IACMI Roadmapping and Technology Update

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Chief Technology Officer

July 27, 2016

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Roadmapping Goals

- Integrate the views and establish consensus of stakeholders from value chains in vehicles, wind & CGS
- Identify other markets in which IACMI capabilities and expertise may be reasonably extended
- Identify & assess pathways for sustainability after year 5
- Develop & periodically revise the targeted technology roadmap
- Mission-critical, market-specific, and cross-market challenges, opportunities and technology solutions

Outline

- IACMI Roadmapping Overview
- Review of Phase 1 Roadmap
- Phase 2 Workshop Summaries
- Testing update

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Roadmapping Overview

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IACMI Roadmapping Overview

Development Approach

✓ **Phase 1**: Accelerated roadmap priority identification

➢ **Phase 2**: Full roadmap process development, stakeholder engagement, and roadmap development

❑ **Phase 3**: Roadmap monitoring and updating

IACMI Five-Year Objectives

- ↓**25%** CFRP **cost**
- ↓**50%** CFRP **embodied energy**
- ↑**80% recyclability** of fiber-reinforced composites

Phase I Roadmap established the Timeline of Activities and Milestones for

- Vehicles
- Wind
- Compressed Gas Storage
- Materials and Processing
- Modeling and Simulation

Impact Ratings of Activities on IACMI Goals: Vehicles

Vehicles	Average Rating	Total Responses
Demonstrate low cost carbon fibers in automotive part applications	4.49	70
Advance high speed, high strength joining techniques for dissimilar materials (e.g., metal and composite vehicle parts)	4.10	73
Develop low scrap, automated composite preforming fabrication techniques to match molding times	4.04	70
Reduce part-molding cycles of RTM fabrication methods from 8 minutes to 3 minutes	3.91	64
Reduce processing cycles of thermoplastic prepreg stamping fabrication techniques from 7 minutes to 3 minutes	3.88	66
Develop discontinuous carbon fiber reinforced thermoset/thermoplastic processing	3.84	68
Generate fast-processing resins with internal mold release for RTM and stamping	3.83	66
Reduce processing cycles of thermoset prepreg stamping fabrication techniques from 10 minutes to 3 minutes	3.78	65
Reduce processing cycles of injection overmolding fabrication techniques for engineered thermoplastics from 3 minutes to 90 seconds	3.76	66
Increase the in-plant reuse rate of carbon fiber process scrap in high quality parts	3.64	69
Develop low scrap, automated tape layup prepreg fabrication techniques to match molding times	3.62	71
Develop NDE validation techniques for fiber-based architectures	3.52	67
Enhance NDE validation techniques for bonded joints	3.51	68
Increase recovery and reuse rates of end-of-life carbon fiber parts	3.47	73
Enable rapid detection of void levels in molded parts	3.42	69
Enhance robotics capabilities to enable high speed handling of materials, preforms and molded parts	3.41	70
Implement low cost tooling (e.g., via additive manufacturing) for molding of automotive vehicle parts	3.37	71
Implement in-situ process controls to monitor the degree of curing in composite parts	3.21	67

Example – Vehicles

BP2 → BP3 → BP4 → BP5

BP2	BP3	BP4	BP5
Reduce processing cycles of thermoset (TP) prepreg stamping from 10 to 3 min; Reduce part molding cycles of HP RTM fabrication methods from 8 to 3 min	**Milestone** TP/Prepreg stamping and HP RTM 5 min cycle time	→	**Milestone** TS Prepreg stamping & HP-RTM 3 min process cycle time
Develop low scrap automated composite preforms and tape fabrication technologies to match molding times	**Milestone** Low waste tape layup & composite preforming	→	**Milestone** Standardized recycling strategies
Demonstrate low cost carbon fibers in auto parts (eg via injection molding)	**Milestone** IOM: 2 minute process cycle times	→	**Milestone** IOM: 90 second process cycle times
Implement low cost tooling (e.g. via additive manufacturing) for molding of automotive parts	**Milestone** Demonstrate low cost AM tooling for low pressure molding of automotive parts	→	**Milestone** Demonstrate low cost AM tooling for high pressure molding of auto parts
Advance high speed, high strength joining and repair for dissimilar materials	**Milestone** Demonstrate dissimilar joining and repair techniques at lab scale	**Milestone** NDE for bonded or repaired joints validation	**Milestone** Demonstrate dissimilar joining and repair techniques at industrially relevant scale and size

Phase II Roadmapping Sessions…

- March 23-24 (Knoxville), and May 10-11 (Detroit)
- Attended by 90 (March) and 110 (May) stakeholders
- Topics: Wind, CGS, Automotive, M&P, M&S
- Professional facilitators – Nexight Group
- Technical Leads assigned to each session
- Raw data gathered through the detailed sessions
- Findings presented at July membership meeting

Inputs/Activities	
Total telephone interviews	40
Total online surveys (1,000+ invitees)	191
Total literature sources reviewed	70
Total roadmapping workshops	4 (250)

