



IACMI-The Composites Institute

U.S. Department of Energy Advanced Manufacturing Office
Program Review

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CEO

June 2016

Institute for **ADVANCED**
Composites Manufacturing
INNOVATION

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Agenda Topics

Item	Agenda Topic
1	Introductions
2	2015 Review and 2016 Overview
3	Organizational Updates
	• Operations
	• Membership
	• Technology Roadmapping
	• Projects
	• Capabilities Expansion: Partnerships, Equipment and Facilities
4	2016/2017 Strategy and Future Successes

2015

Building the Network

- ✓ **January 2015**
President Obama, VP Biden announce IACMI

Institute officially launches in June 2015

- ✓ **June 2015**
Inaugural IACMI Members Meeting with >350 attendees
Purdue breaks ground on \$50M composite facility

- ✓ **September 2015**
IACMI announces Call for Projects
- ✓ IACMI team presentation to over 700 attendees at SPE & Automotive Composites Conference
- ✓ VP Biden announces IACMI's scale-up facility in Detroit

- ✓ **October 2015**
- ✓ MOU announcement with CPC in NY establishing IACMI satellite in the Northeast
- ✓ IACMI ACMA and Composites One partnerships established and announced to over 7,500 attendees at CAMX.



THE COMPOSITES
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U.S. DEPARTMENT OF
ENERGY Advanced Manufacturing

The Institute for Adv

2016

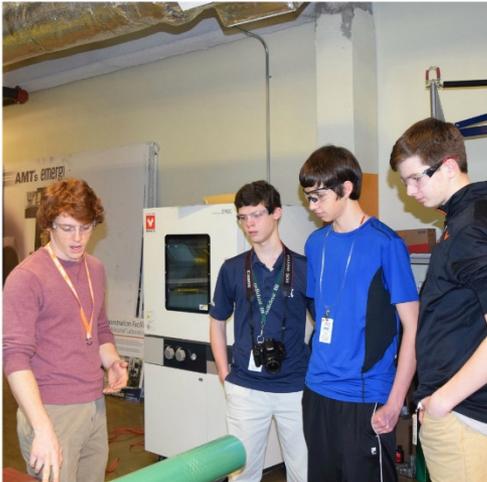
Engaging the Network

- ✓ **January 2016**
Members Meeting in Detroit with over 300 attendees
- ✓ **February 2016**
Over 130 executed membership contracts with 120 additional interested members in the pipeline
- ✓ **March 2016**
 - ✓ SHYFT Innovation Leadership Conference in Chattanooga features Craig Blue as a thought-leader for national innovation in design and manufacturing
October 2015
 - ✓ Technical Roadmapping event in Knoxville brings over 100 people to IACMI HQ
- ✓ **April 2016**
 - ✓ Tennessee workforce training event in collaboration with Composites One
 - ✓ STEM event to educate high school robotics students on advanced materials, specifically composites (100 attendees)
 - ✓ IACMI leadership and external presence at Hannover Messe, Germany
- ✓ **May 2016**
 - ✓ JEC Americas Atlanta- external presence with ORNL
 - ✓ Technical Roadmapping phase 2 in Michigan with 110 attendees
 - ✓ Toray project launch
- ✓ **June 2016**
 - ✓ 15 IACMI Interns in place
 - ✓ Workforce training event at new Wind Technology Facility (NREL, Colorado)



2016 Continued....

2016 Outreach & Programming



July 2016

- MOU with Composites Recycling Technology Center and Peninsula College
- IACMI Members Meeting in Indianapolis
- Purdue Manufacturing Innovation Institute ribbon cutting

August 2016

- University of Tennessee IACMI Fibers and Composites Center facility naming announcement
- Purdue workforce training event in collaboration with Composites One

September 2016

- Colorado Wind Technology Center facility ribbon cutting
- CAMX Outreach event with over 10k attendees

November 2016

- Michigan 250 Ton Vertical Press Installed
- Michigan workforce training event in collaboration with Composites One

