RAPID
Transforming Process Industries

Process Intensification Solutions for U.S. Manufacturing

May 3, 2017

RAPID
Transforming Process Industries

1. Manufacturing USA program
2. RAPID Manufacturing Institute
3. A Look Ahead

RAPID
Transforming Process Industries

1. Manufacturing USA program

Manufacturing USA Overview

Vision	U.S. Global leadership in Advanced Manufacturing
Mission	Connecting people, ideas, and technology to solve industry-relevant advanced manufacturing challenges, thereby enhancing industrial competitiveness and economic growth, and strengthening our national security.
Goals	1. Increase competitiveness 2. Facilitate technology transition 3. Accelerate the manufacturing workforce 4. Ensure stable and sustainable infrastructure

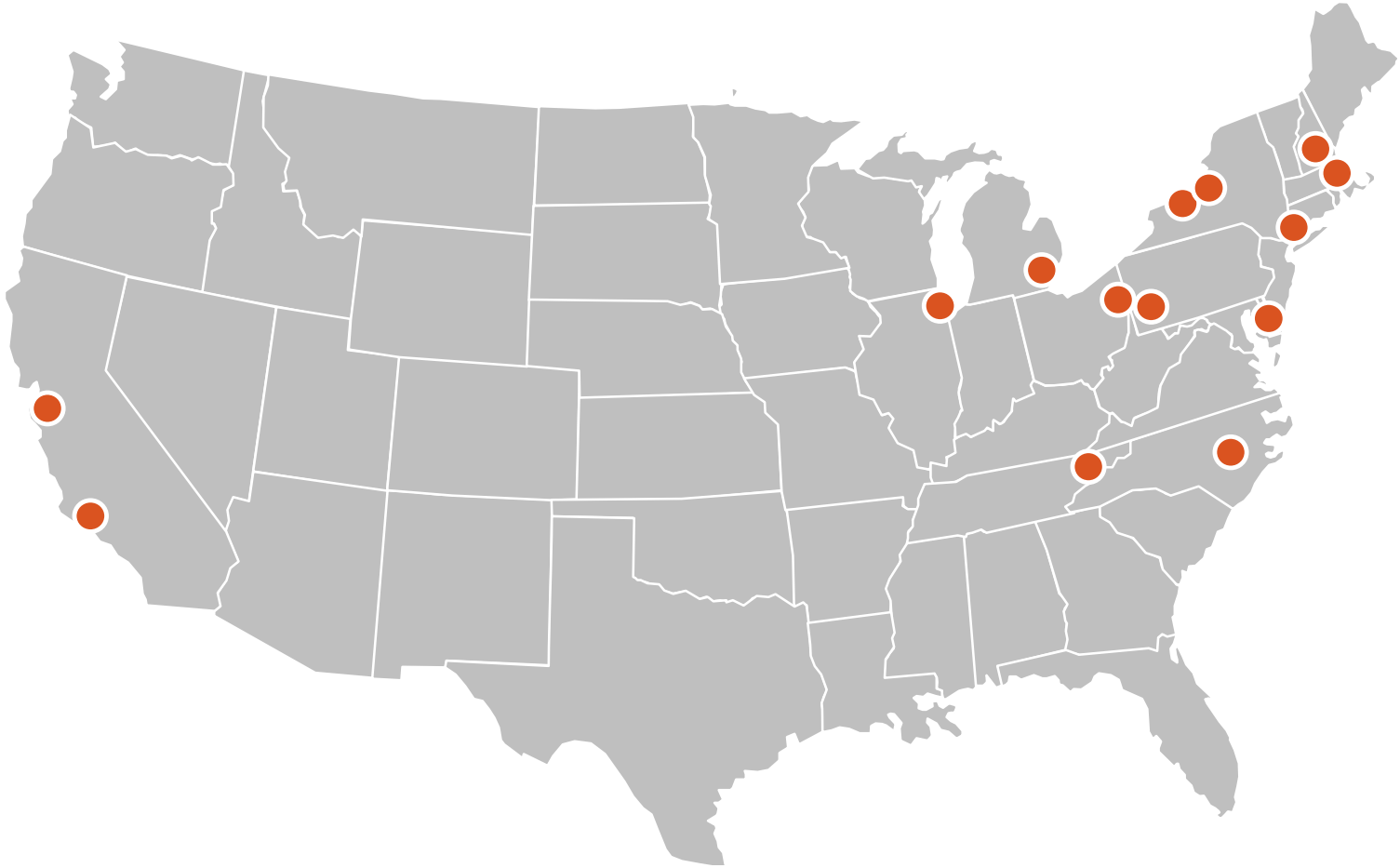
www.ManufacturingUSA.com

Manufacturing USA Overview

- 14 Institutes
- $1B federal funding // $2B matching funds
- 1300 members across these institutes … and growing
- Each institute has a unique mission with common goals:
  - Innovation in manufacturing
  - Workforce development
  - New business investment
- 1st institute piloted in 2012
- RAPID (Institute #10) announced Dec-2016

ManufacturingUSA

14 Manufacturing Institutes



Manufacturing USA
14 Institutes

Institute	Focus	Launch Date	Lead Organization	State
	Advanced Functional Fabrics	April-16	MIT	MA
	Advanced Robotics	Jan-17	Carnegie Mellon	PA
	Advanced Tissue Biofabrication	Dec-16	ARM Institute	NH
	Photonics	Jul-15	SUNY	NY
	Additive Manufacturing	Aug-12	NCDMM	OH
	Digital Manufacturing & Design	Feb-14	UI Labs	IL
	Composites	Dec-14	U. Tennessee	TN

Manufacturing USA
14 Institutes

Institute	Focus	Launch Date	Lead Organization	State
LIFT	Lightweighting	Dec-14	ALMMII	MI
NEXTFLEX America's Flexible Hybrid Electronics Manufacturing Institute	Flexible Hybrid Electronics	Aug-15	FlexTech Alliance	CA
