DOE TECHNOLOGIST-IN-RESIDENCE (TIR) PROGRAM KICKOFF

2018 Annual Report on the U.S. Fluid Power Industry, NFPA

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October 22-24, 2019

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- DEPARTMENT OF ENERGY – ADVANCED MANUFACTURING OFFICE
- CCEFP
- CCEFP AFFILIATES
  - Afton, Evonik, Lubrizol, Donaldson, Eaton, Linde, Parker, FD-Groups, CZERO, Bobcat, CNH, Poclain, NFPA

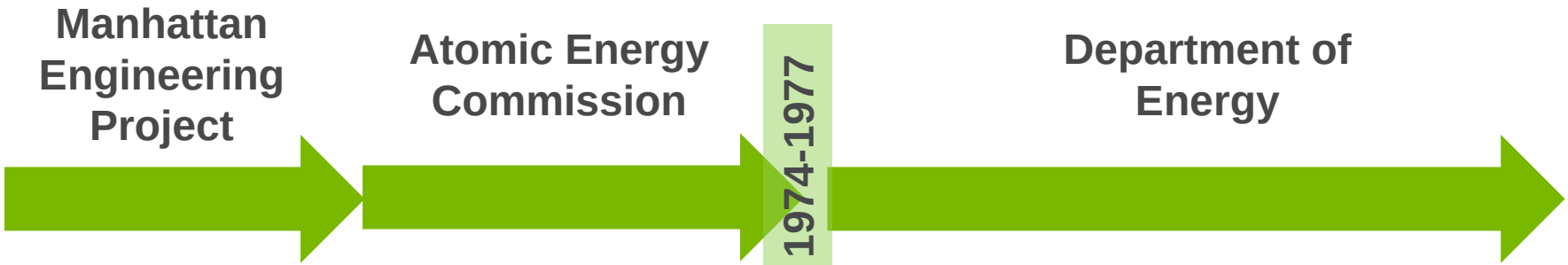
Argonne NATIONAL LABORATORY

OUTLINE:

- **DOE & NATIONAL LABS**
- **TIR - BUILDING COLLABORATIONS**
- **IDENTIFYING AREAS FOR COLLABORATION**
- **FUTURE DIRECTIONS/ACTIVITIES**

