Scaling Up for Advanced Air Mobility

Featured Panel

Moderator: Jonathan Sourkes, VICTREX

Panelists:

Dana Jensen, U.S. Airforce

Martin Peryea, Jaunt Air Mobility

John Geriguis, Joby Aviation

Darren May, General Motors

Cindy Ashforth, Federal Aviation Administration

US Air Force Support for AAM

Accelerating Commercialization & Supply Chain Development

Dana Jensen

US Air Force Office of Commercial & Economic Analysis (OCEA)

AGILITY PRIME

Mission:
Expand technology transition paths to accelerate emerging dual-use markets by leveraging government resources for rapid and affordable fielding, while bolstering U.S. tech advantage.

Why: U.S. Technological Advantage

1. **Strategic**: Build the domestic industrial base for an aerospace market estimated to be $1.5T within 20 years
2. **Process**: Drive innovative new approaches for transiting technology to the field: contracts, airworthiness, testing
3. **Product**: Field new air mobility in FY23 (20+ use cases)

What: Third Revolution in Aerospace

Electric Vertical Takeoff and Landing (eVTOL)
Organic Resupply Bus (ORBs)
Coalescence of 3 technologies fueled by commercial industry

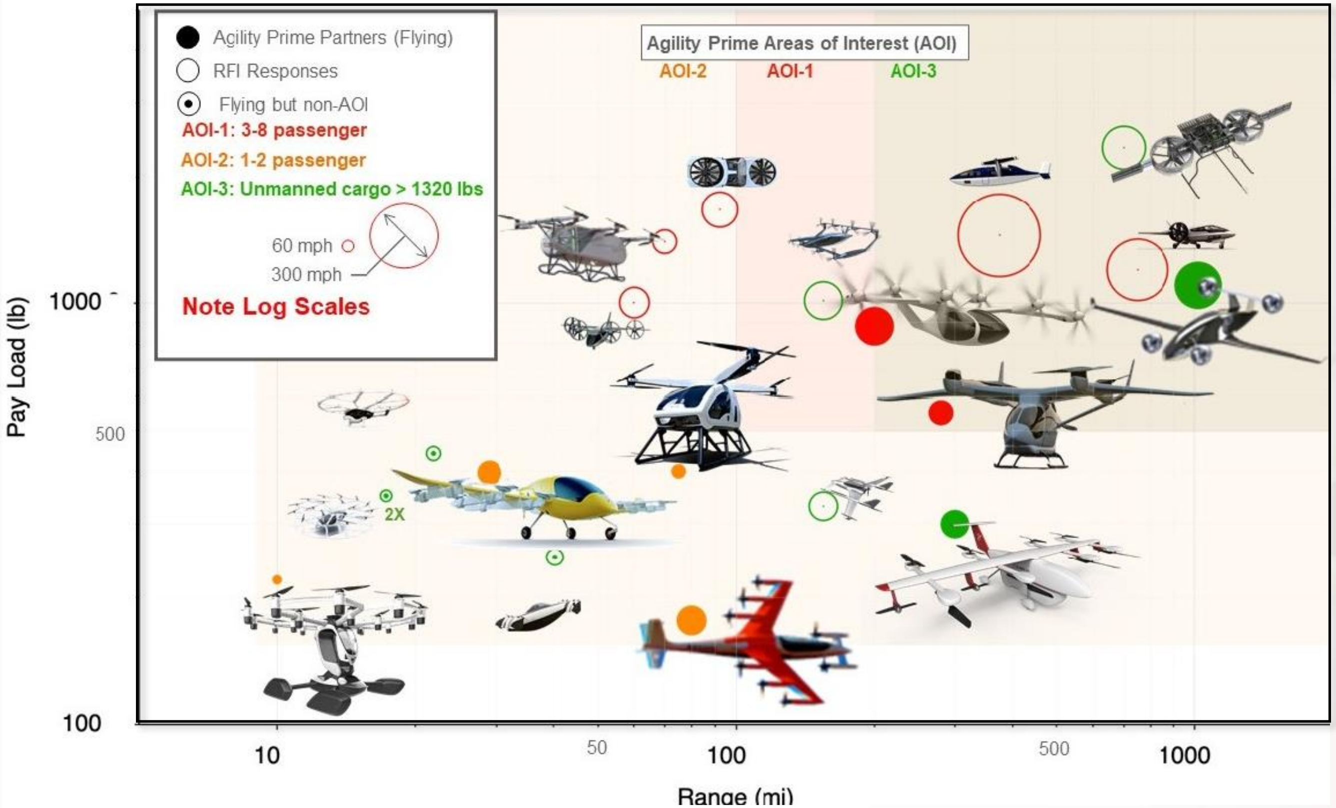
1. **Electric**: Large electric power systems (auto industry)
2. **Autonomy**: AI/Autonomy/Simplified Vehicle Operations
3. **Manufacturing**: Advanced manufacturing and materials

