

CENTER FOR COMPACT AND EFFICIENT FLUID POWER



A National Science Foundation Engineering Research Center



CCEFP Industry Engagement Committee Face to Face Meeting

March 9, 2018



LEAD



ADVOCATE



INNOVATE



EDUCATE



NETWORK

- Roll call
- Review of anti-trust policy
- Government programs - Stelson
- CCEFP membership campaign - Gust
- Go forward, value-added programs - Sun

ANTITRUST GUIDELINES

It is the intention of the Center for Compact and Efficient Fluid Power (CCEFP) that all activities conducted by its Industrial Advisory Committees and other working groups will be in conformance with all Federal Antitrust Laws.

Areas of particular concern include:

- Any effort undertaken whether expressed or implied, that could be considered to restrain trade or act as a barrier to commerce to any individual or group of individuals will be avoided.
- Meetings of members will be structured. There should be proper notification, agenda, and observance of rules of procedure and minutes of the meeting. Adherence to the business items on the agenda will avoid any appearance of conflict.
- Members must take special care to avoid making statements or engaging in conduct prohibited by CCEFP policy and by-laws. Should members have any doubt concerning the propriety of any matters under discussion at such meetings, they must immediately disassociate themselves from the discussion and, if necessary, leave the meeting.

Responsibility for compliance rests with every member of the CCEFP, NFPA and related committees along with any invited guests or participants. Suspected violations of this notice should be communicated to your company representative or responsible CCEFP employee.

Note: Copies of the CCEFP anti-trust policy available upon request.



ADVOCATE: DOE Program Progress



In response to the FY17 E&W Appropriations Report, DOE:

- Conducted a Sept 12, 2017 workshop to understand and prioritize research needs for fluid power systems for commercial off-road vehicles. <https://www.nrel.gov/transportation/mobile-fluid-power-workshop.html>
- Issued a \$3 million solicitation on Oct 17, 2017 for improving efficiency of fluid power systems. <https://eere-exchange.energy.gov/FileContent.aspx?FileID=cd0ab26c-fd14-4959-8ed8-c6b2b385e7f1>

Pros	Cons
<p>Solicitation was focused on early stage R&D with broad focus</p> <p>Proposals solicited for</p> <ul style="list-style-type: none">• New system architectures• Energy storage and hybridization• High efficiency pumps• Engineered fluids	<p>Only \$3 million of the \$5 million appropriated by Congress was made available through solicitation.</p> <p>Little/no coordination between academia and national labs.</p>



- Funding opportunity announcement (FOA) issued on 10/17/2017
- ~25 concept papers submitted
- Research topics included energy saving fluid power components, systems, new architectures, connected vehicles, tribology and coatings, and off-highway vehicle duty cycles.
- Approximately half of these were encouraged to submit a full proposal.
- Funding announcement just came out.
- Next FOA will take place this fall around the same time as last year.



ADVOCATE: DOE Program Update



- Completed a successful visit to Congress on Feb 6-8 to advocate for increased funding for the DOE Energy Efficiency Research and Development for Fluid-Power Systems in Off-Road Vehicles
- Congressional office meetings visited included
 - Sen. Tina Smith (D-MN), Sen. Amy Klobuchar (D-MN), Sen. Bob Casey (D-PA), Sen. Richard Shelby (R-AL), Sen. Diane Feinstein (D-CA), Sen. Chuck Schumer (D-NY), Sen. Lamar Alexander (R-TN), Sen. Tammy Baldwin (D-WI), Sen. Tammy Duckworth (D-IL), Sen. Richard Durbin (D-IL), Sen. John Boozman (R-AR), Sen. Sherrod Brown (D-OH), Rep. Betty McCollum (D-MN), Rep. Terri Sewell (D-AL), Rep. Robert Aderholt (R-AL), Rep. Cheri Bustos (D-IL), Rep. Marcy Kaptur (D-OH), Rep. David Joyce (R-OH), Rep. David Price (D-NC), Rep. Bill Foster (D-IL), Rep. Charles Dent (R-PA), Rep. Ron Blum (R-IA), Rep. Gary Palmer (R-AL), Rep. David Young (R-IA)
- Primary goal was to ensure \$10 million is included in the FY18 & FY19 budgets for the DOE fluid power research program.
- Secondary goal was to ensure that most of the \$10 million is targeted for university-led research projects in collaboration with industry.
- All meetings were cordial and productive. Many staffers recognized us from previous visits and were readily supportive.



This was our recommendation for the FY18 & FY19 language...