DOE NATIONAL LABORATORY COMPLEX

NATIONAL LABORATORY TIMELINE



1939 to 1946

- Development of atomic weapons during WWII

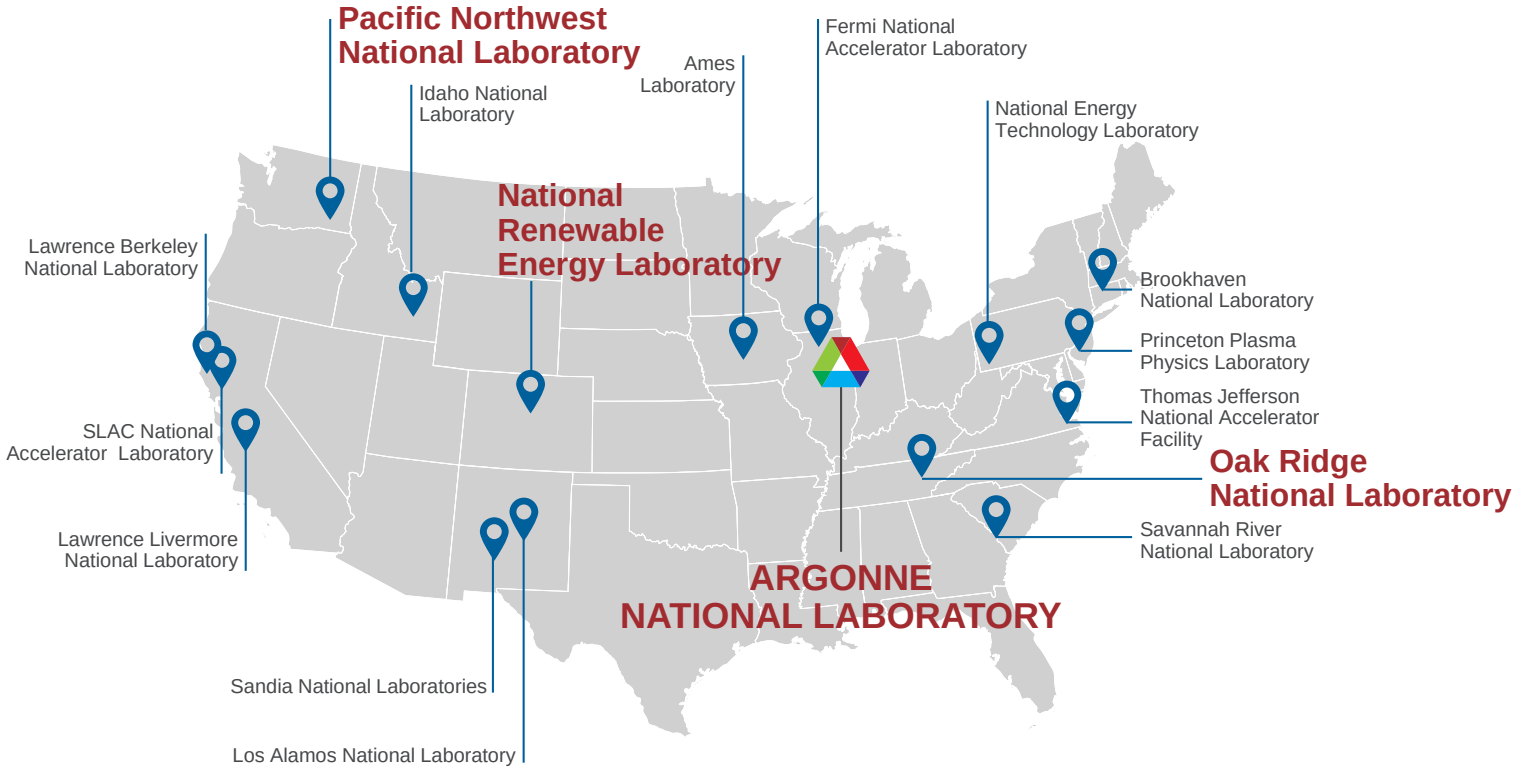
1946 to 1974

- **National Labs established**
- National Nuclear Security
- Peaceful uses of atomic power
- Science & Facilities

1977 to present

- National Nuclear Security
- All forms of energy – nuclear, fossil, solar, wind, water, ….
- Energy conservation & efficiency
- Environment & Clean-Up
- Manufacturing
- Science, Computing & Facilities

THE DEPARTMENT OF ENERGY NATIONAL LABORATORY SYSTEM



https://nationallabs.org/our-labs/

Argonne NATIONAL LABORATORY

ENERGY EFFICIENCY & RENEWABLE ENERGY

https://www.energy.gov/eere/office-energy-efficiency-renewable-energy

Renewable Power

- Solar
- Geothermal
- Wind
- Water

Sustainable Transportation

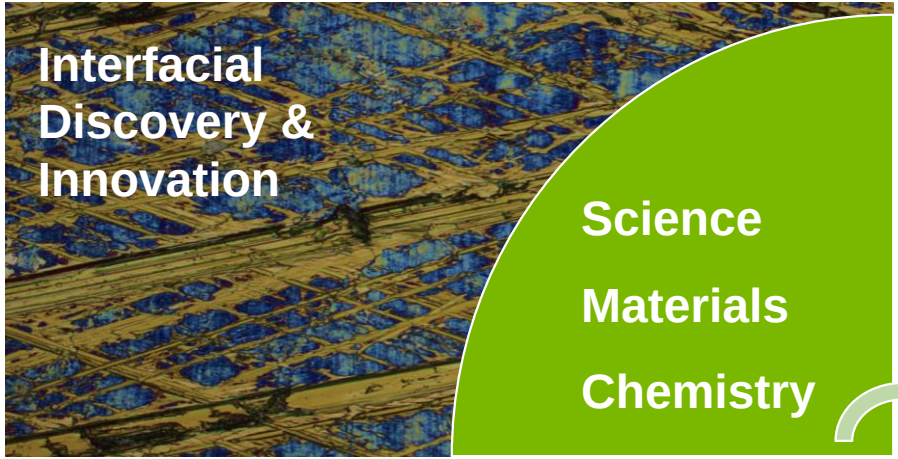
- Vehicles
  - *Home to Mobile Fluid Power Program*
- Bioenergy
- Hydrogen & Fuel Cells

Buildings & Manufacturing

- Buildings
- Advanced Manufacturing
  - *Home to Technologist-in-Residency Program*
- Government Energy Management

Cross-Cutting Initiatives & Programs on: Energy Analysis, Technology-to-Market, Better-Buildings, and Grid Modernization Initiatives

