Institute for Advanced Composite Manufacturing Innovation

Contract No. DE-EE0006926
Project Team: Collaborative Composite Solutions Corporation
Project Period: June 2015 = May 2020

Bryan G. Dods
CEO, Collaborative Composite Solutions Corporation

U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
June 13-14, 2017

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Program Objective

- The technical topic area for IACMI is low cost, energy efficient manufacturing of fiber reinforced polymer composites.
- The Composite Institute targets continuous or discontinuous, primarily carbon and glass fiber systems, with thermoset or thermoplastic resin materials.
- These types of composites are foundational technologies that are broadly applicable and pervasive in multiple industries and markets with potentially transformational technical and economic impact.

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Overview

TIMELINE & BUDGET

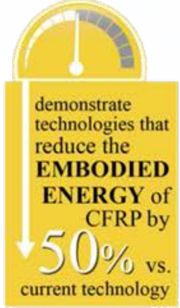
START
June 2015

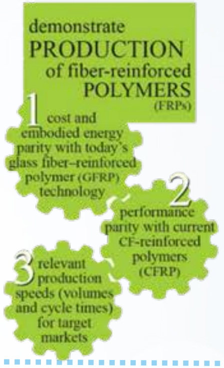
END
May 2020

Total Budget: **$175M**

- Total cost share: **$105M**
- Total federal share: **$70M**
- Total DOE funds spent: **$19M**

TECHNICAL PROJECT GOALS





TECHNICAL AREAS

WIND ENERGY
Derek Berry, NREL

VEHICLES
Lawrence Drzal, MSU

COMPRESSED GAS STORAGE
Brian Rice, UDRI

CROSS-CUTTING AREAS

MATERIALS & PROCESSING
Cliff Eberle, ORNL

MODELING & SIMULATION
Byron Pipes, Purdue University

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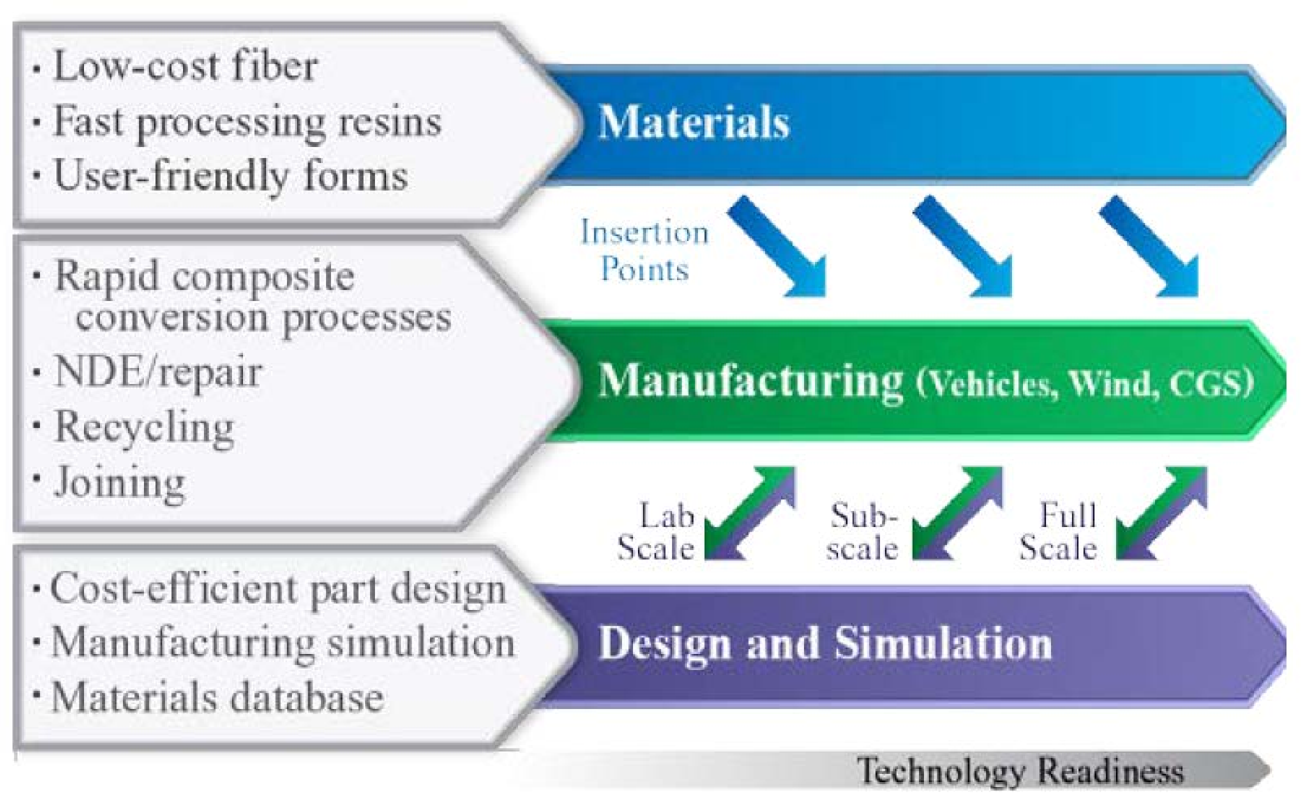
Technology Innovation