How: Collaborative risk reduction

1. **Tech Risk**: Opportunities for collaborative test and eval
2. **Regulatory Risk**: Early military airworthiness review
3. **Financial Risk**: Contracts for testing and early use cases

Strategy: Co-investment with industry to field a capability in 2-4 years

- Partner with investors to identify emerging tech sectors
- Collaborate with the warfighter to find fit of dual-use tech
- Leverage commercial interest for warfighter need in a way that achieves 20:1 return on investment from taxpayer dollars all while bolstering emerging U.S. technologies



AGILITY PRIME

Progress: In just over a year

- **Industry**: 27 companies in Agility Prime "Air Race"
- **Airworthiness**: One complete--4 in process
- **Contracts**: $100M+, 12 small business contracts, 250+ small business and university contracts for R&D
- **Co-investment**: Over $1B in commercial investment
- **Training**: AETC Agility Prime detachment & sims
- **Hardware**: 1st ORB & 1st charging station delivered

Agility Prime Goals for 2021:

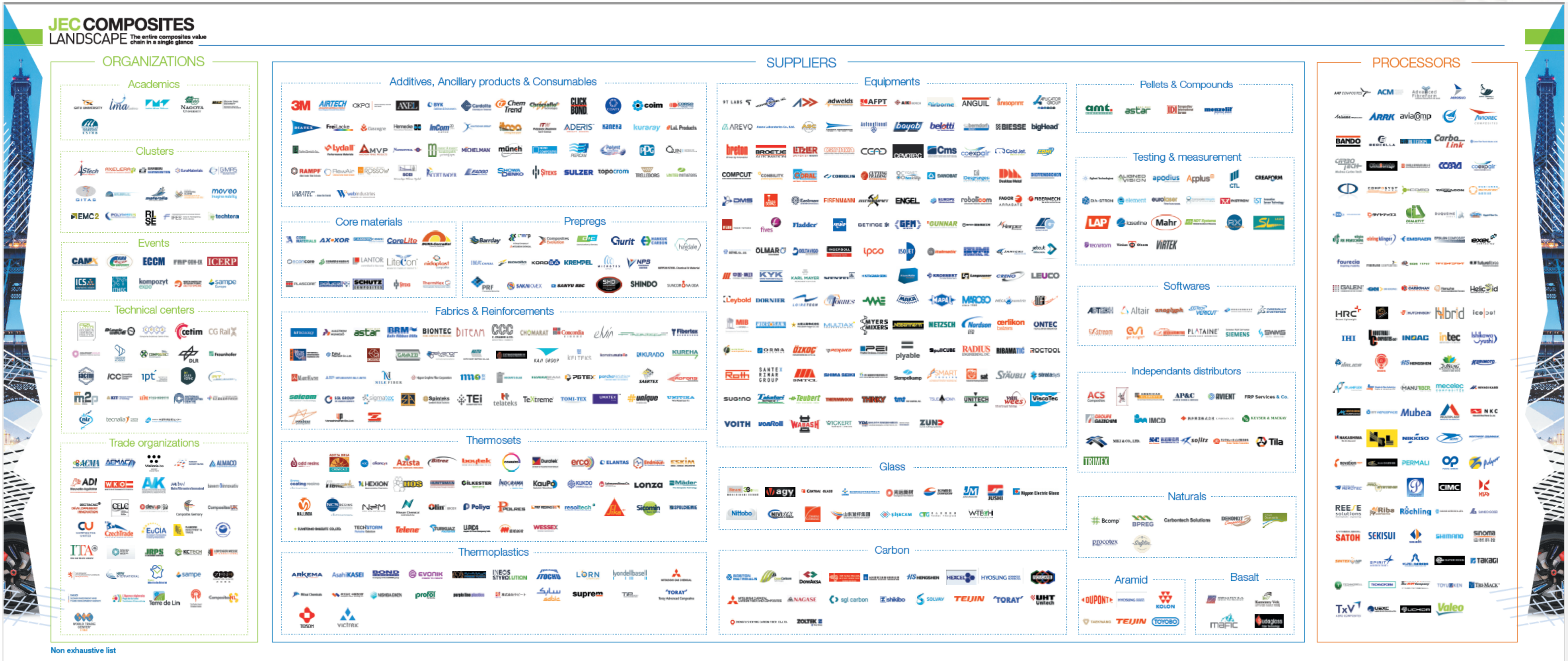
- **Test**: Complete first round of capability assessments
- **Evaluate**: Identify which ORBs are best suited for the 20+ developing use cases--taxpayer savings and tactical utility
- **POM**: Determine best MAJCOMs for Initial Operational Capability by 2023 in a way that creates immediate value
- **Train**: Develop operator and maintainer syllabus in AETC
- **Exercises**: First exercise with Air Combat Command in May 2021 for personal recovery and autonomous logistics

