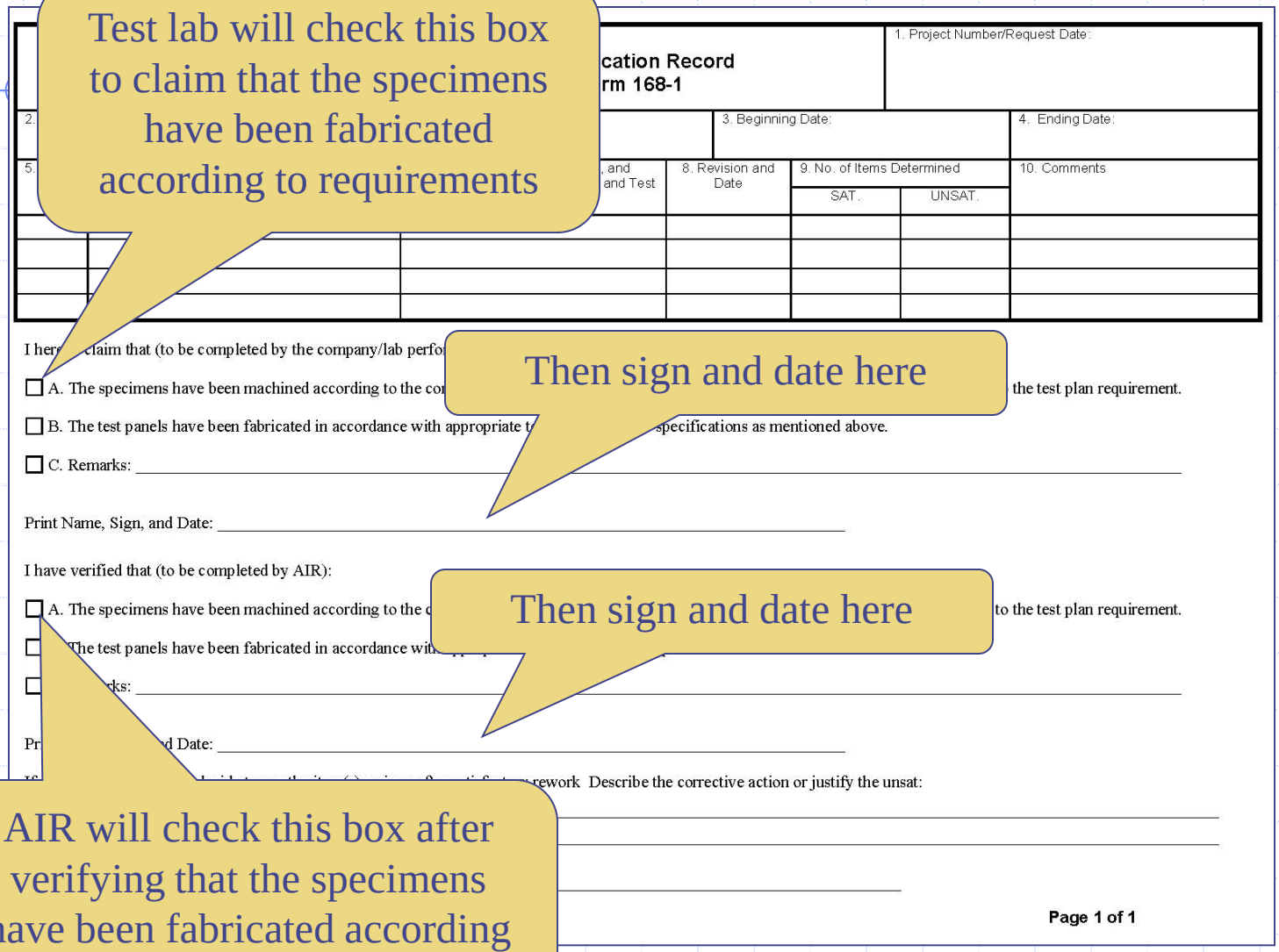
iii. It is not the intent of these instructions to limit the NCAMP AIR in performing the inspections he/she feels are necessary.

Checklist

a. This inspection will be in accordance with:
   i. Test plan NTP 1412Q1 "Material Property Data Acquisition and Qualification Test Plan for Renegade Materials MVK-14 Polyimide FreeForm™ T650 3K 8HS fabric 36% RC," Rev B, dated 5/26/2010 or later NCAMP-approved revision. Appendix 2 of the test plan provides the panel names, stacking sequences, and panel sizes. Some deviations in panel names are allowed to accurately reflect the actual fabrication process used (for example, cure cycle numbers may have C1, C2, C3, C4, etc.)
   ii. Material specification NMS 141/2 "High Temperature Polyimide Composite Prepreg, Type 36, Class 2, Grade 376, Style 3K-135-8HS," Rev -, dated 9/28/09 or later NCAMP-approved revision, and
   iii. Process specification NPS 81141 "Fabrication of NMS 141 Qualification, Equivalency, and Acceptance Test Panels," Rev A, dated 10/26/09 or later NCAMP-approved revision.
b. Verify that NCAMP 168-1 Inspection Verification Record was received for the panel fabrication process
c. For test specimen inspection verification, verify that the specimen dimensions are in accordance with the drawings in the test plan (or the test methods called out by the test plan). At minimum, QA must have inspected at least one specimen per panel per test method for all the dimensions specified in the drawing such as perpendicularity, parallelism, hole size and location, etc. (this assumes that all the specimens are processed at the same time using the same jig setup and technician). In addition, NCAMP AIR should physically measure selected dimensions of representative specimens at a frequency of his/her discretion.
d. When specimen dimensions fail to meet one or more of the drawing requirements, review any MRA/MRB documents for engineering acceptance, including NCAMP AER concurrence when necessary.

NCAMP Requests for Inspection Verification for Test Specimens
To be conducted by AIR

Inspection Verification Record: Test Specimens



cation Record
rm 168-1

1. Project Number/Request Date:

2.	3. Beginning Date:	4. Ending Date:

5.	, and and Test	8. Revision and Date	9. No. of Items Determined		10. Comments
			SAT.	UNSAT.	

I here claim that (to be completed by the company/lab perfo

☐ A. The specimens have been machined according to the co the test plan requirement.

☐ B. The test panels have been fabricated in accordance with appropriate t specifications as mentioned above.

☐ C. Remarks: _____

Print Name, Sign, and Date: _____

I have verified that (to be completed by AIR):

☐ A. The specimens have been machined according to the c to the test plan requirement.

