Outline

• National Network for Manufacturing Innovation
• IACMI-The Composites Institute
  – High Level Goals
  – Technical Focus
  – Technology Areas and Geographic Extensions
  – Integrated Model
• Partnerships
  – DOE
  – States
  – Members
• Projects Driven by Industry, Roadmap, and Quantitative Goals
Existing Institutes in the Network

- **Department of Energy (DOE)**
- **Department of Defense (DOD)**
- **National Institute of Standards and Technology (NIST)**
Bridging the Gap to Manufacturing

AMO: Advanced Manufacturing Office

R&D Investment Level vs. Technology Maturity (TRL; MRL; etc.)

- DOE Energy Innovation Hubs
- NSF Engineering Research Centers
- NSF IUCR Centers
- SBIR/STTR
- NIST Manufacturing Extension Partnership

- AMO
  - R&D Projects
  - R&D Facilities
  - Technical Assistance

Concept → Proof of Concept → Lab scale development → Demonstration and scale-up → Product Commercialization

The Institute for Advanced Composites Manufacturing Innovation
January 9, 2015: President Obama Announces New Composite Institute

“...and today, we’re proud to announce our latest manufacturing hub, and it is right here in Tennessee. Led by the University of Tennessee–Knoxville, the hub will be home to 122 public and private partners who are teaming up to develop materials that are lighter and stronger than steel.”
Technical Focus on Advanced Composites and Structures

Application Areas
- Vehicles
- Compressed Gas Storage
- Wind

Focus Areas
- Energy
- Speed
- Recycling

Enabling Technology Areas
- Design
- Simulation
- Joining
- Nondestructive Evaluation
- Materials

Shared RD&D Facilities

- Wind Turbines
  - Colorado
- Compressed Gas Storage
  - Ohio
- Technology Areas
- Design, Modeling & Simulation
  - Indiana
- Composite Materials & Process
  - Tennessee

The Institute for Advanced Composites Manufacturing Innovation
IACMI – A National Institute for Advanced Composites

>70% of automotive production occurs in IACMI core states

>70% of US auto R&D in Michigan alone
An Integrated Approach to meet our Goals and Metrics

- Low-cost fiber
- Fast processing resins
- User-friendly forms

Materials

- Rapid composite conversion processes
- NDE/repair
- Recycling
- Joining

Manufacturing (Vehicles, Wind, CGS)

- Cost-efficient part design
- Manufacturing simulation
- Materials database

Design and Simulation

Technology Readiness
Key IACMI Capabilities

- 300,000 ft² of space
- $200,000,000 in replacement value investment

Materials
- Production
- Intermediates
- Processing
- Composites
- Manufacturing
- (Sub) System Assembly

Composites Recycling

Product Forms
- Commercial PAN-CF
- Low Cost PAN-CF
- Low Cost PC-CF
- Low Cost Pitch-CF
- Low Cost Lignin-CF
- Biomass PAN-CF
- Glass Fiber
- Thermoset Resins
- Thermoplastic Resins
- Additives

Process Technologies
- Crosscutting Technologies and Shared Services
  - Commercial PAN-CF
  - Low Cost PAN-CF
  - Low Cost PO-CF
  - Low Cost Pitch-CF
  - Low Cost Lignin-CF
  - Biomass PAN-CF
  - Glass Fiber
  - Thermoset Resins
  - Thermoplastic Resins
  - Additives

- Woven Fabric
- Non-woven Fabric
- Braids
- Prepregs
- Towpregs
- Molding Compounds
- Tapes
- Pultruded Forms (rods, beams)
- 3D Parts/Preforms
- Sheet Products
- Pressure Vessels
- Pipes
- Shafts
- Rolls
- Tubes
- Automotive Assemblies
- Bodies, Chassis, Interiors
- Gas Storage Systems
- CNG
- Hydrogen
- Wind Turbines
- Spars (Caps, Shear Webs)
- Blade Skins
- Blades

- Offal/Trim Scrap
- Chopped Fiber
- Roll Goods
- Preforms

- Fiber Spinning
- Solution Spinning
- Melt Spinning
- Gel Spinning
- Electro Spinning

- Fiber Conversion
- Thermal Plasma
- Microwave
- Ultraviolet

- Fabric Weaving
- Fiber Braiding
- Prepregging
- Compounding
- SMC
- BMC
- Extrusion
- Stitching

- Auto Tape Placement
- Preforming
- Thermoforming
- Compression Molding
- Injection Molding
- Transfer Molding
- HP-RTM
- VA-RTM
- Other Variants
- Additive Manufacturing
- Filament Winding
- Pultrusion
- Infusion/Compression
- Resin spraying