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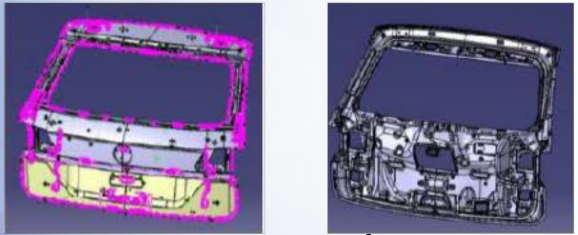
Technology Innovation

Low Cost Carbon Fiber / Recycled Fiber

Dry Fabric, Prepreg, Chopped Fiber, Tow, SMC, Pultrusion,



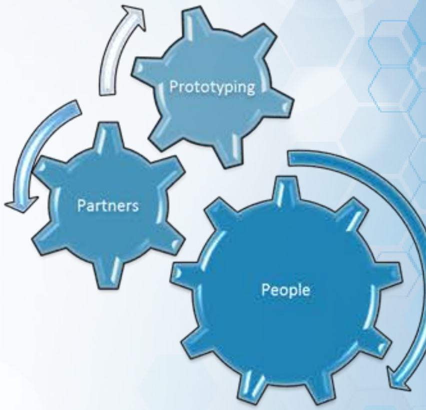
New Designs – 50% faster, 90% part count reduction

Integrated modeling & simulation suite running on high performance computing platform

Automation and Material System with < 3 minute cycle times

Technical Approach

Create Industrial Innovation Collaboration Centers proximity of manufacturing hubs



Application Areas

Vehicles • Compressed Gas Storage • Wind

Focus Areas

Energy • Speed • Recycling

Enabling Technology Areas

Design • Simulation • Joining
Nondestructive Evaluation • Materials

Shared spaces catalyzing ideas, expediting R&D

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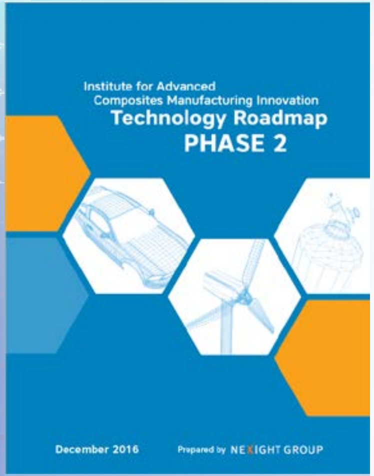
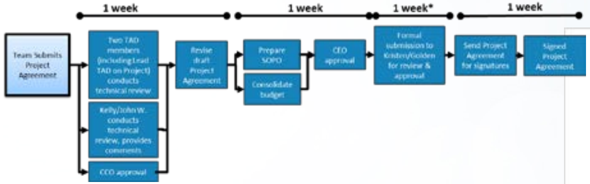
Technical Approach

