Event Summary and Key Observations

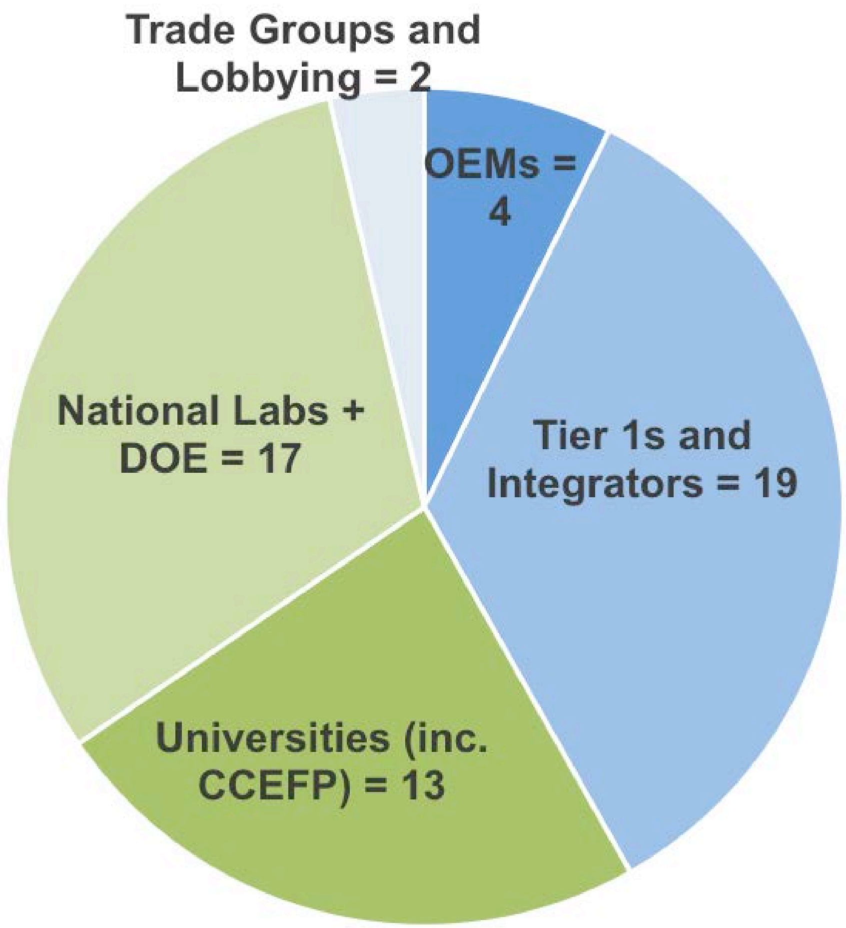
Event: Mobile Fluid Power Workshop

Date: September 12, 2017

Location: National Renewable Energy Laboratory

Participant Overview and Statistics

- 55 Participants
  - OEMs (7%)
  - Tier 1 Suppliers and Integrators (35%)
  - Universities (including CCEFP)(24%)
  - DOE and National Labs (31%)
  - Industry Trade Groups and Lobbying (4%)



Relevant sectors were covered and key stakeholders represented at the event

Workshop Agenda and Structure

- Workshop structured to understand and prioritize the research needs necessary to increase the energy efficiency and reduce emissions of mobile fluid power systems
- Introductions included ongoing needs guidance and research efforts from National Fluid Power Association and the Center for Compact and Efficient Fluid Power
- Introductory presentations on "state of art", insights from other sectors, and OEM perspectives followed by facilitated discussions
- Discussion focused on early-stage, low Technology Readiness Levels (~TRL 2-4) with all comments captured

Agenda structured to capture key low TRL R&D opportunities relevant to DOE Vehicle Technologies Office mission

Summary Concepts and Observations

- Received wide ranging input from stakeholders along the hydraulic fluid power research and development continuum
- Workshop participants identified efficiency opportunities and necessary low TRL research
- Identified opportunities for research across the industry, engaging universities, labs, and industrial partners
- Off-road, mobile fluid power spans a wide range of equipment, with large diversity, versatility, and operational requirements
- Low production volumes for individual equipment types challenge OEMs with development costs and offering equipment improvements with payback periods that are acceptable to customers
- Severe duty cycles, operating conditions, and lifetime/reliability needs challenge direct adoption of some new technologies developed elsewhere

