IACMI Roadmapping for Technology Development & Long-Term Sustainability Planning

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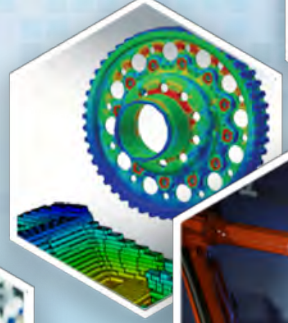
January 31, 2019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Outline

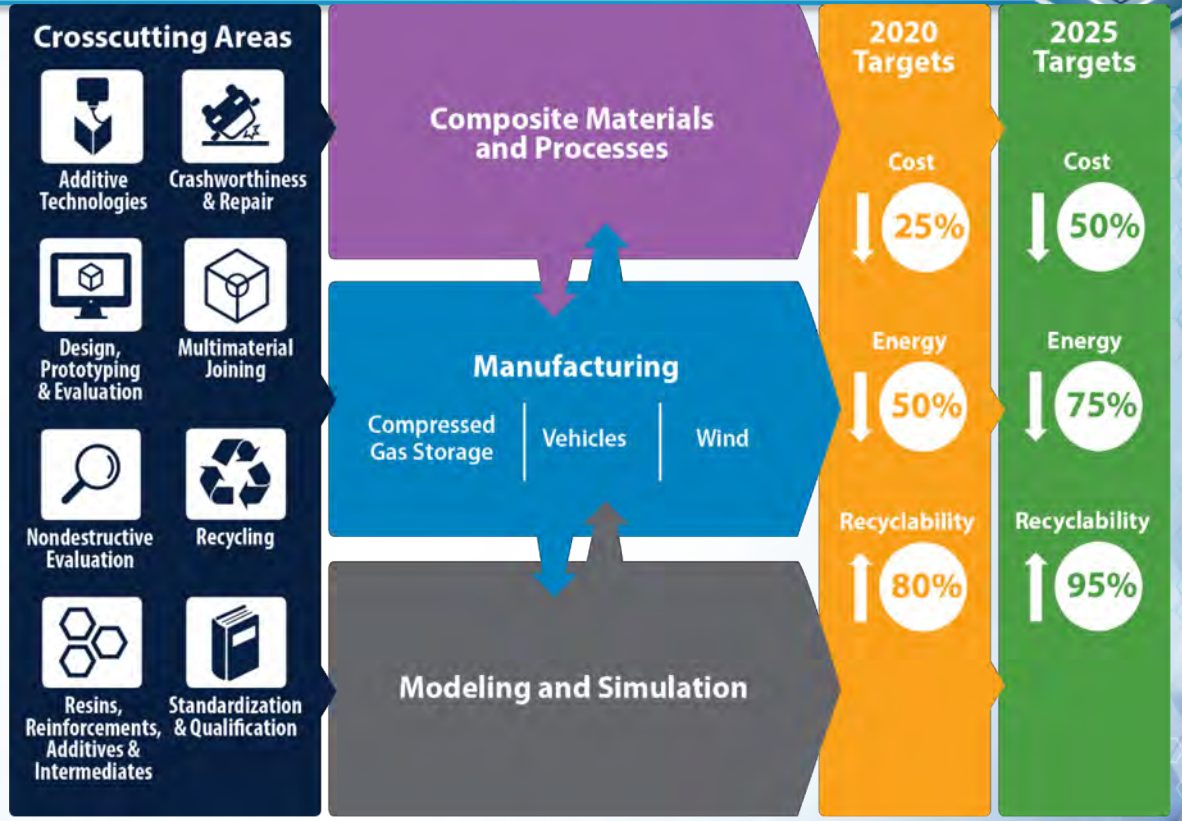
- IACMI Technology Roadmapping Overview – Phase 4
- Debrief of Summer 2018 Members Meeting outcomes
- TBD February/March 2019 webinar and online survey: *FRPC opportunities for future of automotive mobility*

IACMI Roadmap Purpose & Objectives

- The roadmap addresses **mission-critical, market-specific, and cross-market challenges, opportunities, and technology solutions**.
- Roadmap activities represent the **collective inputs** of members, partner organizations, and other stakeholders across the composites manufacturing supply chain.
- The roadmap offers a **consensus view of the technology and business landscape** for composites manufacturing in clean energy applications.
- Roadmap activities serve primarily as **a catalyst for IACMI and its members to**:
  - 1. **Propose and launch technology demonstration projects**
  - 2. **Identify shared existing resources**
  - 3. **Forge strategic partnerships**
- The roadmap is a **guidance document**—a *snapshot* of what IACMI members are currently thinking. **Regular updates** are needed to **accurately reflect the evolving technology development and commercialization needs** of the composites manufacturing industry.