Operations: Staffing Updates



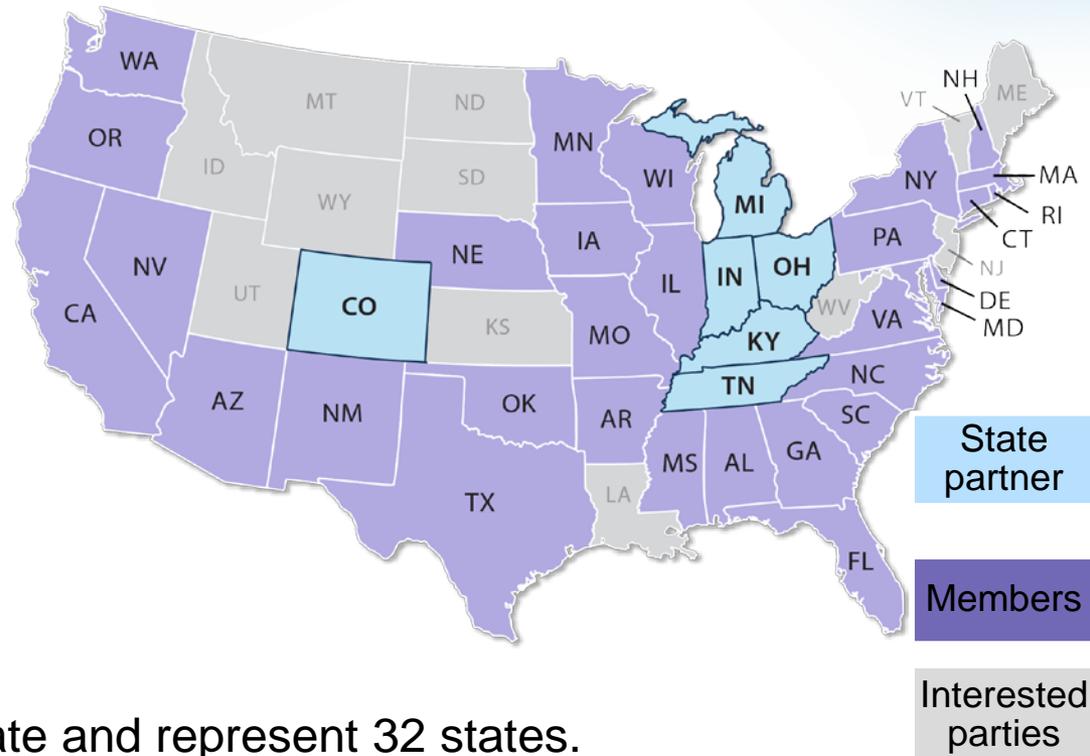
Current Membership

Membership by Level:

Membership Type	Number
Consortium	91+
Resource	12
Premium	13
Charter	9
Total	125

+ Includes ACMA membership

Updated 3/31/2016



- The partners are public and private and represent 32 states.
- IACMI- The Composites Institute has with ACMA, the leading composites industry association with over 500 members in 49 states.

Technology Roadmapping

Goals

Integrate the views and establish stakeholders consensus from value chains in vehicles, wind, and CGS

Identify other markets in which IACMI capabilities and expertise may be reasonably extended

Identify & assess pathways for sustainability after year 5

Develop and periodically revise a targeted technology roadmap

Mission-critical, market-specific, and cross-market challenges, opportunities and technology solutions

Roadmapping Topics Knoxville, March 2016

Modeling & Simulation

Recycling

Nondestructive Evaluation

Reinforcements, Resins,
Additives, and Intermediates

Additive Technologies

Design, Prototyping, and
Validation

Roadmapping Topics Detroit, May 2016

Multi-material joining

Standardization and
Certification

Crashworthiness and Repair

Large Scale Manufacturing

IACMI Sustainability-Part 2

Coming Soon....

