

The Critical Materials Institute

An Energy Innovation Hub

DE-AC02-07CH11358

11 Corporations, 7 Universities, 4 National Labs

Led by the Ames Laboratory

2013 - 2018

Dr. Chris Haase (Director), Prof. Rod Eggert (Deputy Director)

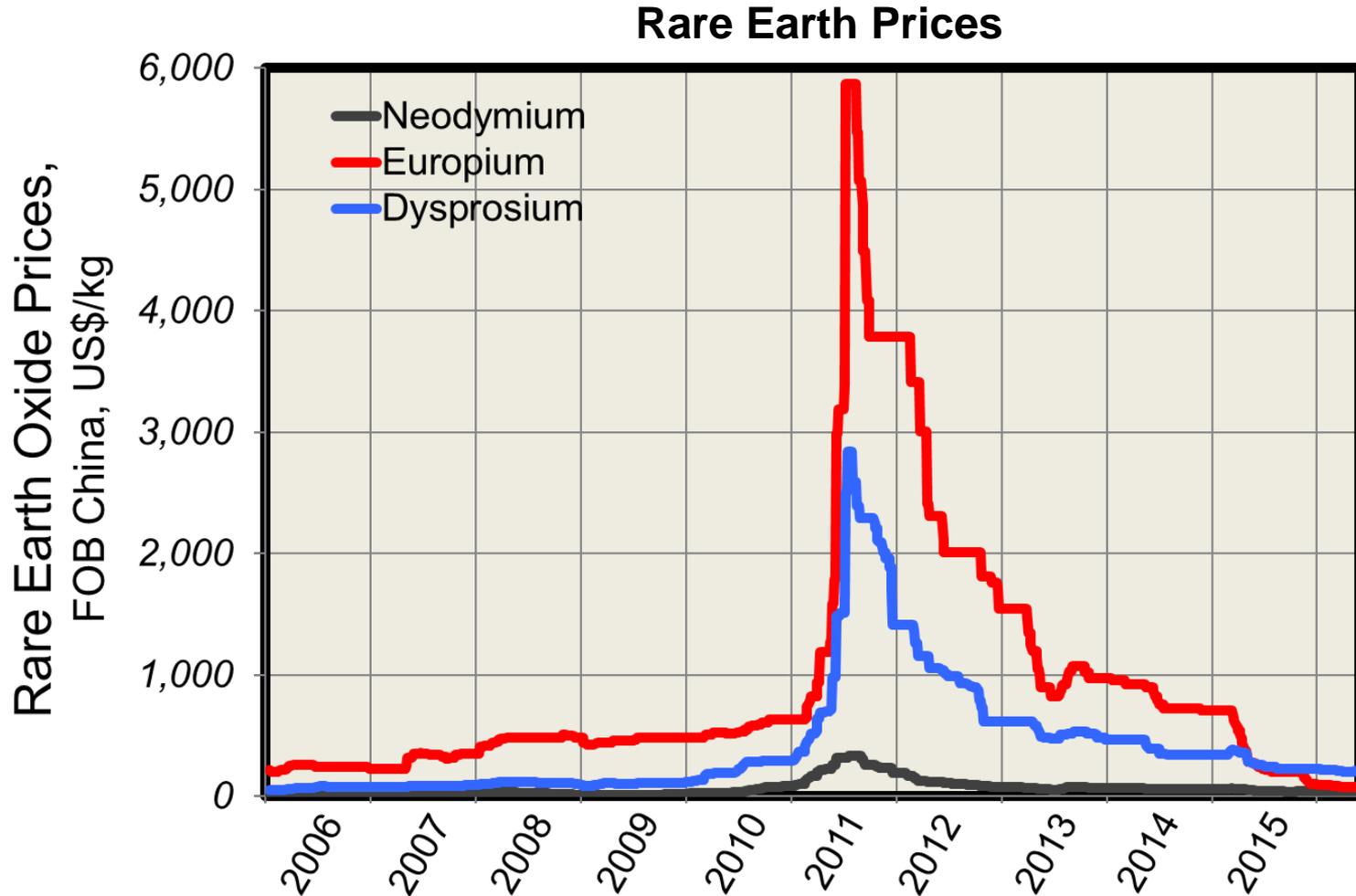
U.S. DOE Advanced Manufacturing Office Program Review Meeting

Washington, D.C.