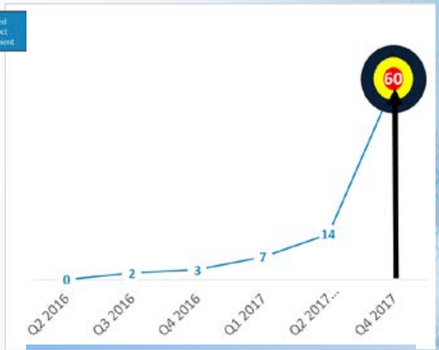


Industry Roadmap Published

Move to more proactive project development



Targeting a 4 week project launch cycle



Project pipeline: 60 – 100 projects

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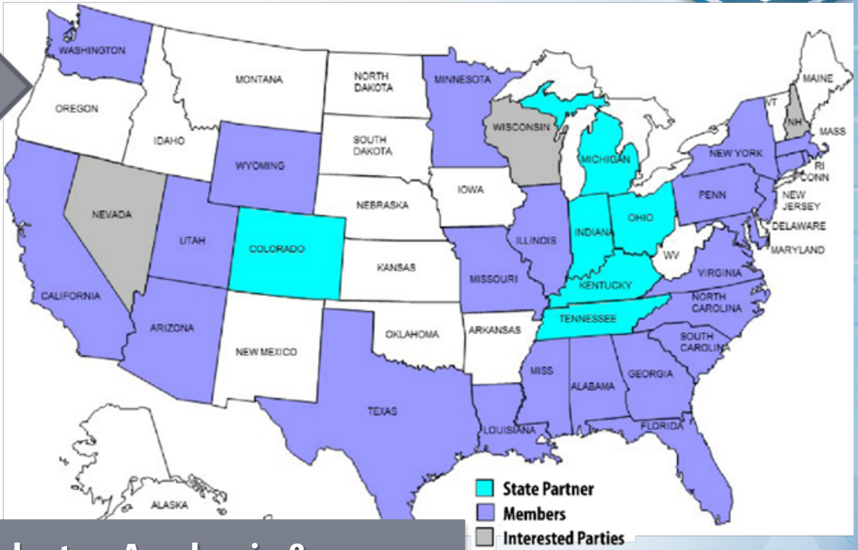
Transition: Membership

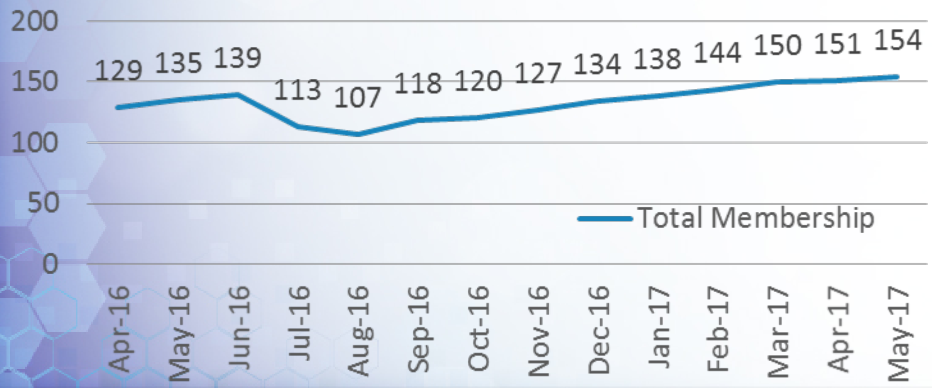
154 Members

9 Charter
13 Premium
8 Resource
122 Consortium
1 associate
1 community college

Representing 34 States

Note: This information includes members in good standing (dues paid). There are approximately 6 additional members in progress.