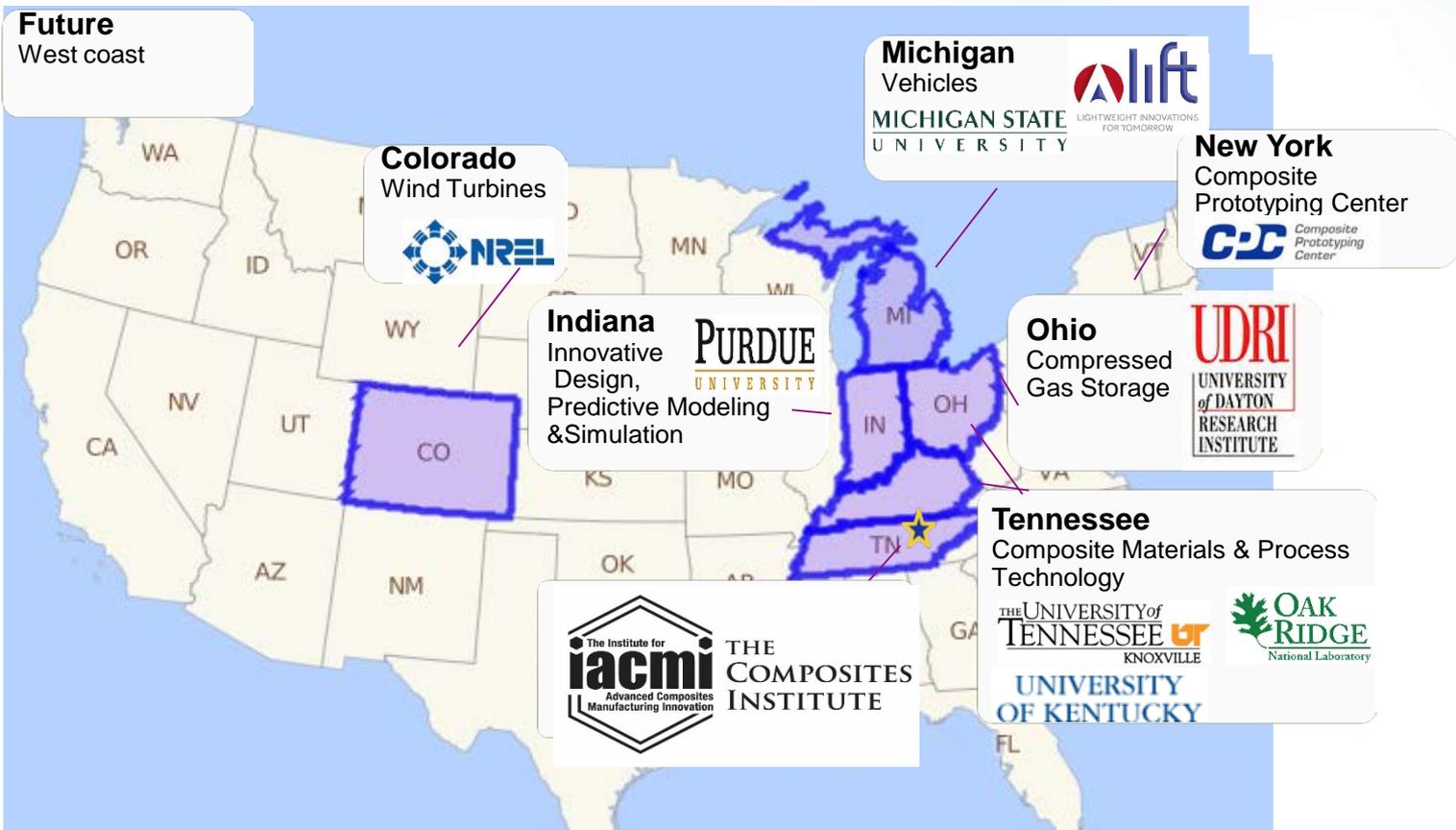
- Memorandum of Understanding signing event on July 1, 2016 with DOE, elected officials, IACMI and Peninsula College
- Expanding IACMI facility access to the West Coast and capabilities in recycling
- CRTC
 - Currently participating in Toray project with IACMI
 - Already partnered with Peninsula College
- Peninsula College
 - Currently offers an Advanced Composites Certification Course
 - Composites lab facility in partnership with CRTC



CRTC
COMPOSITE RECYCLING
TECHNOLOGY CENTER



Capabilities and geographic footprint



- Purdue announced \$50 million composites facility.
- In September, Vice President Biden announced the IACMI colocation with LIFT in Detroit, Michigan expands capabilities and collaboration with auto industry ecosystem.
- MOU signed with the Composite Prototyping Center in New York.
- Future growth



Building on Existing Strong Partnerships

Industry, Academia and Government Stakeholders

A partnership of world-class companies including:



A partnership of outstanding small and medium sized organizations including:



Top universities including:



IACMI Projects

First Group of Selected Projects

Project	Project Lead
Thermoplastic Composite Parts Manufacturing Enabling high Volumes, Low Cost, Reduced Weight with Design Flexibility	DuPont
Enabling Composite Processing through the OEM Assembly Line	PPG
Rapid Carbon Fiber Prepreg Molding Technology for Automobile Structural Parts	Toray Composites
Low Cost Pultruded Carbon Fiber Reinforced Polymer (CFRP) Composites for Spar Caps	TPI Composites
BAAM Materials Development and Reinforcement with Advanced Composites	Local Motors
Composite Components in Vehicle Drivetrains	Eaton

6 recommended for rework

2 not aligned with IACMI

Thermoplastic Composite Parts Manufacturing Enabling High Volumes, Low Cost, Reduced Weight with Design Flexibility

- **Challenge:** High cycle time for production of continuous CF thermoplastic composites increases costs.
- **Approach:** Novel materials and processes that allow flexible prepregs (Fiberflex™) combined with Rapid Fabric Formation technology to provide customizable fiber orientations via thermal bonding to significantly improve cycle time, cost, and waste.
- **Impact:** *Use of emerging materials for impregnation and new approaches for tow coating and fabric formation will lower costs of high volume composites production by 20%.*

- **DuPont, Fibrtec, Purdue, MSU,**
- Vehicles
- TC Phase 1
- TRL/MRL Impact: from 3 to 6/7



Enabling Composite Processing through the OEM Assembly Line

- **Challenge:** Incompatibility with standard adhesives and coatings processes limit low-cost composite scale-up.
- **Approach:** Develop and demonstrate adhesives and e-coat that meet OEM specification when processed at temperatures compatible with low-cost composites.
- **Impact:** *Accelerates market adoption via use of standard techniques for component production: PPG and OEM partner Ford will identify component for volume production.*

- **PPG Industries, Ford, Michigan State**
- Vehicles
- TC Phase 1
- TRL/MRL Impact: from 4 to 6



Rapid Carbon Fiber Prepreg Molding Technology for Automobile Structural Parts

- **Challenge:** High costs and cycle times limit use of CFC in automotive structural parts.
- **Approach:** A supply-chain centric (ecosystem based) approach that integrates material selection, molding methods, preform design patterns, together with waste stream utilization will decrease costs and cycle times.
- **Impact:** *Integrated supply chain-based improvements to materials selection, component design, form set-up, process, and scrap management will decrease costs by 15% for target components.*
- **Toray Composites (America), Inc.,** Zoltek, Reichhold, Janicki Industries, Globe Machine Manufacturing Co., CRTC, ACMA, MSU
- Vehicles
- Project 3.3 TC Phase 1: validation of the approach through flat panel demonstration
- TRL/MRL Impact: from 4/5 to 6/8



Low Cost Pultruded Carbon Fiber Reinforced Polymer (CFRP) Composites for Spar Caps

- **Challenge:** CFRP costs limit its utilization in wind turbine blades.
- **Approach:** Application of highly aligned textile PAN CF fibers in pultruded plates for infused spar caps with high specific stiffness and acceptable compressive strength will enable longer wind turbine blades to increase Annual Energy Production.
- **Impact:** *20% reduction in blade weight at comparable cost.*
- **TPI Composites, DowAksa, Dow, Strongwell, NREL, ORNL, UTK, Vanderbilt, (GE)**
- Wind Turbines
- TC Phase 1
- TRL/MRL Impact: from 4 to 7



BAAM Materials Development and Reinforcement with Advanced Composites

- **Challenge:** Integration of big area additive manufacturing and composite materials for vehicle applications requires new design and materials approaches to meet longevity and crash performance requirements.
- **Approach:** Integrated design and materials selection, together with novel, low-cost reinforcing techniques will be used to optimize components for vehicle application.
- **Impact:** *Creation of multiple US facilities producing cars with substantial advanced composite make-up - 9 new facilities, 900 new skilled jobs by 2017, complementary impact across a broad range of manufacturing sectors leading to 50% reduction in design to manufacturing cycle time.*
- **Local Motors, ORNL, MSU**
- Vehicles
- TC Phase 1
- TRL/MRL Impact: from 4 to 5 (Phase I)



Composite Components in Vehicle Drivetrains

- **Challenge:** Carbon-composite-metal shows promise for drivetrain components, but additional challenges in value proposition, cycle time, product performance, and multi-material interfaces remain.
- **Approach:** Composite material processing and interface capability will be simulated and demonstrated to develop a composite-and-metal drivetrain product leading to product performance verification.
- **Impact:** 160 kg weight savings for HD truck transmission - equivalent to reduction of 50M gal diesel/year consumption in US.