Roadmapping Strategy

- Integrated R&D efforts across IACMI Technology Areas toward 5-/10-year targets
- Industry-led projects draw upon resources from one or more IACMI Technology Areas
- Ccross-cutting subtopics help address full range of enabling technologies



Roadmap Progression (2015 to present)

Phase 1: Accelerated roadmap priority identification

Phase 3: Roadmap Addenda ("Mini-Roadmaps")

Stand-alone documents to communicate topic-specific project opportunities as identified by IACMI members

2015 — 2016 — 2017 — 2018

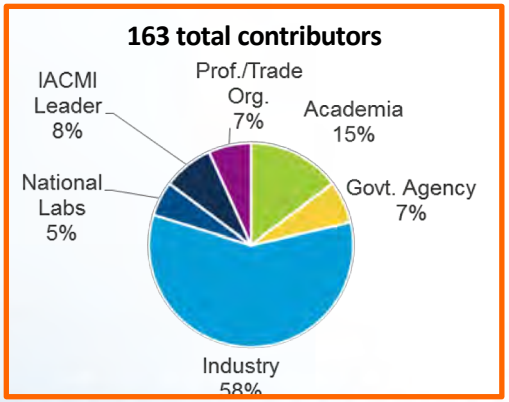
Phase 2: Full roadmap development

IACMI Five-Year Objectives

↓25% CFRP **cost**

↓50% CFRP **embodied energy**

↑80% recyclability



Phase 4: Full roadmap update (now available)

- Reflect on industry needs, membership value
- Examine IACMI post-2020: Future targets, goals, markets
- Ensure alignment of IACMI funded projects with roadmap's R&D activities

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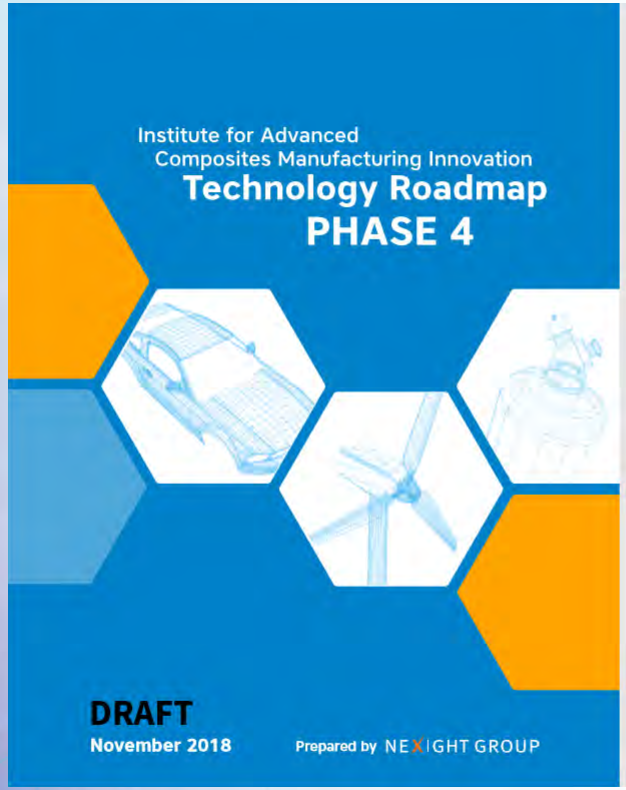
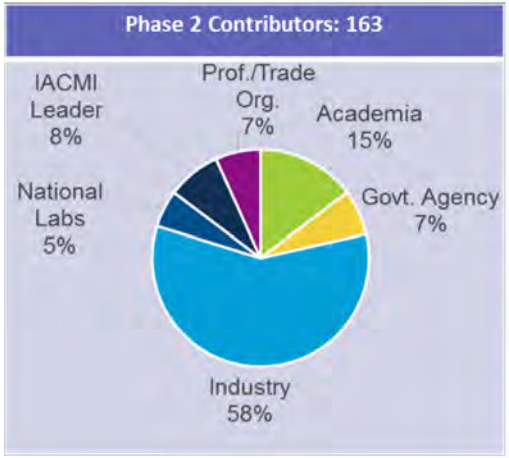
Roadmap Progression contd..



