Simulation of an Electric Utility Network and Control System in SysML

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Power Distribution

- “Electricity”
- A bit of history about electricity…
- … not really ...
- … focus of this paper is about MBSE
- Model-based Systems Engineering

Model-based Systems Engineering

- INCOSE Definition:

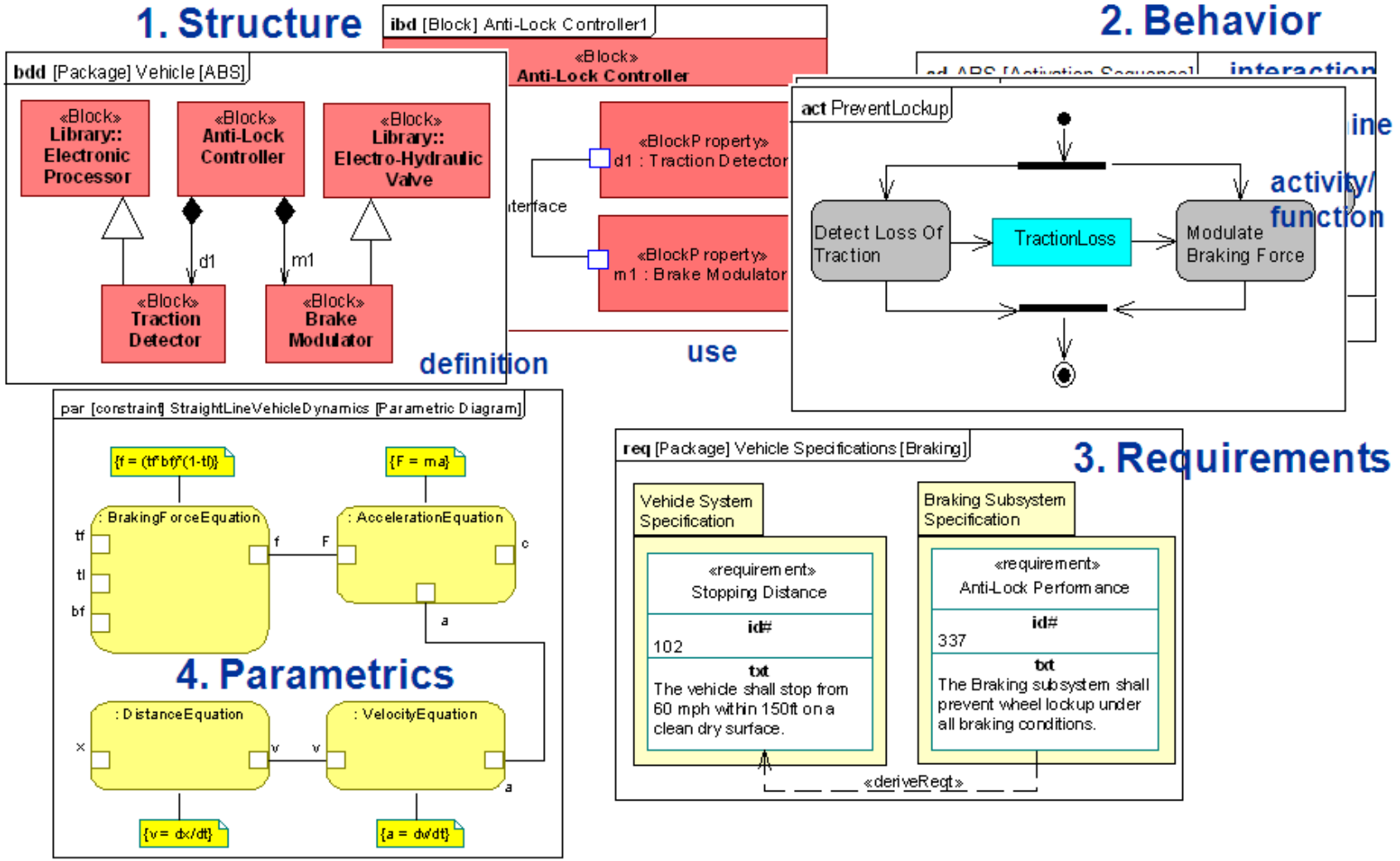
"Model-based Systems Engineering is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later lifecycle phases" (INCOSE, 2007)