The commercial off-road vehicle sector, including industrial, mining, and farm equipment, consumes over 2 Quads of energy per year. The Department is directed to establish a dedicated activity to reduce the energy consumption of commercial off-road vehicles. No less than \$10,000,000 shall be used to issue a competitive solicitation for university/industry led teams to improve the energy efficiency of fluid power systems for commercial off-road vehicles.



DOE programs announced



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Office of Energy Efficiency & Renewable Energy

Department of Energy Announces \$12 Million in Early-Stage Research for Natural Gas Engines and Off-Road Fluid Power Systems

- \$4 million to support three new cost-shared research projects focused on medium- and heavy-duty, on-road natural gas engines.
- \$3 million to support two new cost-shared research projects for advancing fluid power systems for off-road vehicles.
- Complemented by \$5 million in early-stage research at DOE's National Laboratories.
- Engine research compliments CCEFP off-road vehicle research initiatives.



DOE programs announced – Natural gas engines



- Colorado State University (Fort Collins, Colorado) will receive \$1.2 million to research ultra-low emissions, high-efficiency heavy-duty natural gas engines with optimized combustion chamber designs.
- University of Houston (Houston, Texas) will receive \$2 million to develop a new class of catalysts with low levels of precious metals for natural gas engine emissions control.
- University of Minnesota (Minneapolis, Minnesota) will receive \$1.1 million to advance low temperature combustion technologies for higher-efficiency natural gas engines.
- DOE is supporting \$3 million in early-stage research among several National Laboratories.
 - Pacific Northwest National Laboratory (PNNL) and Oak Ridge National Laboratory (ORNL) are researching active and durable catalysts for low temperature methane oxidation to enable efficient CNG engines.
 - Argonne National Laboratory (ANL), National Renewable Energy Laboratory, ORNL, and Sandia National Laboratories are working collaboratively to research fundamental in-cylinder and emissions-control advancements for higher-efficiency medium-/heavy-duty natural gas engines.



- Purdue University (West Lafayette, Indiana) will receive \$1.5 million to research a new architecture for fluid power systems in off-road vehicles that significantly reduces power losses and lower energy consumption by 70%.
- University of Minnesota (Minneapolis, Minnesota) will receive \$1.4 million to research a variable displacement motor for the off-highway market that reduces fuel consumption by 30% while increasing power density.
- DOE is supporting \$2 million in early-stage research on mobile fluid-power systems.
 - ANL, ORNL, and PNNL are developing high performance fluid additives and coatings to improve efficiency, durability, and environmental compatibility of off-road hydraulic fluids and components.

Prime Applicant: PURDUE UNIVERSITY (Control #1815-1511)
Project Title: Individual Electro-Hydraulic Drives for Off-Road Vehicles

Principal Investigator:	Andrea Vacca, Associate Professor Maha Fluid Power Research Center Purdue University
Key Partners:	Scott Sudhoff, Purdue University Gary Kassen, Case New Holland Industrial Uwe Neumann, Bosch Rexroth
Proposed Project Duration:	36 months

Proposed Objectives:

To develop and demonstrate an electro-hydraulic technology that, with respect to current state-of-the-art solutions for off-road vehicles, can:

- Lower power consumption of the fluid power system up to 70%
- Reduce vibrations, up to 60%, and noise up to 10dBA
- Allow for “zero emission” operation of the vehicle (engine off)
- Enable “smart actuators”, operating as modern “plug & play” elements with integrated control and self-diagnostic functions

Project Impact/Takeaway:

- The proposed technology promotes vehicle electrification, and merges the advantages of Fluid Power (high power-to-weight ratio) with those of Electric technology (connectivity, ease of control)
- The proposed technology eliminates almost completely power loss due to fluid throttling, which is typically the main factor affecting the low energy efficiency of current fluid power systems
- The project proposes an electro-hydraulic pump/motor concept that enables the application of the proposed technology to off-road vehicles

Key Deliverables/Accomplishments:

- Fabrication and test of prototypes of smart electro-hydraulic actuators
- Proof of concept of the proposed electric hybrid architecture on two off-road vehicles: an agricultural tractor and a wheel loader

	Federal Share	Recipient Share
Total Project Cost	\$1,919,142	
Total Shares (Prime+FFRDCs+Sub-Recipients)	\$1,500,000	\$419,142
Prime	\$983,780	\$260,423
FFRDCs Total	\$0	\$0
Subrecipients Total	\$516,220	\$158,719

This space reserved for EERE use.