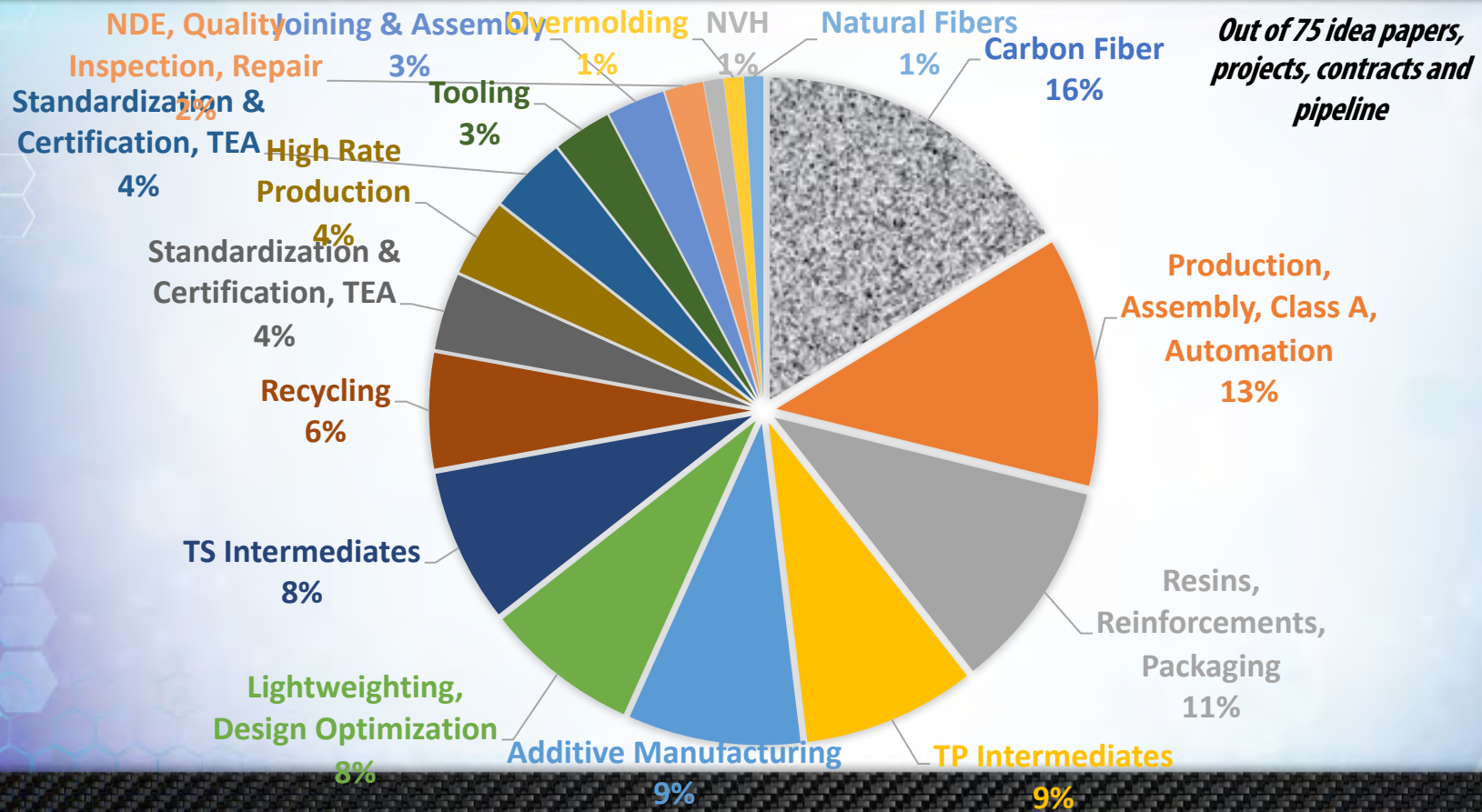
Vehicles | Wind | Compressed Gas Storage
Materials & Processing | Modeling & Simulation