The Systems Modeling Language

- SysML™
- *Applied to a study* about Electric Utility Networks

- SysML is (historically and intentionally) a *semi-formal modeling language*

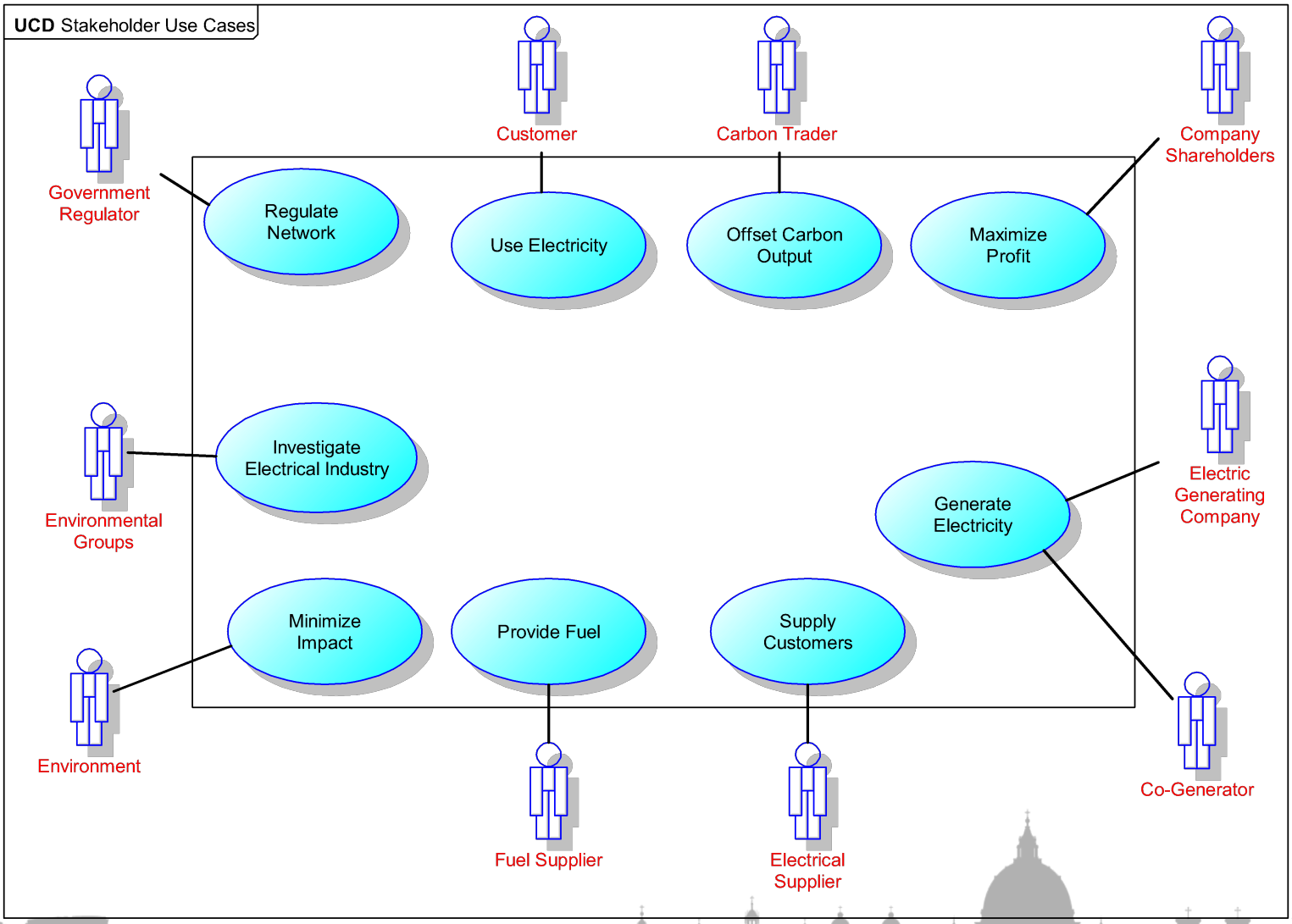
SysML™ Overview



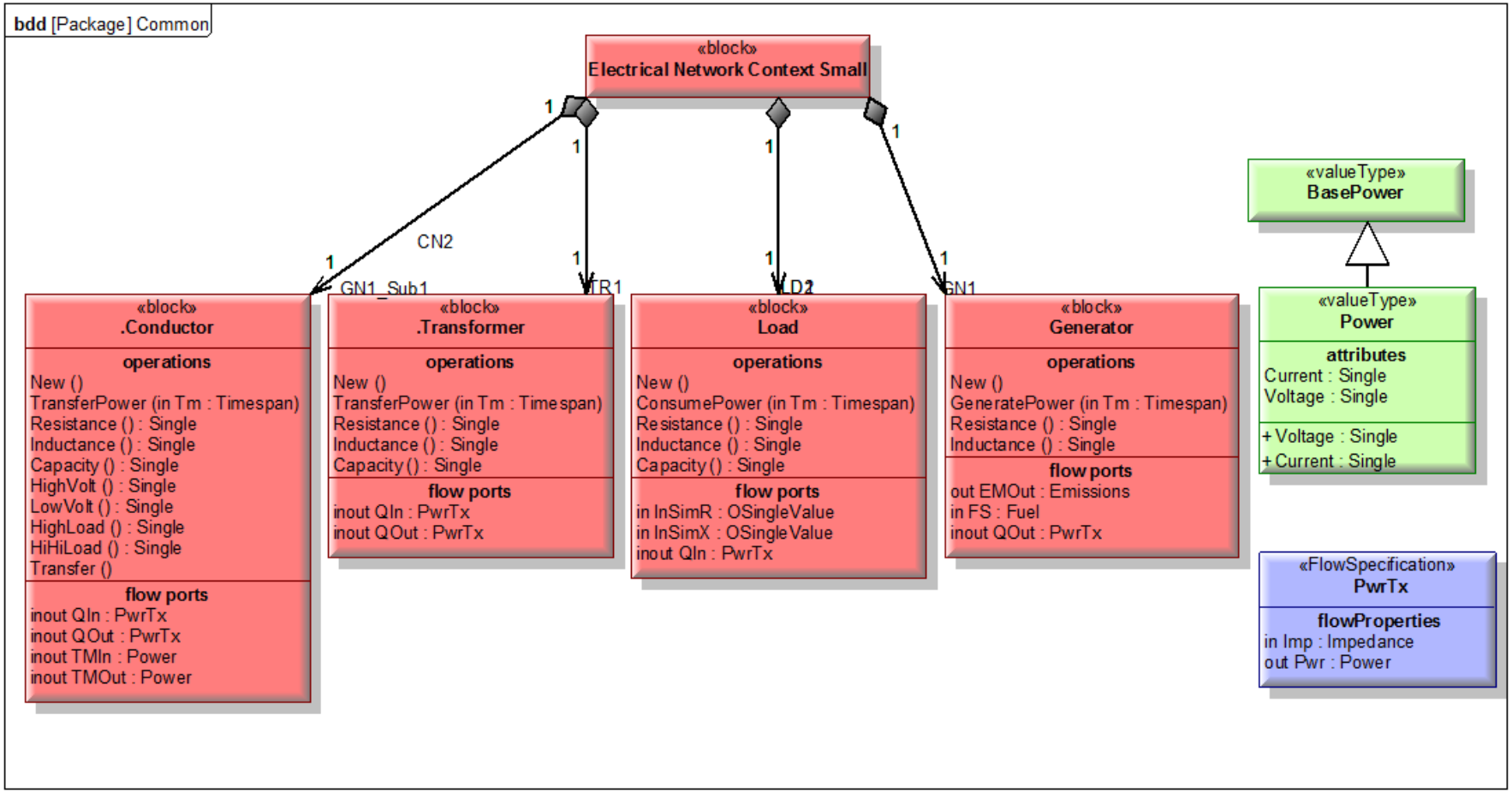
The Goal

- *Can we model* an Electric Utility Network/Control System with SysML?
  - *Yes sure we can*
  - SysML is powerful
  - SysML is mature. It has been on the scene for enough time
- *Can we execute* such a SysML Model effectively?
  - *…? This is The Goal*