NATIONAL LAB MULTIDISCIPLINARY R&D PORTFOLIO



Science
Materials
Chemistry

Engineering
Design
Integration

User
Facilities
Computing

Analysis
Assessments

Sustainable
Transportation

Autonomous Vehicles
Electrification
Alternative Fuels
Novel Architectures

THE NATIONAL LABS ARE YOUR LABS

DOE strongly encourages Lab-Academia-Industry Partnerships

- National laboratories solve important problems in fundamental science, energy, and national security.
- National laboratories steward vital scientific and engineering capabilities including technology transfer that are essential to our nation's continued science and technology primacy in a rapidly changing world.
- National laboratories design, build, and operate unique scientific instrumentation and facilities that serve tens of thousands of scientists and engineers from academia, government, and industry collaborating on solutions to pressing and complex problems.
- National laboratories promote innovation that advances U.S. economic competitiveness and contributes to our future prosperity.

Ernest Moniz, Secretary of Energy, March 2014

BUILDING COLLABORATIONS

WITH A LITTLE HELP FROM MY FRIENDS….

The labs can be a valued asset to industry and academia in the pursuit and development of fluid power systems – the unique tools, facilities, and expertise required to tackle the challenges and barriers, developed using federal support, are available to address your challenges.

Navigating the national labs can be challenging..., but with a little help…

Match industry/academia R&D needs with national lab capabilities

ARGONNE/CCEFP TECHNOLOGIST IN RESIDENCY

Working with DOE AMO, Argonne & CCEFP proposed a TIR project to establish collaborative R&D teams and projects addressing industry needs

- ANL/CCEFP TIR – Goals/Objectives consistent with AMO TIR Program
  - Develop collaborative R&D projects that **apply unique expertise & facilities that exist in DOE's national lab complex** to overcome specific **challenges and barriers that industry identifies** as being critical to their needs.
  - Pairing of lab technologists with industry/CCEFP technologists
  - Development/identification of specific topics that industry and labs want to further pursue through collaborative R&D projects (work-for-others, CRADAs, joint proposals, …)
    - Site visits and meetings (at labs and industrial sites)
    - In-depth definition of challenges, barriers and specific needs (under NDAs)
    - Establish collaborative R&D agreements and funded projects
    - Establish teams, and develop proposals for joint research
    - Carry-out research – the enjoyable part
    - Document TIR activities

CCEFP & NATIONAL LAB AFFILIATES

Thirteen Affiliates, 4 National Labs

Argonne NATIONAL LABORATORY

CNH INDUSTRIAL

EATON Powering Business Worldwide

Linde Hydraulics

Afton CHEMICAL

OAK RIDGE National Laboratory

Bobcat

Donaldson FILTRATION SOLUTIONS

Parker

EVONIK POWER TO CREATE

Pacific Northwest NATIONAL LABORATORY

Czero ENGINEERING TOMORROW

POCLAIN Hydraulics

FD groups america

Lubrizol

NREL NATIONAL RENEWABLE ENERGY LABORATORY

NATIONAL FLUID POWER ASSOCIATION NFPA

ARGONNE/CCEFP TIR METRICS

Summary

- Proposal developed and submitted to DOE and selected
- Argonne (lead TIR) and CCEFP
- Thirteen Industrial Affiliates (+ 2 additional)
  - Off-Road Vehicle OEMs
  - Equipment/Component OEMs
  - Fluids/Additive OEMs
  - NFPA
- End product of project is *COLLABORATION*
- Metric – established R&D projects
  - Number of projects, meetings, teams, topics…

IDENTIFYING AREAS FOR COLLABORATION

TOPICS/AREAS FOR COLLABORATION

Preliminary discussions with affiliates to identify research areas of interest for collaboration; Past DOE Workshops; and Recent NFPA Roadmaps

- **DOE Topical Workshops**
  - NREL Mobile Fluid Power - September 2017
  - ANL Off-Road Vehicles – October 2018
- **NFPA Biennial Roadmap - July 2019**
- **Argonne/CCEFP Technologist-in-Residence Preliminary Meetings**
  - One-on-one discussions with CCEFP industrial members (Late August to Early October)
  - Develop list of areas of interest for national labs
  - Focused Webinars – National Lab Capabilities
    - Vehicle-Level topics
    - Component-Level topics
    - Fluids & Materials related topics
  - 1-on-1 Meetings & Brainstorming
  - One-on-One Lab/Industry Discussions – lab/industry team
    - Brainstorming – proposed focused topics
    - SOWs & Agreements
    - Commence R&D1

