



Systems Realization Laboratory

Model-Based Systems Engineering

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Research Scope and Focus

- **Research Area**
 - Modeling and Simulation in Design
- **Application Focus: Systems engineering**
 - Fluid power systems
 - Mechatronic systems
- **Research Focus**
 - Decision theory
 - Modeling and Simulation
 - Model Management

Create Value

- **Increase Benefit**
 - By using models more effectively to support decision-making
- **Decrease Cost**
 - By managing models more effectively
 - ◆ Reuse
 - ◆ Modularity
 - ◆ Composition



MBSE Example Problem: Hydraulic Systems

Given:

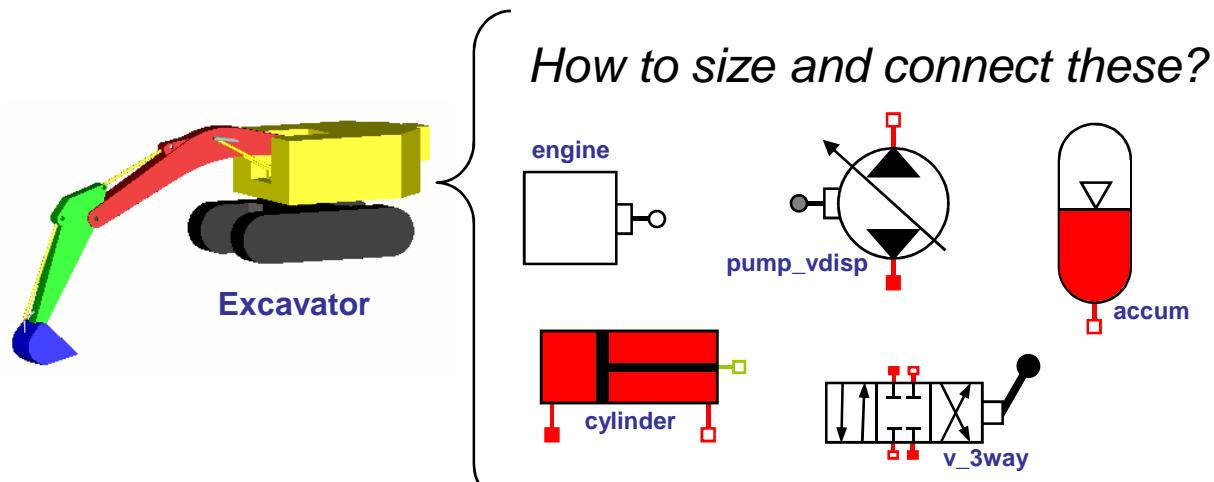
- Primary components
- Decision objectives / preferences

Find:

- Best system topology
- Best component parameters

➤ Very large search and optimization problem

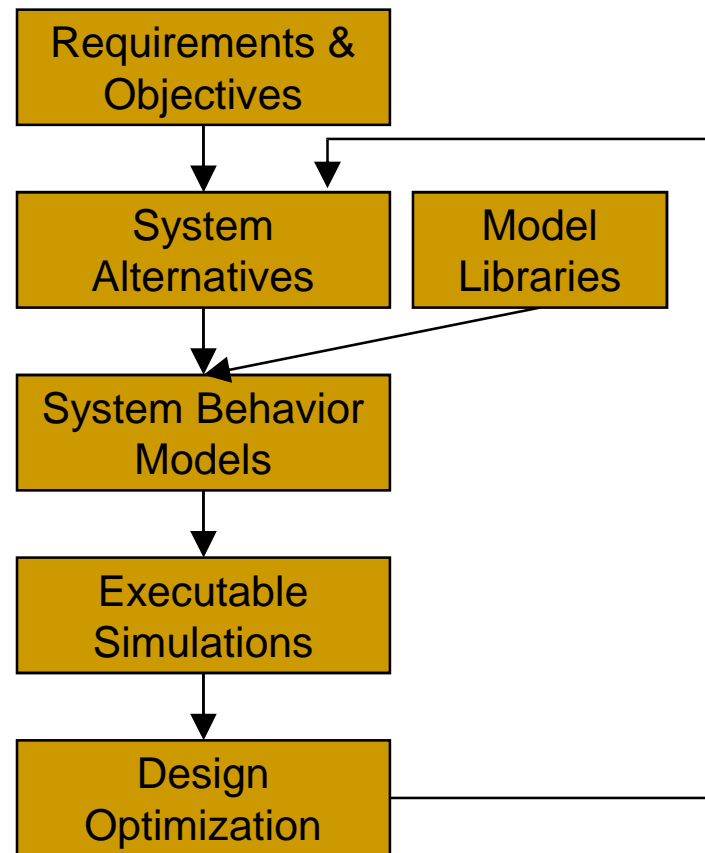
- Many competing objectives
- Many topologies
- Many component types/sizes
- Many control strategies



How do we best capture and use the system design knowledge?