Industry, Academia & Government Stakeholders

Academia: 13
Association: 6
Government: 9
Large Enterprises: 48
Small to Medium-Sized Enterprises: 81

*Updated 5/24/17

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Transition (beyond DOE assistance)

- Technology exit ramps:
  - 150+ Members provide tech transition pathways across the entire composite supply network
  - Manufacturing Extension Partnerships have local SME relationships
  - Economic Development Agencies leverage IACMI for CAPEX and workforce
  - Manufacturing USA institutes expand member network and provide integrated solutions
- Sustainability:
  - Proposals for other federal funding opportunities
  - Private equity, M&A, and venture capital firms
  - Engagement with other states and industries
- Strategic partnerships with American Composite Manufacturing Association, American Chemistry Council, Composites World, American Wind Energy Association

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Measure of Success

Table II.1: Goals, Objectives and Outcomes

FOA Goal/Objective	IACMI 5-year Outcomes	IACMI 10-year Outcomes
Overall Goals		
2X energy productivity of FRP composite manufacturing	Reduce CFRP mfg cost & energy demand by 25% & 50% (1.5X current energy productivity)	Reduce CFRP mfg cost & energy demand by 50% & 75% (2X current energy productivity)
Reduce life cycle energy use and associated GHG emissions	5M bbl petroleum displaced*	40 PJ less energy demand* 20M MT less GHG emissions* 40M bbl petroleum displaced*
Increase domestic production capacity	≥ $500M CAPEX* for new US CF & CFRP production capacity	≥ $3B CAPEX* for new US CF & CFRP production capacity
Increase domestic jobs	5 K new US FRP-related manufacturing jobs*	30 K new US FRP-related manufacturing jobs*
Quantitative Technical Objectives		
Reduce production cost of CF composites >25% in 5 yr on path to >50% in 10 yr	25% lower CF production cost 3 min molding cycle time for primary automotive structure 20% lower blade cycle time 2X higher CGS line throughput	50% lower CF production cost 1.5 min molding cycle time for primary automotive structure 33% lower blade cycle time 3X higher CGS line throughput
Demonstrate production of FRP composites with cost and performance of CFRP composites with cost and embodied energy parity to today's GFP in 5 yr	Produce multiple CFRP components with same or lower (modeled) full-scale production cost and embodied energy as the GFRP analogs	
Demonstrate technologies that reduce embodied energy and GHG emissions of CF by 50% on path to 75% reduction in 10 yr	Produce LCCF at > 10 kg/day with technologies modeled to full scale reduce CF embodied energy & GHG emission by ≥50%	Produce LCCF at > 10 kg/day with technologies modeled to full scale reduce CF embodied energy & GHG emission by ≥75%
Demonstrate technologies for >80% recyclability or reuse of FRP composites in 5 yr into path to >95% in 10 yr	Recover & reuse ≥ 80% of CF & CF intermediates scrap from vehicles center	Recover & reuse ≥ 95% of CF or intermediates scrap & rejected CFRP from vehicles center

*Cumulative

	Manufacturing Process	Non-Recurring	Recurring				Total Cost	Scale, Units	Unit Cost $/kg composite
		Capital	Material	Labor	Energy	Other			
Wind	Vacuum Assisted Resin Transfer Molding[a]	$31K	$121K	$33K	$1K	$4K	$190K	930	$15.58
Auto	HPRTM (Floorpan)	$20	$227	$22	$4	$71	$344	100K	$53.84
	Injection Overmolding (Door Inner) – Carbon Fiber	$11	$65	$10	$0.2	$22	$108	100K	$55.59
	Injection Overmolding (Door Inner) -- Glass Fiber	$11	$22	$10	$0.2	$14	$57	100K	$25.45
	Compression Molding (Hood Inner)	$12	$74	$25	$2	$35	$148	100K	$85.96
Pressure Vessel[b]	Filament Wound, H2 Fil. Wound, CNG (64L) Fil. Wound, CNG (538L)	$99 $26 $110	$2293 $379 $3163	$72 $46 $180	$6 $2 $5	$1210 $615 $1052	$3680 $1068 $4510	130K 500K 100K	$27.42 $27.79 $25.43