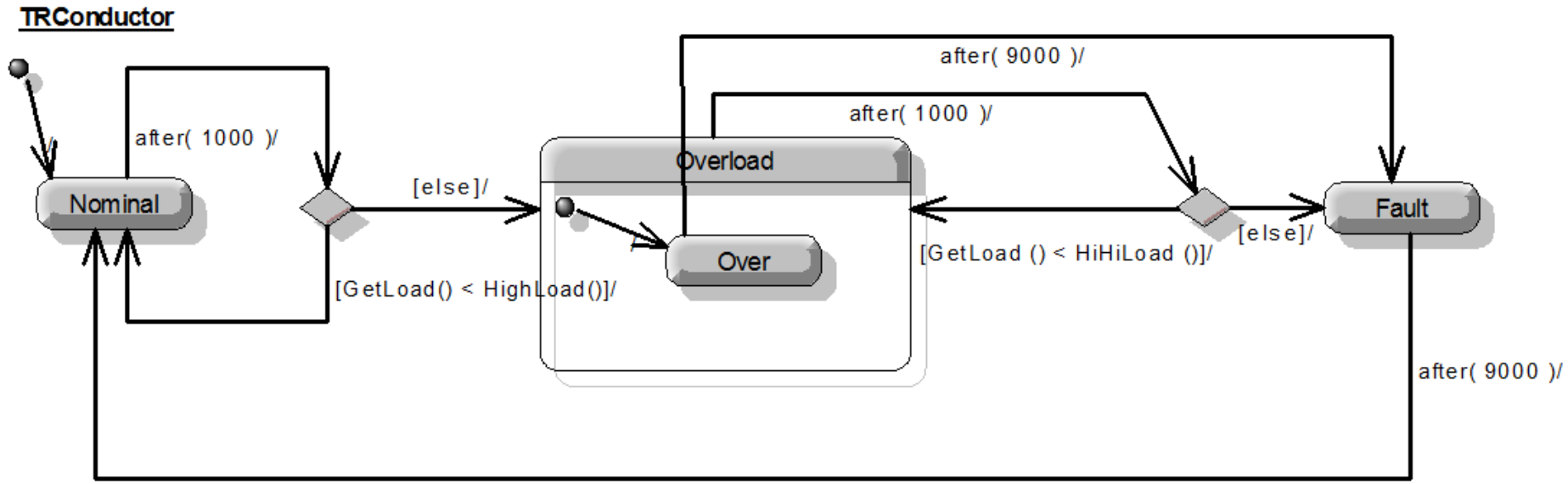
How to Model


UCD Stakeholder Use Cases
Government Regulator
Customer
Carbon Trader
Company Shareholders
Regulate Network
Use Electricity
Offset Carbon Output
Maximize Profit
Environmental Groups
Investigate Electrical Industry
Electric Generating Company
Generate Electricity
Minimize Impact
Provide Fuel
Supply Customers
Environment
Co-Generator
Fuel Supplier
Electrical Supplier

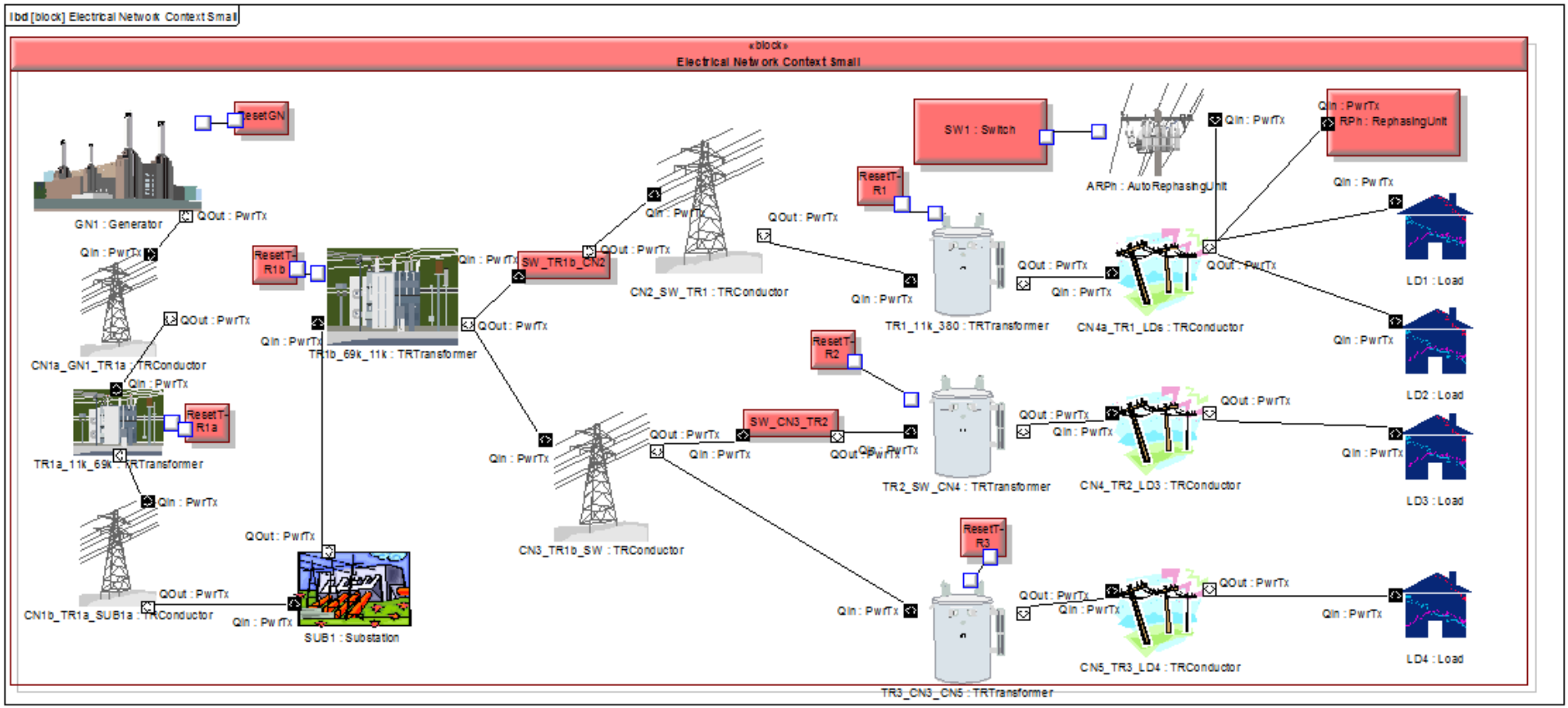
How to Model (cont.)



How to Model (cont.)