DOE ASSESSMENT OF R&D NEEDS FOR MOBILE FLUID POWER & OFF-ROAD VEHICLES

Working with the CCEFP, DOE-sponsored workshops to identify high-priority R&D needs for fluid power and off-road vehicles

- **NREL - Mobile Fluid Power Workshop**
  - September 12th, 2017, NREL
  - https://www.nrel.gov/transportation/mobile-fluid-power-workshop.html
- **ANL – Off-Road Vehicles Research Workshop**
  - October 25-26, 2018
  - https://www.osti.gov/biblio/1493003-off-road-vehicles-research-workshop-summary-report

Information used to develop FOAs

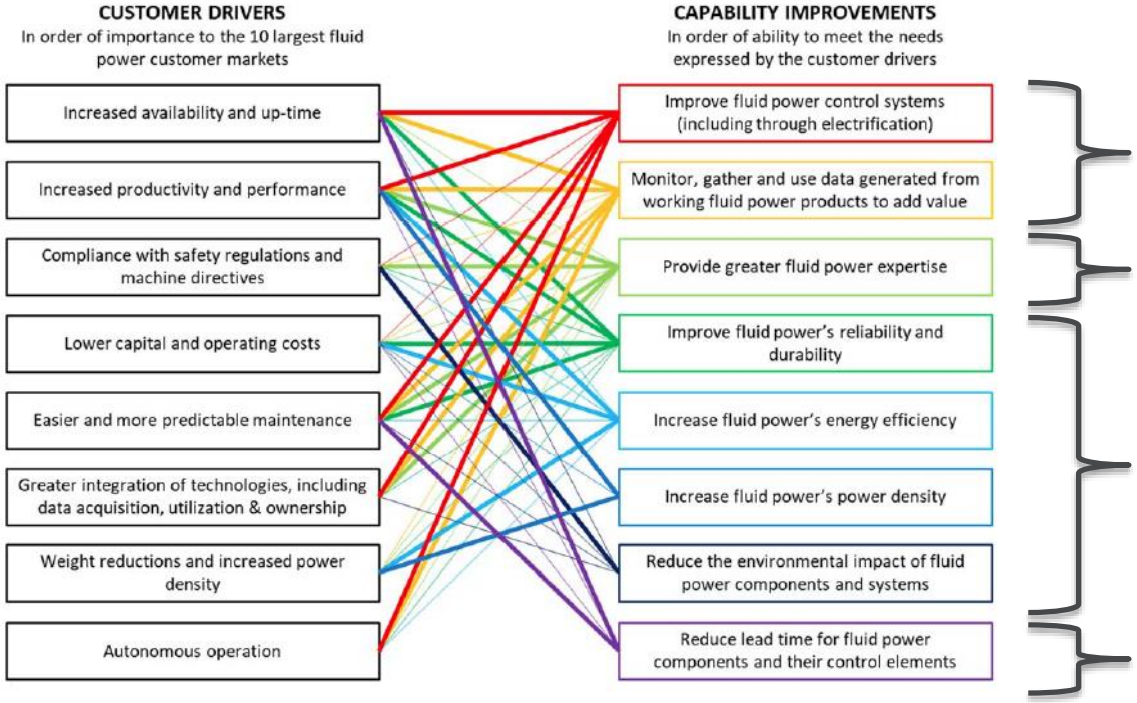
Engine Efficiency and Emissions
- Duty cycles significantly different from on-road
- Autonomous vehicles
- Alternative fuels

Efficient Fluid Power
- System architecture – central vs distributed hydraulic supply
- More efficient components (pumps, motors, valves)
- Efficient fluids
- ‘Smart’ technologies
- Energy storage – batteries vs accumulators

System Integration, Control, and New Technologies
- Hydraulic hybrids
- Electrification – batteries, fuel cells
- Simulation tools – off-road
- Duty cycles
- Autonomous vehicles

INDUSTRY ASSESSMENTS OF R&D NEEDS

Biennial Roadmaps connecting customer drivers and capability improvements identify *Critical R&D Thrust Areas*



Thrust Area 1
Data Acquisition & Control

Thrust Area 2
Education

Thrust Area 3
Performance

Thrust Area 4
Manufacturing

Detailed breakdown of topics within each Thrust Area

https://www.nfpa.com/home/workforce/Fluid-Power-Industry-Roadmap.htm

NFPA ROADMAP – THRUST AREAS

Thrust Area 3: Performance

1. Improve fluid power's reliability and durability
   a) Use metrology (including in-process sensing and control) to improve the reliability and durability of fluid power components
   b) Increase use of "smart" tools in fluid power manufacturing to improve reliability
   c) Use hybrid manufacturing to improve the reliability and durability of fluid power components
   d) Improve surface finish properties for advanced reliability and durability of fluid power components

