



System Model Simulation - Monte Carlo, Probabilities, and more...

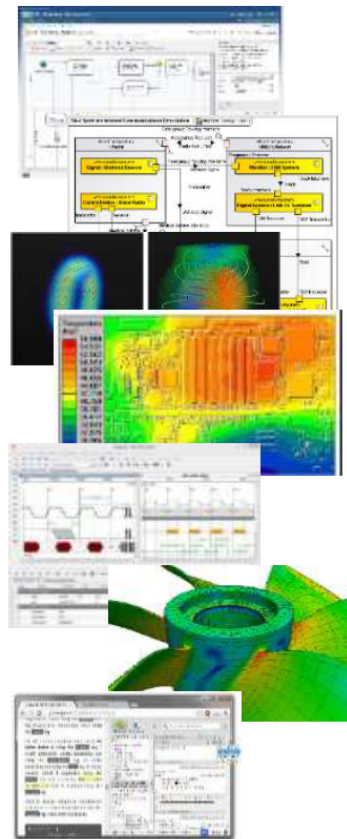
Dr. Saulius Pavalkis, Chief MBSE Solutions Architect



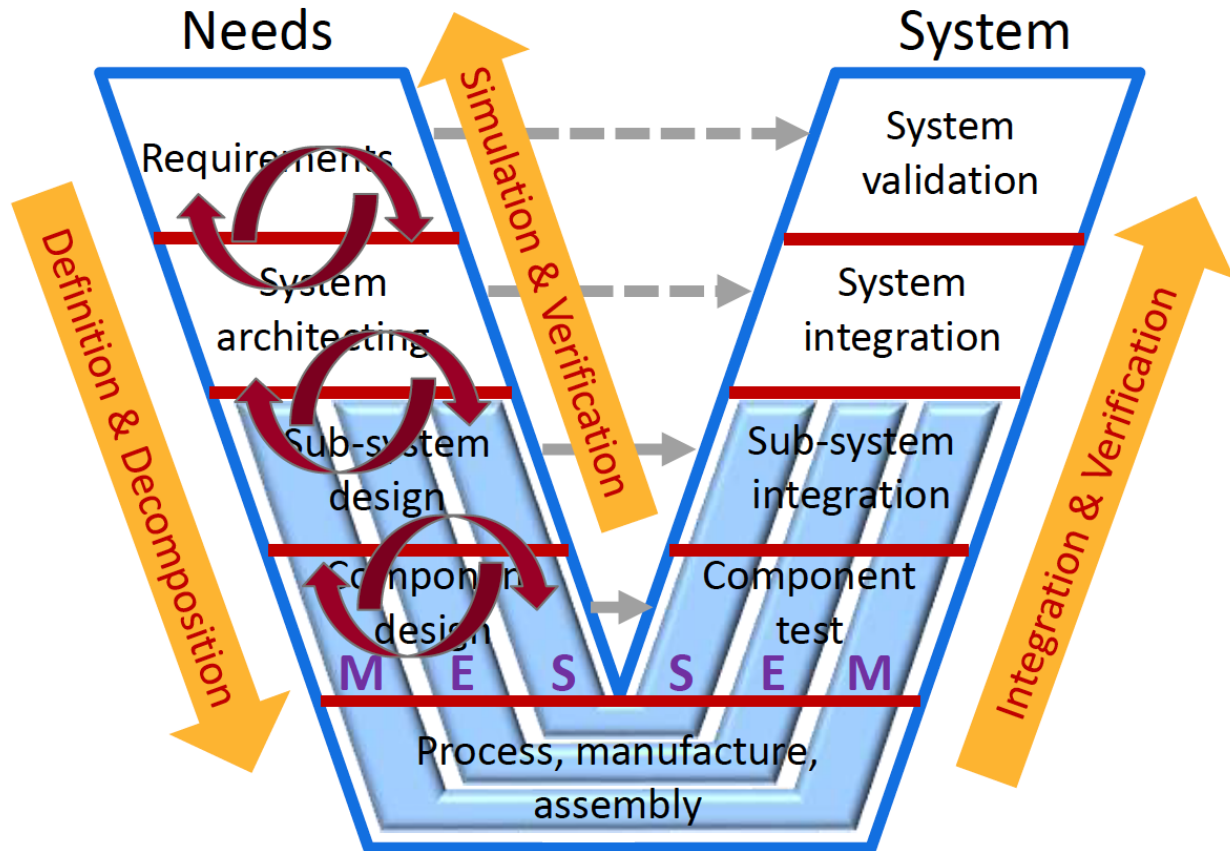
The purpose of a simulation is to **gain system understanding without manipulating the real system**, either because it is not yet defined or available, or because it cannot be exercised directly due to cost, time, resources or risk constraints.