Roadmapping - March 23-24th

Day 1		
Session Topic	Technical Leads	
Modeling & Simulation	Byron Pipes (Purdue)	
Recycling	Geoff Wood (CTRC)	
	Edward Pilpel (Polystrand)	
Nondestructive Evaluation	Doug Adams	
	& Ray Bond (Vanderbilt)	

Day 2	
Session Topic	Technical Leads
Reinforcements, Resins, Additives, and Intermediates	Brian Rice (UDRI)
	Dale Brosius (IACMI)
Additive Technologies	Stephen Szaruga (AFRL)
	Vlast Kunc (ORNL)
Design, Prototyping, and Validation	Leonard Poveromo (CPC)
	Uday Vaidya (IACMI)
Sustainability-1	All

Roadmapping - May 10-11th

Day 1	
Session Topic	Technical Leads
Crashworthiness and Repair	Khaled Shahwan (Chyrsler)
Standardization & Qualification	Suzanne Cole (ACC)
	Rose Ryntz (IAC)
Multimaterial joining	Claus Daniel (ORNL) Steve Duran (ASC) Larry Drzal (MSU)
	Marc Benevento (ASC)

Day 2	
Session Topic	Technical Leads
Large Scale Manufacturing	Jim DeVries (Consultant)
	Ray Boeman (IACMI)
Sustainability-2	All

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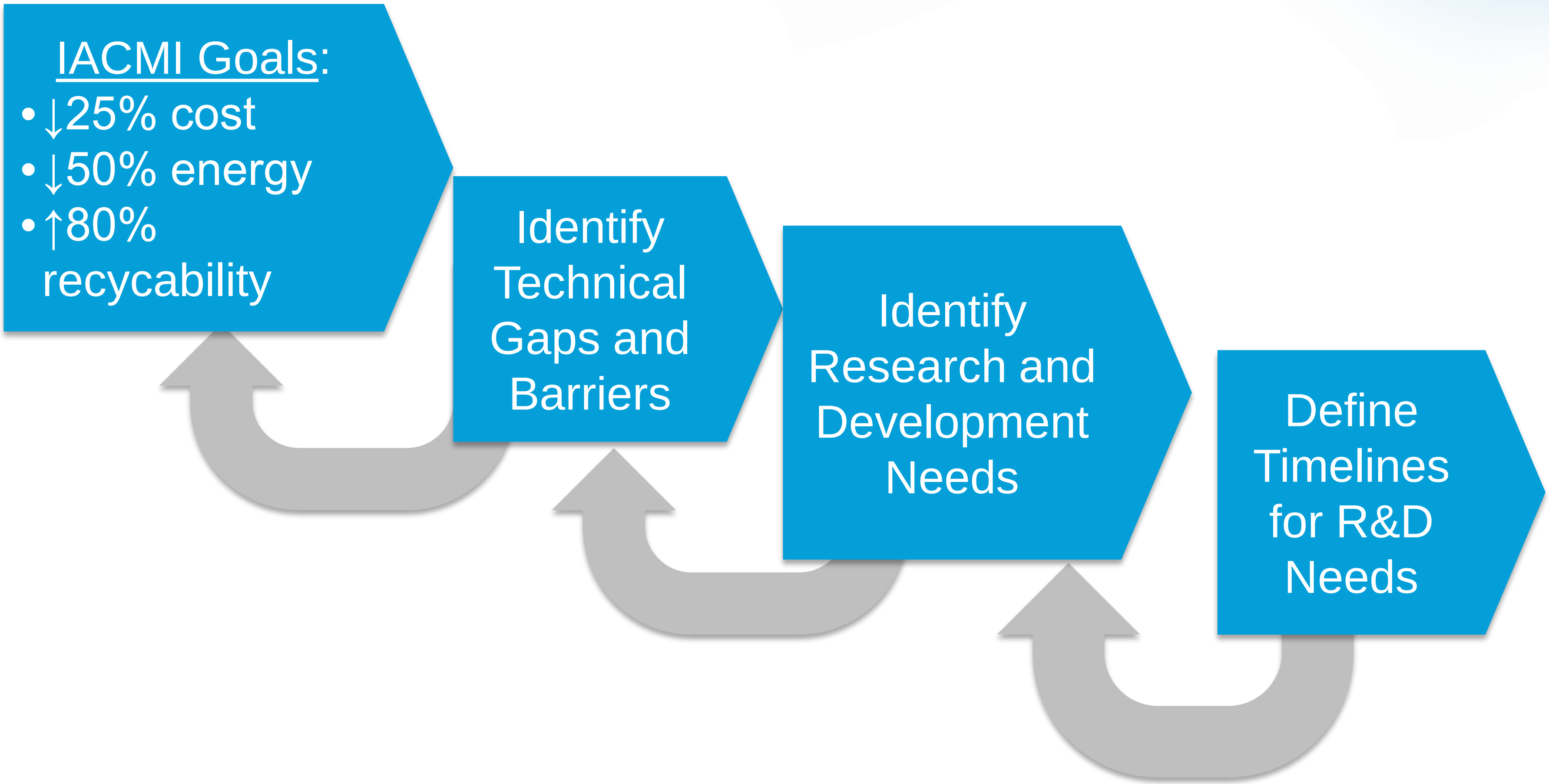
Workshop Structure