- Infusion/Cure/Set
- Cooling (TP systems)
- Thermal Plasma
- Microwave
- Ultraviolet
- Induction
- Infrared
- Magnetic Field
- Electron Beam

- Pyrolysis
- Solvolysis

- Modeling & Simulation
- Supercomputing
- Process modeling
- Microstructure properties
- Probabilistic failure analysis
- Rheokinetics modeling
- Crash modeling

- NDE/NDI
- Thermography
- Spectroscopy
- Fluorescence
- Attenuation/Reflection
- High resolution microscopy
- Scanning lasers

- Materials Characterization
- Microscopy
- X-rays
- Neutrons
- Mechanical
- Physical
- Thermal
- Chemical

- Joining
- Adhesives
- (Reversible, Curie Limited Curing)
- Mechanical fastening
- (For Multi-Material Systems)

- Innovative Design Concepts
- Composite Tube Super-lightweight auto. body structure
- Composite vehicle snap fit joints
- Conformable auto CGS tanks
- Segmented adhesive-bonded wind blades
Scale-up Across IACMI Core Partners

Solution spinning line

Carbon Fiber Technology Facility

Pre-preg production pilot/full scale

Pilot-scale PCM
750 ton press

Full Scale PCM
4,000 ton press

The Institute for Advanced Composites Manufacturing Innovation
Materials and Process

- Materials and Process Technology Area
- Multiple sites: ORNL, University of Tennessee, University of Kentucky, Vanderbilt University
Highlight - textile based CF

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%.

ORNL is currently negotiating with potential licensees.

IACMI will leverage this accomplishment into future projects utilizing M&P capabilities.
IACMI Pultrusion Machine

Strongwell PULSTAR 2408R

Overall Machine Footprint 48 ft (14.6m) X 52 in. (132 cm)
Profile Envelope 24 in. x 8 in. (610 mm x 203 mm)
Pull Force (Tandem) 32,000 lb (14,515 kg)
Pull Force (Continuous) 16,000 lb (7,257 kg)
Clamp Force 24,000 lb (10,886 kg)
Speed Range 1-120 in./min (2-305 cm/min)

Will be deployed and operational in M&P Technology Area in 2016
Big Area Additive Manufacturing

Recent enhancements in physical scale, speed of production, and work in high temperature polymer composites, e.g. PPS/CF
Modeling and Simulation

- Innovative Design, Modeling and Predictive Simulation Technology Area
- Indiana Manufacturing Institute located at Purdue University
Simulation Software Partners

Integration of many major commercial simulation tools

- PAM-FORM
- PAM-RTM
- PAM-DISTORT
- PAM-CRASH
- CATIA
- ABAQUS
- ACCELERYS
- ENOVIA
- DELMIA
- HyperWorks
- MDS
- SwiftComp
- VABS
- COMPRO
- RAVEN
Model Composites Manufacturing Process – High Pressure RTM

1. Preform Stacking
   - CATIA

2. Preform Shaping
   - CATIA

3. Preform Assembly: Fiber Orientation
   - CATIA DIGIMAT

4. Consolidation/Compaction in Mold
   - CATIA COMPRO

5. Heat Transfer and Exotherm in the Press
   - COMPRO

6. Effective Anisotropic Heat Transfer Properties
   - DIGIMAT

7. Resin Infusion
   - PAM-FORM

8. Consolidated Preform Assembly: Fiber Orientation
   - COMPAC/DIGIMAT

9. Cure Kinetics in the Mold
   - RAVEN

10. Effective Mechanical Properties
    - DIGIMAT

11. Residual Stress State
    - COMPRO

12. Post-mold Deformation
    - MARC ABAQUS
Vehicles

- Vehicles Technology Area
- Michigan State University
  - East Lansing
  - Detroit ("Corktown")
Corktown Facility – First Floor Offices

Executive Conference Room

Modular Office Space
Corktown Facility – Collaboration & Training

Open Collaboration

Conference Rooms
Facility Refurb and Construction Begins August 8, 2016

Shared Joining and Pretreatment Area

Carbon Fiber Containment Area
Pre-Preg, Lay-up Etc.

