

Getting a Cohesive Answer from a Common Start: Scalable Multidisciplinary Analysis through Transformation of a Systems Model

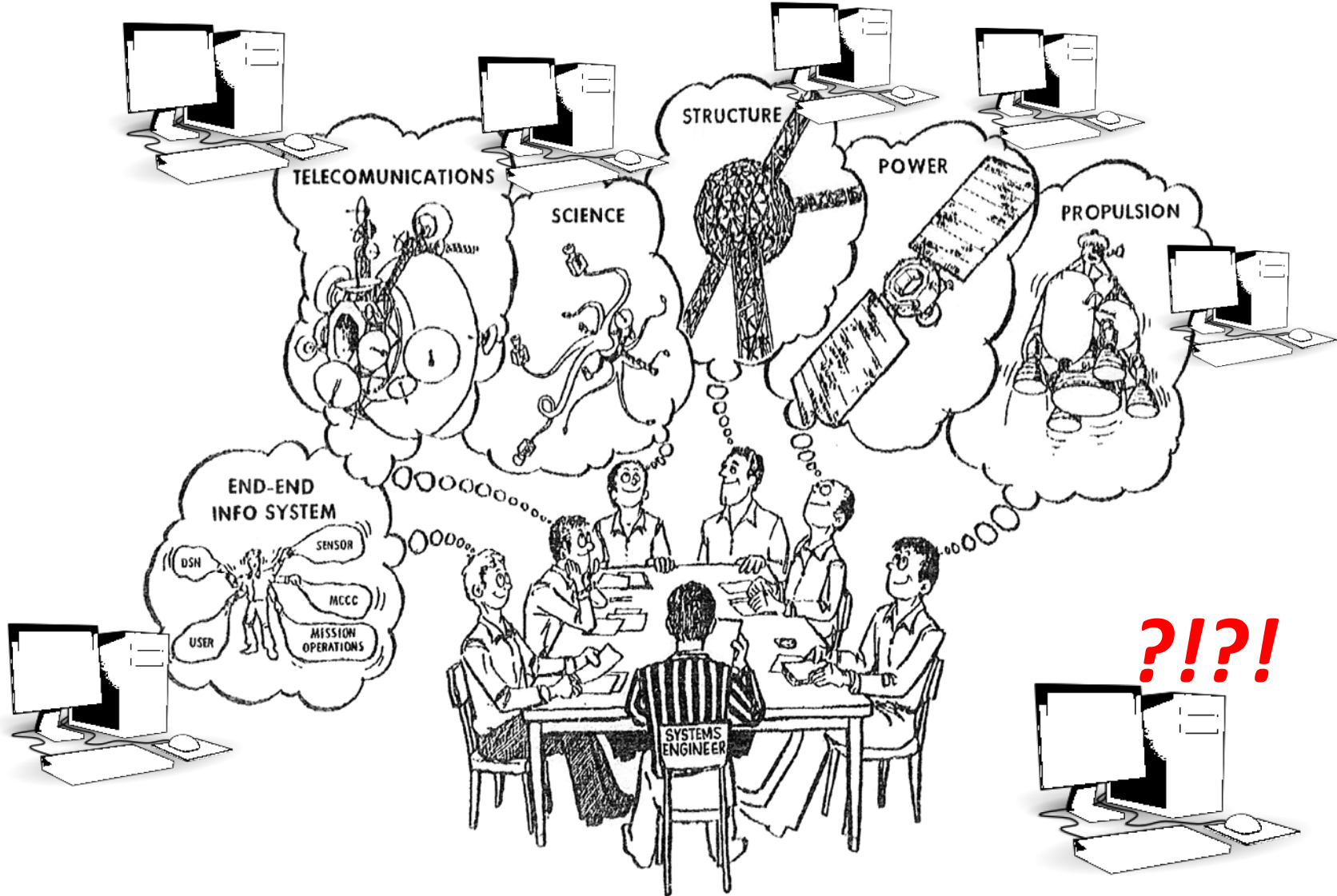
Bjorn Cole, Ph.D.