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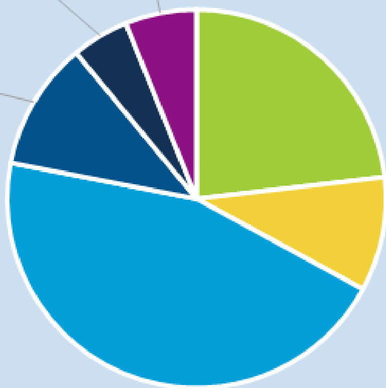
Phase 2 Workshop #1

MARCH 2016

Institute for ADVANCED Composites Manufacturing INNOVATION

Phase 2 Workshop #1: March 23–24, 2016

Total Participants: 82



Workshop Outputs

- Challenges/Limitations
- R&D Activities and Timelines (BP2-BP5)

Focus Areas (Breakout Sessions)

- Modeling & Simulation
- Recycling
- Nondestructive Evaluation
- Reinforcements, Resins, Additives, and Intermediates
- Design, Prototyping, and Validation
- Additive Technologies

Modeling & Simulation

Major Challenges	
Data	➢Poor prediction accuracy due to insufficient materials data ➢Lack of data transfer standards (e.g., materials properties, tool interfaces, data structure)
Workforce	➢Inability to ascertain confidence in models
Specific Applications	➢Insufficient accuracy in composite part cost predictions ➢Limited ability to predict crash performance
Characterization	➢No material characterization protocols for constructing accurate materials models
Complexity	➢Lack of user-friendly modeling & simulation tools
Validation	➢No consensus on protocols for using experimental data to validate simulation results

Modeling & Simulation

High-Priority R&D Activity Pathways*
➢ Simulating Manufacturing Processes
➢ Standardization of Data Transfer
➢ Linking Data and Validated Models to Increase Confidence
➢ Accurate Prediction of Part Cost and Embodied Energy
➢ Enhanced Crash Performance Prediction
➢ Materials Characterization Standards & Minimum Data Requirements
➢ User-Friendly Modeling and Simulation Tools

**Each bullet contains a sequence of multiple R&D activities over Budget Periods 2–5.*

Recycling

Major Challenges	
Infrastructure / Regulatory	➢Inability to effectively collect/consolidate post-consumer/industrial components prevents economy of scale ➢No business/regulatory framework to recycle composites (e.g., consumer-led, producer-led, value-driven)
Reclamation & Reuse	➢Need for integration of reclaimed materials in new, high-value products ➢Low value proposition to use reclaim fibers due to potential loss of fiber properties ➢Difficult to preserve fiber length (i.e., strength properties from length-to-diameter ratio)
Recycling Processes	➢Challenging to recycle thermosets (i.e., non-reversible chemistry) ➢Unable to cost-effectively remove resins from CFRPs
Waste Streams	➢Need for waste stream segregation to enable products with "certified" properties

Recycling

High-Priority R&D Activities	
End-Use Applications	➢Work with OEM to demonstrate prototypical production of recycle-based components
Materials Development	➢Optimize surface treatment/sizing techology to maximize fiber recovery and mechanical properties
Modeling/ LCA	➢Full-scale turbine blade recycling project: Document costs, methods, and challenges ➢Demonstration program on design-for-manufacturability and design-for-recyclability
Reduction/ Reuse	➢Incorporate offal/CF scrap into turbine blades and other high-quality parts
Supply Chain	➢Develop technical marketing materials for recycled carbon fibers
Education	➢Create “design for sustainably” data for end-of-life product design for academic programs

Design, Prototyping, and Validation

Major Challenges	
Design & Optimization	➢Lack of design and manufacturing standards that permit lower partial factors with testing, model validation, manufacturing quality systems, etc.
Education & Training	➢Lack of non-proprietary design allowables for anisotropy and variability in material properties ➢Lack of composite manufacturing training resources for engineers in current workforce
Validation & Testing	➢Lack of test methods and properties for as-manufactured composite parts ➢Lack of representative “test case” samples from OEMs

Design, Prototyping, and Validation

High-Priority R&D Activities	
Benchmarking / OEM Resources	➢Establish design, mfg., and testing standards for auto/wind/CGS ➢Create a techno-economic analysis to provide validation examples to OEMs ➢Conduct auto/wind/CGS demonstration projects to validate performance and cost of composite parts and components
Education/ Training	➢Conduct training workshops to teach composite design methodologies
Material Selection & Design	➢Engage with OEMs to obtain buy-in/feedback on producing a "building block" approach to designing composites with offal
Materials & Processes	➢Develop gap-bridging technology for unidirectional tape processing, layup, and consolidation to an agreeable cost target