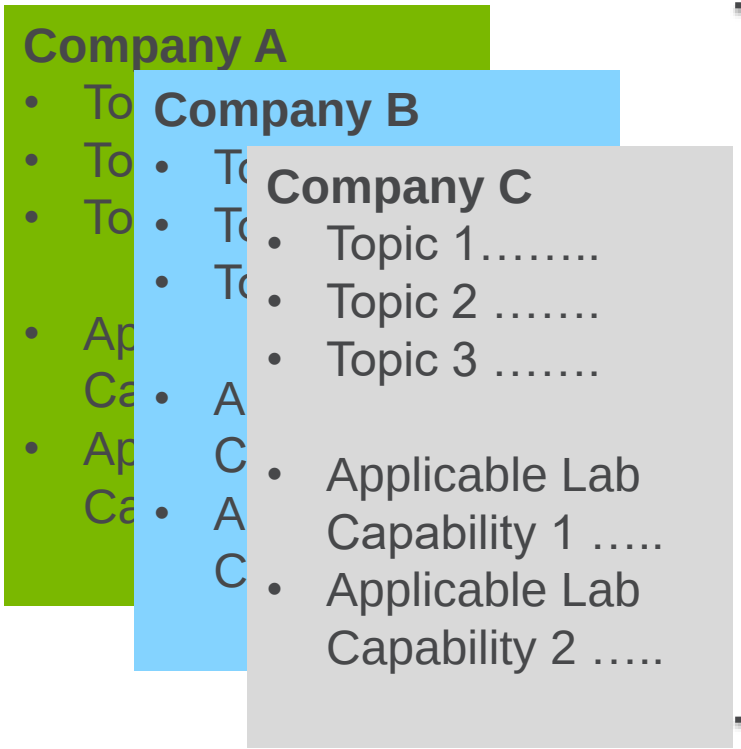
2. Increase fluid power's energy efficiency
   a) Increase energy conversion efficiency in fluid power systems
   b) Develop more energy-efficient fluid power system architectures
   c) Reduce energy consumption of current system architectures
   d) Improve energy recovery methods in fluid power systems
   e) Develop new or improved fluid power components
   f) Improve energy storage capabilities of fluid power components and systems

3. Increase fluid power's power density
   a) Reduce component size/weight without reducing operating pressure and flow
   b) Produce smaller/more integrated components without reducing pressure and flow
   c) Produce higher pressure or additional flow without increasing component size/weight
   d) Integrate component functions/refine system architectures

4. Reduce the environmental impact of fluid power components and systems
   a) Eliminate external leakage in fluid power components and systems
   b) Lower environmental impact of fluid power components and systems
   c) Reduce NVH in fluid power systems to levels lower than prime mover

TIR INDUSTRY SURVEYS

One-on-one discussions with CCEFP industry affiliates to identify topics of interest for collaboration



- Common themes/topics identified & distributed to NLs to identify appropriates capabilities & expertise to discuss with industry.
- Webinar presentations on focused topics
- Brainstorming & development of SOWs - Development of NDAs

TIR INDUSTRY SURVEYS

Example

Topics Discussed	Argonne (GRF) – Intro/Overview of TIR/CCEFP Project.
	
	Topics of interest identified during our initial discussions include vehicle simulation, artificial intelligence/big data/IOT, additive manufacturing/3D printing.
	• Vehicle & System Simulation
	  ○ Modelling and simulation at vehicle level
	  ○ Modelling and evaluation of performance at system level
	  ○ Critical performance attributes – power, efficiency, pressure pulsation/noise, reliability
	• Big Data, AOI, IOT
	  ○ Sensor technologies – what types of data can/should we monitor
	  ○ Data Communication – how do we handle/share data
	  ○ Data processing – how do we handle/process data?
	  ○ Data integration & decision-making – what do we do with the data?
	• Manufacturing – additive manufacturing (AM) – metals and polymers
	  ○ AM of metals
	  ○ Upgrading/enhancing mechanical properties of polymers

Topics Discussed	Argonne (GRF) – Intro/Overview of TIR/CCEFP Project
	• Mid-term 4- 5 year topic on ***mechanistic-based tools*** to predict performance trends for different materials and fluids. Not necessarily interested in brute edisonian testing of different fluids against different materials to generate a database, but rather interested in tools/models of fluid/additive interactions based on material/coating chemical makeup and fluid/additive chemistry
	  ○ Interest in tribofilm formation and performance
	  ▪ Wear, fatigue, scuffing,…
	  ▪ Friction - boundary
	  ○ Interest in bulk fluid property performance (viscosity) – pumping losses, rheological properties at elevated pressures.