☐ The test panels have been fabricated in accordance wit

☐ rks: _____

Pr d Date: _____

rework Describe the corrective action or justify the unsat:

_____

_____

_____

Page 1 of 1

Test lab will check this box to claim that the specimens have been fabricated according to requirements

Then sign and date here

Then sign and date here

AIR will check this box after verifying that the specimens have been fabricated according to requirements

AER Acceptance of Data (or Data Report)

NCAMP FORM 289-3 ENGINEERING ACCEPTANCE (03-09)

National Center for Advanced Materials Performance

NCAMP FORM 289-3 ENGINEERING ACCEPTANCE

1. DATE

IDENTIFICATION

2. NCAMP PROJECT NO.	3. SUBMITTER OF DATA OR DOCUMENT

LIST OF DATA

4. IDENTIFICATION	5. TITLE

6. PURPOSE OF DATA OR DOC

7. COMMENTS

AER will check this box to accept data (after test witnessing)

8. ACCEPTANCE

I (We)

- ☐ Reco[illegible]d acceptance of these documents (note: AER cannot accept test plans)
- ☐ Accept these data (or documents containing data)
- ☐ Reject these data or documents

9. SIGNATURE(S) OF AER(S)	AER NAMES

Page 1 of 1

INSTRUCTION GUIDE FOR NCAMP FORM 289-3 ENGINEERING ACCEPTANCE

PURPOSE

This form should be submitted by AER to NCAMP under the following circumstances:

1. For the purposes of showing that the AER has reviewed documents such as material specification, process specification, and test plans and is recommending acceptance of the documents for a given test program. Note: AER cannot accept test plans; AER can only recommend acceptance of test plans.

2. For the purposes of showing that the AER has witnessed the material testing and is accepting the data for a given test program. Prior to any testing activity, the AER must verify that:
   a. All the specimens have passed inspection verification by an NCAMP AIR; a signed copy of the Inspection Verification Record NCAMP Form 168-1 must show that the specimens have passed such inspection verification.
   b. Appropriate equipment and fixtures are used.
   c. The measuring instruments such as load cell, extensometer, and thermocouple have certified calibrations that are current and valid within the range of interest. Verify that the strain gage indicator(s) has been calibrated using an NIST-traceable calibrator that is current and valid within the range of interest (note: internal shunt calibration alone is inadequate). Since strain gage indicator settings can be altered easily, this verification must be performed for every test setup, taking into account strain gage factor. For modulus measurements, verify that the load cell, extensometer, and strain gage calibration range encompasses the range of interest (typically, 1,000 – 3,000 microstrain for tensile/compressive modulus and 2,000 – 6,000 microstrain for in-plane shear modulus). For strength measurements, verify that the load cell calibration is valid at the expected specimen failure load level. One exception to this requirement is Poisson's ratio measurements where transverse strain range may be below the calibrated range.
   d. For certain tests such as ASTM D3039 that requires system alignment check, verify that the alignment was checked no longer than 30 days ago and that the grips have not been removed/reinstalled in the interim. If in doubt, re-check the system alignment prior to test. Note that most mechanical grips with universal joints will not be able to meet system alignment requirement. Grips with fixed joints are typically required to meet the system alignment requirement. The mating surfaces of the fixed joints must be clean, free of oil, and secure so that the grips will not become misaligned during the tests.

   AERs are typically requested to witness the testing of at least one specimen per test method per test condition per test program. The AER should verify that appropriate failure mode(s) is obtained and that the modulus, Poisson's ratio, and strength values are within expected ranges (where applicable). An AER may elect to witness the testing of more or less specimens at the sole discretion of the AER.

NCAMP Lamina Test Matrix for unidirectional

AER typically witnesses the testing of one or two specimens of every test method and every condition

Layup	Test Type and Direction	Property	Number of Batches x No. of Panels x No. of Specimens			
			Test Temperature/Moisture Condition			
			CTD	RTD	ETD	ETW
$[0]_8$	ASTM D3039 0° Tension	Strength, Modulus and Poisson's Ratio	3x2x3	3x2x3		3x2x3
$[0]_{20}$	ASTM D6641 0° Compression	Modulus	3x2x3	3x2x3	3x2x3	3x2x3
$[90]_{16}$	ASTM D3039 90° Tension	Strength and Modulus	3x2x3	3x2x3		3x2x3
$[90]_{20}$	ASTM D6641 90° Compression	Strength and Modulus	3x2x3	3x2x3		3x2x3
$[0/90]_{3S}$	ASTM D3039 0° Tension	Strength and Modulus	3x2x3	3x2x3		3x2x3
$[90/0/90]_7$	ASTM D6641 0° Compression	Strength and Modulus	3x2x3	3x2x3	3x2x3	3x2x3
$[45/-45]_{4S}$	ASTM D3518 In-Plane Shear	Strength and Modulus	3x2x3	3x2x3		3x2x3
$[0]_{45}$	ASTM D2344 Short Beam	Strength	3x2x3	3x2x3	3x2x3	3x2x3