- **Eaton, MSU, UTK**
- Vehicles
- Enterprise
- TRL/MRL Impact: from 4 to 6



IACMI Projects 3.2 and 4.2

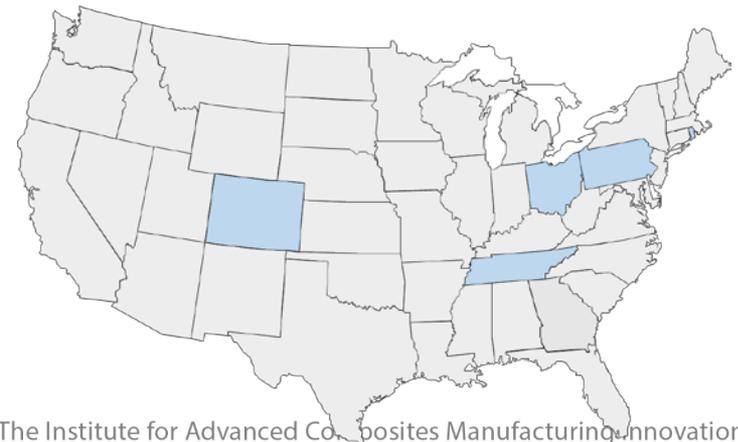
Optimized Carbon Fiber Production to Enable High Volume Manufacturing of Lightweight Automotive Components

- **Challenge:** Carbon fiber consistency and production rate, intermediate production & mechanical performance, molding cycle times, recycle of in-plant scrap
- **Approach:** OEM-Material Supplier-Tier 1 joint development of supply chain to develop, integrate and application-optimize carbon fibers, resin, composite intermediates, molding methods, automation, modeling, and waste reduction
- **Impact:** *Deploy carbon composite components on multiple 100k+ units/yr vehicle platforms to enable early stage mass adoption of technology*
- **Ford, Dow, DowAksa, MSU, ORNL, Purdue, UKY, UT, Vanderbilt**
- Vehicles
- Project 3.2
- TRL/MRL Impact: from 4-5 to 7



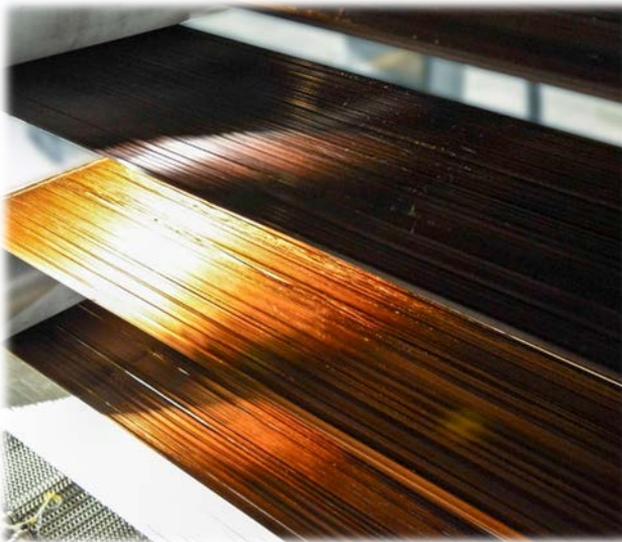
Thermoplastic Composite Development for Wind Turbine Blades

- **Challenge:** Carbon fiber composite reinforced polymers show promise for large scale wind turbine components, but challenges in manufacturing costs, performance, and recyclability limit their application.
- **Approach:** Development of thermoplastic materials to lower production costs and improve recyclability of wind turbine blades and demonstration of applicability to spar caps.
- **Impact:** Implementation of carbon fiber composite materials for wind turbine blades will enable larger scale and increased efficiency..
- **NREL, ORNL, Johns Manville, Colorado School of Mines, TPI, Arkema, Vanderbilt, University of Tennessee**
- Wind
- Project 4.2
- TRL/MRL Impact: from 3 to 4



IACMI Capabilities, Expansion and Facilities

Capabilities Expansion: Oak Ridge National Laboratory Carbon Fiber Licensing Opportunity