July 17-19, 2018

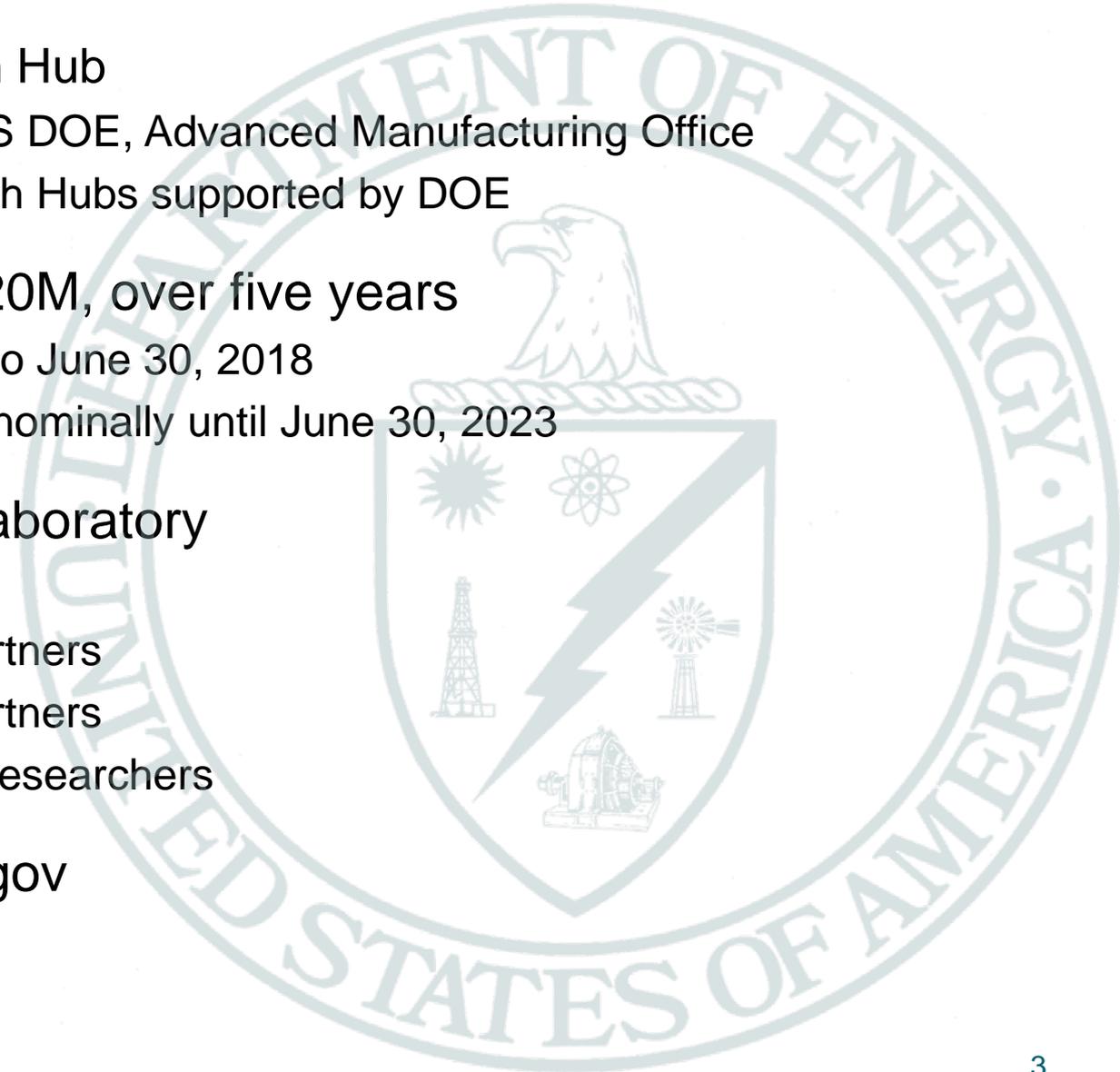
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Overview: History, Context and Objectives



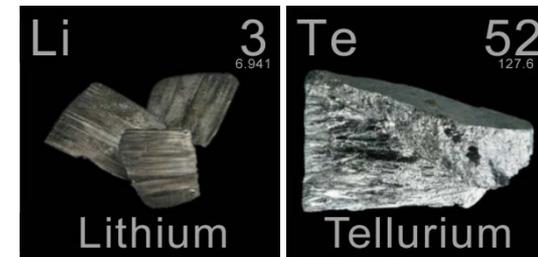
The Critical Materials Institute

- An Energy Innovation Hub
 - Supported by the US DOE, Advanced Manufacturing Office
 - One of only four such Hubs supported by DOE
- Initial budget of \$120M, over five years
 - From June 1, 2013 to June 30, 2018
 - Funding continues, nominally until June 30, 2023
- Led by the Ames Laboratory
 - Four national labs
 - Seven university partners
 - Eleven industrial partners
 - Approximately 350 researchers
- www.cmi.ameslab.gov



Mission of CMI

Eliminate materials criticality
as an impediment to the
commercialization
of clean energy
technologies
for today and tomorrow.