ACTIVITIES TO DATE

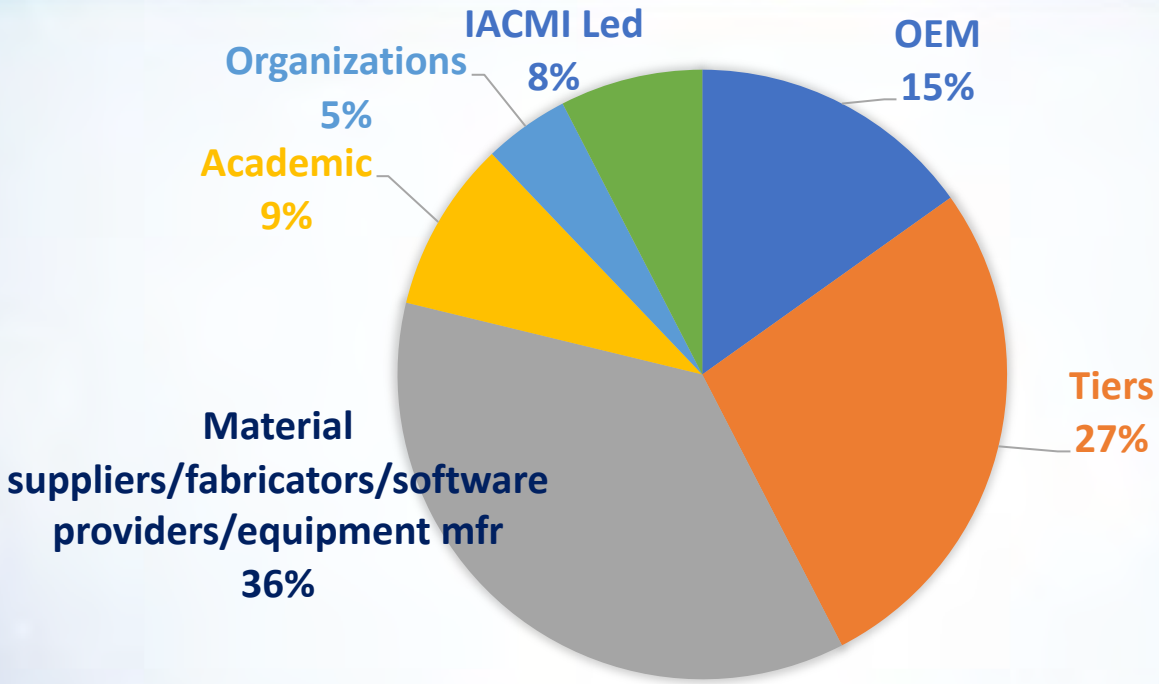
- IACMI Technology Roadmap: Phase 1,2,3
- Roadmap Addenda ("Mini-Roadmaps"):
  - Multimaterial Joining (2017)
  - Embodied Energy Reduction (2017)
  - Recyclability (2017)
  - Noise, Vibration, & Harshness (NVH) (2018)

Projects Portfolio (in alignment with Roadmap)



Out of 75 idea papers, projects, contracts and pipeline

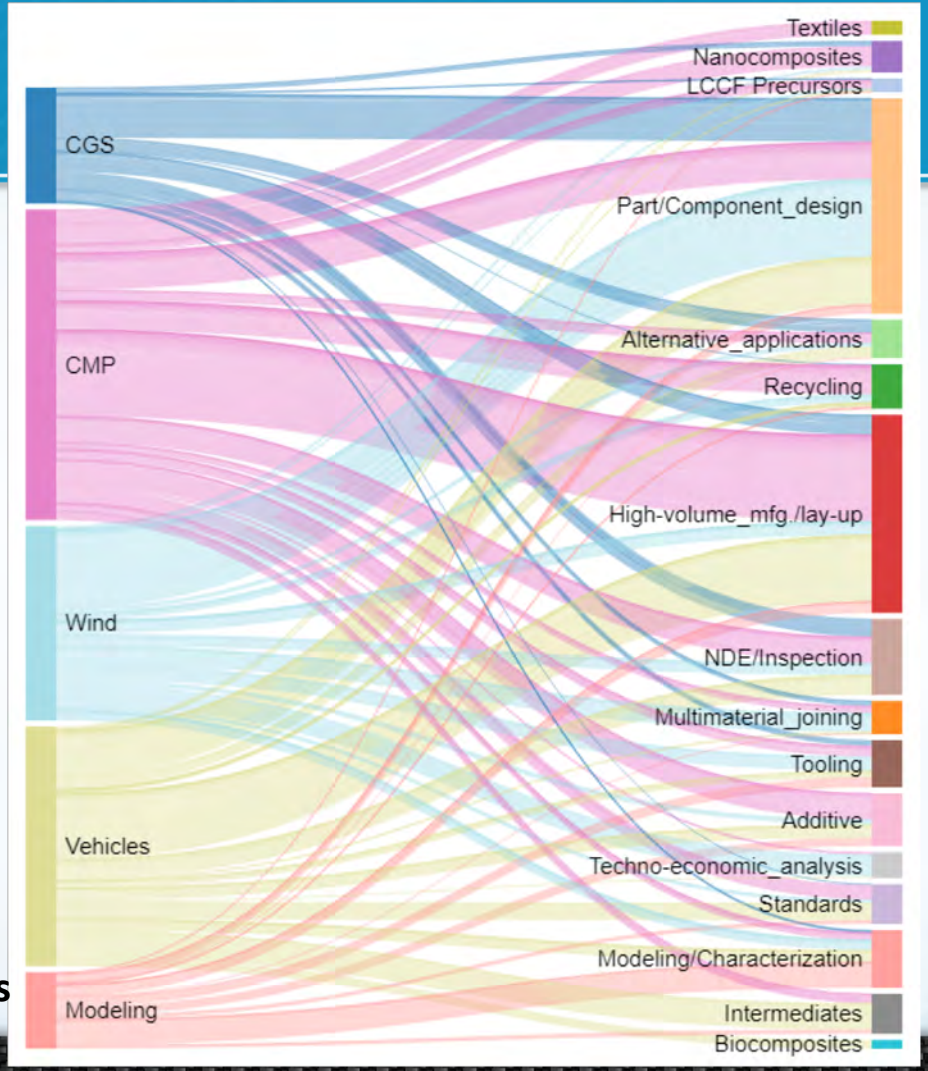
Projects Participation by Organization Type