Efficient, Compact, and Smooth Variable Propulsion Motor

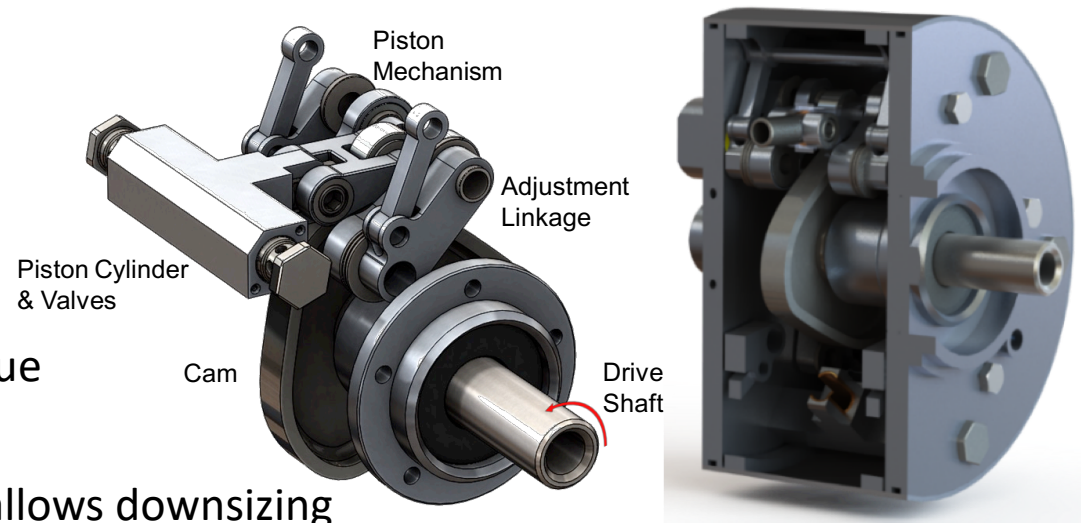
Objectives:

Variable displacement motor with:

- Efficiency $>90\%$ above 15% displ.
- Reduce fuel consumption 30%
- Power density >5 kW/kg
- Torque ripple $<5\%$ of the mean torque

Project Impact/Takeaway:

- High efficiency and smooth torque allows downsizing traction motor
- A traction motor with variable displacement enables:
 - Hybridization of the drive train = Improved efficiency and performance
 - Efficiency improvement by optimizing drive train as a system
 - High-speed “roading” between tasks
- Highly-scalable and applicable a wide variety of off-highway vehicles



Team:

James D. Van de Ven, Univ of MN

Perry Y. Li, Univ of MN

Thomas R. Chase, Univ of MN

Paul Michael, MSOE

Hongbin Wang, Eaton

Gunter Matt, Bobcat



NSF Emerging Frontiers in Research and Innovation: Continuum, Compliant, and Configurable Soft Robotics Engineering (C3 SoRo):

- Full proposal deadline was February 23
- Several CCEFP proposals were submitted

DOD Advanced Robotics for Manufacturing (ARM) Institute

- Fall Call for Proposals (CFP) is now closed
- Expect a Spring 2018 CFP to be announced
- CCEFP is not focusing on ARM funding
- If an industry supporter comes forward we will partner with them

DOD Multidisciplinary University Research Initiatives (MURI)

Program for coatings, fluids and tribology

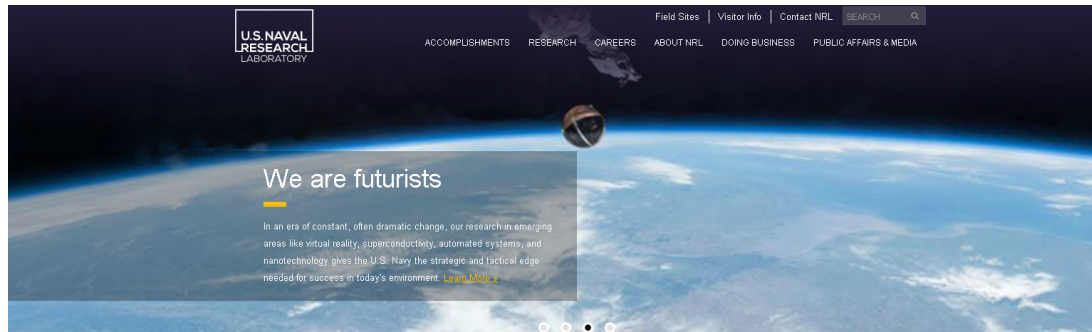
- Preliminary discussions with Prof Gareth McKinley of MIT
- DOD visits planned for April and May