The Approach - Completing the M&P Puzzle

Material Properties
NCAMP Basis Values → CMH-17 vol. 2

Material Specification
NCAMP NMS XXXX/XX → SAE AMS XXXX/XX

Process Control Documents (PCD)
NCAMP Guides → User Reviewed Supplier PCDs

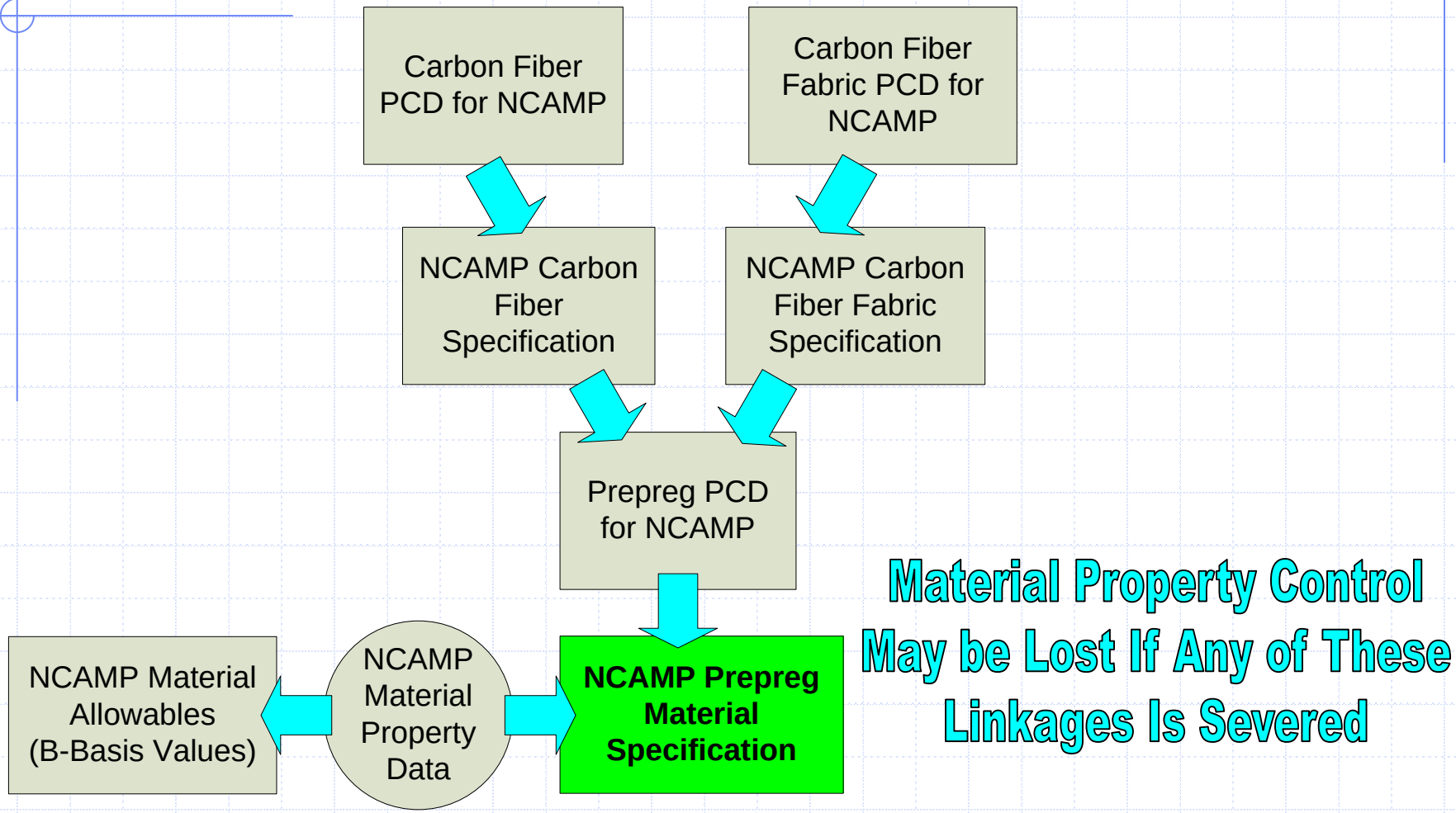
Material & Process Limitation Information
UBC/CMT Process Maps → User Process Specs

Material Design Guidance
NCAMP Recommendations → User Design Manual

Material Specification Callouts

- Recommended:
  - Option 1: For smaller applications, call out NMS directly in engineering drawings
  - Option 2: If an aircraft company desires more control, an equivalent material specification may be created with linkage to NCAMP prepreg specification through a material substitution table, QPL, or equivalent. This is approach is not new; it is a standard industry practice for many fasteners and metals.
- Not recommended:
  - An aircraft company creates a separate/standalone prepreg material specifications with no linkage to NMS – see next slide for reason

Linkages to NCAMP Material Specification



Must Maintain Direct Linkage to NCAMP Prepreg Material Specification and its PCDs

- NCAMP prepreg specification, which helps ensure NCAMP allowables, is usually linked to specific
  - Prepreg PCD
  - Fiber specification and PCD
  - Fabric specification and PCD

- Do not create a separate standalone prepreg material specification for NCAMP allowables because
  - The linkages to all other controlling specifications and PCDs may be lost
  - Loss of material property control
  - May render material allowables invalid
  - Material properties may diverge because material go through changes over time
  - Results in multiple specifications for the same material

OTHERWISE, DO NOT USE NCAMP ALLOWABLES

M&P Controls

"A" is most common; "C" is the minimum NCAMP requirement

Material Name	Process Spec	Prepreg Spec	Prepreg Change Control	Prepreg PCD	Fiber Spec	Fiber Change Control	Fiber PCD	Fabric Spec	Fabric Change COntrol	Fabric PCD
A	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
B	yes	yes	yes	yes	yes	yes	no	yes	yes	no
C	yes	yes	yes	yes	no*	yes	no	no*	yes	no

* fiber and fabric spec control via prepreg PCD and/or prepreg spec

Process Specification Callouts

- NPS are designed to produce test panels only for the purpose of material qualification, equivalency, and acceptance
- Aircraft companies should create their internal process specifications using NPS as the baseline to include
  - Compatible film adhesives, syntactic core, honeycomb, etc.
  - Compatible bagging materials
  - Multiple cure cycles
  - Extremely thick or large parts
  - Ply splicing, temperature uniformity requirement, first part qualification, inspection, discrepancy acceptance/rework criteria, etc.
  - Some additional R&D and testing may be required to create robust (proprietary) process specifications for part fabrication

Cure Cycle Scaling

PART SUPPLIERS ⟷ **OEM** ⟷ **FAA** ⟷ **MATERIAL SUPPLIERS**

- **Conduct autoclave temperature surveys and heating rate studies**
- **Communicate production modifications to baseline cure cycle to OEM**