Simulation is typically performed on a model of the system.

System engineering process (V process)



REQ model
SysML model
Simulation
AML/Software
MCAD
ECAD
Timing
Thermal
Stress
etc.

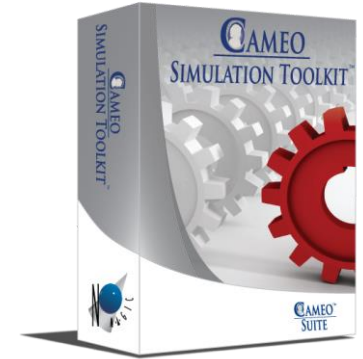


Credits: Pawel Chadzynski & Michael Pfenning - MBSE and the Business of Engineering

Cameo Simulation Toolkit



- Model execution framework for MagicDraw
 - Model debugging and animation environment
 - Pluggable engines, languages and evaluators
 - User Interface prototyping
 - Co-simulation orchestration
- The standard based model execution of:
 - Activities (OMG fUML standard)
 - Composite structures (OMG PSCS)
 - Statemachines (W3C SCXML and OMG PSSM standards)
 - Actions/scripts (OMG ALF, JSR223 scripting)
 - Parametrics (OMG SysML standard)
 - Sequence diagrams (OMG UML Testing Profile)

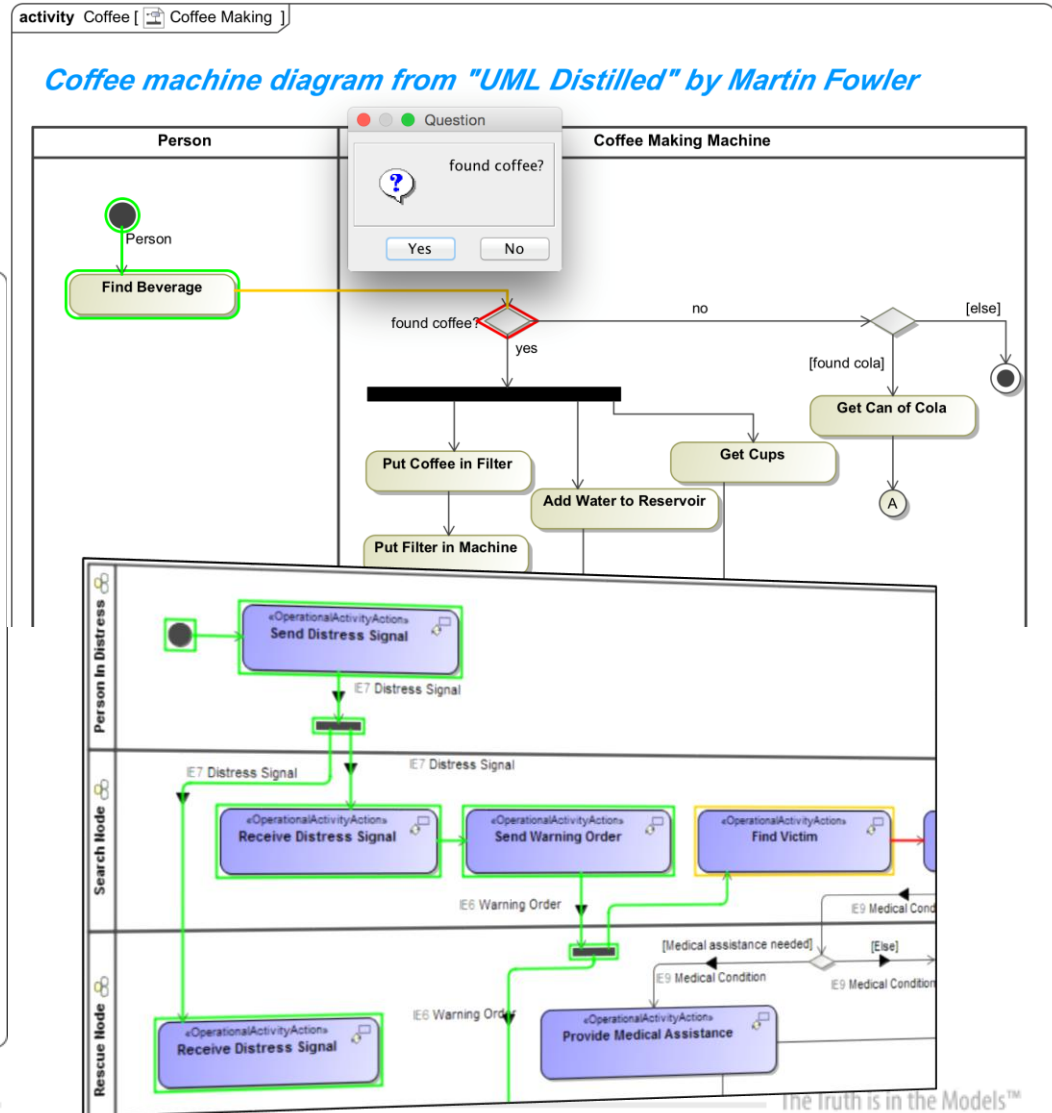
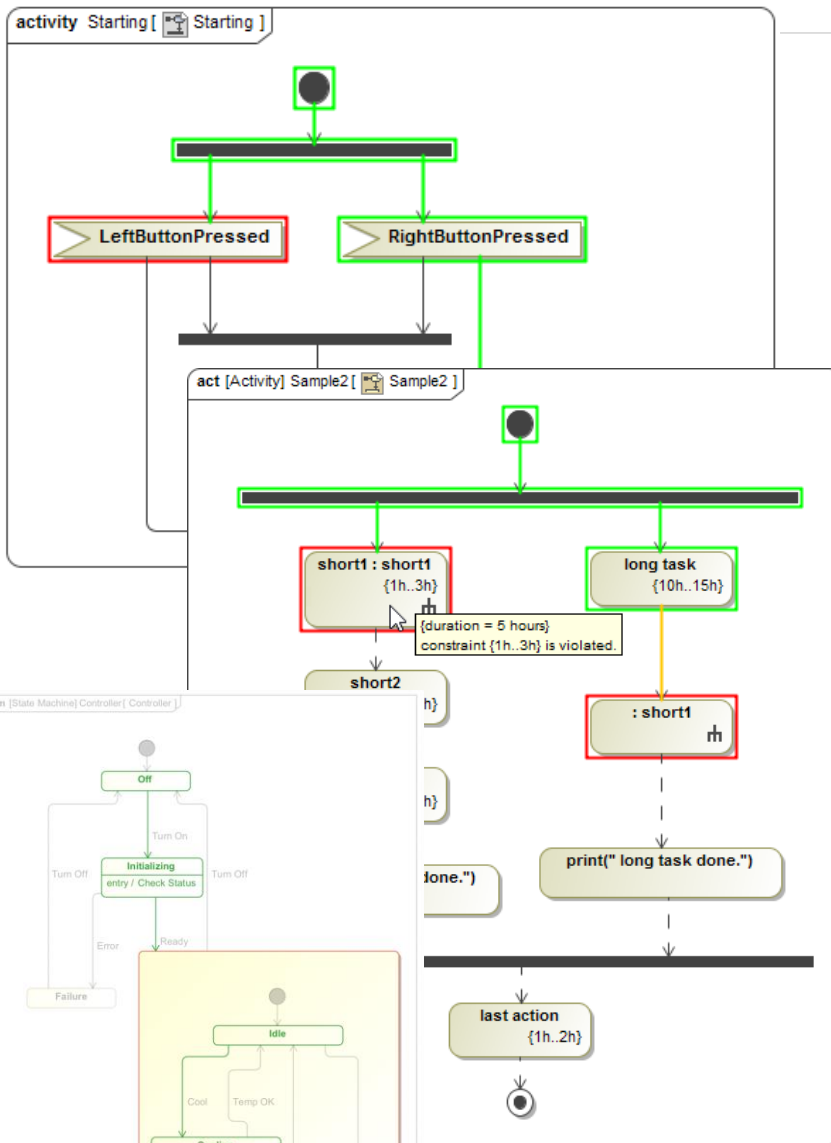