Reinforcements, Resins, Additives, and Intermediates

Major Challenges	
Education	➢Limited exposure to composite performance standards and available data → Precludes impedes effective predictive engineering and composite/multi-materials design ➢Need for education of OEMs and some Tier 1's on the "infinite" possibilities of FRPs
Characterization/Modeling	➢Insufficient holistic modeling approaches to accurately predict material properties, processing approaches, and cost
Processes	➢Need efficient fiber to fabric conversion methods to manage cost and improve availability
Standardization	➢Lack of targets/standards for IACMI application areas (i.e., non-aerospace) ➢No standard data and materials testing methods for required database inputs
Testing	➢Inability to draw part property correlations between disparate lab tests
Value Proposition	➢Difficulty assessing performance gain with respect to the added cost of new materials

Reinforcements, Resins, Additives, and Intermediates

High-Priority R&D Activities	
Education	➢Develop IACMI "road show" using resources of member companies and universities ➢Develop a techno-economic analytical capability within IACMI ➢Form a design competition for technology demonstration and benchmarking
Characterization /Modeling	➢Initiate role at IACMI analogous to National Institute for Aviation Research (NIAR) (i.e., independent material testing and data sharing of materials)
Standardization	➢Convene a multi-stakeholder consortium to establish target application spaces and respective performance requirements
Testing	➢Develop advanced continuous fiber TPs (i.e., sizes, properties, data, testing methods)
Value Proposition	➢Convene a multi-stakeholder consortium to establish target application spaces and respective performance requirements

Non-Destructive Evaluation

Major Challenges	
Business Case	➢Lack of sample techno-economic models for determining optimal NDE approach and assessing impact of measured variations on final product ➢Misconception of NDE as a post-inspection vs. in-line process improvement tool
Data Mgmt.	➢Lack of data reduction methodologies
Characterization	➢Limited understanding of root cause of critical defects in composite parts
Tool Suites	➢Lack of in-line/in-situ NDE tools to reduce manufacturing process variability

Non-Destructive Evaluation

High-Priority R&D Activities	
Process Analytics	➢Develop in-situ process controls to monitor the degree of curing in composite parts ➢Enable rapid detection of void levels in molded parts
Sensors & Tool Suites	➢Conduct pilot demonstration of various NDE techniques (e.g., embedded/in-tool; ultrasonic, acoustic emission, eddy current)
Workforce	➢Train production labor in NDE issues and influence of workmanship on findings

Additive Technologies

Major Challenges	
Business Case	➢Lack of case studies and awareness of available additive manufacturing (AM) tooling
Equipment & Processes	➢Slow processing time of additive technology; Difficulty reaching commercial scale ➢Low CTE of additive materials systems with service temperatures exceeding 350°F
Feedstock Mtrls.	➢Insufficient material options
Modeling & Simulation	➢Lack of efficient/practical software tools (i.e., design-for-mfg., simulation tools) to accelerate AM adoption
Post-Finishing	➢High cost of post-build finishing and inspection
Consistency	➢Difficulty achieving Z-direction materials property improvements

Additive Technologies

High-Priority R&D Activities	
Business Case	➢Conduct/publish techno-economic study comparing metal with composite AM tooling
Materials Development	➢Explore science, chemistry, or processes for improved Z-direction properties (e.g., develop Z-direction stitching of FDM layers)
Feedstock Materials	➢Conduct study on material characteristics for high-temperature (i.e., 350°F) tooling (surface roughness, carbon fiber, glass, and other fillers)
Quality	➢Develop in-situ process monitoring and control (e.g., NDE to show z-direction properties) for FDM processes (link to work of NDE team)
Industry Demo.	➢Create "Challenge" project on simulation effort based on industry needs
Tooling	➢Conduct study on material characteristics for high-temperature (i.e., 350°F) tooling (surface roughness, carbon fiber, glass, and other fillers)

Similar Detailed Outcomes from Workshop 1

- Design, Prototyping and Validation
- Reinforcements, Resins, Additives and Intermediates
- Nondestructive Evaluation
- Additive Technologies

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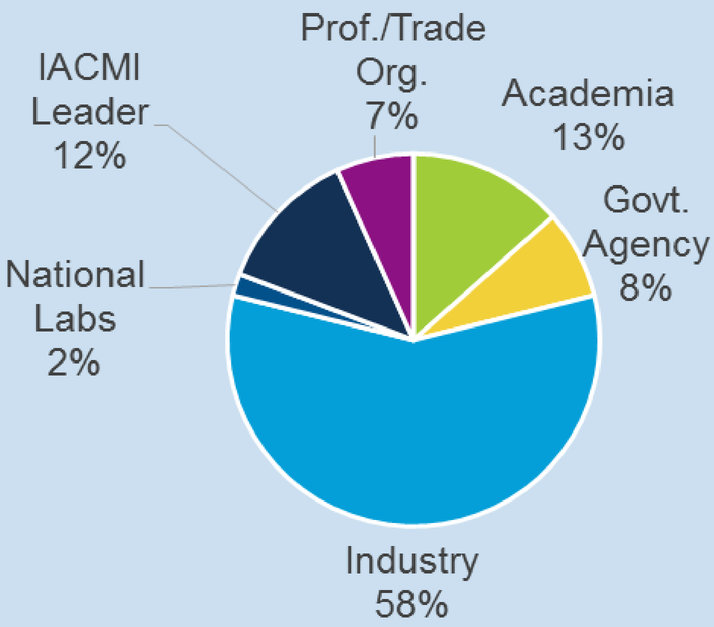
Phase 2 Workshop #2