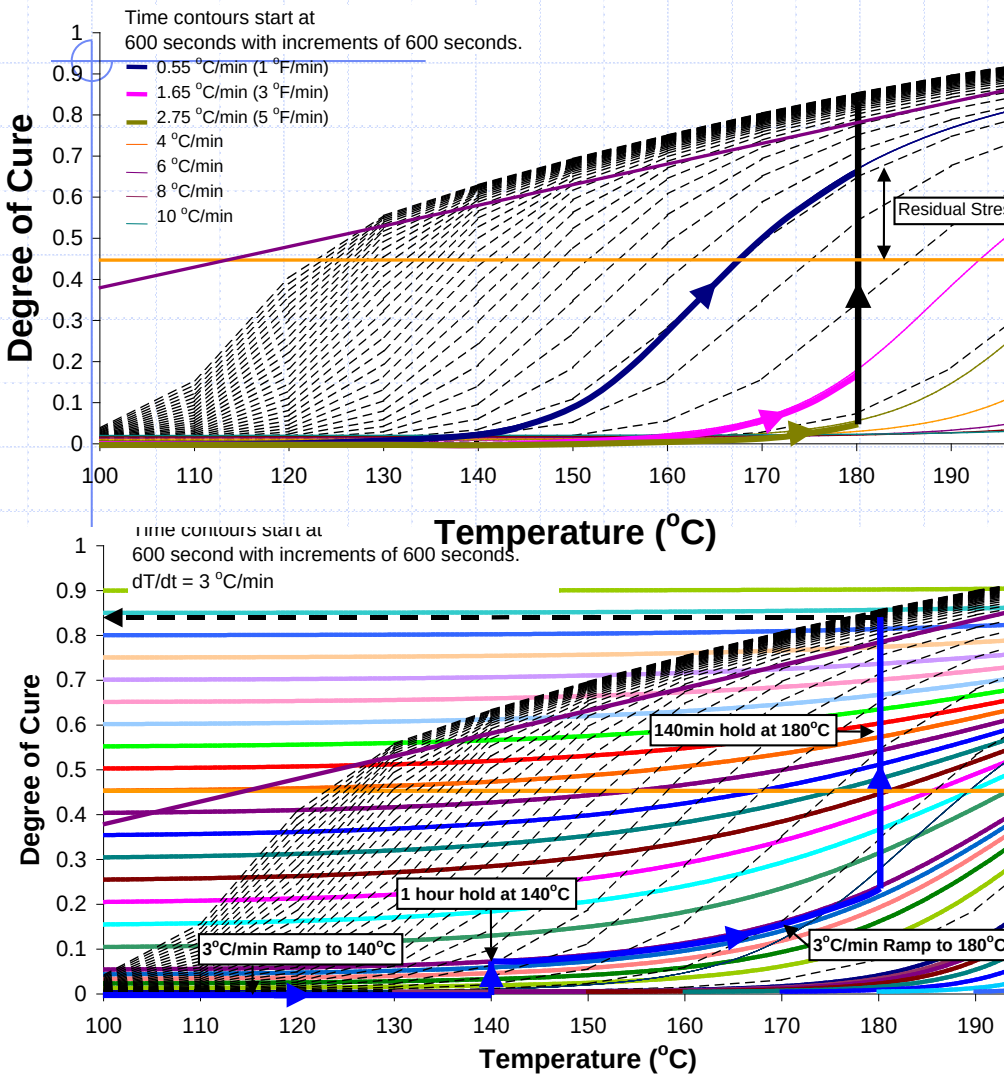
- **Assess part supplier requested production cure cycles**
- **Work with material suppliers to verify full cure with cycle modifications**
- **Conduct equivalency testing to link modified cycle with qualification (baseline) cycle**
- **Incorporate modified cycles into process specs.**
- **Submit cure cycle equivalency data to FAA if required**

- **Review / approve production cure cycles and process specs.**

- **Advise OEM on effects of cure cycle modifications**

Cure Cycle Scaling Tied in with Process Specs. and Equivalency

Process Map Development



- Material is characterized using DSC for degree of cure; optionally other properties can also be characterized using DMA, TMA, etc.
- Process maps are generated with contours of time for isothermal holds, overlaid with dynamic ramps
- A map can either consider multiple ramps at the same ramp rate, or a single ramp at a different ramp rate
  - This is not a fundamental drawback, but a limit to how busy a map can be
- Any cycle can then be followed by following the ramp and hold contours
- The resulting cycle can then be overlaid on property maps with identical axes but with contours of the property of interest
- Other than limitations of graphical representation, same accuracy as running computer model, and much more informative
- A UBC spin-off company, CMT, is developing simple graphical applications using process maps for even further automation and convenience

Material Model (Process Map) Development

- Material Characterization for Processing ACG MTM45-1
- Material Characterization for Processing Hexcel 8552
- Material Characterization for Processing CYTEC Cycom 5250-5
- Material Characterization for Processing CYTEC Cycom 5215
- Material Characterization for Processing Toray 2510
- To get access, contact kmarlett@niar.wichita.edu

Film Adhesive Screening Programs

- Screen for compatible film adhesives for cocure and cobond applications with the prepregs currently undergoing NCAMP qualifications
  - ACG MTM45-1, Cytec 5215, Cytec 5250-5, Cytec 977-2, Hexcel 8552, Newport 4708, Nelcote E752, Tencate TC250
- Two film adhesives per prepreg resin system will be chosen by material users
- It's a screening program; material allowables will not be generated
- Adhesive material specifications will not be created since they are not qualification programs.
- A detailed adhesive information data sheet will be included in the final report. The final report will only contain test results and observations.

NCAMP Test Plans

- Based heavily on DOT/FAA/AR-03/19, DOT/FAA/AR-02/110, DOT/FAA/AR-06/10
  - Generic across commercial, military, space, rotorcraft, and general aviation
  - FAA/NCAMP helps create data pedigree (conformity & witnessing)
  - With NCAMP material & process specifications
  - Prepreg physical, chemical, and thermal properties
  - Lamina static, thermal, and fluid sensitivity
  - Laminate static (soft, quasi, hard): 3 environments, 3 batches
  - Subjected to rigorous industry and government review
- To establish material specification limits for material control
- To generate most basic material properties and basis values (a.k.a material allowables), which is *not* to be confused with design values
- Provides some usable data; additional testing and analysis will be required (see CMH-17 vol.3)

NCAMP Datasets Contain

- Material Property Report
- Statistical Analysis Report
- Test Plan
- Material Specification
- Process Specification
- PMC Data Collection Template
- Raw Data Reduction Files
- Summary Sheets by Test Methods*
- Lamina and Laminate Summary*
- FAA Documentations**
  - FAA Form 8120-10 Request for Conformity
  - FAA Form 8100-1 Conformity Inspection Report
  - FAA 8130-3 Airworthiness Approval Tag
  - FAA Form 8130-9 Statement of Conformity
  - FAA 8110-3 Statement of Compliance with FAA Regulation (by DER)
  - FAA Request for Special Delegation (witness form)
  - Stamped Final FAA Acceptance/Approval on Submitted Documents
- DMA Results
- Test Setup and Tested Specimen Photos
- NDI (TTU) Scans
- Cured Ply Thickness Measurements
- Moisture Conditioning Charts
- Prepreg (uncured) Test Results
- Cured Laminate Physical Testing Results
- Fluid Sensitivity Test Results
- Shelf-life & Out-time Test Results

* Similar to CMH1-7 reporting style

** For newer programs that utilizes NCAMP SOP, equivalent NCAMP documentations are provided

Sample of Lamina Data

Prepreg Material:	Advanced Composites Group - MTM45-1 PWC2 3K PW G30-500 Fabric ACGM 1001-13 or NMS 451/13 Material Specification				
Fiber:	Tenax-J HTS40 E13 3K 200TEX		**Resin:**	MTM45-1	
Tg(dry):	360.36°F	**Tg(wet)**	320.42°F	**Tg METHOD:**	DMA (SRM 18-94)
PROCESSING:	ACGP 1001-02 Process Specification "MH" Cure Cycle				