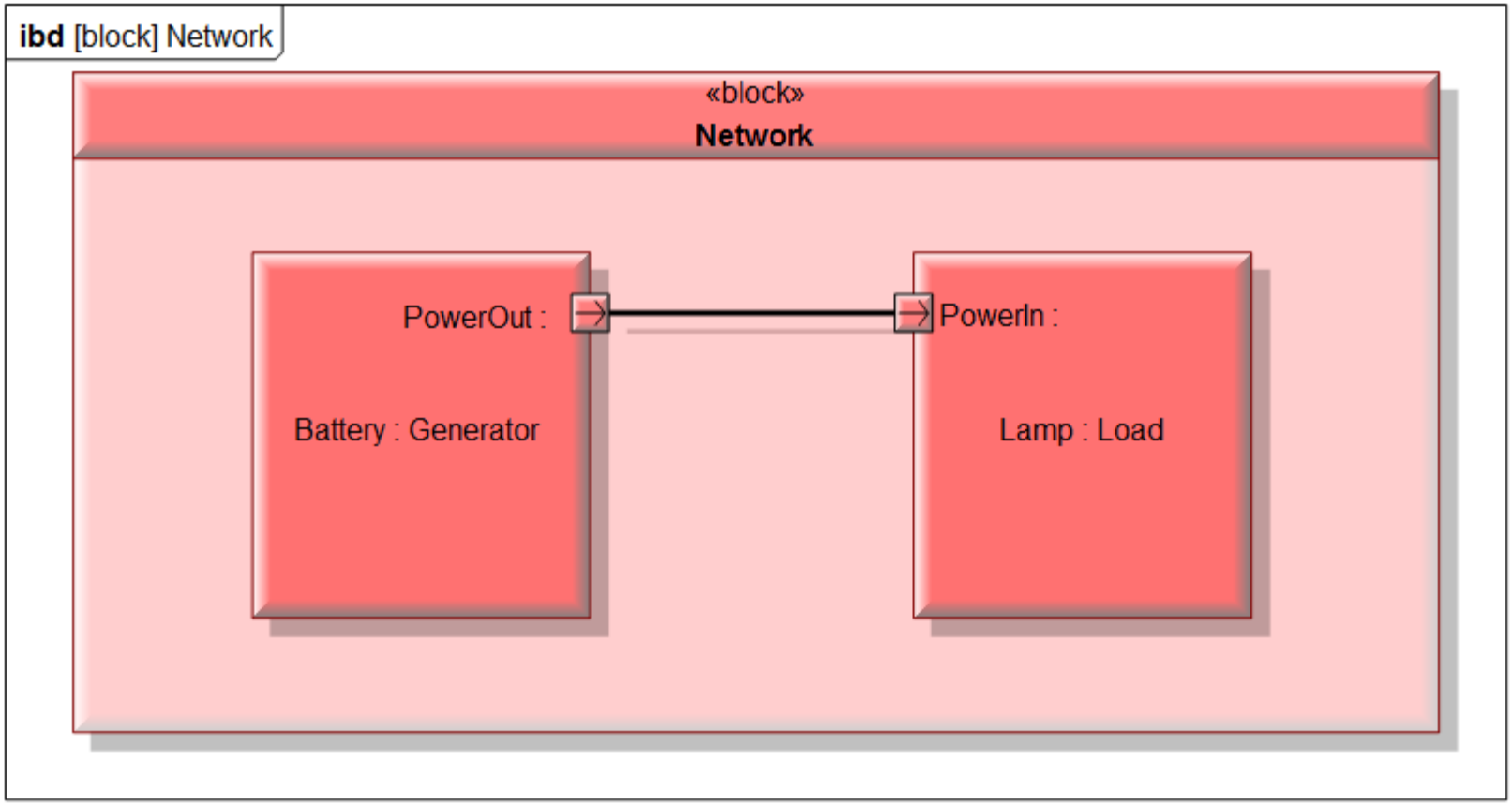
How to Model (cont.)



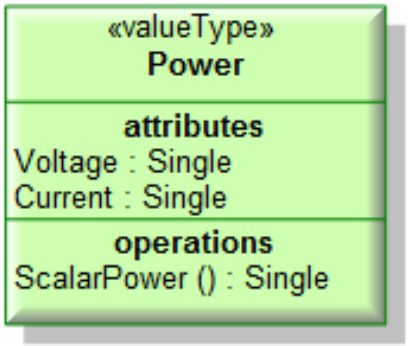
Executable Modeling

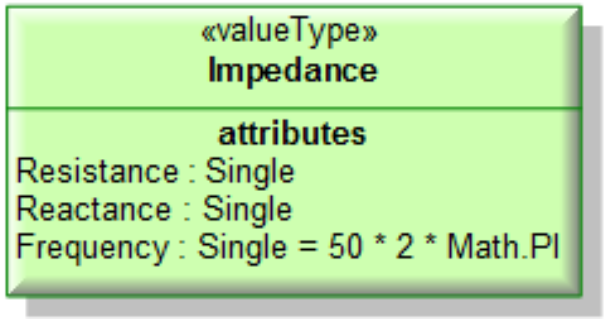
- … vs “Systems Modeling”
  - Similar, but not exactly the same
  - SysML is *semi-formal*
    - We expect an Executable Model needs at least a certain level of formality
  - Where are the needed changes in paradigm?
    - There are certain choices – usually legal – but unsuitable for *executability*