Understanding the Supply Chain

https://nari.arc.nasa.gov/aamsupplychain

Understanding the Supply Chain

Understanding the Supply Chain



Manufacturing at Rate and at Cost

Martin Peryea, CEO/CTO

Jaunt Air Mobility

Jaunt Air Mobility

- Established to develop an all-electric eVTOL aircraft for the AAM market
- Acquired the patents and IP associated with the slowed rotor compound technology
- Partner with major Tier 1 aerospace suppliers
- Designing an all thermoplastic airframe with highly automated systems
- Certify under Transport Rotorcraft rules

Manufacturing at Rate and Cost

- Current aerospace manufacturing methods do not scale to the volume of aircraft that are estimated for the AAM market demand
- Thermosets used in primary and secondary structure
  - Require high capital cost for tooling and processing
  - Require high touch labor cost and difficult to control processes
  - Post bonding operation can't be inspected
  - Require clean rooms and refrigeration for raw material
  - Difficult to repair in the field – typically requires engineering disposition
  - They are not a recyclable material

Thermoplastics Is the Enabling Technology

- Thermoplastics offers the step change in technology needed for AAM
  - Better structural properties than thermosets
  - Better chemical resistance, does not absorb water
  - Better durability characteristics (damage tolerance)
  - Continuous compression molding enabled
  - Hot press forming of large primary structural components
  - Inductively weld complex assemblies using robotics
  - Highly automated with minimal touch labor
  - Easier field repairs
  - An environmentally friendly recyclable material

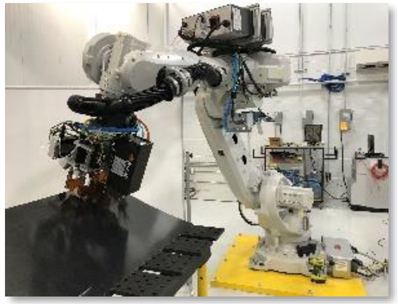
Application of Thermoplastics

Pressed Substructure
(ribs, frames, etc.)