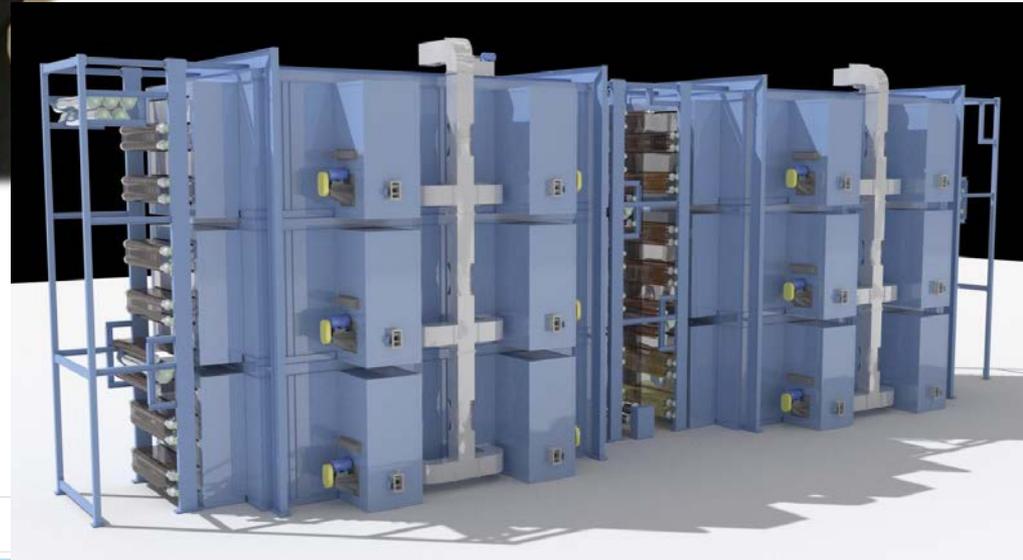


- IACMI partner, Oak Ridge National Laboratory, has demonstrated a production method estimated to reduce the cost of carbon fiber as much as 50% and the energy used in production by more than 60%
- IP Agreements
- Significant textile PAN benefits

Capabilities Expansion: Oak Ridge National Laboratory Carbon Fiber Licensing **Outcome**



- Exclusive invention license to Knoxville company, RMX Technologies
- New innovation has the potential to revolutionize the composites industry creating significant manufacturing impact



Capabilities Expansion: Facilities and Equipment

Equipment

- Michigan: Press (2, Schuler and Milacron) representing over \$2M investment
- Purdue: 250 Ton Vertical Press Resin Transfer Molding (RTM) Facility, 330-Ton Injection Molding Machine, Tape Layup Machine, all representing over \$2M investment

Facilities

- Indiana Manufacturing Institute
- Michigan Corktown Lightweighting Facility
- Colorado Wind Technology Expansion
- Tennessee plans



Tennessee



Michigan



Colorado



Indiana



IACMI Fibers and Composites Manufacturing Center at UTK

Capabilities added since August 2015

- 400 square feet of composites manufacturing
- 20 undergraduate (Freshman to Senior), 8 graduate (MS, PhD) students and 3 post docs engaged in IACMI R&D.
- Equipment:



IACMI/MDF Composites Center

- Seamless interaction of students and staff between UT and ORNL/IACMI ~ 30 students per semester
- Workforce development and training
- Summer internships
- Intermediate to large scale composite fabrication
- Discontinuous & continuous fiber processing
- Range of tools
- Plus.....**FUTURE EXPANSION**



Capabilities: Indiana Facilities



- Indiana Manufacturing Institute broke ground in June 2015 and had researchers working in the facility by June 2016.
- \$50M Composites facility
- Purdue equipment plans:
 - 250-Ton Vertical Press
 - Resin Transfer Molding (RTM) Facility
 - 330-Ton Injection Molding Machine
 - Tape Layup Machine
 - These represent more than \$2M total cost



Capabilities: Michigan Corktown Vehicle Scale Up Facility



- **Multi-material lightweighting facility with over \$40M invested**
- **Equipment capabilities:**
 - **Most recent acquisitions include two presses (Schuler and Milacron) representing over \$8M investment**
- **100,000 square feet for two complementary innovation institutes**

“Lightweighting is **critical to our future**... **We** want to own the 21st century in innovation and composites are a big part of that goal. That’s why we’re making a \$40 million investment in composites in the Composites Institute [IACMI] co-locating in a facility in Detroit,” said Vice President Joe Biden.