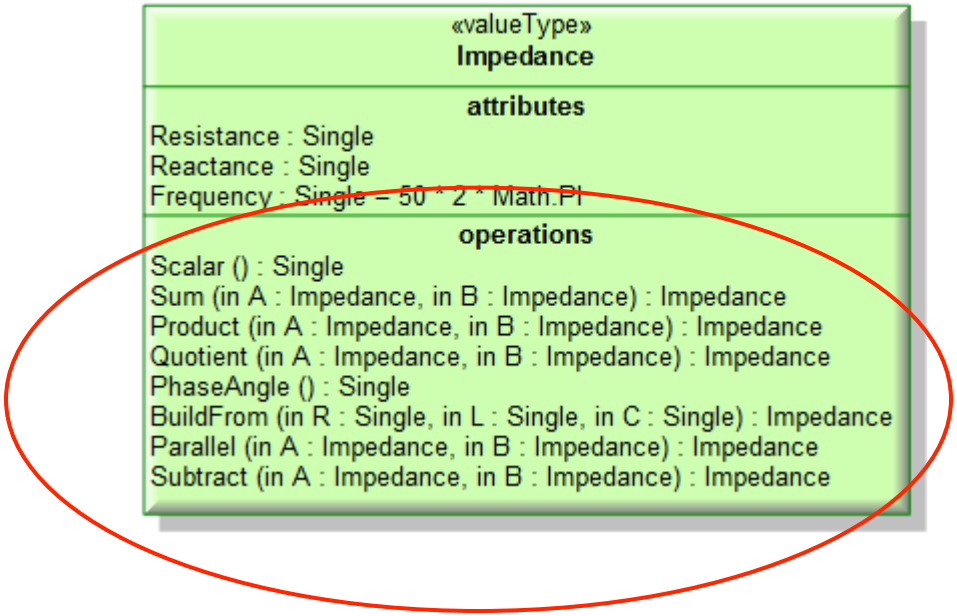
A Harmless Example



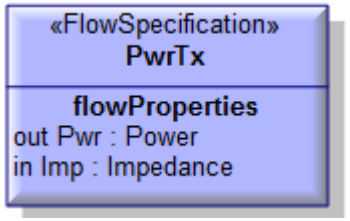
Adopted Solution