Compression Molded Chopped
Fiber Fairings/Fittings

Fiber Placed Wing
Skins/Spars/Tailboom

Fuselage Designed for High
Volume Manufacturing



Induction Welding
Fuses It All Together

JAUNT
AIR MOBILITY

Scaling Up for Advanced Air Mobility

John Geriguis

Joby Aviation

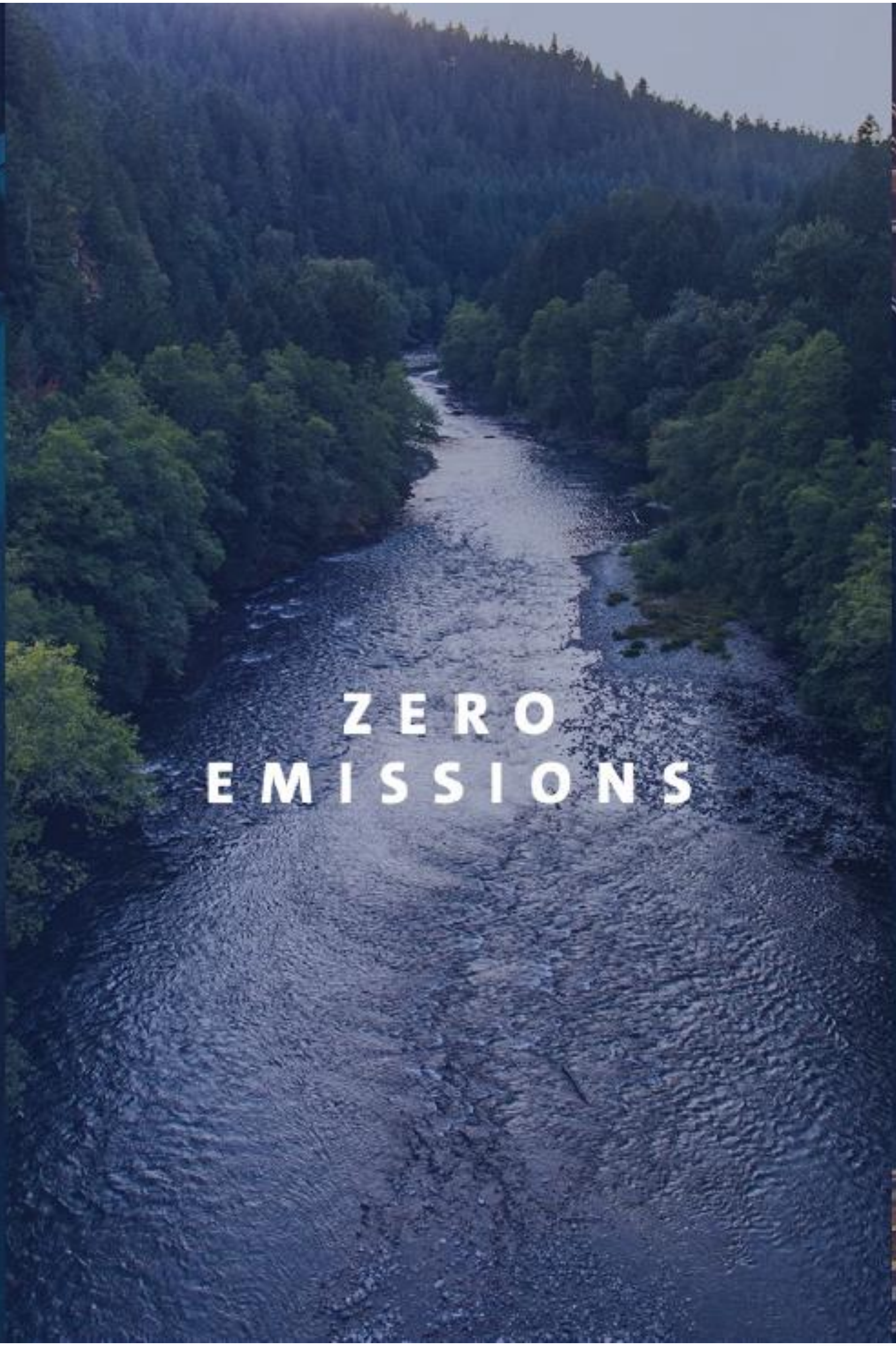
NOTE: Due to the proprietary information in this presentation, John Geriguis’s slides are not available for download