92 member companies out of 160 members participating in IACMI Projects

Mapping each project to the roadmap

Total connections between IACMI projects and priority roadmap activities



IACMI Technology Areas

50+ IACMI Projects (Generic categories)

Example IACMI Projects Aligned to Roadmap

CGS	Materials/Processes
Vehicles	Modeling/Simulation
Wind	

Lead Partner: LeMond Composites
Project Title: Next Generation Carbon Fiber for High Volume Applications

Roadmap Activity	Tech. Areas
Increase efficiency of pre-forming process (i.e., from fibers to parts)	
Develop application-specific low-cost tooling method	
Develop adhesive application method with high bond uniformity	
End-to-end process models: Quantify variability, integrate with FEA tools	
Establish validation methods for CGS fabrication upscaling	

Lead Partner: ELG Carbon Fibre
Project Title: Enabling Technology For The Use Of Recycled Carbon Fiber Materials in Mobility Applications

Roadmap Activity	Tech. Areas
Coordinate with OEM to demonstrate prototypical production of automotive components using recyclate materials	
Characterize molded parts of recycled CFRPs	
Develop robust composite fabrication processes/equipment for reclaimed materials	

Example IACMI Projects Aligned to Roadmap

Lead Partner: Ford Motor Co.

Project Title: Optimized Carbon Fiber Production to Enable High Volume Manufacturing of Lightweight Automotive Components

CGS | Materials/Processes
Vehicles | Modeling/Simulation
Wind

Roadmap Activity	Tech. Areas
Develop/demonstrate in-line diagnostics for fiber/resin production	
Coordinate with OEM to demonstrate prototypical production of automotive components using recyclate materials	
Characterize molded parts of recycled CFRPs	
Develop energy efficient, high-throughput CF processes	
Develop fast-curing resins and adhesives	
Reduce the cost of carbon fiber by increasing manufacturing efficiency	
Create “building block” offal design method	
Create data sharing methodologies for computational tools	
Develop simulation process models, define data needs, and determine data uncertainty on four chosen manufacturing processes	
Enable material property data sharing for process models	
Increase prediction confidence in durability/ crash performance correlation	
Develop advanced computational methods for composite vehicle part design	
Establish and validate cost/performance models for automotive parts	
Develop TS/TP composite manufacturing methods with cycle times under three minutes	
Investigate reuse tech. and secondary uses for CFRP offal	

Key Updates: *IACMI Technology Roadmap: Phase 4*

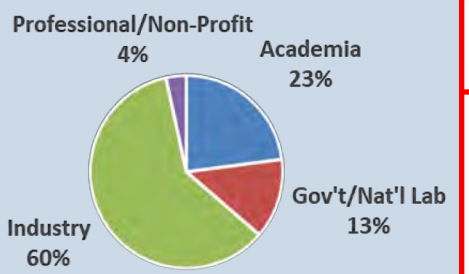
- **Roadmap Alignment with IACMI Projects**
  - **50+ IACMI-funded projects align with 75% of Phase 2 priority roadmap activities**
  - **94%** of **project-aligned priority activities** address IACMI's **cost reduction target**
- **Featured IACMI Project Case Studies**
  - Optimized Resins and Sizings for Vinyl Ester/Carbon Fiber Composites
  - Thermoplastic Composite CGS Tanks
  - Thermoplastic Composite Wind Turbine Blades
  - High-Volume Flexible Design Thermoplastic Composite Parts Mfg.
  - Optimized Carbon Fiber Production: High Volume Mfg. of Lightweight Automotive Composites
- **Focused expansion of crosscutting subtopic areas—or "mini-roadmaps"**
  - Embodied Energy Reduction
  - Recyclability of FRPCs
  - Multimaterial Joining
  - Noise, Vibration, and Harshness (NVH)
- **Examination of potential new technology areas**
  - Aerospace
  - Buildings & Infrastructure
  - Mass Transit