NIMBL	Biopharmaceutical Manufacturing	Dec-16	U. Delaware	DE
PowerAmerica	Next Gen Power Electronics	Dec-14	NC State	NC
RAPID Transforming Process Industries	Process Intensification	Dec-16	AIChE	NY
REMADE INSTITUTE	Reuse, Recycle, and Remanufacture Materials	Jan-17	SMIA	NY
Clean Energy Smart Manufacturing Innovation Institute	Smart Manufacturing	Jun-16	SMLC	CA

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2. RAPID Manufacturing Institute

Rapid Advancement in Process Intensification Deployment (RAPID)

RAPID's Industry-Led Vision

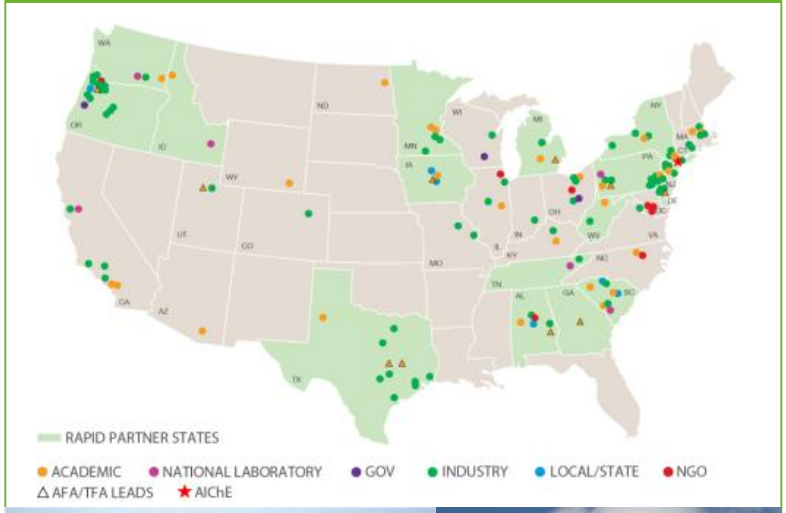
*A dynamic network of partners who collectively build a sustainable **ecosystem** that:*

… researches, develops and broadly commercializes new technology for modular chemical process intensification

… delivers dramatic reductions in energy, greenhouse gas, capital and operating cost

… makes U.S. Manufacturing and our workforce more competitive

RAPID's Ecosystem



Industry leaders, researchers, educators, engineers, operators and facilities

Our Mandate

- Lead a national effort to research, develop and demonstrate high-impact modular chemical process intensification solutions for U.S. Manufacturing.
- Actively build RAPID membership through an inclusive and attractive value proposition.
- Leverage $70 million of federal funding with cost share from members.
- Operate the Institute to benefit a wide range of stakeholders.
- Establish an infrastructure that enables access to process intensification resources, tools, expertise, and facilities.
- Bring together private and public entities to co-invest in R&D, commercialization, and deployment of innovative technologies.
- Establish a technical education and workforce development program.

