U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

AMMT Demonstrations

AMMT Industry Workshop
May 2023

Ryan Dehoff

Oak Ridge National Laboratory

Manufacturing Demonstration Facility is focused on Advanced Manufacturing

AMMTO's Manufacturing Demonstration Facility, **MDF Innovation Ecosystem** provides access to 1,000's of companies, small business, universities and other stakeholders annually to **co-develop** advanced manufacturing technologies to secure a US supply chain, address affordability of clean energy technologies, and improve the energy efficiency in fabrication and application of components

$1B+ impact on U.S. manufacturing
>20:1 ROI of DOE funding

240+ partnerships with **$123M+** in CRADAs (50% industry)

80-100 student interns per year
>50 university collaborations

+100 publications/year
182 awards since 2012

100+ Industry Fellows at MDF from industry and academia

57 licensed technologies
>200 patents/applications

OAK RIDGE National Laboratory | MANUFACTURING DEMONSTRATION FACILITY

U.S. DEPARTMENT OF ENERGY

AMMTO's MDF Consortium Model

The United States' most effective laboratory consortium model for accelerating innovation for clean energy.

America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition: The U.S. must expand domestic manufacturing capabilities, lower manufacturing costs of clean energy technologies and improve efficiency.

Challenge for Industry: Capital investments and R&D are expensive endeavors, especially for SMEs. Diverse expertise is required to maximize impact.

The MDF Ecosystem enables access:

1. MDF research leverages next generation equipment. >50% of MDF equipment is industry owned.
2. MDF can pull from over 6,000 experts at ORNL with diverse backgrounds and experience including advanced materials, characterization, computational capabilities and energy systems.

Manufacturing Demonstration Facility

Started October 2011

Additional Funding of >$160M in R&D (Enabled by Core Research from AMO)

4 Manufacturing Technology Areas

5 Core R&D Areas

>250 Industry Collaborations

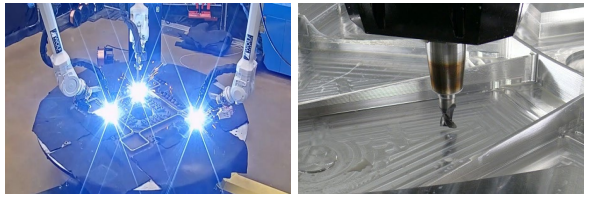
Manufacturing Technology Areas:
Enable integration of multiple areas of expertise to demonstrate implementation of components with industry

Core R&D
Critical Areas of R&D Need defined based on industry feedback, national priority and AMMTO Mission.

Technical Collaborations
Mechanism for rapid access to national laboratory infrastructure to reduce risk and accelerate development and deployment