	Manufacturing Process	Fiber Volume Fraction	Embodied Energy Intensity (MJ/kg)				
			Fiber	Int. Fiber Form	Resin	Molding and Curing	Total
Wind[c]	Vacuum Assisted Resin Transfer Molding[11]	74%	118[g] [1,2]	5[3]	4[10]	4[12]	131
Auto	HPRTM (Floorpan)	50%	1130[1]	34[3]	46[10]	63[14]	1273
	Injection Overmolding (Door Inner)[d] – Carbon Fiber	24%	538[1]	8[5]	52[9]	12[15,16]	610
	Injection Overmolding (Door Inner)[e] – Glass Fiber	23%	26[g] [1]	8[5]	48[9]	12[15,16]	94
	Compression Molding (Hood Inner)	50%	1183[1]	127[4]	70[10]	29[13]	1409
Pressure Vessel[f]	Filament Winding	68%	739[1]	NA	34[10]	4[11]	777

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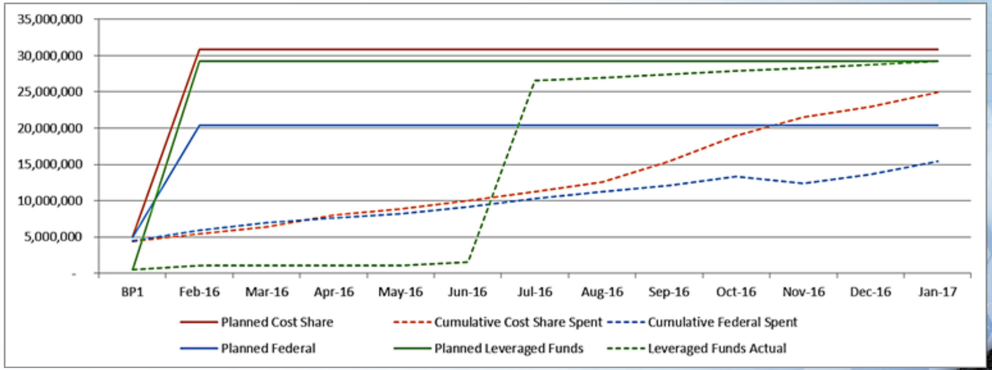
Project Management & Budget

IACMI BP3 Target Performance Metrics	Baseline	Stretch	Long Stretch
Prominently display IACMI brand in/throughout facilities	Yes		
Facility visitors	540	1300	2070
New Members	30	40	50
Project proposals in pipeline (lead)	60	80	100
Spend rate (000s) (industry/fed/state)	$65,216	$71,738	$75,324
Schedule performance	100% Go/No-Go Milestones	95% Milestone Completion Rate	98% Milestone Completion Rate
Resource provided as cost share (Equipment & materials. ex-software) (000s)	$5,000	$10,000	$15,000

Total Project Budget		
DOE Investment	$44,252,026 obligated	$57,302,793
Cost Share		$105,000,000
Project Total		$162,302,793



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Results & Accomplishments

Workforce 2017: 480+ Workshop Participants

Built2Last

Vanderbilt University
February 2017

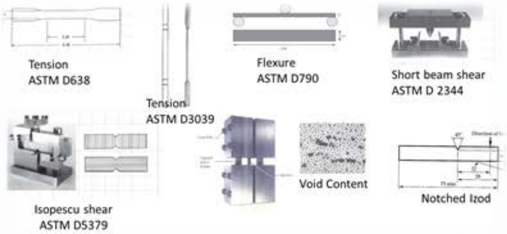
Composites in Wind

National Wind Technology Center
April 2017

Road2Composites

Michigan State University
May 2017

9m Wind Blade Tech Demo



Intermediate product form made from LCCF property testing

First recycled carbon fiber part made on a mold from 3D printed recycle carbon fiber

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