"The goal for these Institutes is to revitalize American manufacturing and support domestic manufacturing competitiveness."

— U.S. DOE

Initial Partners

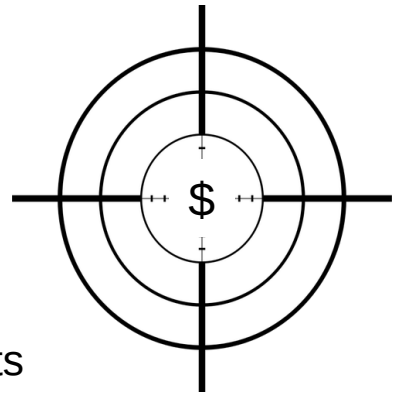
Industry … Academia … National Labs & Non-Profits

RAPID Transforming Process Industries

50 of our 75 companies are shown here

An “Industry-Centric” Institute

- Access to new process intensification technology and tools with the potential for:
  - Lower capital cost
  - Lower operating cost
  - Improved process efficiency
  - Improved energy efficiency
  - Reduced waste
  - Reduced environmental footprint

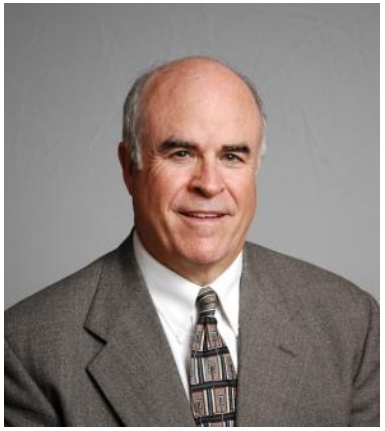


- Participation in roadmapping workshops with access to finished products
- Leveraged investment in R&D projects that directly address industry challenges
- Access to tools, models, and educational materials
- Networking and collaboration with academia, national labs, supply chain partners

6 Technical Focus Areas

Chemical & Commodity Processing

- Develop guidelines for integration of novel reaction and separation modules
- Validate design tools for process intensification

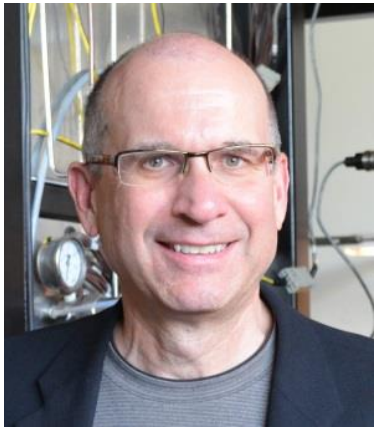


Thomas Edgar
Univ. of Texas

Ramanan Krishnamoorti
Univ. of Houston

Renewable Bioproducts

- Prototype and scale novel bio-conversion processes
- Improve energy & capital efficiency of existing and emerging processes



Robert Brown
Iowa State Univ.

Shri Ramaswamy
Univ. of Minnesota

6 Technical Focus Areas

Natural Gas Upgrading

- Maximize impact through transfer of technologies and learnings across industries
- Mature and demonstrate transformational and enabling technologies for gas utilization

Modeling & Simulation

- Develop methods & tools for design, optimization, and intensification across multiple length and time scales
- Establish methods for intensification of dynamic/periodic operations

Michael Matuszewski
Univ. of Pittsburgh

Levi Thompson
Univ. of Michigan

David Sholl
Georgia Tech

Stratos Pistikopoulos
Texas A&M

6 Technical Focus Areas

Intensified Process Fundamentals

- Advance inherently energy efficient separation processes & reaction platforms
- Develop fundamentals for multifunctional modules such as hybrid separation/reaction schemes