OAK RIDGE National Laboratory | MANUFACTURING DEMONSTRATION FACILITY

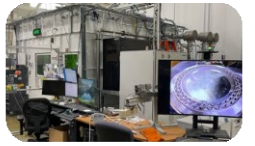
U.S. DEPARTMENT OF ENERGY



Additive | Machining

Composites | Hybrid

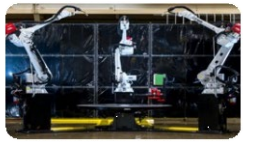
Digital Factory



Industrialization of Powder Bed AM

Integrated, Smart Polymer Processes

Digital Factory



Directed Energy Deposition

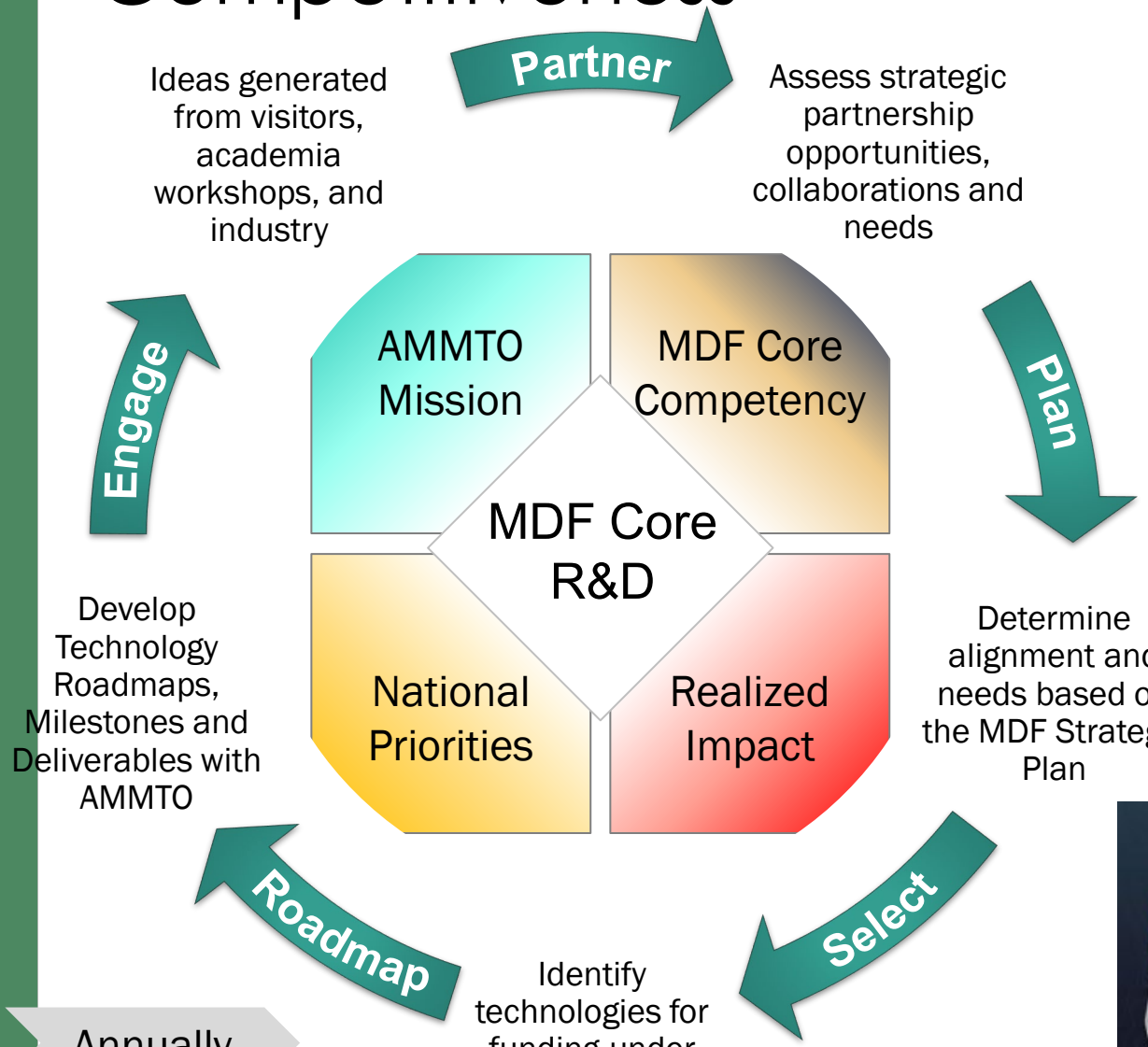
AM Hybrid Systems

Core R&D

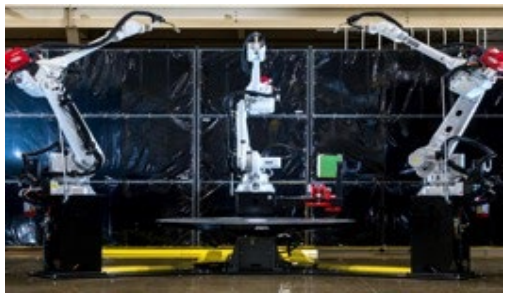
254 Approved Projects

Industrial Collaborations

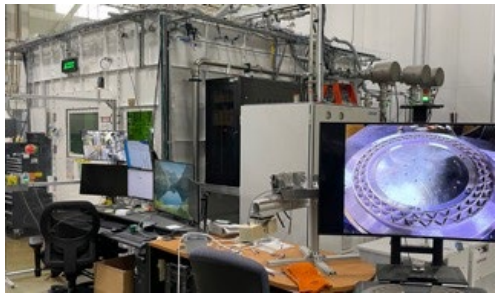
Core Research Cycle Drives Industry Adoption & Competitiveness