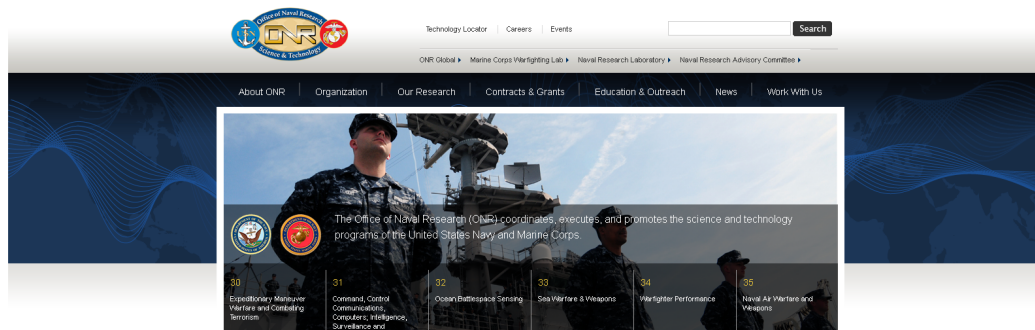
ADVOCATE: DOD Program Update



U.S. Army Research Office – Mechanical Sciences
Divisional Chief: Dr. Ralph A. Anthenien



Us Naval Research Lab
Dr. Kathryn J. Wahl,
Head of the Molecular
Interfaces and Tribology
Section, STLE Fellow



Office of Naval Research
Dr. Julie Christodoulou,
Director of the Naval
Materials Science and
Technology (S&T) Division