Sample Only
Lamina Properties Summary

Date of fiber manufacture	10/2003; 7/2004; 6/2005	**Date of testing**	02/2006 - 07/2006
Date of resin manufacture	11/2005 -12/2005	**Date of data submittal**	03/2008 - 08/2008
Date of prepreg manufacture	11/2005-12/2005; 4/2006		
Date of composite manufacture	12/2005 -3/2006; 4/2006		

LAMINA MECHANICAL PROPERTY SUMMARY
Data reported as: Normalized & Measured
(Normalized by CPT= .0079 inch)

	CTD Mean		RTD Mean		ETD Mean		ETW Mean		ETW2 Mean	
	Normalized	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**
F_1^{tu} (ksi)	137.39	135.47	141.31	139.63	---	---	134.53	134.10	130.24	130.15
E_1^t (Msi)	9.37	9.23	9.24	9.13	---	---	8.98	8.95	---	---
F_2^{tu} (ksi)	125.64	127.06	128.26	129.21	---	---	117.18	117.28	110.44	109.71
E_2^t (Msi)	9.07	9.17	8.88	8.95	---	---	8.64	8.64	---	---

Sample of Lamina Data

Sample Only

(continued from last page)

F_1^{cu} (ksi)	104.85	105.08	99.43	99.86	---	---	65.30	66.46	58.45	59.70
E_1^c (Msi)	8.80	8.82	8.32	8.36	---	---	8.33	8.48	---	---
ν_{12}^c	---	0.048	---	0.057	---	---	---	0.048	---	---
F_2^{cu} (ksi)	96.41	98.60	88.68	89.44	75.42	75.93	58.31	57.90	51.85	51.59
E_2^c (Msi)	8.40	8.59	8.20	8.28	8.21	8.27	7.89	7.84	---	---
ν_{21}^c	---	0.051	---	0.056	---	0.050	---	0.047	---	---
$F_{12}^{s5\%strain}$ (ksi)	---	14.08	---	10.77	---	---	---	6.80	---	5.67
$F_{12}^{s0.2\%}$ (ksi)	---	8.27	---	6.12	---	---	---	3.88	---	3.25
G_{12}^s (Msi)	---	0.661	---	0.557	---	---	---	0.401	---	0.340
SBS (ksi)	---	12.86	---	10.29	---	7.97	---	6.53	---	5.24

ETW2 Modulus and Poisson's Ratio values removed pending investigation into high CV obtained

NCAMP Recommended B-basis Values
(Sample Only)

Sample Only

All B-basis values in this table meet the standards for publication in CMH-17G Handbook
Values are for normalized data unless otherwise noted

Lamina Strength Tests

Environment	Statistic	WT	WC	FT	FC	SBS*	IPS*	
							0.2% Offset	5% Strain
CTD (-65 F)	B-basis	122.85	92.32	111.69	86.59	11.88	7.22	NA
	Mean	137.39	104.85	125.64	96.41	12.86	8.27	
	CV	6.42	9.33	6.08	7.96	6.72	6.40	
RTD (75 F)	B-basis	127.28	86.97	114.31	78.86	9.31	5.37	9.57
	Mean	141.31	99.43	128.26	88.68	10.29	6.12	10.77
	CV	6.27	6.82	6.92	7.50	6.00	6.67	6.11
ETD (200 F)	B-basis				65.61	6.99		
	Mean				75.42	7.97		
	CV				7.30	6.00		
ETW (200 F)	B-basis	119.91	53.07	103.31	48.49	5.54	3.43	NA
	Mean	134.53	65.30	117.18	58.31	6.53	3.88	
	CV	6.00	7.57	6.71	6.00	6.00	6.00	
ETW2 (250 F)	B-basis	115.84	42.40	96.49	42.09	4.25	2.85	4.86
	Mean	130.24	58.45	110.44	51.85	5.24	3.25	5.67
	CV	6.00	8.39	6.84	7.80	6.00	6.39	7.29

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
NA indicates that tests were run but data did not meet CMH17-G requirements.
* Data is as measured rather than normalized

Material: Advanced Composites Group - MTM45-1 PWC2 3K PW G30-500 Fabric
ACGM 1001-13 or NMS 451/13 Material Specification

Fiber: Tenax-J HTS40 E13 3K 200TEX **Resin:** MTM45-1

Tg(dry): 275°F **Tg(wet):** 265°F **Tg METHOD: DMA (SRM 18-94)**

PROCESS ACGP 1001-02 Process Specification "MH" Cure Cycle

ACG - MTM45-1/ 3K Plain Weave G30-500 Fabric Lamina Properties Summary

Sample Only

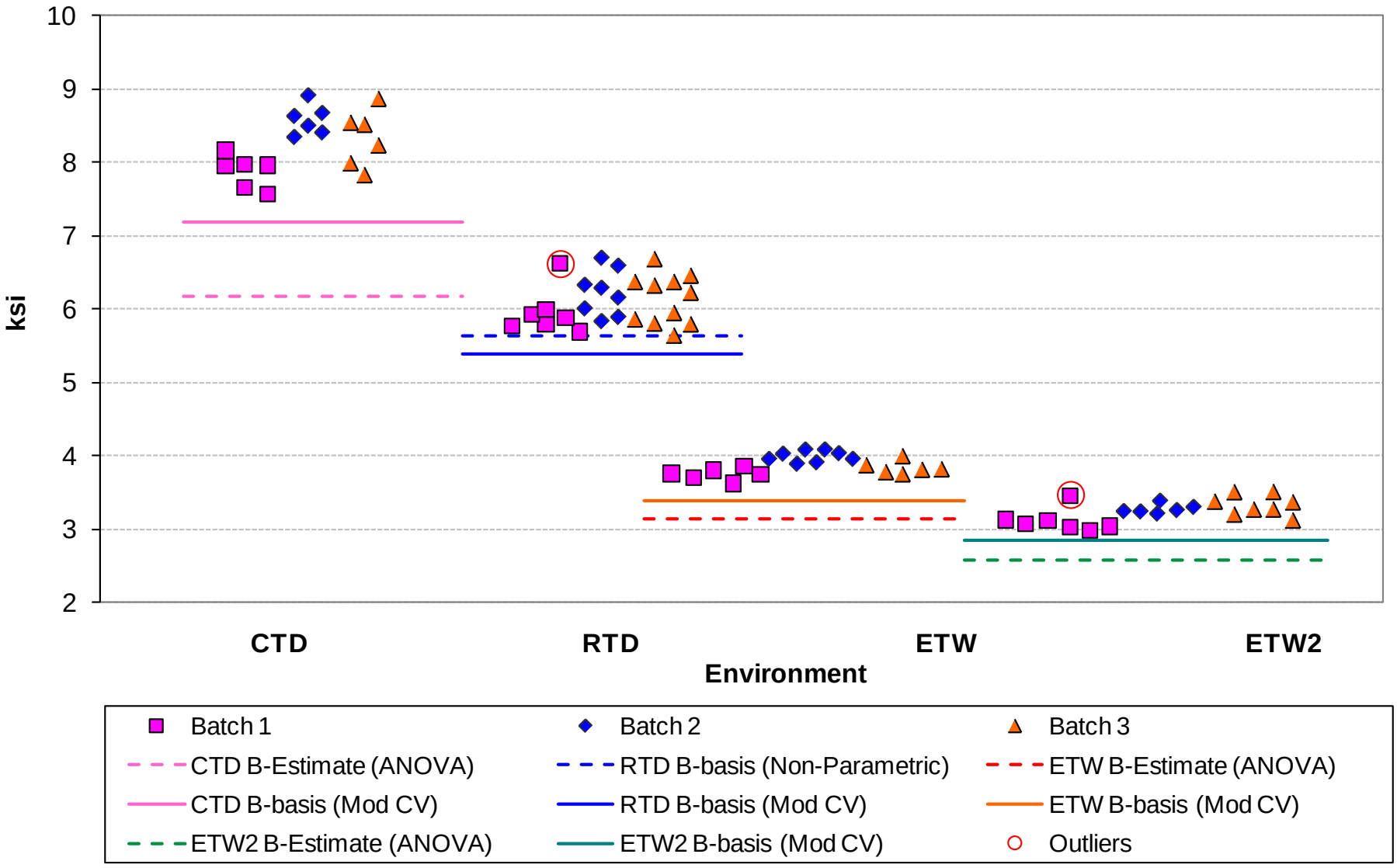
Date of fiber manufactur	10/2003; 7/2004; 6/2005	**Date of testing**	02/2006 - 07/2006
Date of resin manufactur	11/2005 -12/2005	**Date of data submittal**	03/2008 - 08/2008
Date of prepreg manufac	11/2005-12/2005; 4/2006	**Data of analysis**	10/2006 - 3/2009
Date of composite manu	12/2005 -3/2006; 4/2006		