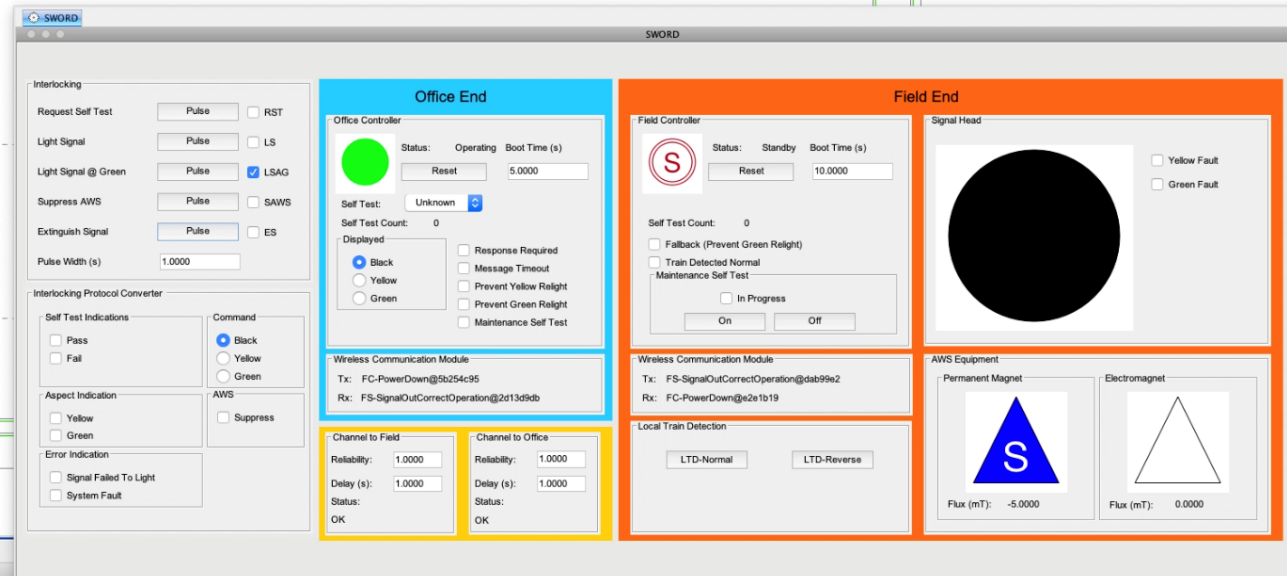
Engineering analysis



- Automated Requirements Verification
- Trade studies / trade-off analysis
- Mass/cost/power rollups
- Timing and duration analysis
- Monte Carlo analysis
- Model-based testing
- Co-simulation environment

Simulation and Analysis





GUI examples



The collage displays several distinct GUIs:

- Power Control Interface:** Features a voltage meter (220V), a consumption meter (0), and a manual power switch labeled 'Actif' and 'Inactif'. It also includes three small display screens showing different data points.
- Train Control HMI:** A central interface with 'LEFT DOORS' and 'RIGHT DOORS' sections, each with 'RELEASE' and 'CLOSE/INTERLOCK' buttons. It also features a 'TCMS HMI' section with a central display and various status indicators.
- Solar Panel Control System:** Includes a 3D model of solar panels, a 'Night/Cloudy/Sunny' weather selector, and a 'CBW (Left)' section with 'Cab Door A' and 'Key Switch' controls.
- Internal Variables Panel:** A detailed panel with multiple sections for 'CBTC', 'EDCU', and 'CTC', each containing numerous boolean and numerical variables with their current states.
- Passenger Vehicle Controls:** A section with 'EXTERNAL DOOR' and 'INTERNAL DOOR' controls, including 'LOCK DOOR' and 'UNLOCK DOOR' buttons.
- SysML State Machine Diagram:** A complex diagram showing states, transitions, and events, with a 'Régles' (Rules) panel on the right for configuration.
- Train Display:** A digital display showing train status, including '01' and '02' indicators.

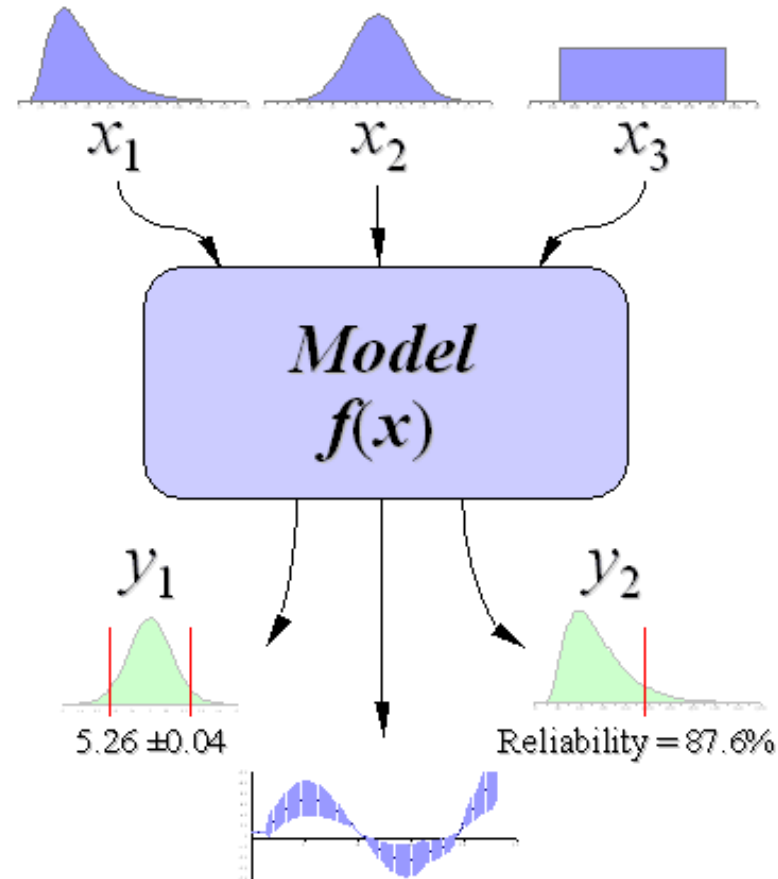


Monte Carlo Analysis

Monte Carlo - Uncertainty Propagation



The Monte Carlo method is a method for analyzing uncertainty propagation, where the goal is to determine how random variation, lack of knowledge, or error affects the sensitivity, performance, or reliability of the system that is being modeled.