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IMMEDIATE RELEASE

Defense Department Awards \$163 Million in University Research Funding

Press Operations

Release No: NR-132-17

April 14, 2017

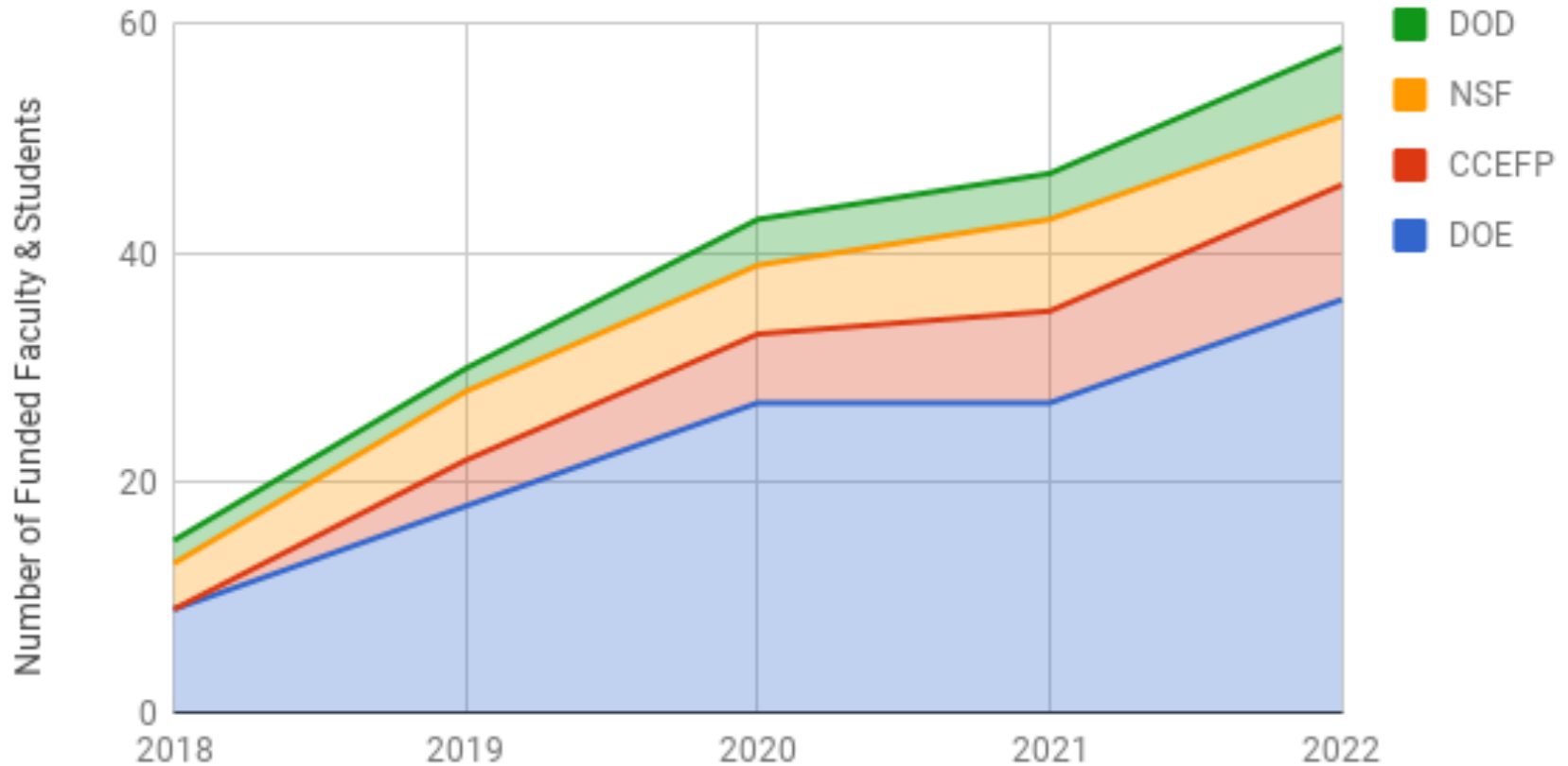
US DOD MURI program

- In 2017, 23 awards totaling \$163 million were announced
- FY2018 proposal deadline was 11/1/2017.
 - Research topics are not a good fit for CCEFP.
 - Need to influence the FY19 research topics.
- Only academic institutions can apply
- Five year awards
- MURI Program Manager:
Dr. Ellen Livingston
MURI Program Manager
Office of Naval Research



Fluid Power Sponsored Research -- All Agencies

Anticipated Trends of Fluid Power Research





- **Effective July 1, 2018 Prof Sun will assume the role of Director for the CCEFP**
- **Prof Stelson will transition to the role of Founding Director and CCEFP Ambassador**
 - He will be available for regular consultation on strategic issues.
 - He will assist with ongoing government advocacy efforts.
 - When appropriate he will represent the Center on behalf of the Director.
- **Effective July 1, 2018 Mike Gust will transition to a part time role focused on industry relations**
 - He will assume a 25% minimum appointment for CCEFP duties
 - He will also focusing on commercializing CCEFP research
 - Mike will support Prof Sun and Alyssa Burger on CCEFP industry related activities
- **CCEFP Future State**
 - The Center will be led and administered by a Center Director + 1 FTE of staff support
 - Operating expenses will be less than \$200,000 per year
 - CCEFP will implement a Strategic Advisory Council consisting of the Director, CCEFP Ambassador, Deputy Directors, industry relations rep, IEC Chair and IEC Vice Chair

Membership Campaign Update



LEAD: New CCEFP



- All industry members have equal rights and membership benefits, including a seat on the Industry Engagement Committee.
- Associations and Trade Press may join the IEC with restricted rights
- Membership dues are scalable based on the sales content of fluid power sales manufactured (i.e., not purchased) or, in the case of associations and press, a fixed fee.
- Industry dues can be designated for research areas chosen by the IEC.
- The IEC will provide industry perspective to key CCEFP activities, such as research areas of focus, project selection, and project progress.
- CCEFP Director will provide leadership for the strategic, research and administrative functions of the CCEFP.
- CCEFP support staff will assist the Director in implementing the strategic direction, guiding the research process and administering the day-to-day operations.
- CCEFP expenses will be capped at \$200,000 max through job share opportunities, part-time employment, external grants, gifts, etc.

CCEFP Sponsorship Structure (Previous)



Company size	Annual global fluid power sales	CCEFP Sponsorship
Very Large	Over \$1.5 billion	\$60,000
Large	Between \$500 million and \$1.5 billion	\$40,000
Medium	Between \$50 and \$500 million	\$20,000
Small	Between \$10 and \$50 million	\$10,000
Start-Up	Below \$10 million	\$1,000
Sponsorship Responsibilities & Opportunities		
Recommend the selection of pre-competitive CCEFP-funded fluid power research projects		✓
Invitation to CCEFP Summits, Fluid Power Innovation & Research Conference, and other special events		✓
Participation in Industry Engagement Committee monthly teleconferences, research, and special topic webinars		✓
Early access to research progress and results		✓
Networking opportunities with students, faculty, and other industry supporters		✓
Notification of government funding programs and industry/academic partnerships		✓
Leverage government relations initiatives creating fluid power research programs		✓
Optional tax-deductible donation		✓
Sponsorship Supports		
CCEFP research projects, events, fluid power government relations programs, webinars, supplemental research grants, travel, and operations		✓