LAMINA MECHANICAL PROPERTY SUMMARY FOR MTM45-1/ 3K PLAIN WEAVE G30-500 FABRIC
Data reported: As measured followed by normalized values in parentheses, normalizing tply: 0.0079 in
Values shown in shaded boxes do not meet all CMH17 Rev G requirements and are estimates only
These values may NOT be used for certification unless specifically allowed by the certifying agency.

	CTD			RTD			ETD			ETW			ETW2		
	B-Basis	CV B-	Mean	B-Basis	CV B-	Mean	B-Basis	CV B-	Mean	B-Basis	CV B-	Mean	B-Basis	CV B-	Mean
F_1^{cu} (ksi)	87.31 (93.01)	92.55 (92.32)	105.08 (104.85)	73.20 (87.65)	87.39 (86.97)	99.86 (99.43)				57.88 (53.75)	54.22 (53.07)	66.46 (65.30)	50.28 (42.40)		59.70 (58.45)
E_1^c (Msi)			8.82 (8.80)			8.36 (8.32)						8.48 (8.33)			
ν_{12}^{cu}			0.048			0.057						0.048			
F_1^{tu} (ksi)	125.07 (127.86)	120.72 (122.85)	135.47 (137.39)	129.59 (132.11)	125.40 (127.28)	139.63 (141.31)				123.64 (124.95)	119.27 (119.91)	134.10 (134.53)	119.86 (120.80)	115.55 (115.84)	130.15 (130.24)
E_1^t (Msi)			9.23 (9.37)			9.13 (9.24)						8.95 (8.98)			
F_2^{cu} (ksi)	89.23 (87.20)	88.64 (86.59)	98.60 (96.41)	80.07 (79.47)	79.48 (78.86)	89.44 (88.68)	66.56 (66.22)	65.98 (65.61)	75.93 (75.42)	48.53 (49.10)	47.95 (48.49)	57.90 (58.31)	42.27 (42.70)	41.69 (42.09)	51.59 (51.85)
E_2^c (Msi)			8.59 (8.40)			8.28 (8.20)			8.27 (8.21)			7.84 (7.89)			
ν_{21}^{cu}			0.051			0.056			0.050			0.047			
F_2^{tu} (ksi)	114.77 (114.50)	112.48 (111.69)	127.06 (125.64)	116.92 (117.12)	114.64 (114.31)	129.21 (128.26)				105.05 (106.10)	102.78 (103.31)	117.28 (117.18)	97.42 (99.30)	95.13 (96.49)	109.71 (110.44)
E_2^t (Msi)			9.17 (9.07)			8.95 (8.88)						8.64 (8.64)			
$F_{12}^{s5\%}$ (ksi)	13.10	12.26	14.08	9.95	9.57	10.77				4.18	5.84	6.80	3.66	4.86	5.67
$F_{12}^{s0.2\%}$ (ksi)	6.19	7.22	8.27	5.64	5.37	6.12				3.15	3.43	3.88	2.59	2.85	3.25
G_{12}^s (Msi)			0.66			0.56						0.40			0.34
SBS (ksi)	12.26	11.88	12.86	9.69	9.31	10.29	7.36	6.99	7.97	5.92	5.54	6.53	4.63	4.25	5.24

In Plane Shear 0.2% Offset Strength

Sample Only



Sample of Laminate Data

Prepreg Material:	Advanced Composites Group - MTM45-1 PWC2 3K PW G30-500 Fabric ACGM 1001-13 or NMS 451/13 Material Specification			Sample Only **Laminate Properties Summary**	
Fiber	Tenax-J HTS40 E13 3K 200TEX		**Resin** MTM45-1		
Tg(dry)	360.36°F	**Tg(wet)**	320.42°F	**Tg METHOD**	DMA (SRM 18-94)
PROCESSING:	ACGP 1001-02 Process Specification "MH" Cure Cycle				

Date of fiber manufacture	10/2003; 7/2004; 6/2005	**Date of testing**	02/2006 - 07/2006
Date of resin manufacture	11/2005 -12/2005	**Date of data submittal**	03/2006 - 08/2006
Date of prepreg manufacture	11/2005-12/2005; 4/2006		
Date of composite manufacture	12/2005 -3/2006; 4/2006		

LAMINATE MECHANICAL PROPERTY SUMMARY
Data reported as: Normalized & Measured
(Normalized by CPT= .0079 inch)