MAY 2016

Institute for ADVANCED Composites Manufacturing INNOVATION

Phase 2 Workshop #2: May 10–11, 2016

Total Participants: 104



Focus Areas (Breakout Sessions)

- ➢Multimaterial Joining
- ➢Crashworthiness & Repair
- ➢Standardization & Qualification
- ➢Large-Scale Composites Manufacturing:
  - Wind Turbines
  - Compressed Gas Storage
  - Vehicles

Workshop Outputs

- ➢Challenges/Limitations
- ➢R&D Activities and Timelines (BP2-BP5)

Multimaterial Joining

Major Challenges	
Design Methodologies	➢Limited selection of non-adhesive joining processes & methodologies ➢Lack of robust, experimentally validated design tools for multimaterial joining
Automation	➢Need for automation techniques focus on consistency rather than production volume
Inspection/ Data Acquisition	➢Insufficiently validated in-situ inspection techniques for detection of kissing bond defects
Joining Techniques	➢Lack of robust, repeatable surface treatment preparation techniques with 60-second cycle times
Modeling/LCA	➢Difficult to account for material and process parameter sensitivities (e.g., process/cure times, cure temperatures, heating/cooling rates)
Performance Limitations	➢Need high-strength adhesives with reliable substrate interfacial bonding characteristics ➢Adhesive bonds prone to long-term performance degradation from operating environments

Multimaterial Joining

High-Priority R&D Activities	
Benchmarking	➢Round-robin matrix study on joint design (adhesive bonding, mechanical fastening) ➢Educational seminars on multimaterial joining for IACMI members ➢Compile existing programs/databases on adhesive bonding property/failure data
Joining Techniques	➢Develop novel non-adhesive joining methods (e.g., brazing, soldering, fasteners) ➢Design multimaterial joining adhesives reinforced with additives (e.g., nanoparticles)
Modeling/LCA	➢Develop accelerated ageing tests for joints applications to generate experimental data
Inspection/ Data Acquisition	➢Develop interfacial inspection/quantification methods for adhesive quality, integrity, uniformity ➢Incorporate embedded NDE sensors in joining & assembly approaches that fit manufacturing line speed and size limitations
Techology Demonstration	➢Leverage LIFT/IACMI assets to provide cross-technology MM joining programs

Crashworthiness & Repair

Major Challenges	
Inspection/NDE	➢Lack of data and test methods on durability of repaired automotive or wind structures; no definition of a "representative" component for testing
Modeling	➢Lack of end-to-end mfg. process modeling tools that encompass part-to-part variation
PSP Relationships	➢Undefined correlation between mfg. processes, mech. properties, and variability ➢Insufficiently characterized mtrl. properties (e.g., strain rate) for predictive modeling use ➢Rapid change in mfg. process → Barrier to downstream crash and repair issues
Quality/Standards	➢Limited understanding of the needs of underwriters and the insurance industry

Crashworthiness & Repair

High-Priority R&D Activities	
Modeling	➢Conduct sensitivity analysis to determine process window effects (e.g., tolerance, impact)
Collaboration	➢Identify top 5 auto component/application focuses for adoption of composite solutions ➢Convene aerospace OEMs/operators and automotive OEMs to develop a shared low-cost, high-quality repair technology
Data & Knowledge Sharing	➢Develop a database (e.g., MAT-spec) of physical properties (e.g., fatigue, long-term testing, impact) based on currently available composite materials to inform modeling efforts
Workforce	➢Fund internships for new engineers to teach supply chain aspects: design to production
Physical Demonstration	➢Demonstrate mfg. processes to validate latest predictive tools for part design/fabrication ➢Launch demo. effort for representative crush components: characterization through crash including models
Quality/Standards	➢Develop composite repair cert. program accepted by OEM/Tier 1/insurance industry ➢Develop/define repair acceptability standards and ranges of acceptability

Standardization and Qualification

Major Challenges	
Properties	➢Difficulty accessing/using composite material property reference data as inputs for computer-aided engineering (CAE) software ➢Inability to establish confidence in predicted composite properties of modeling tools
Processes	➢Challenging to efficiently quantify variability of composite manufacturing processes
Databases	➢Limited availability/accessibility of composite material performance/characterization data
Qualification	➢Nonexistence of composite material and part qualification standards

**Each bullet contains a sequence of multiple R&D activities over Budget Periods 2–5.*

Standardization and Qualification

High-Priority R&D Activity Pathways*
➢ Demonstration of Standard Reference Composite Part
➢ Develop a “Composite Decision Tool” Database
➢ Information Dissemination & Sharing

**Each bullet contains a sequence of multiple R&D activities over Budget Periods 2–5.*

Large-Scale Manufacturing: Vehicles

Major Challenges (across 6 breakout groups)

Design:

- Difficult to reconcile differences between designs from metals and composites, which creates a lack of OEM confidence in composite solutions
- Limited ability to make near-net shape pre-pregs
- Need to improve resin and fiber compatibility to improve properties of thermoplastic composites
- Design at the component level rather than system level fails to take full advantage of what composites offer, such as part consolidation and weight reduction
- Need specific performance targets (e.g., cycle time, processes, vehicle weight savings) set by IACMI, informed by OEMs

Manufacturing/Automation:

- Manufacturing part-to-part cycle time is inefficient and can't compete with steel standards, in part due to the handling logistics of loading/unloading of parts to and from molds
- Lack of automated, high-speed technologies for layup of high-performance parts
- While industry wants plug-and-play solutions in a segmented fashion, they are not compatible with existing infrastructure
- Lack of baseline for embodied energy (e.g., lifecycle assessment)
- Insufficient in-plant waste reduction and recycling processes
- There are no suppliers currently in place who can demonstrate a large-scale run

Other:

- Workforce is limited—existing workforce cannot take on introduction of carbon fiber technology
- Customer expectations do not currently allow appearance of composites to be acceptable for class A parts, in terms of noise, vibration, and harshness

Large-Scale Manufacturing - Vehicles

High-Priority R&D Activities (across 6 breakout groups)

Value Proposition:

- Demonstrate the benefits of a composite by designing new systems with composites (i.e., reimagine the car with composites)
- IACMI to serve as a change agent to demonstrate the case for composites use throughout the value chain (including Tier 1), including technical, financial, and business factors
- Conduct a pre-competitive optimization study on large modules integrating manufacturing processes from constituents to final part, to achieve short cycle time
- Develop a study that conceptualizes usage scenarios that drive decision-making on equipment placement and workspace flexibility for ideal conditions at Corktown demonstration facility
- Compare additive and subtractive solutions for large-scale manufacturing

Predictive Modeling:

- Develop simulations to predict quasi-static and lifetime performance of composites
- Develop tools for service life prediction of bonding dissimilar materials

Novel Technologies:

- Develop processes for rapid near-net shape pre-pregs
- Develop layered material joining technology (e.g., orthopedics industry)
- Identify a technique to increase fiber deposition speed while maintaining high performance

Large-Scale Manufacturing Vehicles (cont.)

High-Priority R&D Activities (across 6 breakout groups)
Automation/Efficiency:
➢Reduce cycle time for the layup and fiber placement processes by 50% ➢Increase speed of load/unload process by implementing better automation and increasing compatibility of processes with existing infrastructure ➢Reduce the cost of carbon fiber by increasing manufacturing efficiency ➢Investigate reuse of carbon fiber waste (offal) in the manufacturing process, engaging designers
Other:
➢Develop a long-term manufacturing plan that demonstrates longevity and sustainability in the long term, once government funding goes away ➢Expand composite manufacturing education and training activities through universities and consortia ➢IACMI facilitates alignment and setting of targets with OEMs

Large-Scale Manufacturing: CGS

Major Challenges (**Bold** = recurs across 3 breakout groups)

1. **Lack of design, testing, and certification standards for conformal tanks**
2. **Limitations with liner performance/permeability:**
   - **Lack of industry requirements for liners/thin prepregs**
   - **Difficult to satisfy high permeability requirements for hydrogen storage tanks**
3. Limited experience with thermoplastics; questionable energy savings when switching from thermosets
4. Lack of screening methods (e.g., coupon-level testing) to predict performance without testing full-scale tanks; Target of reducing screening costs by 50%
5. Limited innovation in fiber deposition; Target of reducing fiber deposition cycle times by 30%
6. Lack of a supply base for high-tensile, high-strength, and low-cost fibers
7. High tensile strength fiber required; need for increased toughness
8. Lack of predictive models for design, scale-up, and conformable geometries
9. Lack of cost model for high-volume manufacturing of tanks

Large-Scale Manufacturing: CGS

High-Priority R&D Activities (Bold = recurs across 3 breakout groups)

1. **Develop a toughened system and method to assess trade-offs between higher tensile-strength and higher cost of fibers**
2. **Develop standards and testing methods for non-standard tank designs**
3. Developing new fiber deposition technology which is cost-competitive with current methods
4. Evaluate benefits of alternate fiber architecture designs (e.g., braided continuously wound thermoplastic [TP] unidirectional [UD] tape)
5. Develop alternate TP materials, screening and testing methods, and validate tank performance
6. Assess energy savings pathways associated with thermoplastics versus thermosets
7. Evaluate/develop open-source predictive models using new or developmental materials

Large-Scale Manufacturing- Wind

Major Challenges (Bold = recurs across 3 breakout groups)

1. **Limited ability to transport large wind turbine blades**
2. **Manufacturing and inspection cost limitations: Labor cost (1,000 hours per blade), tooling cost, in-field inspection ($30k/yr per blade)**
3. **Performance/Quality:**
   - **Limited in-field performance and quality of wind turbine blades**
   - **Limited damage/environmental tolerance of blades and nacelles (salt, hail)**
4. Inability to meet in-mold cycle times
5. Lack of a single design capability that makes full use of CFRP benefits
6. CFRP manufacturing is manual; sensitive to human factors – consistency is limited when automating due to low volumes
7. Lack of material formats that are sympathetic to wind applications