An Automotive Perspective

Opportunities, Challenges, and Call to Action for Composites

Darren May


ZERO
CRASHES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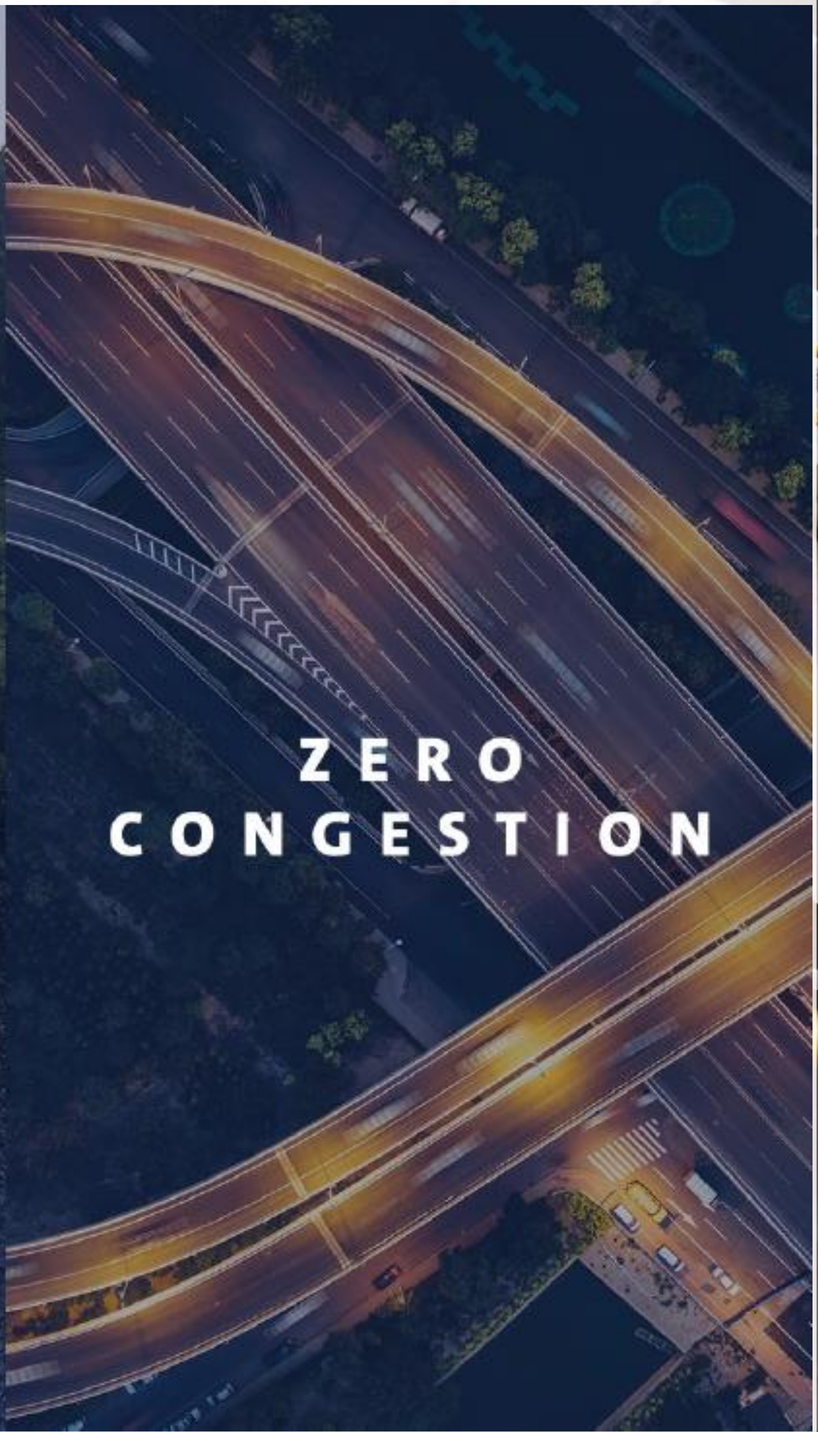
EMISSIONS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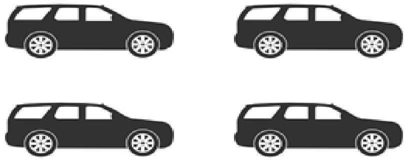
CONGESTION