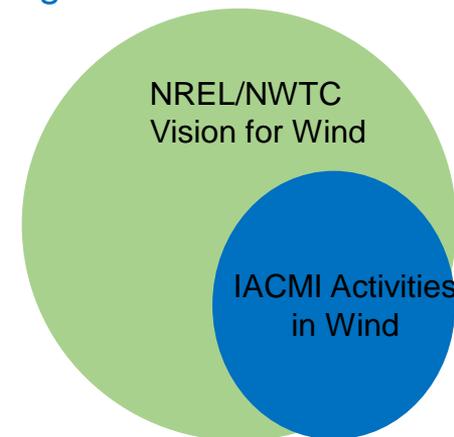
Colorado: IACMI Wind TA Facility Expansion

IACMI Focused Needs:

- Low cost carbon fiber
- New materials evaluation
- Reactive thermoplastic scale up
- Segmented 3D printed tooling
- Low cost, high quality spar cap manufacture
- Large area rapid NDE
 - In-situ measurement
 - Post molding inspection
- Performance Modeling and manufacturing Simulation
- Workforce development: Technician Training (CCT), Internships and Engineers



Existing Quonset hut on
NWTC grounds
55' wide, 200' long
18'-4" ceiling height
Adjacent to blade test
facility



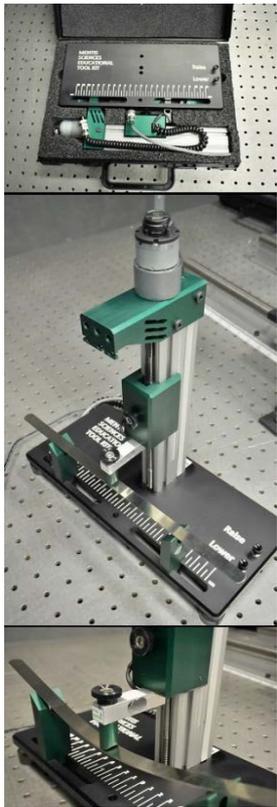
2016 IACMI Workforce Training Events



Online	Hands-On Demonstrations	Partnership Demonstrations	Internships
<ul style="list-style-type: none">• CCT (Composite Certification Tech) course in collaboration with ACMA (American Composites Manufacturers Association)• Encyclopedia of Resources	<ul style="list-style-type: none">• In collaboration with Composites One, four hands-on demonstrations in four different states will train approximately 500-600 manufacturing employees this year	<ul style="list-style-type: none">• In collaboration with IACMI partners, The University of Tennessee and Oak Ridge National Laboratory, over 200 students have been introduced to composites materials during STEM demonstrations and training	<ul style="list-style-type: none">• 15 IACMI internships, 5 different locations• EERE STEM Internships, 45 fully funded student opportunities in the 2016

Workforce Training

IACMI-led STEM Education for Younger Students



**SILVIA
MENDE**

First Robotics Mentor
Roane County
Optometrist

April 25, 2016



"Dear Dr. Blue:
Thank you and your team for hosting the Composites Workshop this week. I brought three students from Roane County and we had a wonderful time learning about composites. The presentation from Dr. Vaidya was interesting and the University of Tennessee students had great demonstrations set up for the attendees. The best part was our high school students talking to the UT engineering students- all of whom were fun, articulate and encouraging. It was wonderful.

I'd especially like to thank the UT students: Brandon, Adam and of course, Jimmy- the Ping Pong Cannon expert, for their extensive effort in getting to know the high school students. You all made an impact on their career choices."

Workforce Training

IACMI-led STEM Education for Younger Students



Workforce Activities: IACMI Internship Program

- Administered by ORAU
- 15 graduate or undergrad interns at IACMI technology areas
 - 4 in Michigan
 - 4 in Indiana
 - 4 in Tennessee
 - 2 in Colorado
 - 1 in Ohio
- Interns selected and managed by IACMI TA Directors
- Interns will attend and present at July IACMI Members Meeting
- Estimated cost: \$165,000



July 2016: IACMI Members Meeting in Indiana

- 300 attendees expected:
 - From at least 20 states
 - Entry level to experienced professional
 - Representing government, academia and small, medium and large industry organizations
 - Collaboration opportunities
- Indiana Manufacturing Institute ribbon cutting ceremony
 - \$50M Composites Facility at Purdue University)
- Short term regional economic impact estimate is over \$150k