Sample Prep Wet Lab and Analysis Area

4000 T Schuler Comp. Press
Installed 2Q 2017

3000 T Milacron Inj Press
Installed 4Q 2016
Prepreg machine acquired

• Acquired from TenCate
• Produced commercial product through Dec 2015
• Specifications
  – 0.5m (20in) width
  – 120 - 600gsm
  – 2m/min
• Operation status expected late Q4 2016
Injection molding press

• Ordered from Milacron

• Specifications
  – 29,500kN (3,315T)
  – Platen: 3m x 2.5m (~10ft x 8ft)
  – 413 oz. max shot size (multiple screw sizes)

• Operation status expected November 2016

Photo Source: Milacron
Compression press

- Ordered from Schuler
- Short-stroke design
- Multi-process capable
  - “Closed mold” infusion
  - Compression molding
  - Thermoplastic forming, etc.
- Specifications
  - 36,000kN (4,000T)
  - Platen: 3.6m x 2.4m (~12ft x 8ft)
- Installation begins November 2016
- Operation status expected March 2017
HP-RTM/Liquid Compression Molding

- Request for proposals in Q3 2016
- HP-RTM for “closed mold” infusion
- Liquid Compression with flat preforms (Wet Compression)
- Operation status to coincide with compression press in March 2017

Photos Source: KraussMaffei Technologies GmbH
IACMI has 140 Members and Growing

- SMEs: 45%
- Industry Large: 32%
- Academic: 12%
- Industry Assoc.: 4%
- Economic Development: 1%
- States: 4%
- National Labs: 2%
- Economic Development: 1%
## How to Engage: Membership

<table>
<thead>
<tr>
<th>Charter</th>
<th>Premium</th>
<th>Resource</th>
<th>Consortium</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INVESTMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$5 million over 5 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least 50% in cash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$100k cash annually toward IACMI overhead expenses</td>
<td>$1 million over 5 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At Least 50% in cash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$20k annually toward IACMI overhead expenses</td>
<td>Provides resources of interest to our members for use in multiple projects. (e.g. equipment, materials, or software) as cost share</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash contribution eligible for match subject to available funds</td>
<td>Cash contribution eligible for match subject to available funds</td>
<td>Exposure to potential customers</td>
<td></td>
</tr>
<tr>
<td>Leverage significant intellectual and resources capabilities</td>
<td>Participate in governance</td>
<td>Participate in projects to improve their products</td>
<td></td>
</tr>
<tr>
<td>Influence in creation and direction of IACMI</td>
<td>Elect one rep for the Board</td>
<td>Opportunities to engage</td>
<td></td>
</tr>
<tr>
<td>Participation in governance</td>
<td>Elect one rep for the Technical Advisory Board</td>
<td>Opportunities to build key relationships</td>
<td></td>
</tr>
<tr>
<td>All Charters have a Seat on the Board</td>
<td>Leverage significant intellectual and resources capabilities</td>
<td>Opportunities to participate in governance</td>
<td></td>
</tr>
<tr>
<td>Elect one rep for the Technical Advisory Board</td>
<td>Enterprise-wide proprietary projects</td>
<td>• Elect one SME rep for the Board</td>
<td></td>
</tr>
<tr>
<td>Rapid access to shared RD&amp;D facilities</td>
<td>Resource Provides resources of interest to our</td>
<td>• Elect one SME and one Large Co rep for the Technical Advisory Board</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>BENEFIT</em></td>
<td>Opportunities to fuel your company’s growth within the composites ecosystem.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Building on Strong Partnerships

Industry, Academia and Government Stakeholders

A partnership of world-class companies including:

- Volkswagen
- Ford
- BASF
- Dassault Systèmes
- DuPont
- DowAksa
- Lockheed Martin
- General Electric
- Dow

A partnership of outstanding small and medium sized organizations including:

- Techmer ES
- CARBON CONVERSIONS
- TRIDesign
- MVP
- Magnum Venus Products
- Local Motors

Top universities including:

- The University of Tennessee
- UT Research Foundation
- Michigan State University
- Vanderbilt University
- Mines
- UDRI
- University of Dayton Research Institute
- Purdue University

The Institute for Advanced Composites Manufacturing Innovation
RD&D Projects are focused on Industries’ Problems that align with our Metrics/Goals and Technical Roadmap.
IACMI is a Goal-Focused Institute

Five Year Technical Goals

• 25% lower carbon fiber–reinforced polymer (CFRP) cost
• 50% reduction in CFRP embodied energy
• 80% composite recyclability into useful products

Impact Goals

• Enhanced energy productivity
• Reduced life cycle energy consumption
• Increased domestic production capacity
• Job growth and economic development
**RD&D is Driven by the Technology Roadmap**