5 MDF Core R&D Portfolios



Directed Energy Deposition



Industrialization of Powder Bed AM

Integrated, Smart Polymer Processes

AM Hybrid Systems

Digital Factory

OAK RIDGE National Laboratory | MANUFACTURING DEMONSTRATION FACILITY

ENERGY

Manufacturing Demonstration Facility "Moonshots"

Robotic arm

Strati

Cobra

AMIE

Bamboo pavilion

Excavator

Submersible

Autonomous bus

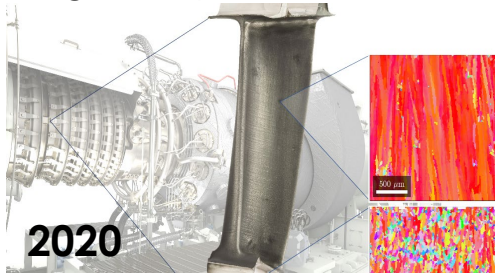
Die in a Day

Domino Sugar Bldg.

Nose Cone

Machine Tool

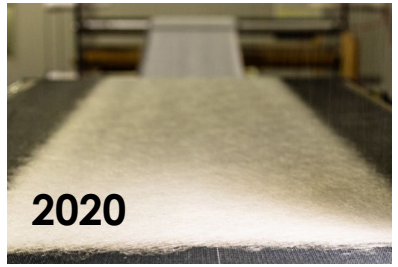
High Temp. Turbine Blades



EMPOWER Wall

Peregrine License

COVID Response



AM in Reactor

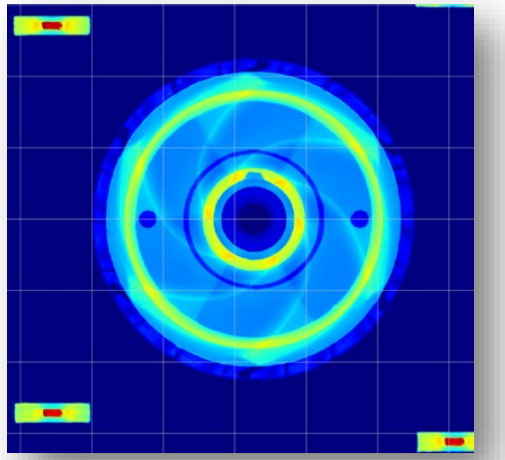
Heat Shield

Industry engagements aligned with the AMMT Program will be a key enabler of technology demonstrations