Large-Scale Manufacturing: Wind

High-Priority R&D Activities (Bold = recurs across 3 breakout groups)

1. **NDE/Inspection:**
   - **Develop low-cost in-field SHM/NDE technologies**
   - **Develop carbon-based sensors for in-situ SHM (e.g., conductivity sensors, embedded nanoparticles)**
2. Design and manufacture wind turbine blade joints (in factory) to enable high-quality in-field manufacturing/assembly
3. Develop rapid production, low-cost tooling (e.g., via additive manufacturing)
4. Build large-scale demonstrator of fully CFRP, jointed blade that employs multi-materials
5. Explore hybrid, multi-material CFRP systems for large, high-performance blades
6. Assess range of tailored CFRP formats, such as pultruded bars and rods
7. Conduct economic analysis on automated tape placement – learn from aerospace industry
8. Develop in-field coatings for enhanced reliability

Roadmap Utilization….

Phase I

Fall 2015

Phase 2

Spring 2016

Stakeholders input – Alignment with DOE FOA

Staging upcoming RFPs

Transparency of IACMI approach to projects selection

Track each project technical milestones to Roadmap milestones

Quantifiable metrics in projects

IACMI strategic assets and timeline of these investments

Public version of roadmap – benefits the global composites community

Are Technical Barriers & Gaps identified in the Roadmap being addressed in the projects?

What will IACMI do with the Roadmap findings

- State of the art debrief to stakeholders by TADs and tech leads
  - Educational webinars
  - Collaborations with ACMA, ASC, CPC, CTRC, C1
- IACMI projects are aligned to critical feedback from the workshops
- Sub-topic sessions tied back to Technology Areas – CGS, Wind, Automotive, M&P, M&S
- Roadmap – Project scope correlations
- Continuous monitoring

Summary

- The road map is gathering a consensus view of the technology and business landscape for composites manufacturing in clean energy applications
- The roadmap is helping to prioritize investments in IACMI's technology development pathways, RFPs and shared infrastructure
- The detailed discussions within the sub-topics provide significant granularity to the technical activities and quantifiable milestones
- Continual monitoring and updating of Roadmap to maximize IACMI impact to stakeholders, technology advances and implementation

A public version of the Phase 2 detailed roadmap will follow.

Mechanical properties of low cost textile based carbon fiber based composites and bench marking with Zoltek fiber

Dayakar Penumadu
Cliff Eberle
Robert Norris
Uday Vaidya

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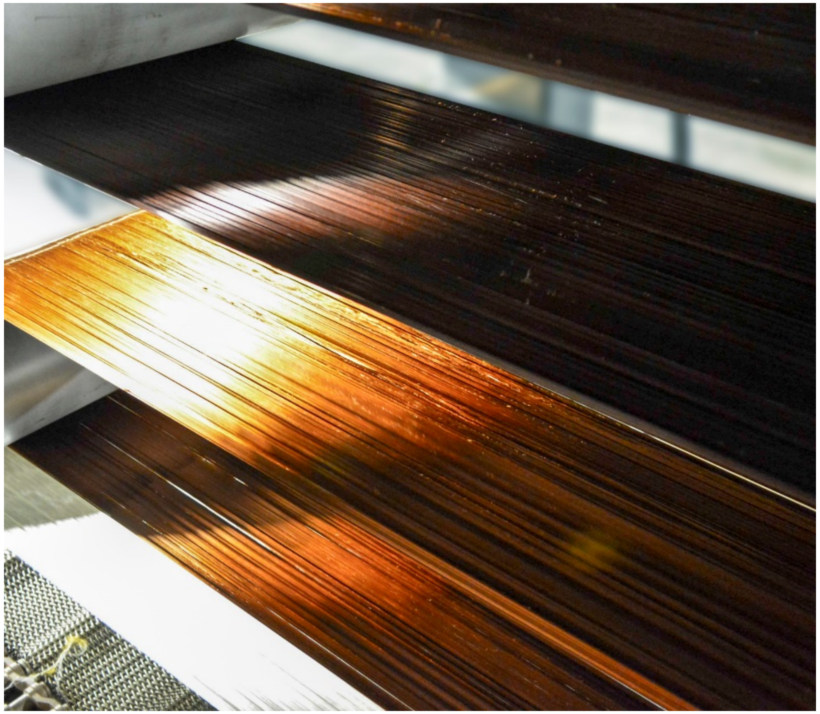
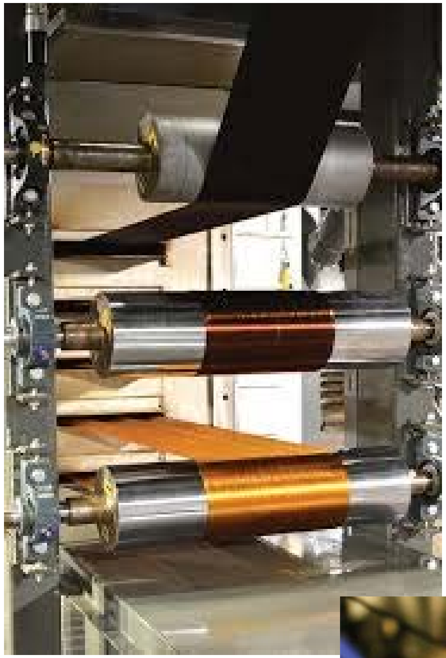
Background

- Licensing opportunity for the LCCF has been announced by ORNL (March 2016)
- Limited properties database for carbon fiber composites in areas of IACMI focus areas
- Need to generate representative properties that would be useful to the IACMI stakeholders, and community at large.