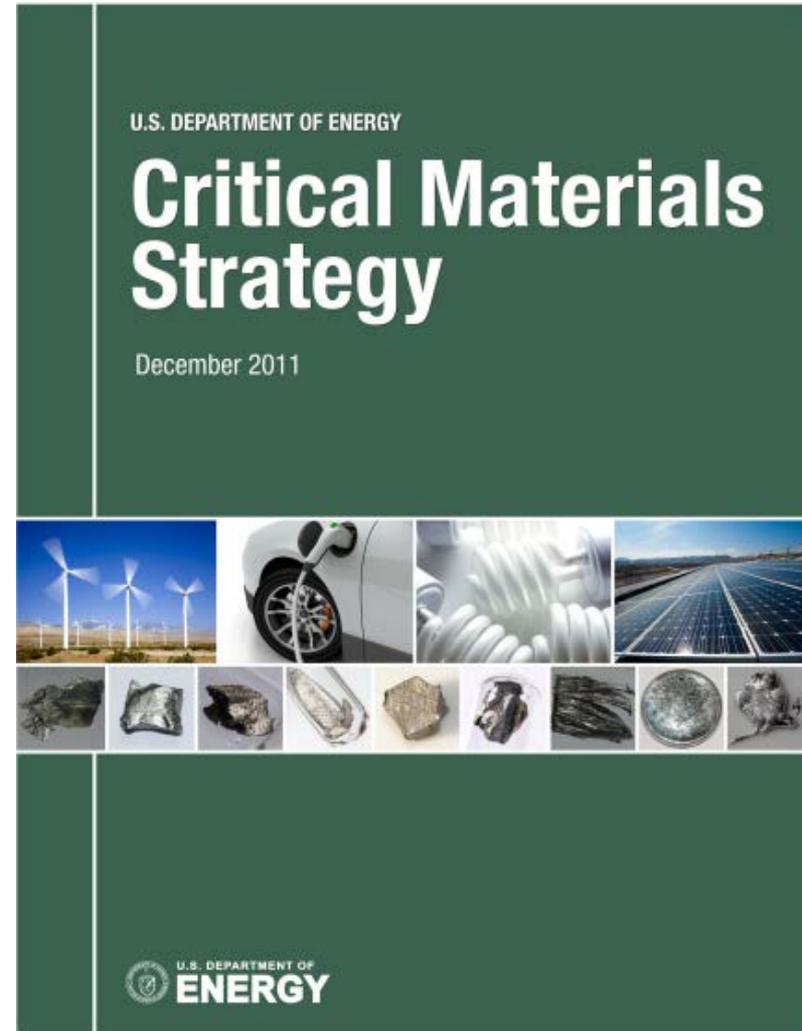


Strategy

Finding ways to:

- diversify our sources;
- provide alternatives to the existing materials;
- make better use of the existing supplies through efficient manufacturing, recycling and re-use.

Some of these approaches work better than others for specific materials.



Original Five-Year Goals

Within its first five years, CMI will develop at least one technology, adopted by U.S. companies, in each of three areas:



Diversifying & expanding production



Developing substitutes



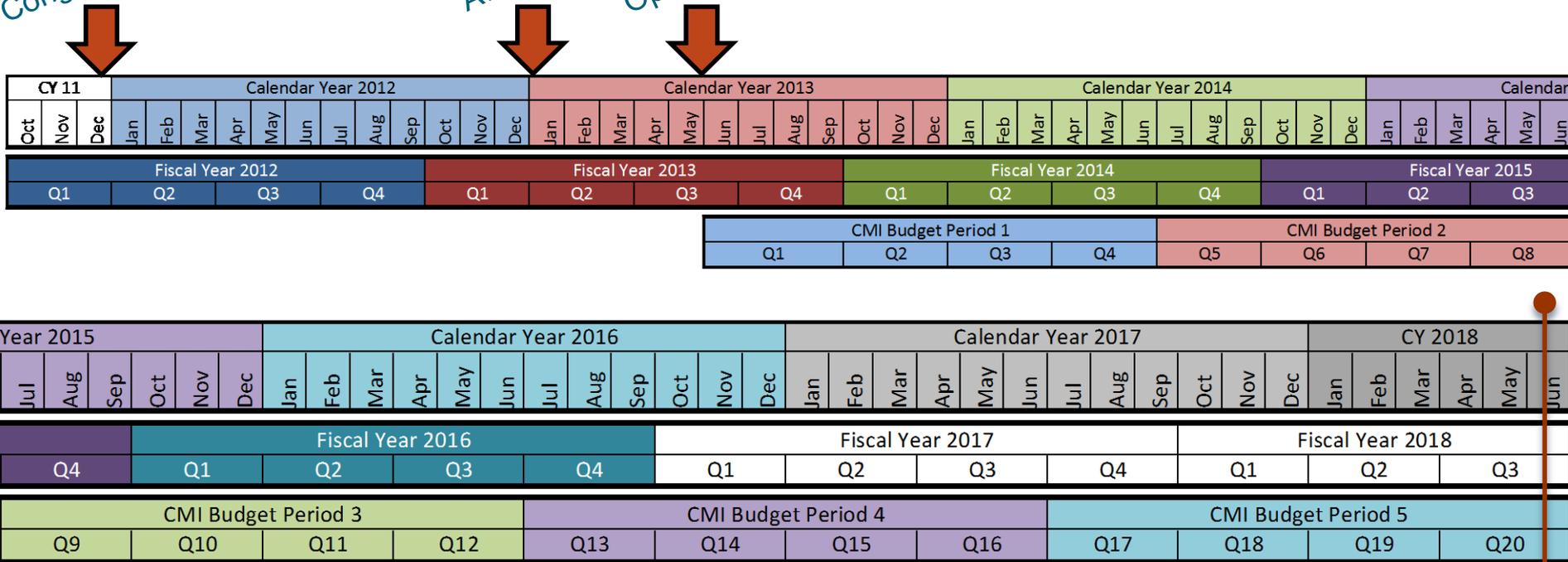
Reducing wastes

Timeline

Congress approves funding

Award announced

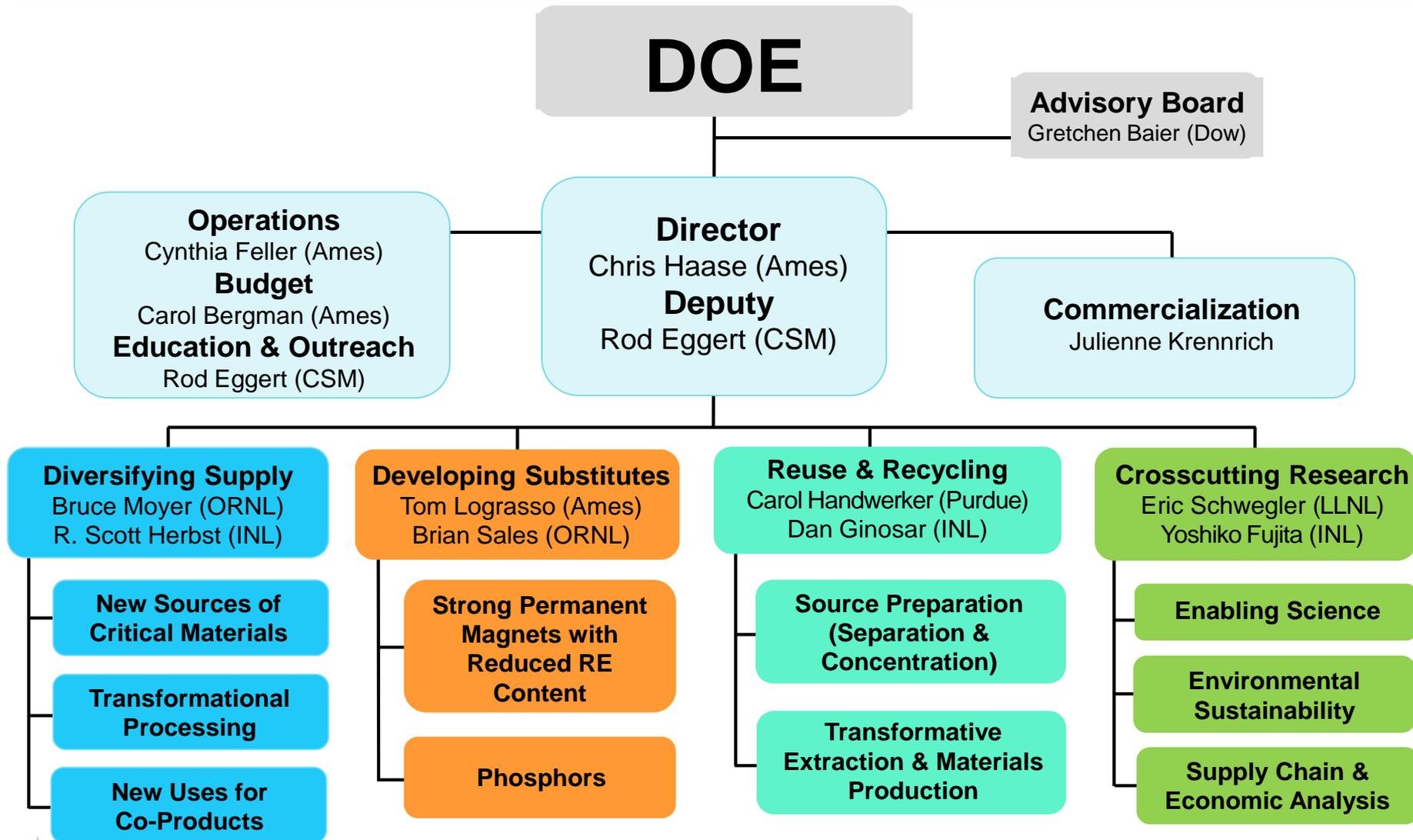
Operations commence



First 5-year funding cycle ends: **June 30, 2018**
 Funds have been appropriated for Years 6 and 7.