Model-based Systems Engineering (MBSE)

MBSE: Model formally all aspects of a systems engineering problem



Effective and Efficient Analysis of Alternatives

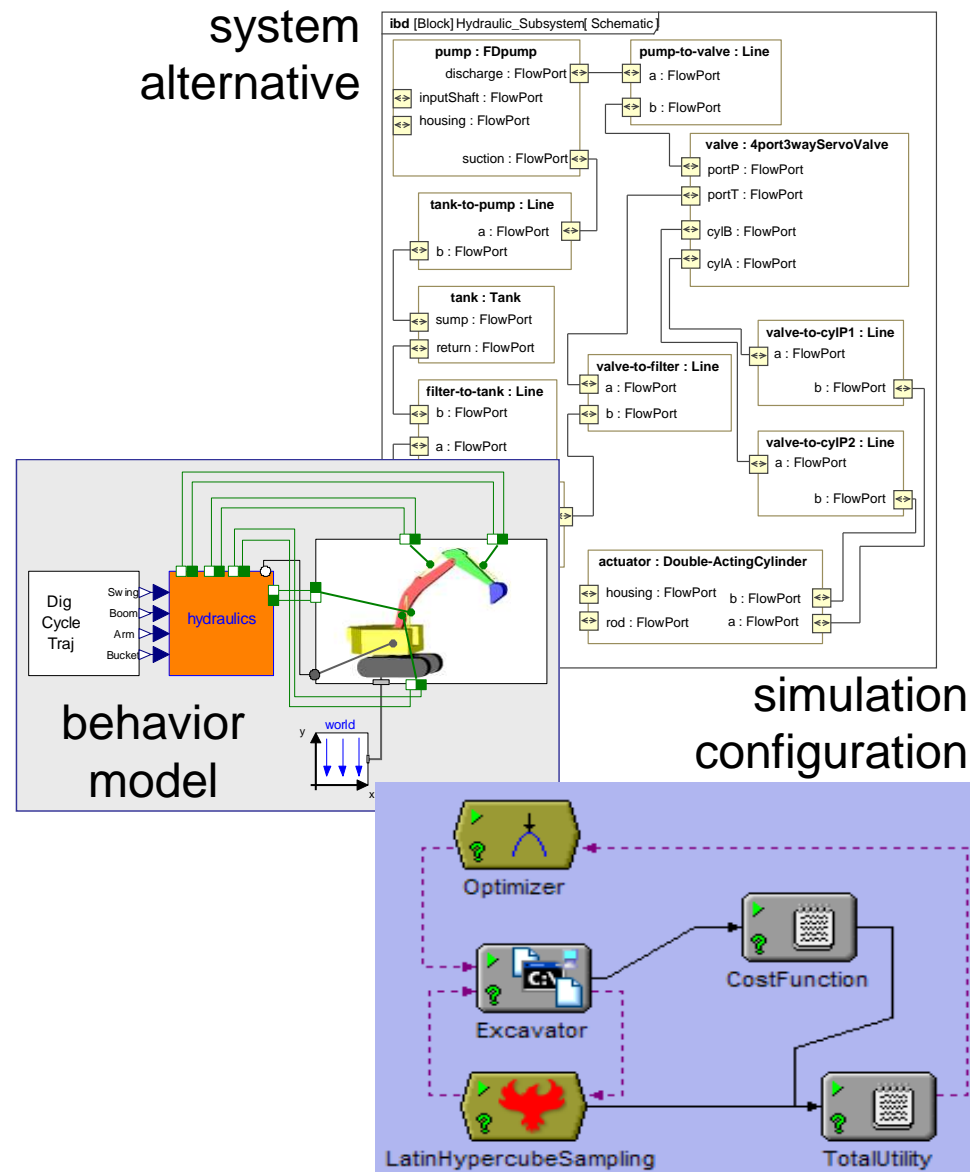
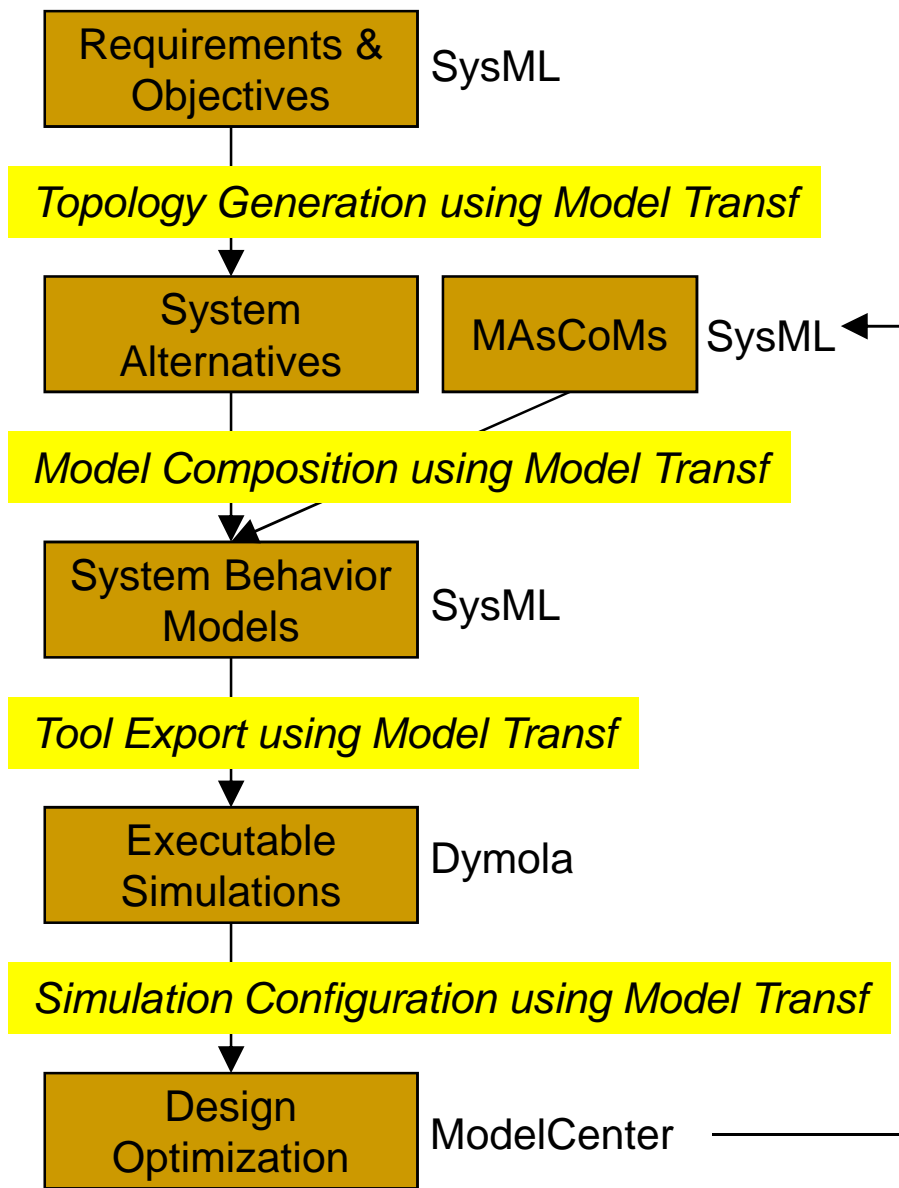
- Model from different perspectives
- Model at different levels of abstraction
- Multiple formalisms
- Variable-fidelity modeling
- Model reuse & modularity

Effective Generation of Alternatives

- Graph transformations for generating plausible system architectures
- Automated generation of system models



Approach: Modeling and Model Transformations



Other Model-Related Activities

■ **OMG → SysML**

- SE DSIG — Systems Engineering Domain Special Interest Group
- Lead a working group on Modelica-SysML integration

■ **Conferences**

- Workshop on Model-Based Systems Engineering at ASME IDETC/CIE in San Diego (Sept 09)
- EOOLT'09 Workshop at MODELS'09 in Denver (Oct 09)
- Modelica'09 in Como, Italy (Sept 09)



Discussion Topics of Interest

- **Formalization of systems engineering problems in terms of models and transformations**
 - Models for the problem, the solution space, the analysis models, etc.
- **Synthesis knowledge – generating plausible solutions**
 - Generative grammars: how to encode/enforce constraints?
 - How is expert knowledge most easily encoded?
 - Generating all and only relevant solutions
- **Meta-information about models**
 - Applicability and validity — model context
 - Fidelity, abstraction, accuracy
- **Maintaining consistency between models / model views**
 - Not all the information is stored in a single model