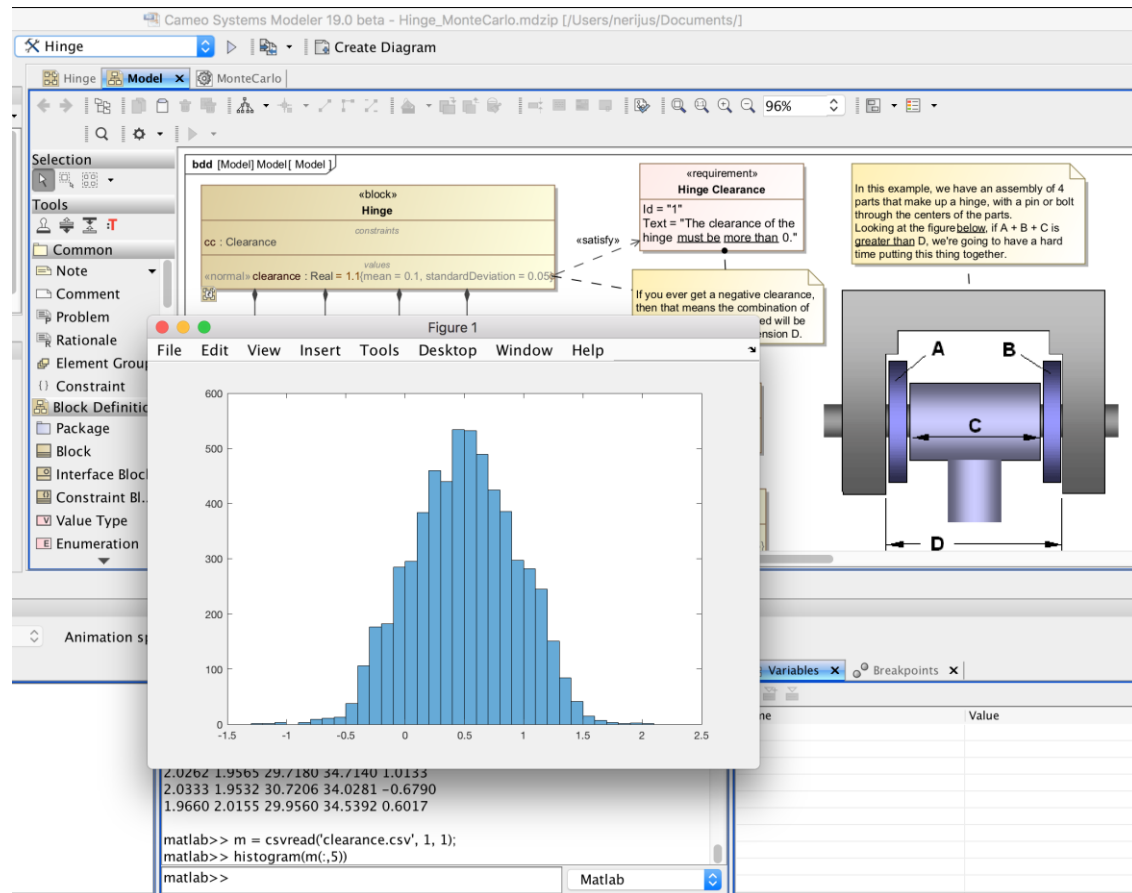
Monte Carlo simulation



Distributed Property

- Normal distribution
 - Mean +- Standard deviation
- Uniform distribution
 - Min - max