CCEFP Research Collaborator Sponsorship Structure

Published March 14, 2018



OEMs, Manufacturers, and Suppliers Annual global fluid power sales from products manufactured	CCEFP Sponsorship	Distributors, Associations, Small Business/Start-ups, Trade Press	CCEFP Sponsorship
Over \$1.5 billion	\$60,000	Distributors	\$7,500
Between \$500 million and \$1.5 billion	\$40,000	Associations*	\$2,500
Between \$50 and \$500 million	\$20,000	Small Business / Start-Up**	\$1,000
Under \$50 million	\$10,000	Trade Press***	\$500
Sponsorship Responsibilities & Opportunities			
Recommend the selection of pre-competitive CCEFP-funded fluid power research projects			✓
Invitation to CCEFP Summits, Fluid Power Innovation & Research Conference, and other special events			✓
Participation in Industry Engagement Committee (IEC) monthly teleconferences, research, and special topic webinars			✓
Early access to research progress and results			✓
Networking opportunities with students, faculty, and other industry supporters			✓
Notification of government funding programs and industry/academic partnerships			✓
Leverage government relations initiatives creating fluid power research programs			✓
Regular dissemination of CCEFP news and reports			✓
Sponsorship Supports			
CCEFP research projects, strategic initiatives, events, fluid power government relations programs, webinars, supplemental research grants, travel, and operations			✓

*The definition of annual global fluid power sales from products manufactured include the market value of fluid power components and systems manufactured internally; this definition does not include fluid power components and systems purchased. *Association representatives do not advise research project selection. **Total annual global fluid power component and system sales under \$10 million. ***Media representatives do not advise on research project selection and do not attend closed-door IEC meetings.*



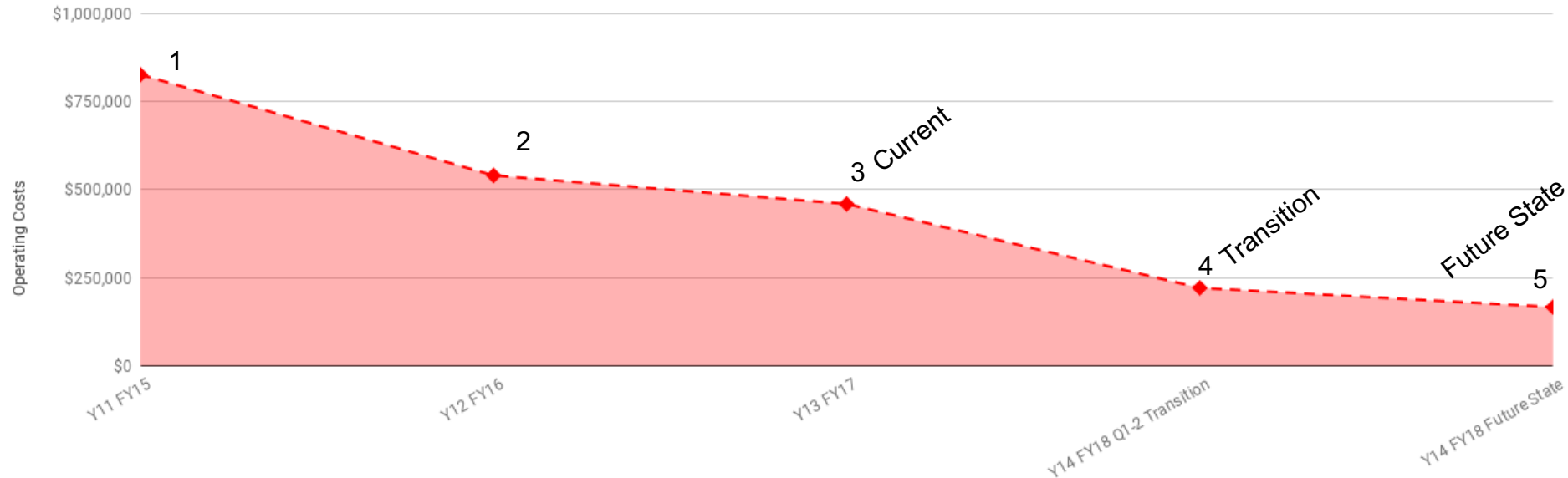
LEAD: CCEFP Leadership Transition Plan



1. Director + 3 FTE Staff + full indirect
2. Director + 3 FTE Staff + 0% indirect
3. Current: Director + 2 FTE Staff + 0% indirect
4. Transition: Director + 1.25 FTE Staff + 0% indirect
5. Future State: Director + 1 FTE Staff + 0% indirect = \$200,000 or less