General Market Trends

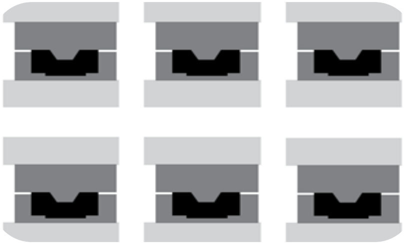
Opportunities



More Vehicles

More Variants

Faster Refreshes



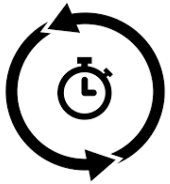
More Molds

Challenges

Lower Per Mold Prices

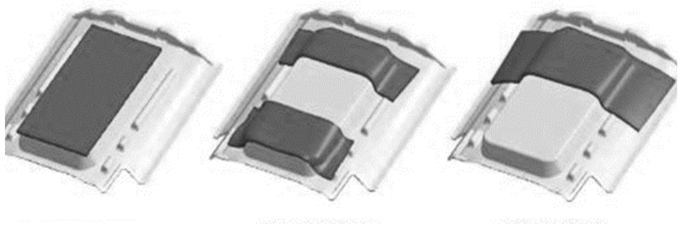
Reduce Mold Lead Times

Reduce Part Weight

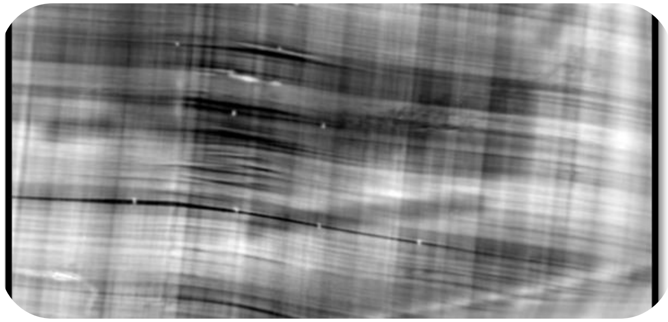


Faster Part Cycle Times

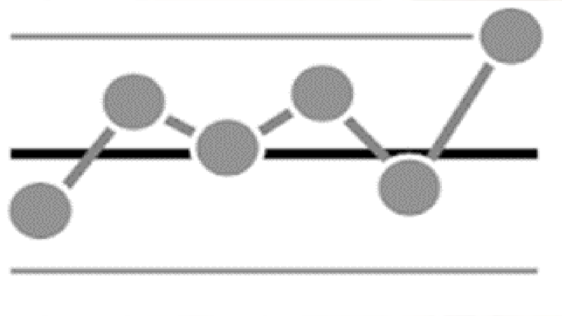
Composite Industry Urgent Call to Action



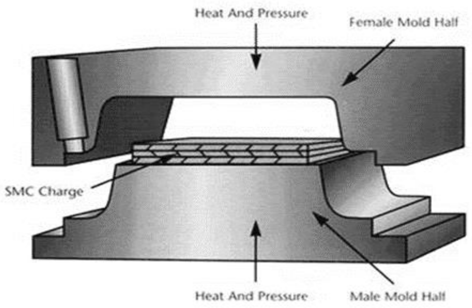
Improve Analytical Tools & Material Characterization



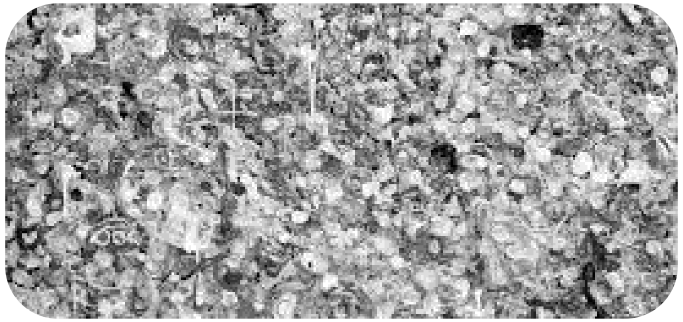
Develop Non-Destructive Defect Detection Tools



Reduce Part to Part, Run to Run Variation



Advance Machinery, Equipment, and Processes



Create Sustainable Material Solutions (Thermoplastics)

