Project 2E: Component Integration for Compact Fluid Power Systems

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What fluid power-related question is being answered?

- How can one most effectively represent design knowledge about fluid power systems?
- How can one capture analysis knowledge about fluid power components from multiple disciplinary perspectives and at multiple levels of abstraction?
- How can one use fluid power models at different levels of fidelity to search the system design space most efficiently?

How does this fit into the Center’s overall strategy?

- Enable designers to make efficient and effective comparisons of different system architectures relative to their preferences for system-level trade-offs → Efficient Systems and Compact Integrated Systems
- Enable the evaluation of the impact of introducing new component technologies → Efficient Components
- Enable the fluid-power industry to predict the impact of technology trends on overall system performance → Efficient Systems and Compact Integrated Systems

On which test bed will it be demonstrated?

- The model-based systems engineering approach for fluid-power systems will be used to perform a thorough exploration of the space of system architectures for both TB1 (Excavator) and TB3 (Hydraulic Hybrid Passenger Vehicle)

Main idea: Formally define models that capture knowledge about fluid power systems.

- Formal models of system, requirements, and test cases
- Models represented in a general purpose modeling language: OMG SysML™
- Model Transformations automatically generate additional models
  - Descriptive and Analytical Models
  - GAMS (General Algebraic Modeling Language) for:
    - Cost, Mass, and Steady-State Analysis Models

What progress has been made?

- **ModelCenter Framework**
  - GAMS and SysML
    - Defined a method for formulating hydraulic systems in terms of declarative algebraic models
    - Acausal Mathematical Programming approach instead of imperative Simulation-based Optimization
  - **Hydraulic Hybrid Vehicle (TB3)**
    - Formulated dynamic model of TB3 as a Mathematical Programming problem
    - Approximated differential equations with algebraic differences
    - Initial results using MINLP solvers are promising
  - **Value of Information Variable-Fidelity Modeling Framework**
    - Defined a method for incorporating multiple models into a Gaussian process surrogate model
    - Proposed using of Value of Information to determine design sites of interest for front end exploration

**Publications**


Who are the industry and university collaborators?

- **University**
  - Linköping University
  - Univ. of Darmstadt
  - Univ. of Stuttgart
  - Univ. of Bath

- **Industry**
  - Deere & Co., Sauer-Danfoss
  - Lockheed Martin, No Magic Inc., Phoenix Integration