CCEFP's Transition Plan & Future State

CCEFP's plan includes reorganization and decreased administrative expenses



Revenue forecast



Row Labels	Apr 2017	Apr 2017	Jan 2018	Jan 2018	Mar 2018	Mar 2018
	Est Number	Est Support	Est Number	Est Support	Est Number	Est Support
Current Supporter	43	\$818,000	22	\$ 425,500	23	\$415,500
1 - Very Large	5	\$250,000	3	\$ 180,000	3	\$180,000
2 - Large	8	\$240,000	5	\$ 100,000	5	\$ 80,000
3 - Medium	17	\$255,000	7	\$ 110,000	8	\$120,000
4 - Small	10	\$ 70,000	6	\$ 34,500	6	\$ 34,500
5 - Start-up	3	\$ 3,000	1	\$ 1,000	1	\$ 1,000
Newly Identified Companie:	6	\$109,000	4	\$ 32,000	7	\$ 35,500
1 - Very Large	1	\$ 50,000		\$ -		\$ -
3 - Medium	3	\$ 45,000	1	\$ 20,000	1	\$ 10,000
4 - Small	2	\$ 14,000	1	\$ 10,000	1	\$ 10,000
(blank)		\$ -	2	\$ 2,000	5	\$ 15,500
Grand Total	49	\$927,000	26	\$ 457,500	30	\$451,000

Most Probable:
 Industry members
 80% of Current Supporter Total
 90% of Newly Identified Co's Total

37
\$ 654,400
<u>\$ 87,200</u>
<u>\$ 741,600</u>

- New MA results in 4 more members but is revenue neutral.
- Both approaches are ~\$200k short of initial revenue goal.

Note: this plan should allow for funding of 2 research projects this fall. A call for proposal must be announced soon. The CFP topics and research projects chosen for funding can be led by the IEC.

Membership agreement drive



- **Next week**
 - Update membership agreement to reflected survey and closed-door meeting discussions and redistribute.
- **March – April**
 - Facilitate signed collaboration agreement campaign
 - Legal company name and mailing address.
 - CCEFP rep name, title, email and mailing address.
 - Authorizing rep name, title, email and mailing address.
 - Accounts payable name, phone number, email and billing address.
 - Identify who should receive our invoice, preferred method of receipt, preferred payment method and preferred billing cycle.
 - Self identify which appropriate sponsorship level based on latest criteria.
- **May – June**
 - Distribute invoices with a due date of July 1 and net 30 terms

Discussion & Feedback

Looking forward: long term vision



Provided more value to our stakeholders through high quality research and training of graduate students.

- Focus on growing our research portfolio by bringing in additional resources through government programs such as the DOE off-highway and NSF I/UCRC programs.
- Drive down CCEFP administration costs with a goal of \$0.
- Grow the number of industry members, especially OEMs.
- Operate under a heightened sense of urgency.

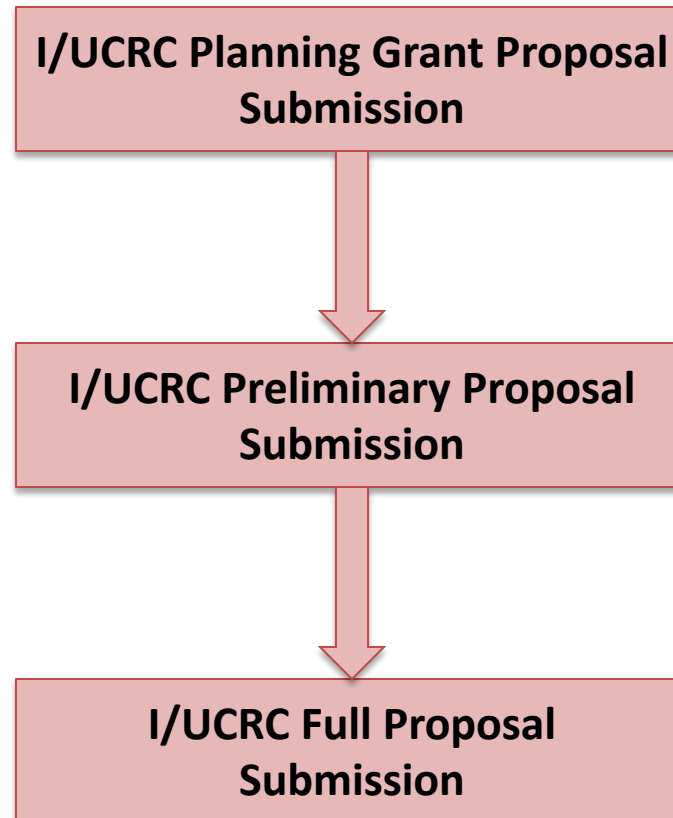
How will this be accomplished?

- Support two research projects this fall in areas identified by the IEC.
- Visiting existing and potential industry members for research collaboration and recruitment.
- Continue to foster the DOE off-road vehicle fluid power research program and to engage our industry members for research under this program.
- Explore additional venues in government agencies that are compatible with CCEFP to grow our research portfolio.