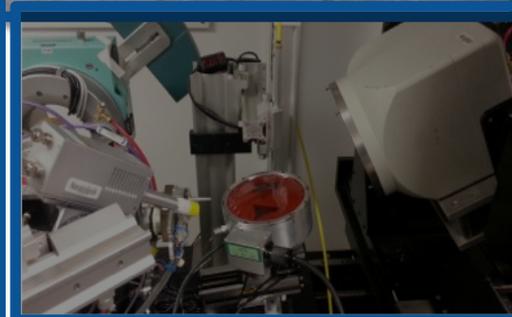
TECHNICAL APPROACH

Organization

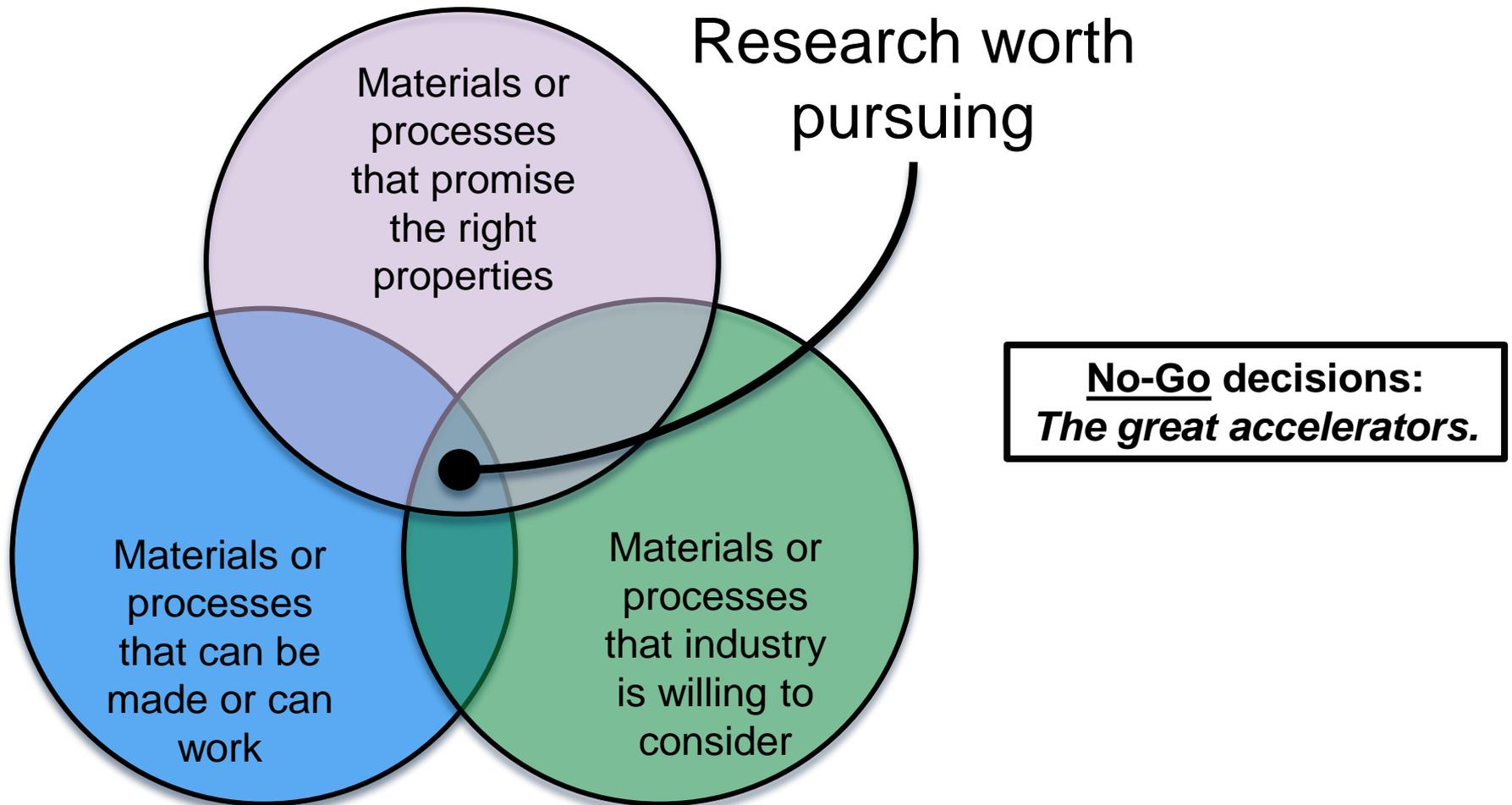


Facilities & Capabilities

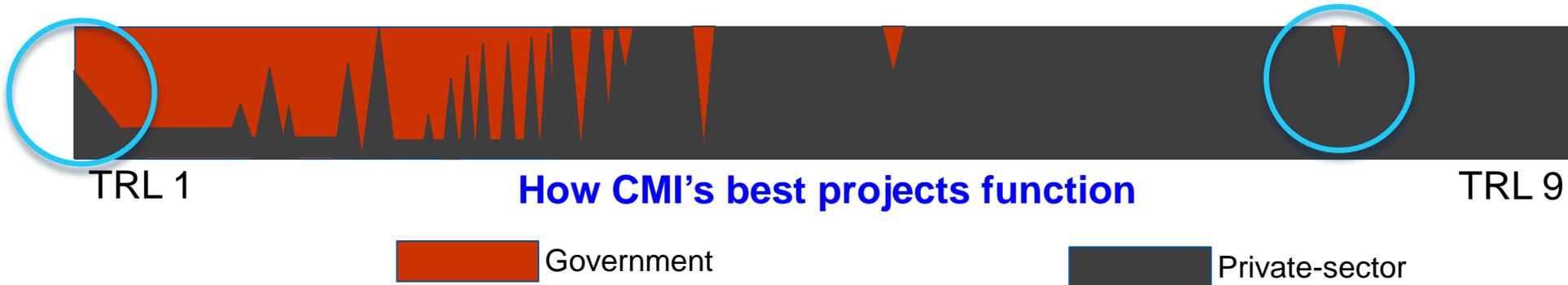
- Bulk combinatoric library production facility
- Thin-film combinatoric library production facility
- High-throughput analysis (with JCAP and JCESR)
- Solvent exchange (SX) pilot scale test facility
- Electrophoretic deposition capability
- Filtration test facility
- Toxicology test capability
- Thermal analysis in high magnetic fields
- Rapid magnetic property assessment
- Rapid thermodynamic property assessment
- Automated high-resolution adiabatic calorimeter
- Micro-x-ray fluorescence analysis capability
- Robotic catalyst development system
- 3D printing of bonded magnets
- Criticality assessment tools & techniques



CMI's Research & Development Paradigm



Government & Private Sector Contributions



Early-stage industry input is essential
Late-stage basic science input is essential

Government & Private Sector Contributions

- Team Members
 - Participate in CMI research projects
 - Share in the research costs
 - Participate in the IP management plan
- Associates
 - Sponsor research using CMI's assets
 - May wholly own the resulting IP, subject to DOE rules & regulations
- Affiliates
 - Participate in CMI meetings and information streams
 - Pay an annual membership fee
 - Get an “early look” at CMI intellectual property



MANAGEMENT APPROACH

Managing a Dispersed Team

- Clear expectations
- Clear timelines
- Clear lines of authority and delegation
- Predictable, reliable, performance-based resource allocations
- Relentless multi-channel communication
- As much lead-time as can be provided for all deliverables

~35 Individual Projects

- Impactful
- Interdisciplinary
- Interinstitutional – *the best talent from anywhere in the Hub*
- Collaborative with each other
- Collaborative with industry – *possible exceptions for crosscutting research*
- Clear Deliverables and Timelines

Project Management

- **Roadmaps**

- Where do we start, where are we going, how do we relate to other CMI efforts?
Where are the key decision points?