COMMON THEMES FROM SURVEYS

- Survey represents input from 13 industrial affiliates that expressed interest in collaborations with National Labs
- Forty-five topics identified – overlap between affiliates
- Grouped responses/topics by product
  - Vehicle OEM/Engineering
  - Component/equipment Manufacturer
  - Additive/Fluid Supplier

Vehicles

- Autonomous vehicles, design, simulation, AI/ML, big data, duty cycles
- Vehicle simulation - modeling - FEA, CFD, Autonomie; dynamic/dyno testing/validation.
- Propel, hydraulic drives/transmissions
- Integration of new/novel architectures into vehicles - electrification, alternative fuels, modular hydraulic loops
- Manufacturing, materials (high pressure)

COMMON THEMES FROM SURVEYS (CONT'D)

Components

- Contamination (debris, water, air) - impact on wear, reliability, performance, fluid properties. Contamination remediation - filtration, separation.
- AI, Big Data, Data Communication (IOT), diagnostics, sensors, data processing, decision making, robotics (algorithms)
- Electrification, new/novel designs & architectures
- Simulation - mechanistic, multiphysics simulation & modeling of performance, dynamic simulation - system level, component-level. Performance prediction - flow, pressure, efficiency. Noise & NVH, CFD of fluid flow.
- Fluids, materials, durability, reliability, manufacturing (AM)

Fluids and Additives

- Mechanistic-based tools/models of fluid/surface interactions
- Fluid properties (current & novel), tribological and rheological properties at elevated pressures
- Additives (environmentally-friendly, low-ash/heavy-metals)
- Fluid Flow - CFD of flow, flow visualization, noise, turbulence, vortex formation
- Fluid/Additive/Coating Interactions

MULTIFACETED OPPORTUNITIES FOR LAB-INDUSTRY COLLABORATIONS

What are the R&D needs and what capabilities does Argonne (NLs) have to address industry needs

Industry Needs

- **Vehicle Level**
  - Autonomy, AI, Big Data, Computing, Communication (IOT), Diagnostics, Prognostics, Efficiency, Electrification, Energy Storage, Engines, Lubricants, Manufacturing, Noise/NVH, Performance, Reliability, Service Intervals
- **Component Level**
  - Autonomy, AI, Big Data, Computing (Simulation), CFD (Turbulence/Vortices), Electrification, Batteries, Energy Storage, New Architectures (Modular), Efficiency, Fluids & Additives, Engines/ICEs, Mechanistics, Reliability/Wear, Sensors, Simulation.
- **Fluids & Materials**
  - Additives, Aging, Chemistry, Coatings, Compatibility, Contamination, Diagnostics, Fluids, Mechanistics, Modeling, Performance, Reliability, Rheology, Turbulence, Vortex Formation, Wear

Collaborative R&D Projects

National Lab Capabilities

- **Discovery & Innovation**
  - DOE MultiLab Fluid Power Project (Fluids, Materials, Coatings), Atomic Layer Deposition, Electrospinning, Characterization (AM), Batteries & Energy Storage
- **Computation & Analysis**
  - High-Performance Computing, Simulation (Autonomie, MaLTESE), CFD, FEA, AI/ML, Big Data. Battery Anode/Cathode AI/ML
- **Engineering & Experimentation**
  - Material & Polymer Synthesis, Manufacturing, Tribology, Reliability, Simulation, Batteries/Energy Storage
- **User Facilities**
  - Xray scattering, Neutron scattering, Electron Microscopy, MERF, AM, Hardware-in-Loop, HPC

NEXT STEPS

- Outreach to National Labs to identify key technologies and players that align with themes identified above.
- Establish connections/introductions between lab personnel and affiliates
  - Host focused webinars to highlight lab capabilities
    - Vehicles
    - Components
    - Additives & Fluids
  - One-on-One discussions & visits as the opportunity arises

COMMENTS & QUESTIONS

- Project Overview & Objectives, National Lab
- NDAs
- Company/Lab Visits
- Were topics (to be sent to NLs) captured correctly?

QUESTIONS & COMMENTS

QUESTIONS ??

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