- Grow and expand fluid power research into off-road vehicles.
- Research focus to include power generation, power transmission, vehicle motion control, fluids, etc.
- Leverage existing UMN engine lab infrastructure.
- Use the administrative support provided by NSF to oversee both the I/UCRC and CCEFP.
- Become the leading academic candidate for DOE off-road funding and other government funding opportunities.

I/UCRC Application Process

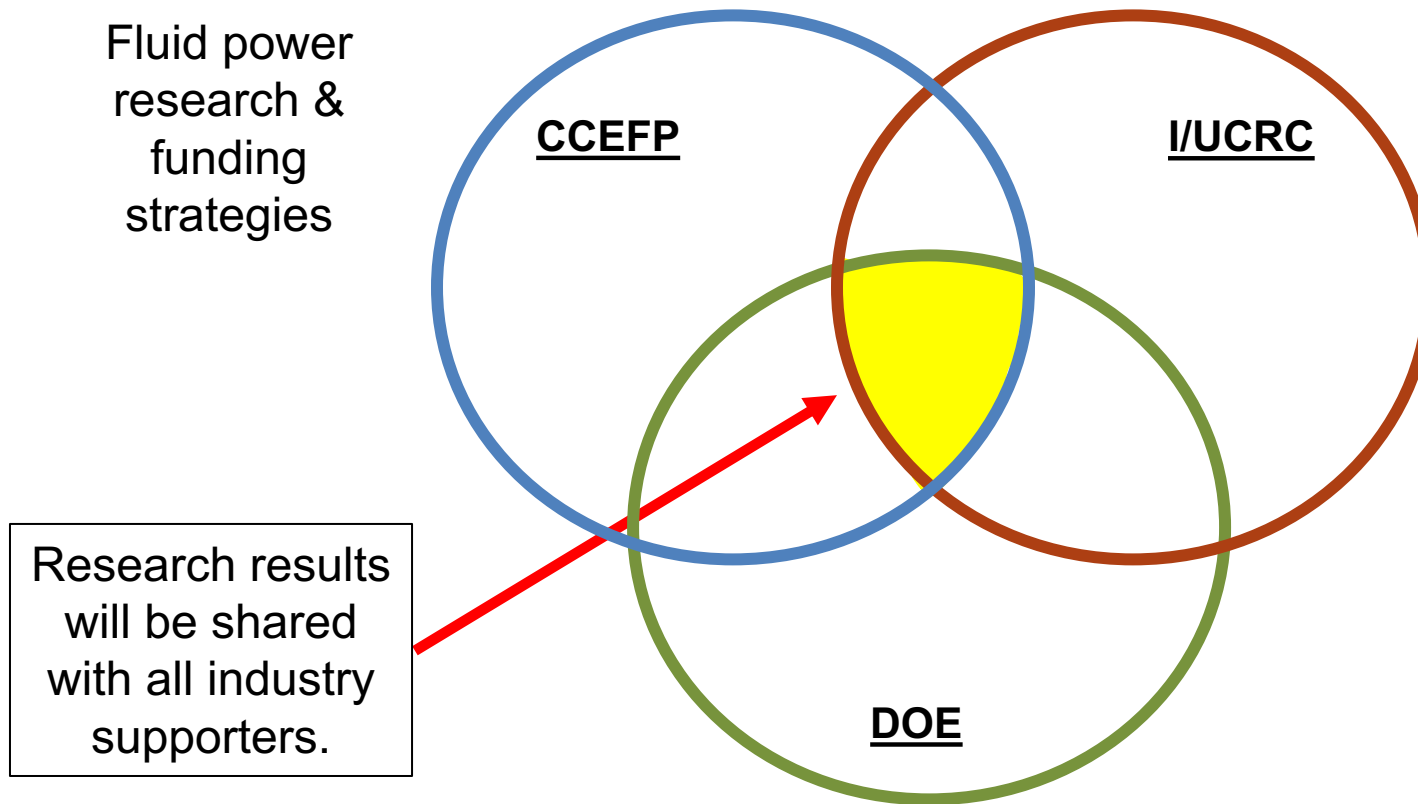
In order to qualify to become an I/UCRC, all member universities must first apply for and receive a planning grant and complete the I/UCRC “boot camp”.



Provides synergistic leverage

Fluid power
research &
funding
strategies

Powertrain
research &
funding
strategies



Research results
will be shared
with all industry
supporters.

Off-highway vehicle fluid power efficiency
improvement research

Discussion & Feedback