- **Quarterly Reports**

- Progress Measures
- SMART Milestones – *Specific, Measurable, Aggressive, Relevant, Timely*
- Go/No-Go Decisions
- Cost status, Accomplishments, Risks, Challenges, Staffing...

- **Techno-Economic Analyses**

- Required of all Tasks and Projects after they reach TRL 4.

- **Annual Project Evaluations**

- Two-thirds of our projects have been changed in some way, over the five-year program in this process.

ACHIEVEMENTS

Metrics Since Inception

Refereed publications: **220**

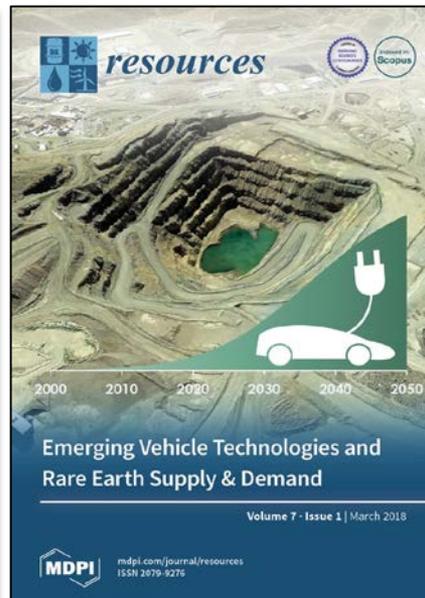
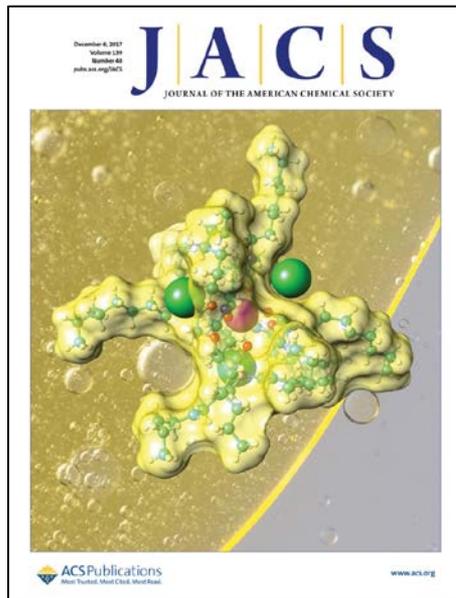
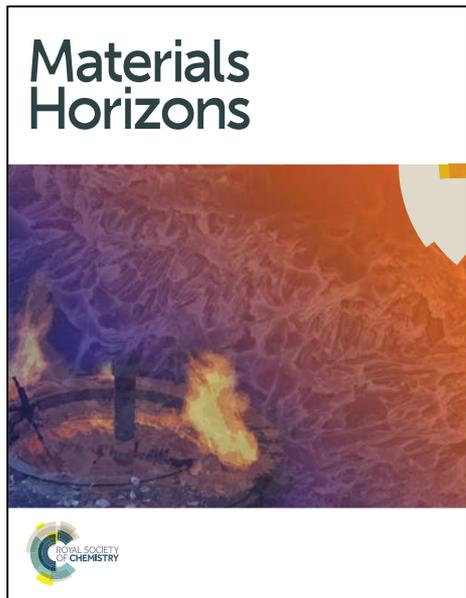
Invention disclosures: **78**

Patent applications: **50**

Patents awarded: **5**

Technologies licensed: **7**

Publications



- 220 **total** archival publications to date
- 73 in the last twelve months

Industry Adoption

- Membrane Solvent Extraction for Rare Earth Separations
 - *Licensed to Momentum Technologies, Inc.*
- Additive Manufacturing of Bonded Permanent Magnets using a Novel Polymer Matrix
 - *Licensed to Momentum Technologies, Inc.*
- High Throughput Rare Earth Magnets Recycling System
 - *CRADA with Oddello Industries; Licensed to Momentum Technologies, Inc.*
- Yttria-Stabilized Zirconia Thermal Barrier Coating Reversion Process
 - *In use by GE Aerospace.*
- Selective Surface Modification of $\text{Nd}_2\text{Fe}_{14}\text{B}$ Magnets to Achieve High Performance
 - *Licensed to Momentum Technologies, Inc.*
- Castable High-Temperature Ce-Modified Al Alloys
 - *Licensed to Eck Industries. **First commercial sales in August 2017***
- Novel 3D Printing Method to Fabricate Bonded Magnets of Complex Shape
 - *Licensed to Momentum Technologies, Inc.*
- Additive Printing of Bonded Magnets Using Magnet Powders and a Polymer Composition
 - *Licensed to Momentum Technologies, Inc.*
- Process for Recovering Mercury & REEs from Used Fluorescent Lamps
 - *CRADA with LCW Supercritical Technologies Corp.*



AlCe Alloy Cast



3D Printed Magnet

Awards

- Two CMI technologies received R&D Magazine's prized R&D 100 award
 - Presented annually to the top 100 scientific innovations as judged by a panel of 50 R&D leaders from a variety of fields



Awards

2018 Federal Lab Consortium Commercialization Award

– *and reaction from
Sen. Lamar Alexander*

LAMAR ALEXANDER
TENNESSEE



United States Senate
WASHINGTON, D.C. 20510

March 30, 2018

Dear Dr. King,

I am delighted and honored to congratulate The Ames Laboratory for winning a 2018 Federal Laboratory Consortium for Excellence in Technology Transfer Award.