Low Cost Carbon Fiber – Wide tow



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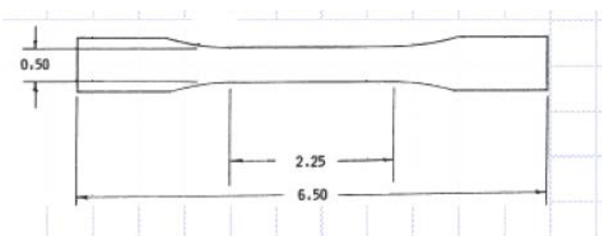
Carbon Composite Properties for End Users…

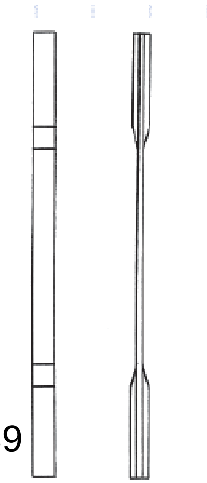
- IACMI is undertaking a limited study to generate a basic database - use in design, modeling and application development
- The data generated will be applicable to IACMI core areas
- The materials portfolio will be expanded on continuous basis

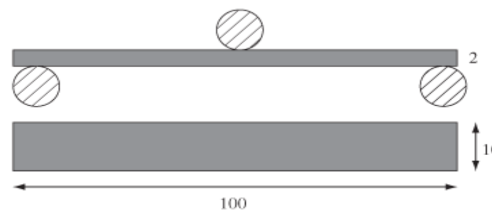
IACMI is undertaking a limited study to generate a basic database for use in design, modeling and application development - Applicable to IACMI core areas



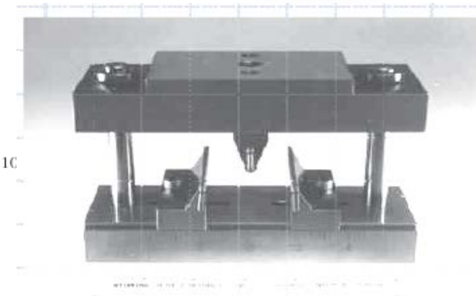
Tension
ASTM D638

Tension
ASTM D3039

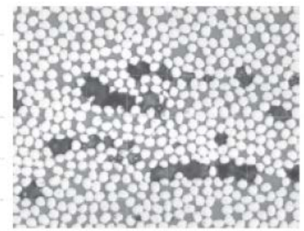




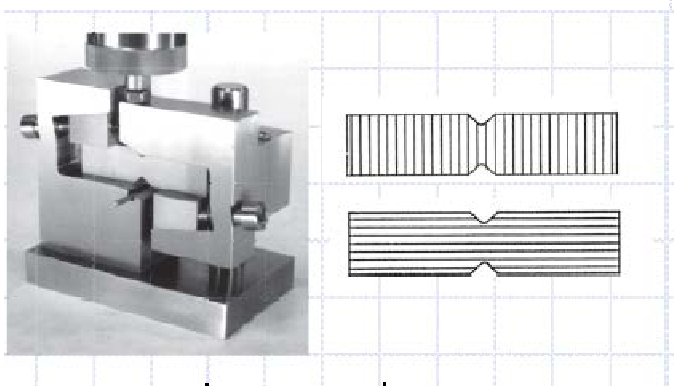
Flexure
ASTM D790



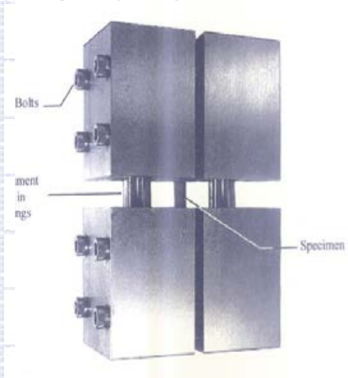
Short beam shear
ASTM D 2344



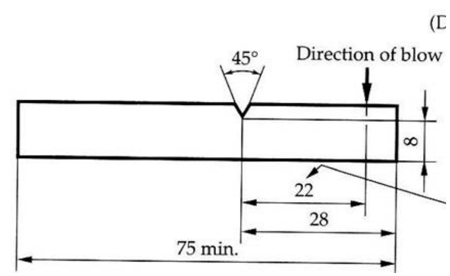
Void Content



Isopescu shear
ASTM D5379



Compression
ASTM D6641



Notched Izod

- Limited data was presented at the membership meeting.

- The comprehensive data from this exercise will be made available by mid-Fall 2016 upon completion of the round robin exercise.