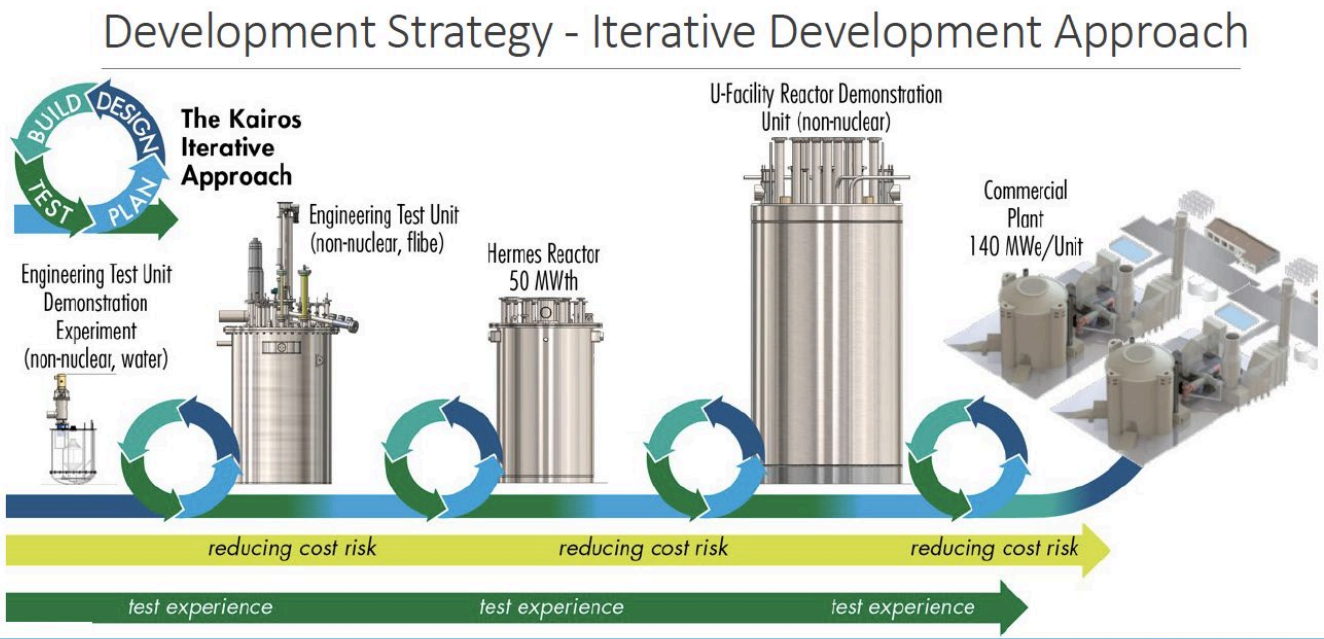
"The innovation embodied in the TCR program strategy, and the opportunity to have close physical proximity to its major AM work, were central factors in our Kairos decision to locate our Hermes reactor adjacent to ORNL in eastern Tennessee.

Kairos has already benefited directly from advances led by the TCR program's development work. We will have ORNL-TCR AM hardware in our Hermes reactor."

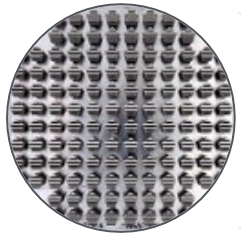
Kairos Power



Need for larger Components:

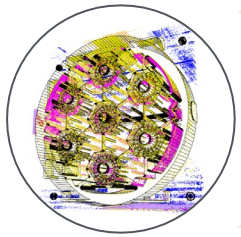


Framatome Channel Fasteners inserted into TVA's Browns Ferry Unit 2 reactor April 26th, 2021



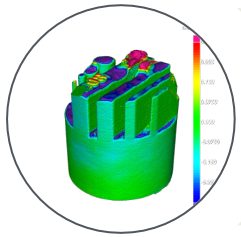
Powder Bed Laser Printing Expertise

MDF Process and Process Understanding from



Peregrine

In-Situ Process Monitoring of builds to determine defects



3D Characterization

Leveraged the Zeiss CRADA and ORNL Equipment for full component inspection

"The fuel assembly channel fasteners were printed at ORNL using additive-manufacturing techniques, also known as 3D printing, as part of the lab's Transformational Challenge Reactor Program and installed on ATRIUM 10XM fuel assemblies at Framatome's nuclear fuel manufacturing facility in Richland, Washington."

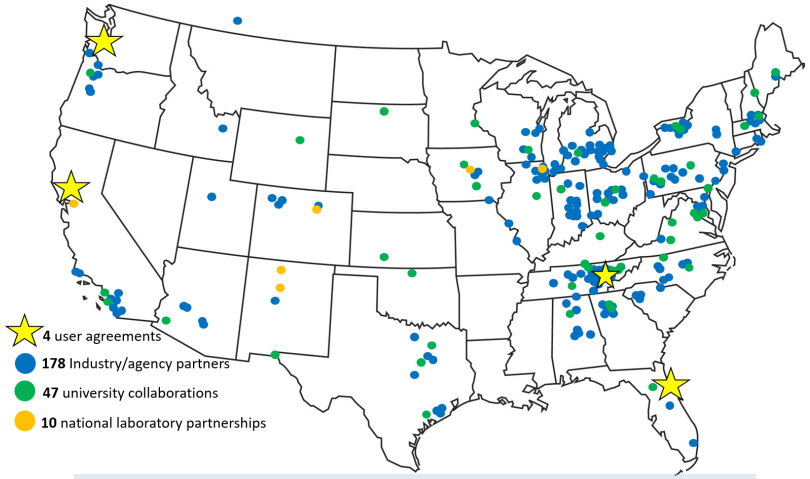
Framatome website (Dec 2020)