	Layup:	**25/50/25**		**10/80/10**		**50/40/10**	
	Test Condition	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**
OHT Strength (ksi)	**CTD**	51.27	50.81	45.23	44.22	65.31	64.40
	RTD	52.16	51.95	40.06	39.26	62.56	62.51
	ETW	49.52	48.73	---	---	---	---
	ETW2	51.21	50.74	31.17	30.48	64.13	63.53
OHC Strength (ksi)	**RTD**	41.71	40.71	36.94	36.47	48.78	47.06
	ETW	31.46	30.58	---	---	---	---
	ETW2	28.92	28.00	26.40	25.69	30.74	29.76
UNT Strength (ksi)	**CTD**	94.45	92.96	59.19	58.28	122.05	121.11
	RTD	96.42	94.79	58.23	56.84	124.20	122.67
	ETW2	78.13	77.49	45.64	44.47	113.66	112.32
Modulus (msi)	**CTD**	6.61	6.51	4.33	4.26	8.32	8.26
	RTD	6.46	6.35	4.12	4.02	8.16	8.06

Sample of Laminate Data

(continued from last page)

Sample Only

UNC	**RTD**	74.05	74.70	50.88	51.02	84.84	85.57
Strength (ksi)	**ETW**	52.91	53.05	---	---	---	---
	ETW2	48.79	48.76	32.16	31.88	52.64	52.83
						---	---
Modulus (msi)	**RTD**	5.94	5.98	3.88	3.89	7.52	7.58
	ETW	5.61	5.62	---	---	---	---
νUNC	**RTD**	---	0.322	---	0.554	---	0.144
	ETW	---	0.304	---	---	---	---
FHT	**CTD**	54.12	53.09	46.52	46.11	64.40	62.82
Strength (ksi)	**RTD**	52.47	51.66	41.25	40.65	60.95	59.43
	ETW2	---	---	33.43	32.61	---	---
FHC	**RTD**	59.80	59.04	50.05	49.46	66.30	65.32
Strength (ksi)	**ETW2**	44.30	43.38	31.65	30.98	48.01	47.27
LSBS	**RTD**	---	9.99	---	---	---	---
Strength (ksi)	**ETW**	---	6.33	---	---	---	---
	ETW2	---	5.26	---	---	---	---
PB							
2% offset Strength	**RTD**	88.26	87.98	86.80	86.38	82.13	80.38
Strength (ksi)	**ETW2**	73.86	73.95	66.36	66.11	70.18	70.57
ILT	**RTD**	---	7.68	---	---	---	---
Strength (ksi)	**ETW2**	---	3.32	---	---	---	---
CAI	**RTD**	33.84	33.69	---	---	---	---
Strength (ksi)							

ETW2 Modulus and Poisson's Ratio values removed pending investigation into high CV obtained

NCAMP Recommended B-basis Values
(Sample Only)

All B-basis values in this table meet the standards for publication in CMH-17G Handbook
Values are for normalized data unless otherwise noted