Dion G. Vlachos
Univ. of Delaware

James A. Ritter
Univ. of South Carolina

Module Manufacturing

- Standardize modules and components to drive demand and capital investment within the supply chain
- Lower the cost of PI equipment using advanced manufacturing technology

Brian Paul
Oregon State Uni

Ward TeGrotenhuis
Pacific Northwest Nat'l Lab

Facilities and Testbeds

- Leverage extensive, existing capabilities and capital already invested by our partners
- Key to our RD&D program are testbeds in the areas of module manufacturing, CPI for membranes and reactive distillation, and pulp & paper dewatering
- Access to >10 testbeds and 20 facilities

Representative Examples

Austin testbed
University of Texas - Austin

Modules undergoing tests at the
Modular Energy Production Systems Demonstration Facility
Easy Energy Systems—Emmetsburg, IA

Dow's Multipurpose Piloting Facility
Freeport, TX

Education & Workforce Development

- Education & WFD Committee
  - Reports to Technical Advisory Board
  - Committee Members
  - Process Intensification Workforce Development Roadmap (PIWDR)
  - Establish curricula for target audiences:
    - Professionals
    - Undergraduate and graduate students
    - Faculty
    - High school students
  - Start with survey to assess current state

What's Happening NOW?

1. Start-up the Institute
   - Governance
   - Membership drive
   - Website, communications, …

2. Roadmapping
   - One for each Focus Area
   - Strong participation by members, experts
   - Launch in May

3. "Jump Start" projects (4)

RAPID Value Proposition

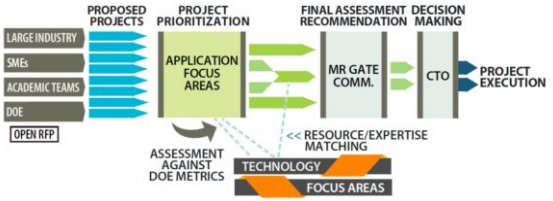
RAPID Transforming Process Industries

1. Roadmapping & Strategy with Partner input

2. Address the Barriers to PI Adoption

- Modeling/Simulation/ Optimization & Control for Existing PI Processes
- Material & Chemistry Intensification for Existing Processes
- Low Energy Separation for Existing Processes
- Module Manufacturing for PI and MCPI
- Modular Decentralized Scale-Out Processing

3. Disciplined / Gated Work Processes



4. Demonstration & Scale-up

5. Deliverables

- Technology
- Technology Solutions
- Standards/ Design Tools/ Design Specs Available
- Work Force Trained

Capital Investment/ Commercial Deployment

6. Progress toward long-term targets

IMPACT

- 800,000 Jobs Created
- 1100 TBtu Energy
- 82 MT CO_2
- 1900 Trained/Yr
- Design Tools
- >120 Industry Partners

7. Feedback, Guidance

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3. A Look Ahead

10 Years from now

RAPID Outcomes…

- Commercial Successes
- Module Supply Chain
- Project Pipeline
- Workforce Development

Indicators…

Member testimonials

PI-related capital spending

Module production

PI models, tools

RAPID project portfolio

PI conferences

Training tools

Job creation

RAPID Roadmapping Goals

- Demonstrate MCPI with >20% energy efficiency **Delivered**
- Develop tools to reduce the cost of deploying MCPI in existing processes by 50%
- Demonstrate 2x energy productivity by a combination of capital and operating cost related to improved feedstock and fuel efficiencies.
- Scale-out module manufacturing that reduce >20% cost/unit, with each doubling in module manufacturing production
- 10x reduced capacity cost, 20% improvement in energy efficiency and 20% lower waste relative to commercial state-of-the-art

DOE Performance Metrics

Delivered

- Energy Efficiency
- Energy Productivity improvement
- Intensification in Individual Process Modules
- Cost-Effective Manufacturing of Modules
- Cost Effective Deployment
- Enabling R&D Portfolio
- Industrial Partnerships
- Pathway to Self-Sustainment
- Train the Trainers
- Educate Students
- Annual Planning Process
- Industrial Roadmap
- Emerging Supply Chain
- Diversity of Firms and Individuals in the Eco-System

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To learn more about RAPID:

www.AICHE.org/RAPID

KareF@aiche.org