MDF "Technical Collaborations" Program: Goals

- Provide open, affordable and convenient access to national lab infrastructure, hosted resources, tools, and expertise to facilitate rapid development and adoption of new energy efficient manufacturing technologies.
- Collaborate with industry through cost shared projects to investigate, improve, and scale process methodology to reduce the risk and accelerate the development and deployment of innovative energy efficient manufacturing and materials technologies
- Enable creation and preservation of domestic manufacturing jobs is a primary goal

MDF Strategic Goals Supported

1. Improved Performance of AM Components
2. Testbed for Digital Mfg.
3. Develop Next Gen. Mfg. Systems
4. Sustainable Mfg. & Circular Economy
5. New Practices for Transfer of Mfg. Technologies



254 Approved Projects with Industry through TC Program

OAK RIDGE National Laboratory | U.S. DEPARTMENT OF ENERGY

MDF Technical Collaborations: Overview

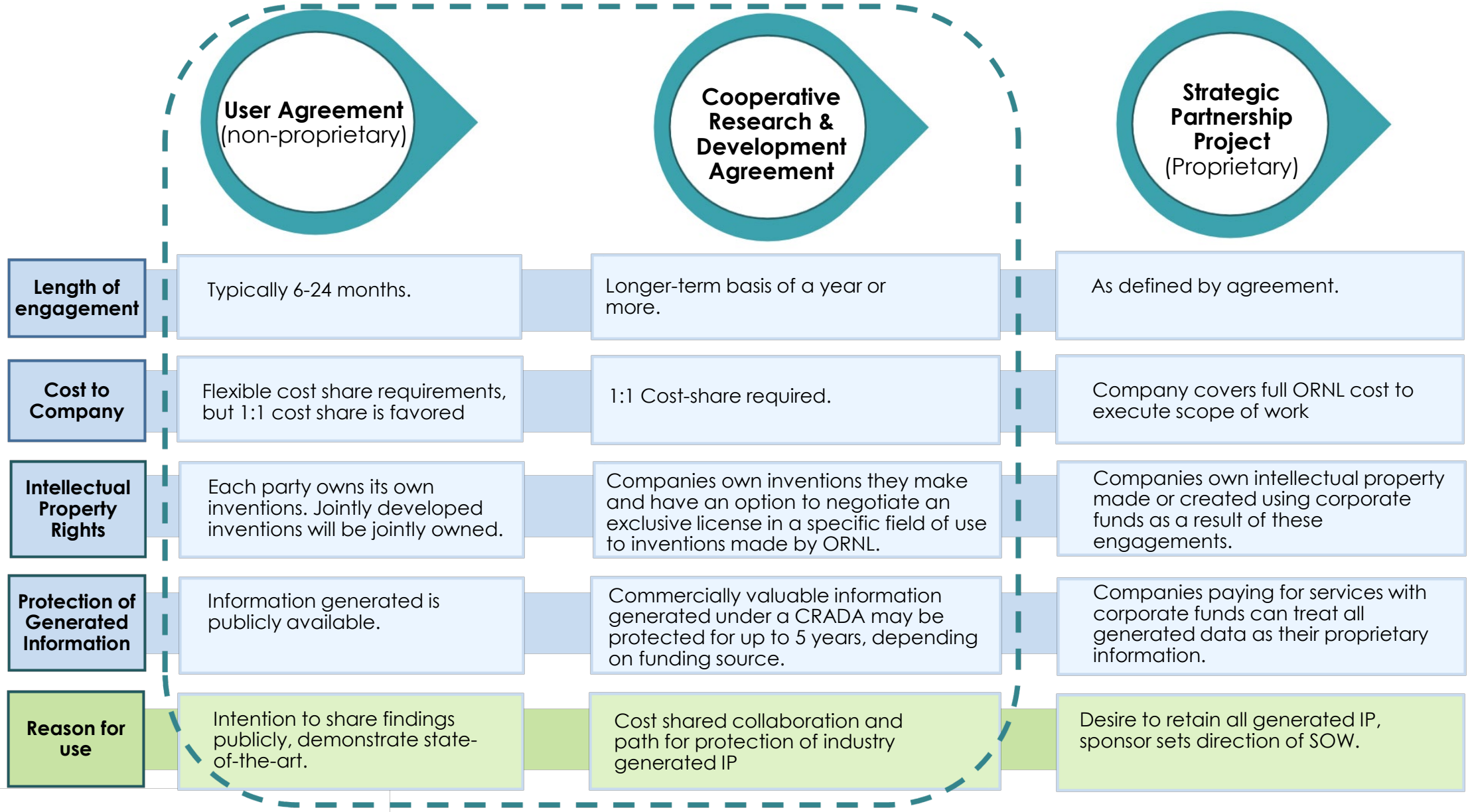
Strategic partnerships developed between ORNL and industry that seek to leverage collective assets to address the following areas:

1. Evaluation: new materials, systems, software and end use applications to evaluate their use within key technologies and fundamental research that could impact core R&D.

2. Development: strategically accelerate the development of advanced manufacturing and energy relevant technologies along with the institutional knowledge that enables them.

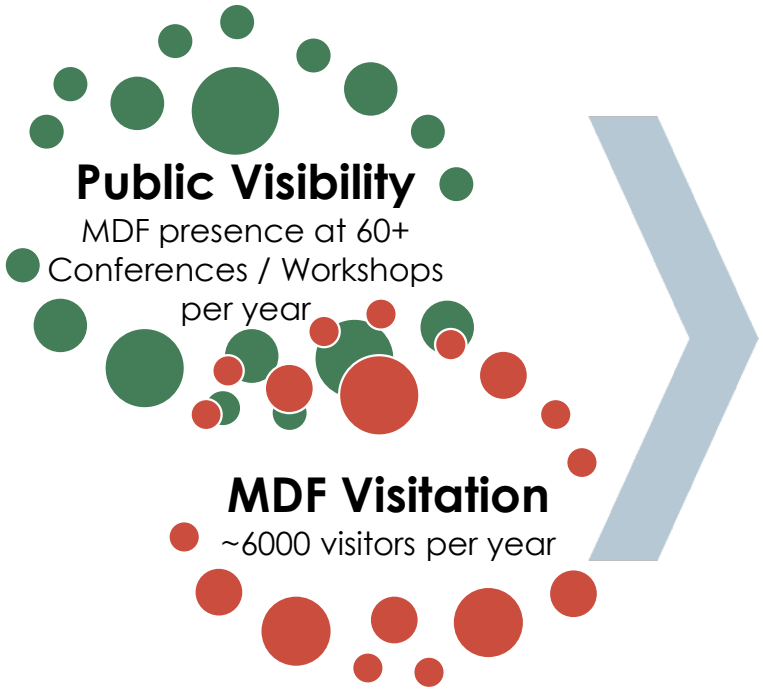
3. Deploy/Transfer: investigate, improve, and scale process methodology to reduce the risk and accelerate the deployment and adoption of innovative energy efficient manufacturing and materials technologies.

Agreements: Working with Oak Ridge National Laboratory



Agreements utilized within Technical Collaboration Program

Technical Approach: Industry Technology Collaborations



The Collaborative Process

Explore	Engage	Execute
Opportunities for industry to discover and apply new manufacturing technologies. Find a willing industrial partner.	Work with MDF staff and the industrial partner to develop the scope of work	Non-Negotiable *Collaborative Research and Development Agreement (**CRADA**)* *-or- **User Agreement***