Number of runs
Recording CSV
Histograms

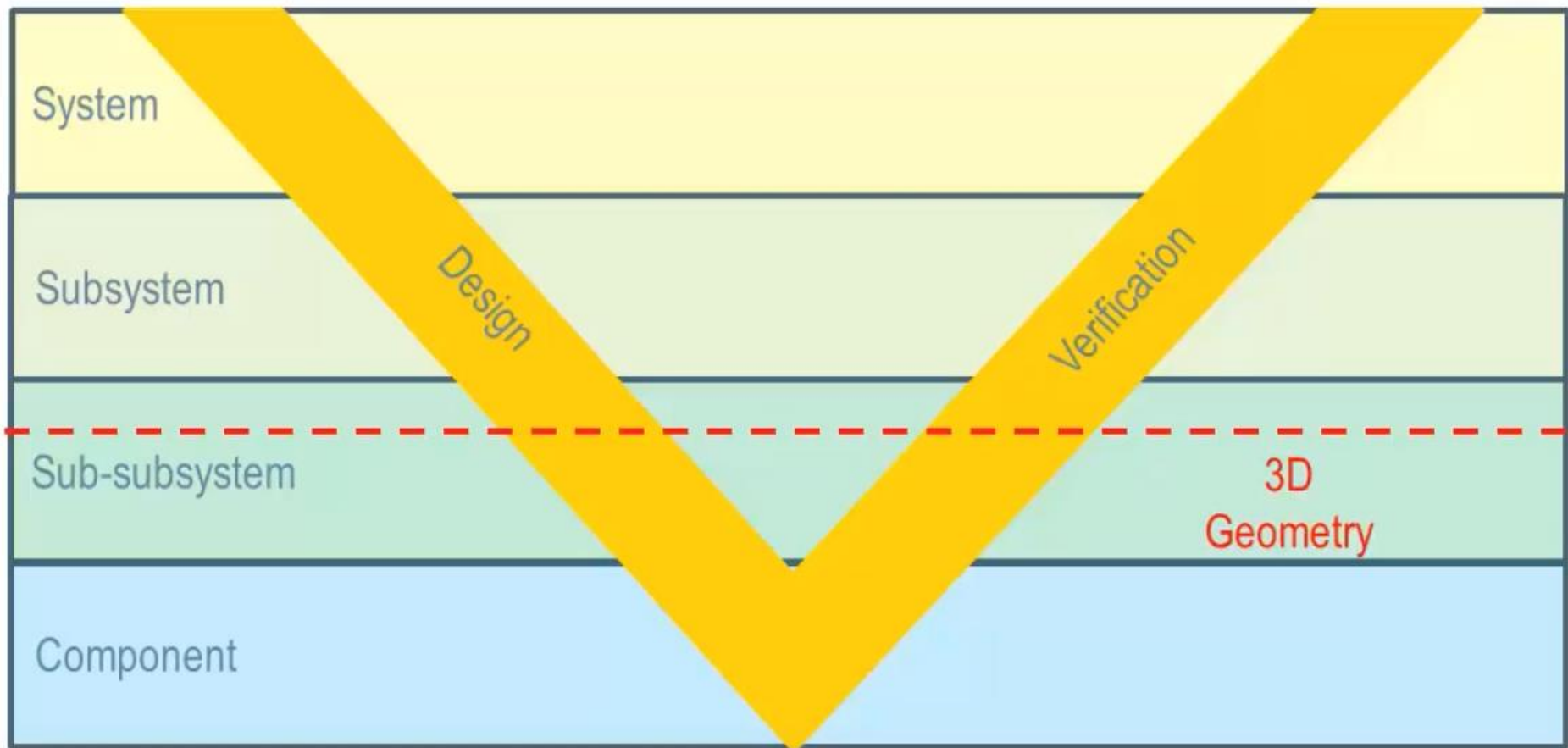




Demo!



Questions?



Lumped element model



The **lumped element model** (also called **lumped parameter model**, or **lumped component model**) simplifies the description of the behaviour of spatially distributed physical systems into a [topology](#) consisting of discrete entities that approximate the behaviour of the distributed system under certain assumptions. It is useful in [electrical systems](#) (including [electronics](#)), mechanical [multibody systems](#), [heat transfer](#), [acoustics](#), etc. Mathematically speaking, the simplification reduces the [state space](#) of the system to a [finite dimension](#), and the [partial differential equations](#) (PDEs) of the continuous (infinite-dimensional) time and space model of the physical system into [ordinary differential equations](#) (ODEs) with a finite number of parameters.