Phase 2 Roadmap → Phase 4 Roadmap = ↑70% increase in total activities in roadmap

IACMI Technology Roadmapping: 2015—Present

Overview: Summer 2018 Members Meeting

Stakeholder Mix



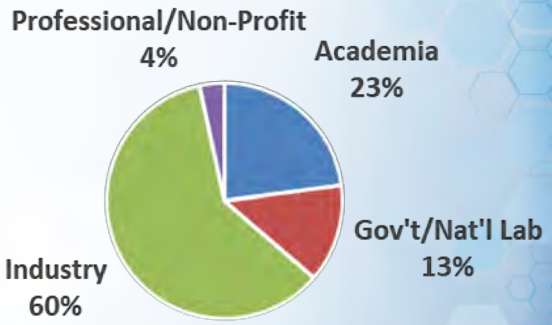
Wednesday, July 25	Thursday, July 26
• 30-minute scoping session • 400+ IACMI members	• 60-minute wrap-up session • 15-20 key IACMI leaders/directors

Focus Questions		Approach/Method
Future IACMI Technology Areas & Composites Manufacturing Industries	➢ Which topic should IACMI consider establishing as a future Technology Area? *(Select one response)*	➢ 225 total responses; Aggregate of pre-meeting survey results and live workshop polling (via IACMI Event App)
Roadmapping Subtopics & Areas of Interest	➢ Which of these composites manufacturing subtopics should be the focus of collaborative IACMI project opportunities? *(Select up to five responses)*	
Member Needs for IACMI Roadmap	➢ How can the IACMI roadmap be more useful to you as an IACMI member organization?	➢ Paper worksheet responses from group breakout sessions; 5-10 workshop participants per table, 35 tables
Future Targets to Drive Technology Development	➢ What other targets (quantitative or qualitative) should IACMI set to drive technology development? What metrics are most important to you?	

Survey/Poll Results: Summer 2018 Members Meeting

1. Which **composites manufacturing subtopics** should be the focus of collaborative IACMI project opportunities?
2. Which topic should IACMI consider establishing as a **future Technology Area (TA)**?
3. What is the biggest barrier **preventing** your organization from **submitting a project proposal to IACMI**?
4. How can the **roadmap** be **more useful** to you as an IACMI member organization?

400+ IACMI Members



Survey/Poll Results: Summer 2018 Members Meeting

1. Which **composites manufacturing subtopics** should be the focus of collaborative IACMI project opportunities?
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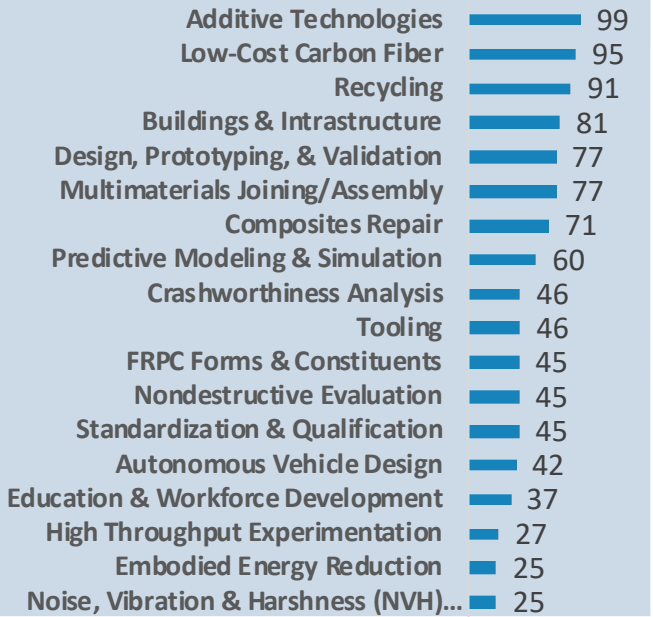
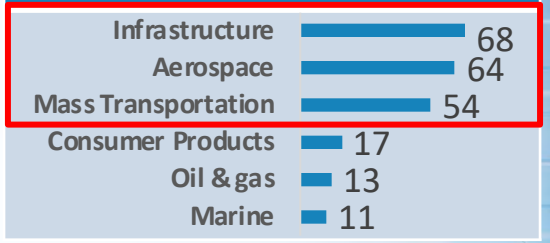
3. What is the **biggest barrier** preventing your organization from **submitting a project proposal to IACMI**?
4. How can the **roadmap** be **more useful** to you as an IACMI member organization?