- **Move at the speed of industry** – projects developed and started in 3-4 months vs 1 yr+
  - Project funding is on hand at ORNL as part of DOE AMO AOP process
  - Rapid proposal submission/approval (submit every 2 weeks / 2 weeks review)
  - Fast-track CRADA approval established for Tech Collab project
- **Cost share levels that are manageable** for small/medium enterprises ($40K Phase 1)
- **Phased project approach** to allow for expanded research based on initial Phase 1 findings
- **Leverage lab-wide resources:** Cross-functional teams (Materials, Imaging, Computation)

MDF Technical Collaborations Process

Explore

ORNL MDF Introduction
- Industry call /visit with MDF Management / R&D Leads
- High level overview of MDF capabilities/role
- Discussion of industry needs/interests

Review Program Agreements
- Short-form CRADA
- User Agreement
- Industry (internal) review of agreements

Engage

Proposal Development
- ORNL and Industry develop TC Proposal
- ID Phase 1&2 SOW
- ID measurable goals
- Define budget/cost share

Proposal Submission
- ORNL submits to DOE
- Submissions every 2 weeks

DOE Proposal Phase 1 Review
- DOE-AMO review
- AMO approves **or** ORNL/Industry rework SOW per AMO feedback

Execute

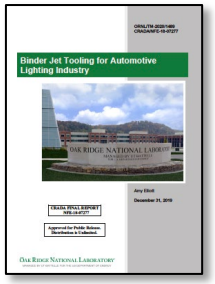
Agreement Processed
- CRADA (US) (~2 mon.)
- CRADA (Foreign) (~4-5 mon.) — DOE Foreign Review
- User Agrmt. (~1 week)

Agreement Signed
- Short-Form CRADA Signed
- - or -
- User Agreement Signed

Project Execution
- Phase 1 SOW executed
- If no Phase 2, final project report issued

DOE Proposal Phase 2 Review
- Proposal updated with Ph1 findings, resubmitted to DOE AMO
- AMO approves
- **or** ORNL/Industry rework SOW per AMO feedback

Project Execution
- Phase 2 SOW executed

Final Report


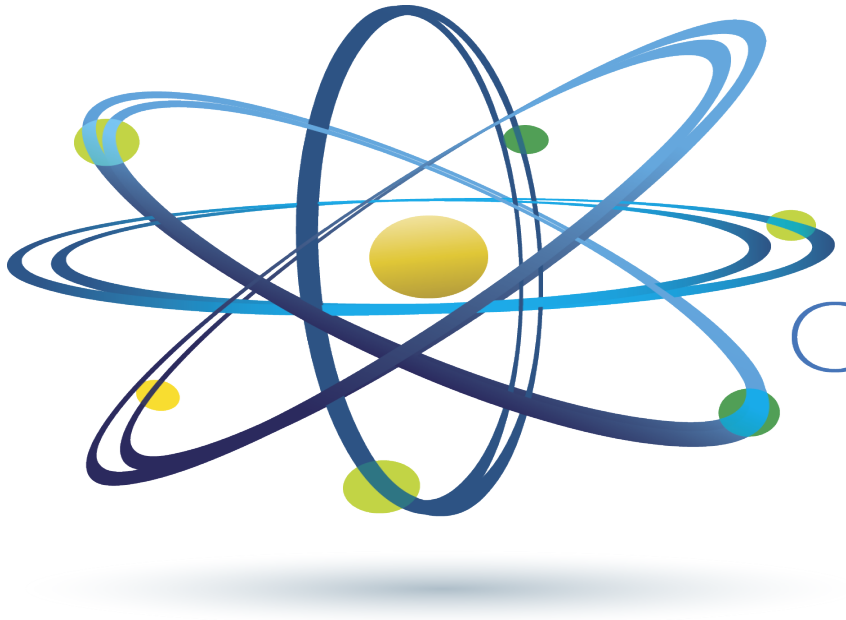
ORNL project report(public)

Cycle time Summary: Proposal Development to Project Start

CRADA (US):	3-4 months
CRADA (Foreign):	5-6 months
User Agreement:	1-2 months

OAK RIDGE National Laboratory | U.S. DEPARTMENT OF ENERGY

Questions?



Clean. **Reliable. Nuclear.**