The Ames Laboratory's work on aluminium cerium casting alloys is an excellent example of how national laboratories can work successfully with private industry to develop cutting-edge technology.

Very best wishes.

Sincerely,

A handwritten signature in black ink that reads "Lamar Alexander".

Dr. Alexander King
The Ames Laboratory
Wilhelm Hall
Rm 134
Ames, IA 50011

Education & Workforce Development

- CMI Leadership Academy
 - Year-long experience designed to develop leadership management skills for a group of emerging leaders within the CMI community



- Educational Outreach
 - Webinars, professional societies (e.g., SWE), undergraduates, high-school students
 - CMI Museum at CSM



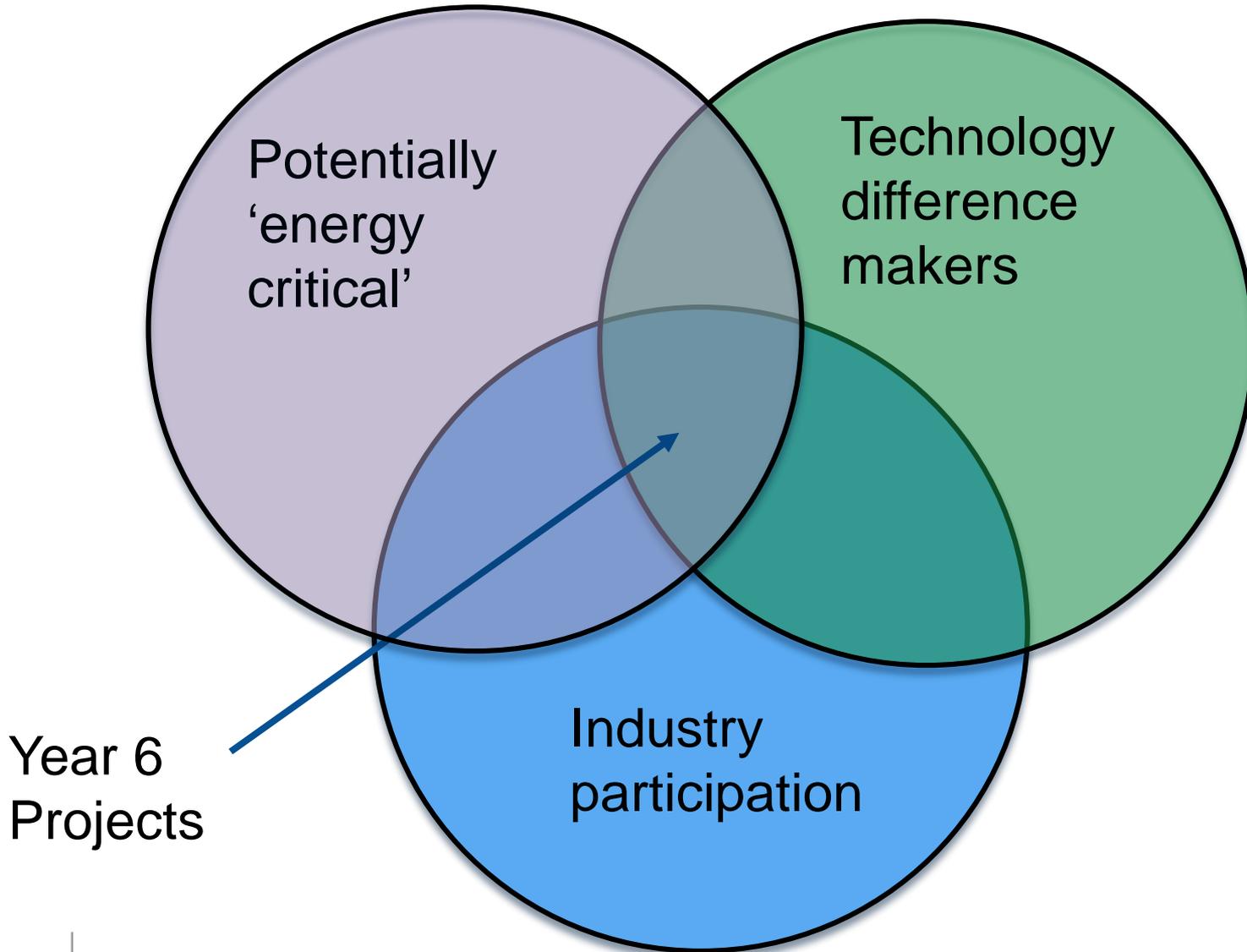
- Education Toolkits
 - Resources for K-12, university teachers and students



THE NEXT FIVE YEARS

Expanded Palette, Path to Sustainability

Year 6



Our Extended Palette of Materials

- Initially rare earths & lithium
- Expansions
 - Cobalt, graphite, manganese, vanadium
 - Gallium, indium
 - Platinum-group elements
- Areas of importance
 - Magnets
 - Lighting
 - Batteries
 - Catalysts
 - Nuclear
 - Solar

Emerging Unifying Themes

- Co-production pervades most materials on CMI palette
- Resource Efficiency related to but not overlapping to Co-production
- Emerging opportunities for application of machine learning and artificial intelligence
- Linking basic and applied research across a portfolio of Basic, Core and Game-Changing projects