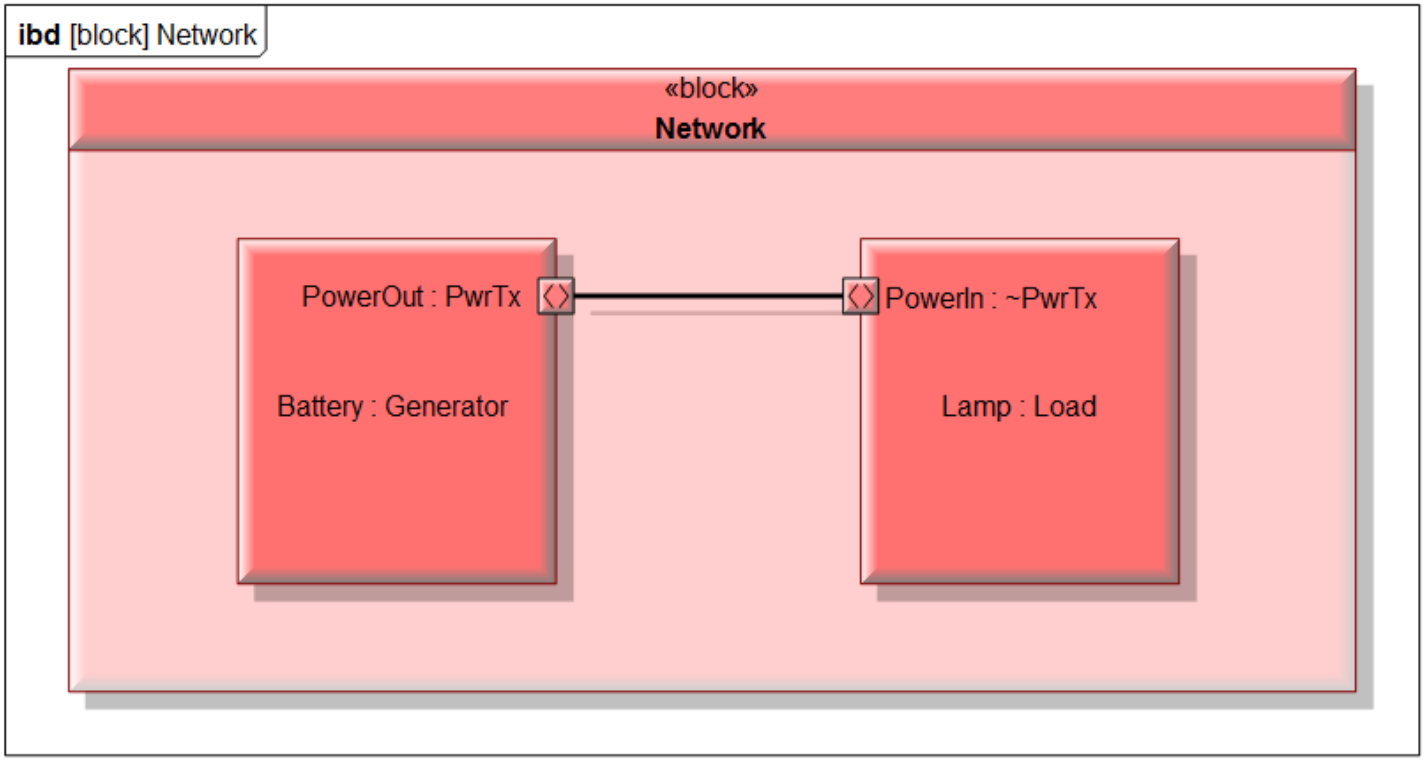




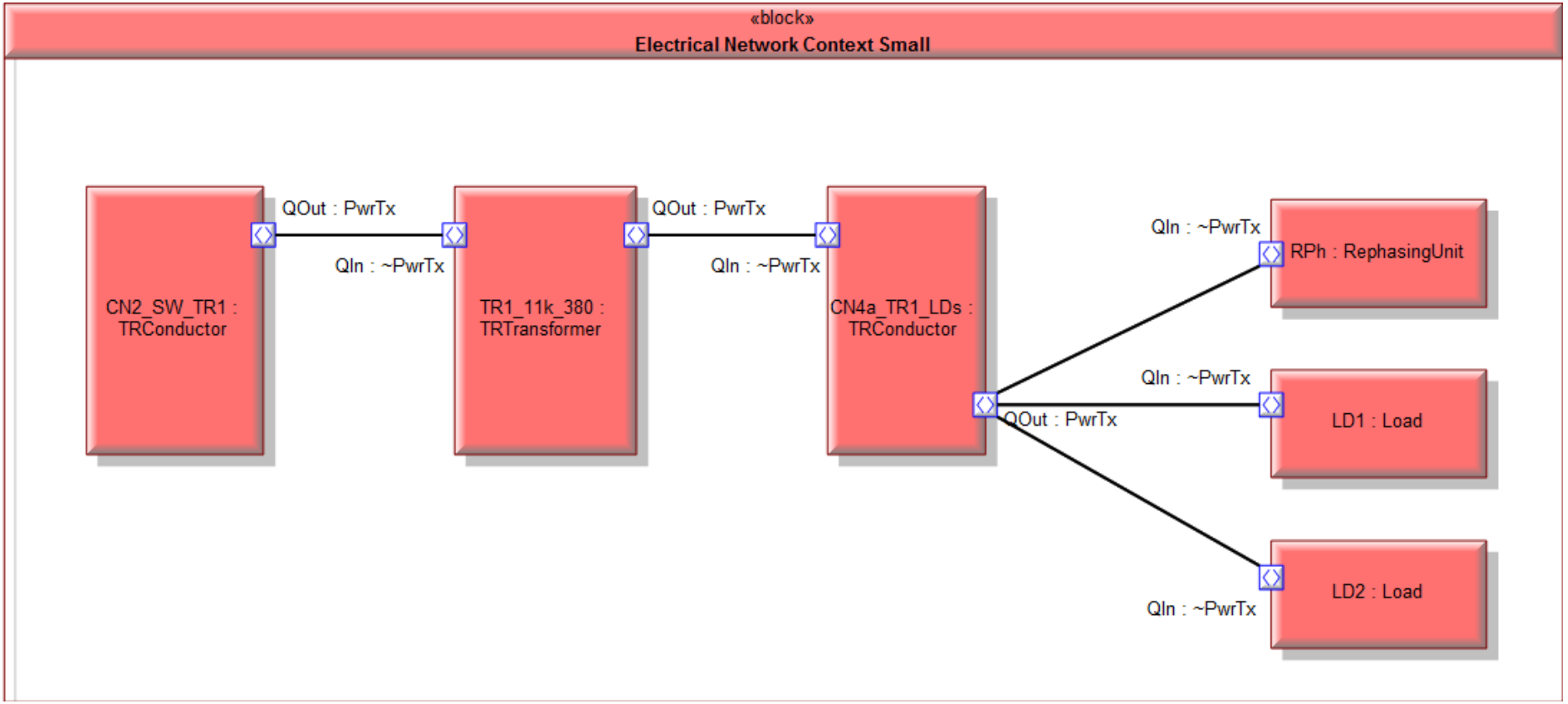


Adopted Solution (cont.)