Increase Additive Manufacturing Usage

Certification by Analysis

Considerations for Advanced Air Mobility Vehicles

Cindy Ashforth, Senior Technical Specialist

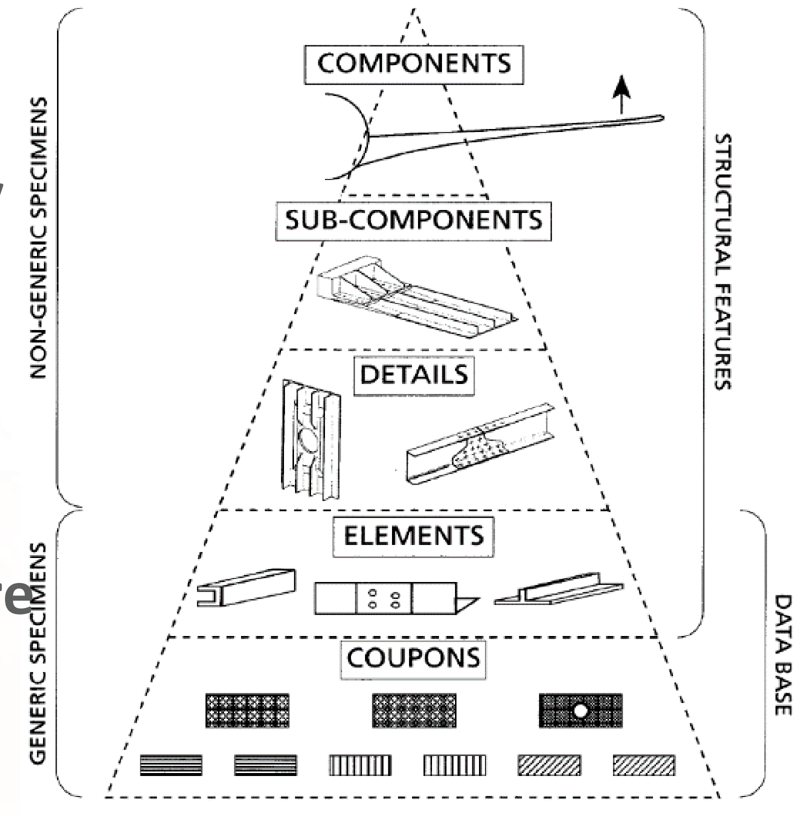
Federal Aviation Administration

FAA Overview

- **FAA role in AAM is the same as all air operations – to provide the safest, most efficient air transportation system in the world**
- **Vehicle standards in part 23 for normal category aircraft for 0-19 passengers**
  - If vertical lift is part of the design, a unique certification basis is defined that draws from parts 23 and 27 for rotorcraft
- **Structural regulations generally the same for all product types**
  - Material and process definition and control
  - Structural substantiation (including F&DT)
  - Exception: Crashworthiness varies by product
- **Note: The FAA does not certify composite materials independent of a product or article**

Structural Certification Options

- **Advisory Circular (AC) 20-107B "Composite Aircraft Structure" describes two methods of structural substantiation:**
  1. Certification by Analysis Supported by Test
  2. Certification Primarily by Test
- **The "analytical method" is semi-empirical; no getting away from testing** *Interpolation allowed; extrapolation is not*
- **While regulations are the same, the degree of rigor can be scaled to the risk of the product and the criticality of the specific application**
- **Other "analytical tools" that do not support certification are widely used** *Typically to speed development efforts*
  - Process modeling
  - Tools that support sizing/initial design



Static Strength Substantiation

<u>Analysis Supported by Test:</u>

- **If static strength is substantiated through analysis supported by test, Design Values* must be selected:**
  - ➢At the worst-case environmental conditions,
  - ➢At the appropriate (rationally derived in design value testing) statistical reliability, and
  - ➢With expected damage
- **All analyses must be validated**
  - ➢Match strains (a.k.a. *Load path predictions*)
  - ➢Predict failure modes (ensure failure modes match those of the design values)

**Note "design values" may be created for unnotched properties at the lamina/coupon level but they have little usefulness; most Design Values are generated for structural properties at higher levels of the building block*

Analytical Modeling Approach

- **Test-Analysis Correlation Through the Building Block:**
  - Base material properties at the lamina level are important to quantifying variability, environmental effects and moduli, but have limited use in predicting static strength
  - Design values are typically developed at laminate, element and detail levels.
  - Laminate level testing may allow proper studies on various manufacturing defects and smaller damage types. Environmental effects generated at this level have more meaning to the structural tests at higher building block levels.
  - Element level tests evaluate manufacturing tolerances on bonded and bolted joint details, they allow for some of the secondary loading affects owed to eccentricities in load paths for assembled joints, and stability and fracture elements are used for stiffener crippling and radius bend details at this level.
  - Detail level tests are used to validate analytical techniques built on data from the coupon – element level tests. Analytical tools are often developed or “calibrated” at the detail level such that they can be used with confidence in higher-level assemblies. For example, a single element might be created to model the behavior of a fastened joint, rather than have a model that distinguishes fastener from laminate
  - Sub-component tests consist of combined load testing for empennage, wing, and fuselage structures with damage in critical locations. Semi-empirical engineering approaches are typically used to address the many factors that localize damage and affect static strength (e.g., larger cutouts and stiffened panel tests with skin buckling and frame or rib details added).
  - A full-scale test is required to demonstrate final proof-of structure of static strength, fatigue and damage tolerance. The test validates analytical predictions of structural load paths, stress concentrations in reinforcements for major cutouts, and secondary loads

Questions?