Vision for Sustainability: Enabling U.S. Manufacturing

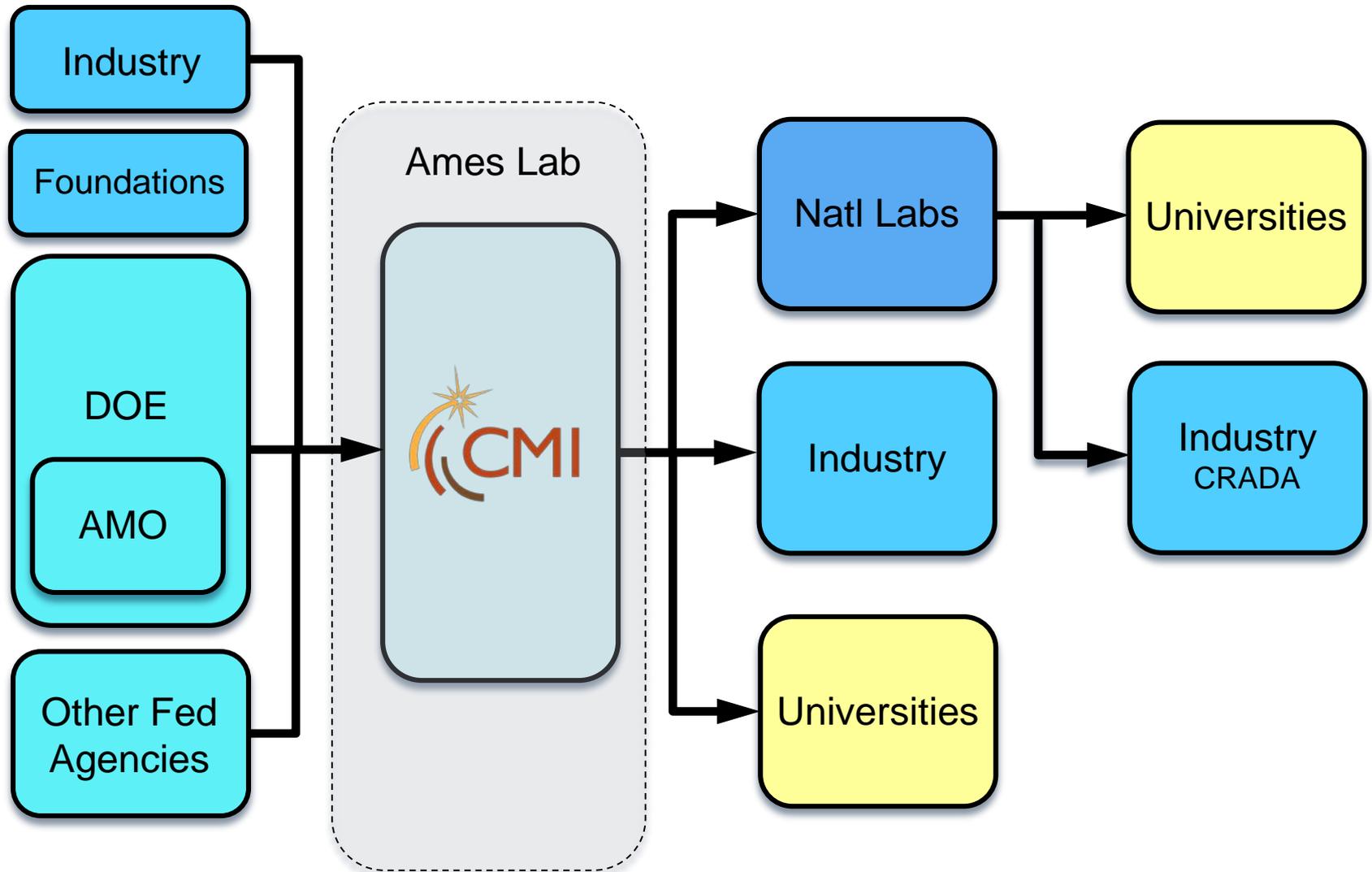
CMI will be the established resource for delivering critical and strategic materials solutions. It will:

- Have unique skills and information relative to critical materials.
- Provide an innovative ecosystem in which industry, academia and government share information and contribute to solving critical materials challenges.
- Sustain cutting-edge knowledge in relevant fields, and apply it to industry and societal needs.
- Provide foresight into emerging factors that may affect materials criticality.
- Stand ready to respond to emerging problems.

Funding Scenario: Base Case

CMI Budget Period	6	7	8	9	10
Period of Performance	7/18 - 6/19	7/19 - 6/20	7/20 - 6/21	7/21 - 6/22	7/22 - 6/23
Funds Appropriated	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
AMO Funding	25	25	20	15	15
Cost Share	5	5	10	15	15
Total Funding	30	30	30	30	30

Vision for Sustainability: Enabling U.S. Manufacturing



Key Messages

- 1st Five Years
 - Recognized exemplar of inter-institutional and disciplinary collaboration
 - Delivered a high-performing research institution with facilities and capabilities dedicated to critical materials R&D
 - Accelerated delivery of translational R&D into industry to mitigate risks to US supply chains
- 2nd Five Years
 - Leveraging R&D network and capabilities to focus on a broader palette of materials
 - Crafting a long-term path to funding sustainability
 - Applying a pragmatic approach with industry to linking DOE capabilities with applied needs through world-class basic research

Thank You!

Questions?