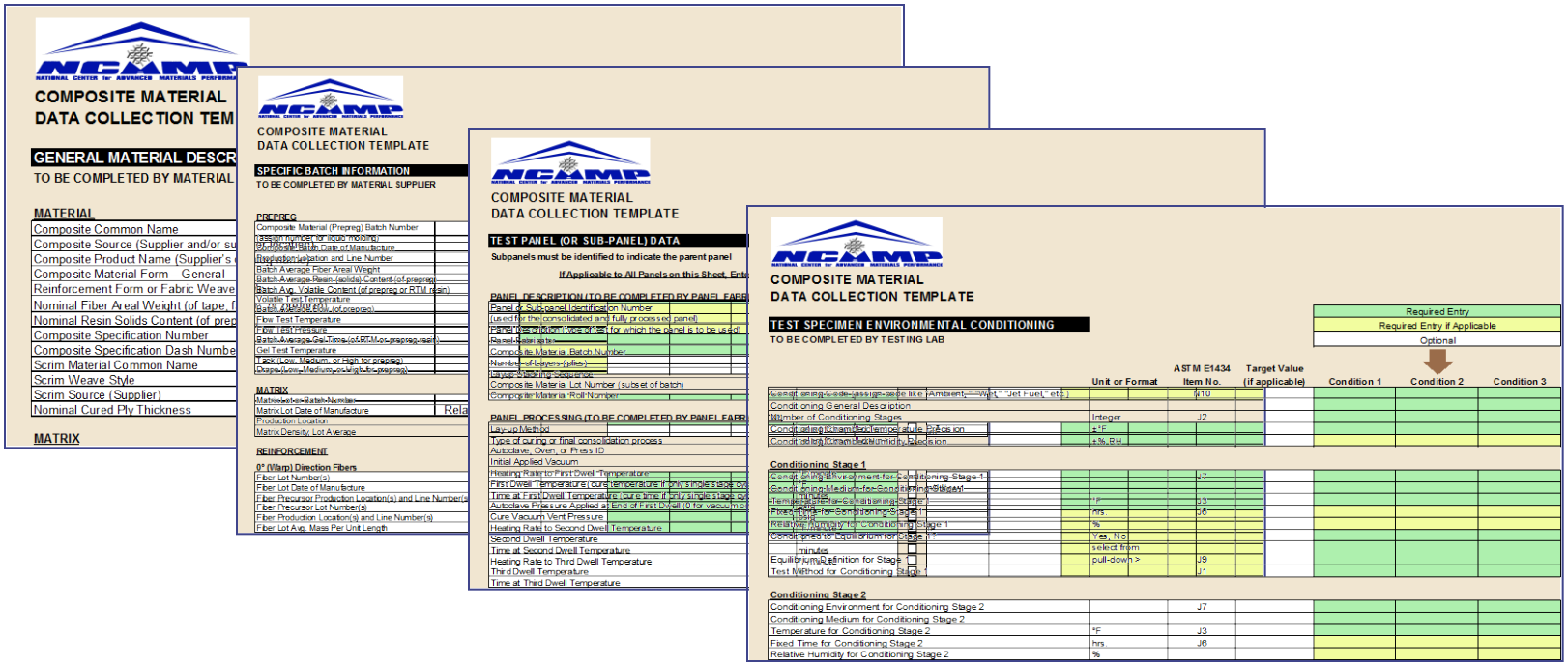
Laminate Strength Tests

Lay-up	ENV	Statistic	OHT	OHC	FHT	FHC	UNT	UNC	PB 2% Offset	LSBS*
25/50/25	CTD (-65 F)	B-basis	45.64		47.71		84.42			
		Mean	51.27		54.12		94.45			
		CV	6.00		6.00		6.00			
	RTD (75 F)	B-basis	46.54	37.85	NA	NA	86.34	65.34	78.31	9.15
		Mean	52.16	41.71			96.42	74.05	88.26	9.99
		CV	6.00	6.00			6.00	6.03	6.01	6.00
	ETW2 (250 F)	B-basis	45.59	25.06		NA	NA	43.01	64.05	4.42
		Mean	51.21	28.92				48.79	73.86	5.26
		CV	6.70	6.18				6.00	7.54	6.00
10/80/10	CTD (-65 F)	B-basis	39.88		NA		NA			
		Mean	45.23							
		CV	6.00							
	RTD (75 F)	B-basis	NA	NA	NA	NA	NA	NA	NA	
		Mean								
		CV								
	ETW2 (250 F)	B-basis	NA	23.62	NA	26.51	NA	NA	56.90	
		Mean		26.40		31.65			66.36	
		CV		5.20		8.22			7.49	
40/20/40	CTD (-65 F)	B-basis	55.62		NA		NA			
		Mean	65.31							
		CV	7.52							
	RTD (75 F)	B-basis	NA	NA	NA	NA	NA	NA	NA	
		Mean								
		CV								
	ETW2 (250 F)	B-basis	NA	26.55		40.03	NA	NA	45.56	
		Mean		30.74		48.01			70.18	
		CV		7.08		7.72			11.46	

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
NA indicates that tests were run but data did not meet CMH17-G requirements.
* Data is as measured rather than normalized

Detailed Documentation of Material, Panel Fabrication Procedures, and Test Methods Used

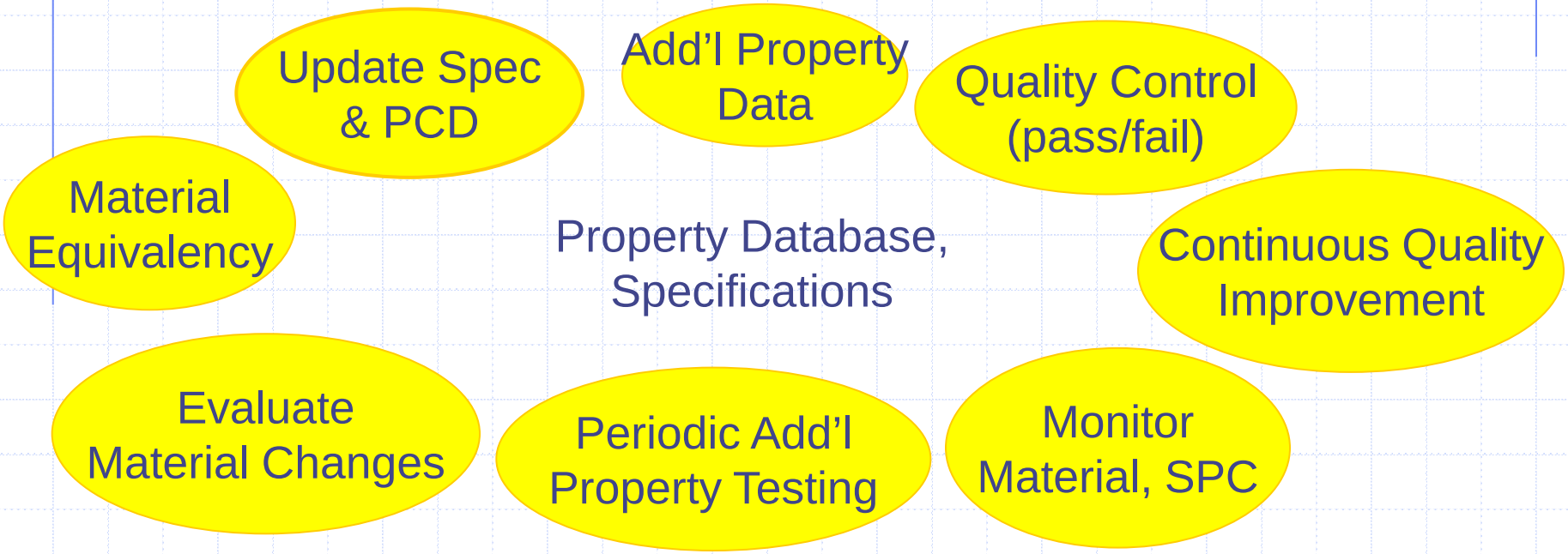
- Detailed documentation of pedigree information is a very important part of material qualification programs
- Standard forms have been created for use by NCAMP material qualification programs



OEM/Tier-1 Participation is Crucial

- Recall from the preceding presentation that “OEM is the Communication and Coordination Hub”
- Your workload is alleviated but your responsibility is not – just ask the FAA!
- Review and approval of test plan, test report, M&P specification, and PCD
- Maintenance of M&P specifications & PCD is an ongoing process

Compliance with AC23-20 is An Ongoing Process



Active Supplier and User Participation Required with *minimal* FAA & DoD oversight

Lessons Learned

- Only one cure cycle is used in the qualification/allowables program; not all cure cycles will yield the same material properties
  - You may have heard that some materials can be cured multiple ways
  - Check the qualification report to see which one was actually used
- Not all companies that participate in equivalency will “pass”
  - CMH-17 section 8.4.1 provides the statistical tests
  - Some failures are common simply due to chance (Type I error probability is 5%) – OEM and FAA will make the final decision
- Make sure the material will work for your application before investing heavily
  - Some modification to the cure cycle and bagging may be necessary
- Don’t write your own material specification unless it shares the same PCDs

The Future of Shared Database

- Government matching funds will not continue forever – need to become self-sufficient
  - Database must continue to grow and be maintained
  - Material specifications & PCD maintained by industry with *minimal* FAA & DoD oversight
- Material suppliers develop *PUBLICLY AVAILABLE* **basic** lamina and laminate material properties
  - Several variants of CMH-17/NCAMP test matrices available to suit the budget and application
  - The test matrices are designed for multi-purpose use, although incomplete for many applications, is a significant cost and time savings for the material users
- Material users develop *PROPRIETARY* more detailed laminate and higher level building block properties

Desired Impact of Shared Database

- More material choices = more efficient designs
- One material = one qualification (cost savings)
- One material = one material specification (standardization)
- Improved availability: purchase “over-the-counter”
- Reduced price: you are not the only customer
- Preferred by Tier 1 suppliers (when materials are not defined by OEMs) and small to midsize OEMs
- Designed by anyone, built by those who have proven equivalency (simple parts)
- Material properties are available before design begins
- Qualify only matured materials → more accurate data → improved structural efficiency & safety
- More resources are available to validate detail, sub-component, and component levels
- Leverage experts from all companies = improved safety
- **Promotes the use of composites through standardization and availability of material property data**
- **More use of lightweight materials such as advanced composites will lead to more fuel efficient transportation system which will minimize the impact on the environment and reduce energy prices**

Thank you

Questions?