**Goals**
- Integrate the views & 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

The Institute for Advanced Composites Manufacturing Innovation
Roadmap Alignment

**Example – Vehicles**

- **BP2**
  - 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
  - Develop low scrap automated composite preforms and tape fabrication technologies to match molding times
  - Demonstrate low cost carbon fibers in auto parts (e.g., via injection molding)
  - Implement low cost tooling (e.g., via additive manufacturing) for molding of automotive parts
  - Advance high speed, high strength joining and repair for dissimilar materials

- **BP3**
  - Milestone: TP/Prepreg stamping and HP RTM 5 min cycle time
  - Milestone: Low waste tape layup & composite preforming
  - Milestone: IOM: 2 minute process cycle times
  - Milestone: Demonstrate low cost AM tooling for low pressure molding of automotive parts
  - Milestone: Demonstrate dissimilar joining and repair techniques at lab scale

- **BP4**
  - Milestone: TS Prepreg stamping & HP-RTM 3 min process cycle time
  - Milestone: Standardized recycling strategies
  - Milestone: IOM: 90 second process cycle times
  - Milestone: Demonstrate low cost AM tooling for high pressure molding of auto parts
  - Milestone: NDE for bonded or repaired joints validation

- **BP5**
  - Milestone: Demonstrate dissimilar joining and repair techniques at industrially relevant scale and size
RD&D Projects
- Industry, Goal, and Roadmap Driven

The RFP page is one of the most visited pages on the IACMI website.

11 projects underway or in contract with many more in the pipeline

Project Document Downloads:

- RFP
- IACMI RFP V2.0
- Frequently Asked Questions

- Foreign Entity Participation Guide
- Co-Funding Model and Cost Share Examples
- White Paper Short Form Template
- White Paper Long Form Template
- Budget Forms
- TRL Guidelines
- MRL Guidelines
- Full Proposal Template
- TAD Qualification Statement
## Project Types

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Project Budget</th>
<th>Cost Share</th>
<th>Duration</th>
<th>Other Requirements</th>
<th>Intent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enterprise</strong></td>
<td>&gt;$600K</td>
<td>Minimum 1:1 with 50% being cash</td>
<td>Up to 5</td>
<td>• A small number of value-chain members can jointly submit</td>
<td>Bigger projects with multiple partners that significantly contributes to achieving IACMI goals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>years</td>
<td>• Must involve team collaboration &amp; potential large economic and commercial impact</td>
<td></td>
</tr>
<tr>
<td><strong>Technical Collaborations</strong></td>
<td>$20K—$600K</td>
<td>Minimum 1:1 (large entities: 50% being cash)</td>
<td>Up to 2</td>
<td>• Phase 1 is &lt;6 months and $150 K total costs</td>
<td>Smaller investigatory efforts that can be started up quickly.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>years</td>
<td>• Optional Phase 2 is &lt;18 months and $450 K total costs</td>
<td></td>
</tr>
</tbody>
</table>
Economic Development Council
A Platform for State Economic Collaboration

Collaboration of state development leaders seeding economies worth $2 trillion

Each state deploys hundreds of millions of dollars annually to create jobs and investment through:

- Business services/incentives
- Venture funds
- Workforce training
- Innovation incubation

The Institute for Advanced Composites Manufacturing Innovation
Workforce Development

TARGET:
Established workforce  Mid-career/Students  Students
Internships
- **15 IACMI internships**, in 5 states
- EERE STEM Internships, **45 fully funded student opportunities** in 2016

Hands-On Demonstrations
- 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

Partner Training Events
- In partnership with Composites One, four hands-on demonstrations in four different states. On target to train approximately **500-600 manufacturing employees** this year

Online
- **Free CCT (Composite Certification Tech) Test Prep Course pilot** in collaboration with ACMA (American Composites Manufacturers Association)
- Encyclopedia of Resources
IACMI-led STEM Education for Middle and High School Students

Dr. Uday Vaidya conducts the materials demonstration.
Members Meeting January 2016 in Michigan

- 300 attendees
- Engagement from several elected officials, including Michigan Governor Snyder
- Henry Ford Museum Reception
- Networking
- Members attended adjacent Auto Show event, courtesy of MEDC.
Members Meeting July 2016 in Indiana

300 attendees

- $50M IMI Ribbon-Cutting
- IEDC President, Victor Smith
- Reception at Dallara
- Indiana Motor Speedway
- Networking
- Project Reviews, Roadmapping and Data/Results
Summary

• Advanced Composites Focus
• Leveraged and New Capabilities and Expertise
• Strong Public Private Partnership
• Industry, Roadmap and Goal Driven RD&D
Success means IACMI becomes the Industry’s Institute
Thank You & Questions