Data Needs

Research Need	Key Observations
Characterization of duty cycles	• Industry feedback stated it was too costly to develop a duty cycle per application due to low volumes and wide diversity • Diverse application and versatility of use result in multiple modes of operation • Instrumentation of the fluid power system (downstream of engine) is challenging • Simulation and modeling require more operating data for development and analysis
Definition and measurement of performance and efficiency	• Unable to compare performance due to varying test methods, environmental conditions (rocks, dirt, payload characteristics etc.), varying operator practice • Need to understand the statistical significance of measured differences • Industry feedback confirmed a need for baseline protocol to compare performance at a system level, components level, and fluid level
Development and definition of standardized equipment level test methods	• Difficult in standardizing equipment level test methods due to diverse applications and operating modes • Concerns of how standardized testing may be used

Industry feedback showed interest in low TRL aspects of characterizing duty cycles in order to develop modeling and simulation tools, as well as standard test methods for defining and comparing efficiency

New Technologies & Architectures

Research Need	Key Observations
New technologies to increase power density of stored energy	• Increasing the power density of energy storage is required, as fluid power has high specific power needs or requirements to begin with • Rate of energy capture, storage, and reuse is equally important • Industry feedback stated a need to reduce the packaging of concepts, and develop scalable and modular concepts for multiple use across multiple applications
New architectures to recover and apply stored energy	• Hybrid concepts with increased power density, light weight, compact packaging, and low cost • Holistic view is critical, as operator control and productivity must be maintained • OEMs have insight as to what applications may benefit most from hybridization and understand how to hybridize; the challenge is most often changing these systems at reasonable cost (vs. benefit)

Both new technologies and new architecture concepts are of interest for OEMs, but require costly validation efforts to verify the operability, reliability, and durability. Cost increases without demonstrable operational savings are a barrier to adoption. Modularity to adopt across multiple applications is an enabler.

New Technologies & Architectures

Research Need	Key Observations
New technology to reduce fluid power system losses	• Interest in technology that converts fuel energy directly to fluid power, minimizing conversion steps • Potential to integrate components to reduce frictional and parasitic losses • Industry expressed interest in a fluid power transformer • Waste heat from engine is also a large “system” loss that may be recaptured to increase efficiency
New architectures to level and reduce the peak system load requirements	• Energy storage to reduce the peak demands on the engine and pump(s) • Multi-modal operating capability defined by load requirement

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Optimization – Fluids, Components & Integration

Research Need	Key Observations
Fluid development and evaluation	• Hydraulic fluid development must balance all system design factors • Need to understand the viscosity impacts from the entire wide range of various operating conditions • Need to understand tribochemical interactions between formulated fluids (additives and basefluids), near-surface properties (mechanical, texture, microstructure, and chemical), and tribological environment to optimize performance. • Extending the lifecycle of the hydraulic fluid to eliminate the need of replacing the fluid and prevent degradation requires fundamental knowledge of degradation mechanisms • Co-development of fluids and components will increase component and system efficiency • Develop an environmentally friendly hydraulic solution to eliminate risks if leaked and disposal requirements • Develop standardized labscale and component test methods to validate and compare performance under consistent prototypical conditions.

Integration of fluids, materials, and component designs to improve efficiency will require component and system-level development and standardized test methods to consistently measure performance

Optimization – Fluids, Components & Integration

Research Need	Key Observations
Component design	• Industry is interested in optimization of component design to reduce frictional losses and has a payback period of less than two years (ex: integrated components) • Need to better understand interaction of fluid and material surfaces (including coating and texture) • Digital concepts that improve pressure control (ex: electronic valve vs. spool valve) • Need to overcome design challenges of durability for severe duty cycles, noise, vibration and harshness of the operating conditions
Integration of fluid monitoring and advanced component design	• Industry agreed that being able to monitor the efficiency of the hydraulic fluid in operation would better define design and development needs based on performance • Real time data collection and telematics integration is difficult and costly • Identify advanced material and coatings to overcome cavitation limits

Integration of fluids, materials, and component designs to improve efficiency will require component and system-level development and standardized test methods to consistently measure performance