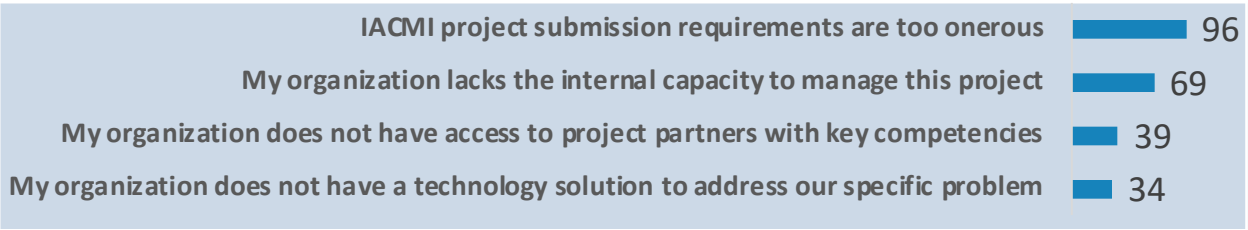
1) Key Subtopics *(Select 5)*



2) Future TAs *(Select 1)*



3) Barriers to Project Proposal Submission *(Select 1)*



4) Roadmap Usefulness *(Top responses)*

- Show progress via **alignment with IACMI funded projects**
- Explore **new/future IACMI Technology Areas** and key R&D opportunities
- Summarize **impact/benefits of IACMI project investments** (e.g., mass/cost reduction)
- Define **low-level technical targets** to increase **small business participation**
- Incorporate **interactive features** or improve the **"searchability"** of the roadmap
- Use **IACMI member *crowdsourcing*** to expand/share ideas, audit roadmap

Proposed Phase 5 activity

Summer 2018 Members Meeting: Reflections from IACMI Leadership Team

Potential pathways to new technology areas/industries:

Pathway 1: Establish new IACMI Technology Area(s)

- Requires significant IACMI member interest (and likely, the **availability of Federal resources**) to advance new application-specific technologies
- New **centers of excellence (COEs)** attract new universities and IACMI members

Pathway 2: No new TAs; Focus instead on broadly applicable foundational technologies

- Engage new sector(s) and identify key application needs; Foster expertise/capabilities before considering new IACMI partner/COE
- Quantify societal benefits of pursuing opportunities for new composites manufacturing sectors
- Advance **foundational technologies** and **transfer to other sectors/applications**

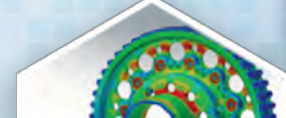
IACMI Roadmapping Phase 5: Next Steps

- Primary focus areas:
  - **Long-term IACMI sustainability strategic planning** discussions including a *Sustainability Roadmap*
  - **Mini-roadmap** on *Composites for Mobility*
- Key events/activities:
  - **March 2019**—(TBD) *Composites for Mobility* webinar
    - Nexight Group will disseminate online survey next week (February 4-8) to solicit member views on **CFRPs opportunities for future mobility applications**
  - **April to August 2019**—Establish roadmap focus groups/panels (8-10 people each)
    - Multiple expert panels to address **new sector/technology area opportunities** (aerospace, infrastructure, mass transit)
    - Additional expert panel focused on **long-term IACMI sustainability**
  - **July/August 2019**—Summer 2019 Members Meeting
    - Extended sustainability roadmapping session

Thanks to all IACMI members for your continued support and contributions to the roadmap!

Winter 2019 Members Meeting:
IACMI Focus Group:
Lunch Wrap-up Discussion

January 31, 2019



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Discussion Topics

- [**15 min.**] IACMI future direction on composites for mobility
- [**45 min.**] Open discussion about IACMI long-term sustainability

TBD March 2019 Webinar: *Composites for Mobility*

- **What**: **IACMI will host a 90-minute webinar in March 2019 to**:
  - 1) Introduce key **automotive mobility megatrends**;
  - 2) Discuss IACMI's aspirations to address **FRPC opportunities for future mobility applications**, and;
  - 3) Solicit IACMI member inputs on **specific industry needs and key roadmapping activities (i.e., IACMI project opportunities)**.