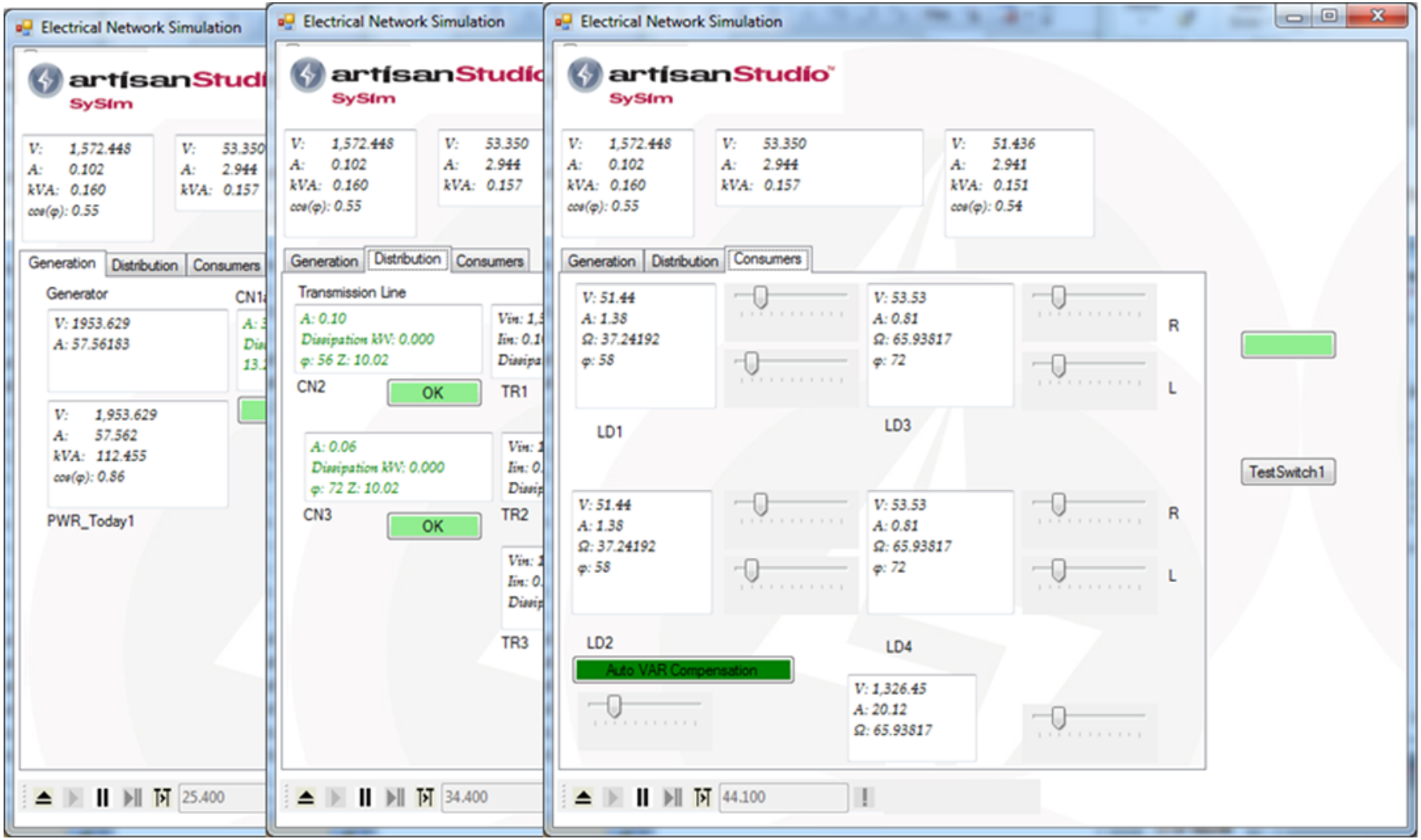




Realistic Example



Running Executable Model



Future Work

- Future plans include the following:
  - Expand the model to much greater complexity
  - Add data logging for trending analysis of both analog and digital values
  - Add network diagrams as part of the UI
  - Add new types of load – automatic load generation over time, etc.
  - Automate the inputs for running different failure scenarios in random order
  - The model will be proposed as one of the MBSE challenge problems

Conclusions

- Generic, Industrial Standard SysML™ was able to model an Electrical Network
  - … versus bespoke tools normally used for this
- SysML™ Modeling was *Accurate* and enough *Formal*
  - … resulting into an *Executable Model*
- SysML™ can go far beyond a static *specification*
  - … transformation into executable form took a minimal fraction of the overall design time