1. What **existing IACMI activities/capabilities are required for future automotive mobility opportunities and funded projects**? (e.g.:)
   - **Autonomous vehicles**—Lightweighting to offset heavy advanced driver-assist systems (~200-300 lb)
   - **Electrification**—Lightweighting to extend vehicle range, reduce recharging downtime
   - **Shared mobility**—High durability vehicle interiors, corrosion-resistant structural components, and more recyclable materials to increase lifespan of shared and fit-for-purpose vehicles
2. **Suggestions for March 2019 webinar guest speaker?**

   Existing Recommendations:
   - **Dan Work**, Associate Professor of Civil and Environmental Engineering, Vanderbilt Center for Transportation and Operational Resiliency
   - ***Gary Silberg**, National Automotive Leader, KPMG
   - ***** **John Waraniak**, Vice President of Vehicle Technology, Specialty Equipment Market Association (SEMA)
   - ***** **Hagen Radowski**, CEO, Mieschke Hofmann and Partners (MHP) Americas Inc. (A Porsche Company)

   (* = presented at Southern Automotive Conference)

IACMI Long-Term Sustainability

1. What are IACMI's potential or likely future funding sources?

- What's the case for seeking additional funding support **from DOE**? Are **there other federal agencies** that would likely fund IACMI?
- What **non-federal agencies**, such as State- or regionally based economic development organizations, could provide future funding support?
- What funding sources, if any, would IACMI **refuse to accept** (e.g., international governments)?
- How would IACMI operate in the **absence of additional government funding support**?
- What implications would the discontinuation of government funding have on **IACMI's membership model**?

IACMI Long-Term Sustainability

2. **What successful approaches have other Institutes taken to secure funding and long-term sustainability support?**

Looking Forward: Summer 2019 Members Meeting

- Extended sustainability roadmapping session
- Role of BOD-CEO-appointed Sustainability Committee

Question #1:

*Which topic should IACMI consider establishing as a **future Technology Area**?*

Votes	Technology Areas/Industries
30%	Buildings/Infrastructure
28%	Aerospace
24%	Mass Transportation
7%	Consumer Products
6%	Oil & gas
5%	Marine

Question #2:

*Which of these **composites manufacturing subtopics** should be the focus of collaborative IACMI project opportunities?*

Votes	Subtopics
47%	Additive Technologies
45%	Low-Cost Carbon Fiber: Processes, Precursors
43%	Recycling
38%	Buildings & Intrastructure
36%	Design, Prototyping, & Validation
36%	Multimaterials Joining/Assembly
33%	Composites Repair: Techniques, Technologies
28%	Predictive Modeling & Simulation
22%	Crashworthiness Analysis
22%	Tooling
21%	FRPC Forms & Constituents: Resins, Reinforcements, Additives, & Intermediates
21%	Nondestructive Evaluation: Techniques, Technologies
21%	Standardization & Qualification
20%	Autonomous Vehicle Design
17%	Education & Workforce Development
13%	High Throughput Experimentation
12%	Embodied Energy Reduction
12%	Noise, Vibration & Harshness (NVH) Mitigation

Other: Bio-based materials and biological technologies

Question #3:

How can the IACMI roadmap be more useful to you as an IACMI member organization?

- Show progress made on **existing roadmapping activities** (i.e., overlap/**alignment with IACMI funded projects**)
- Explore composites manufacturing **technology commercialization opportunities** for new/future IACMI Technology Areas (infrastructure, aerospace, mass transit)
- Summarize **impact of IACMI investments** (projects); Benefits for industry end-products (lightweight, cost reduction, etc.)

Question #4:

*What **other targets** (quantitative or qualitative) should IACMI set to drive technology development? What **metrics** are most important to you?*

- **Application-specific performance me**trics and methods to measure increased/superior performance
- **Total weight of composites manufactured/installed** (e.g., total pounds installed in infrastructure applications)
- Measures of **technology uptake/adoption** in **non-research-related applications**
- Establish metrics to measure **project "efficiency"** (e.g., frequency and quality of member company interactions)
- Re-focus on using **technology readiness levels (TRL)** to more effectively communicate IACMI's project portfolio to all members/disciplines
- Metrics for **scalability**; viability for increased production scale

Day 2: Wrap-Up Session

- **Day 2**:
  - 60-minute wrap-up discussion
  - 15-20 key IACMI leaders/directors
  - Discussion about future pathways to new technology areas/industries
- **Option 1: Establish new IACMI Technology Area(s)**
  - Requires interest and availability of Federal resources to advance new application-specific technologies
  - New centers of excellence (COEs) attract new universities and IACMI members
- **Option 2: No new TAs; Focus instead on broadly applicable foundational technologies**
  - Engage new sector(s) and identify key application needs; Foster expertise/capabilities before considering new IACMI partner/COE
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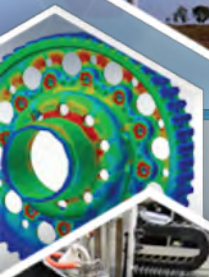

Questions?