Seung Chung, Ph.D.

Jet Propulsion Laboratory,
California Institute of Technology

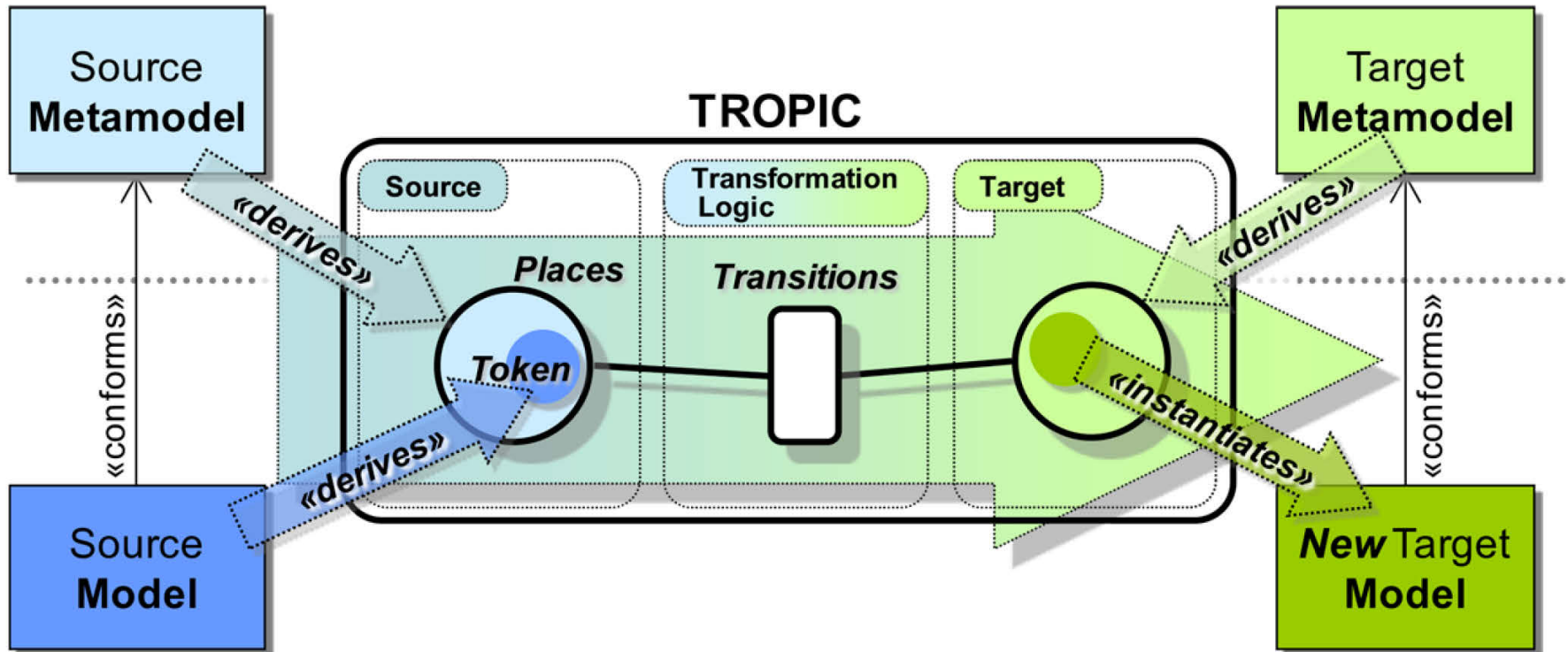
Bjorn.cole@jpl.nasa.gov

The Problem



Transformation in General

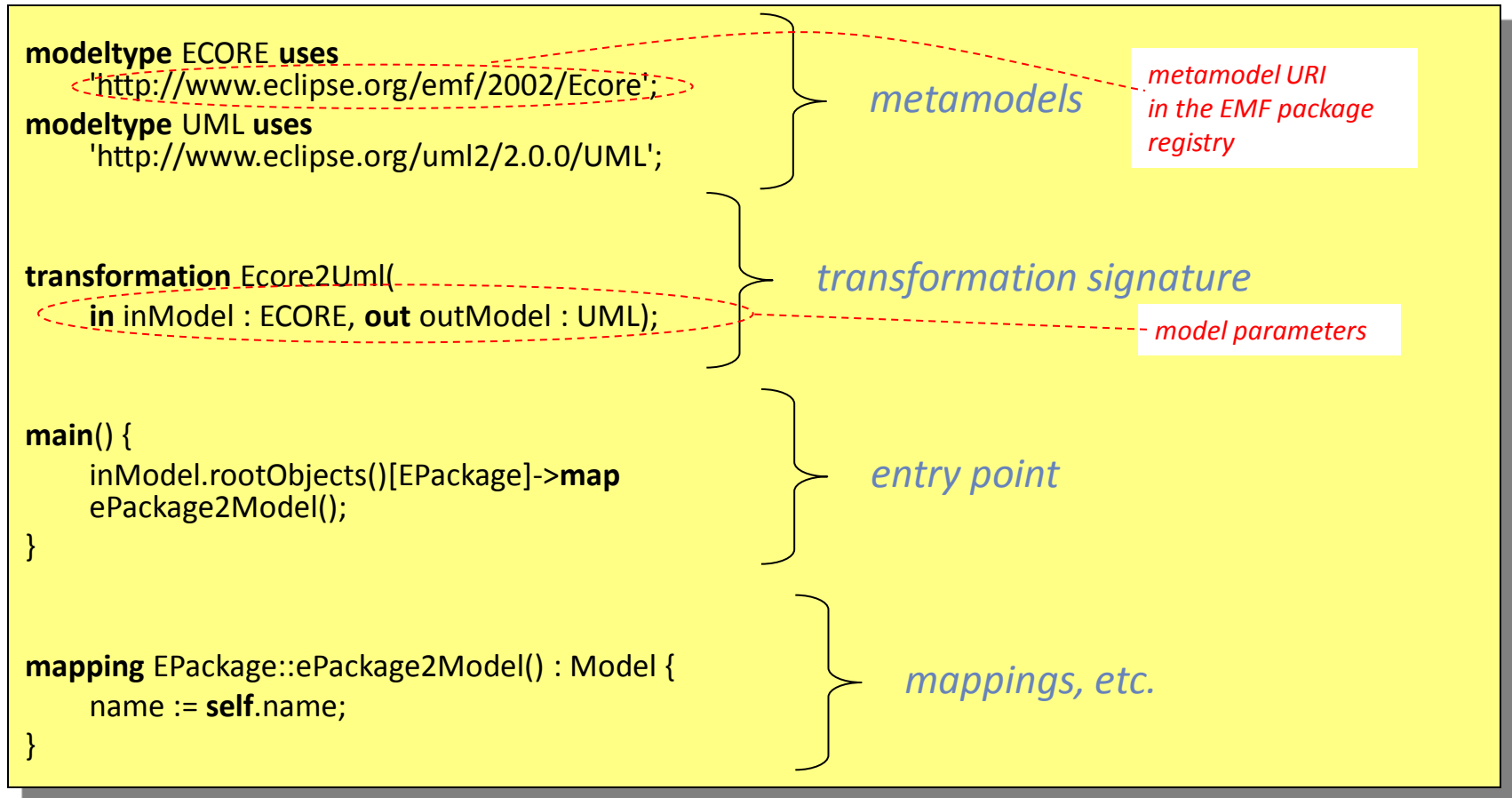
Image from webpage of Business Informatics Group, Vienna University of Technology



What QVTo looks like

A simple transformation example (from The Art of Model Transformation with Operational QVT - Sergey Boyko, Radomil Dvorak, Alexander Igdalov; March 2009)

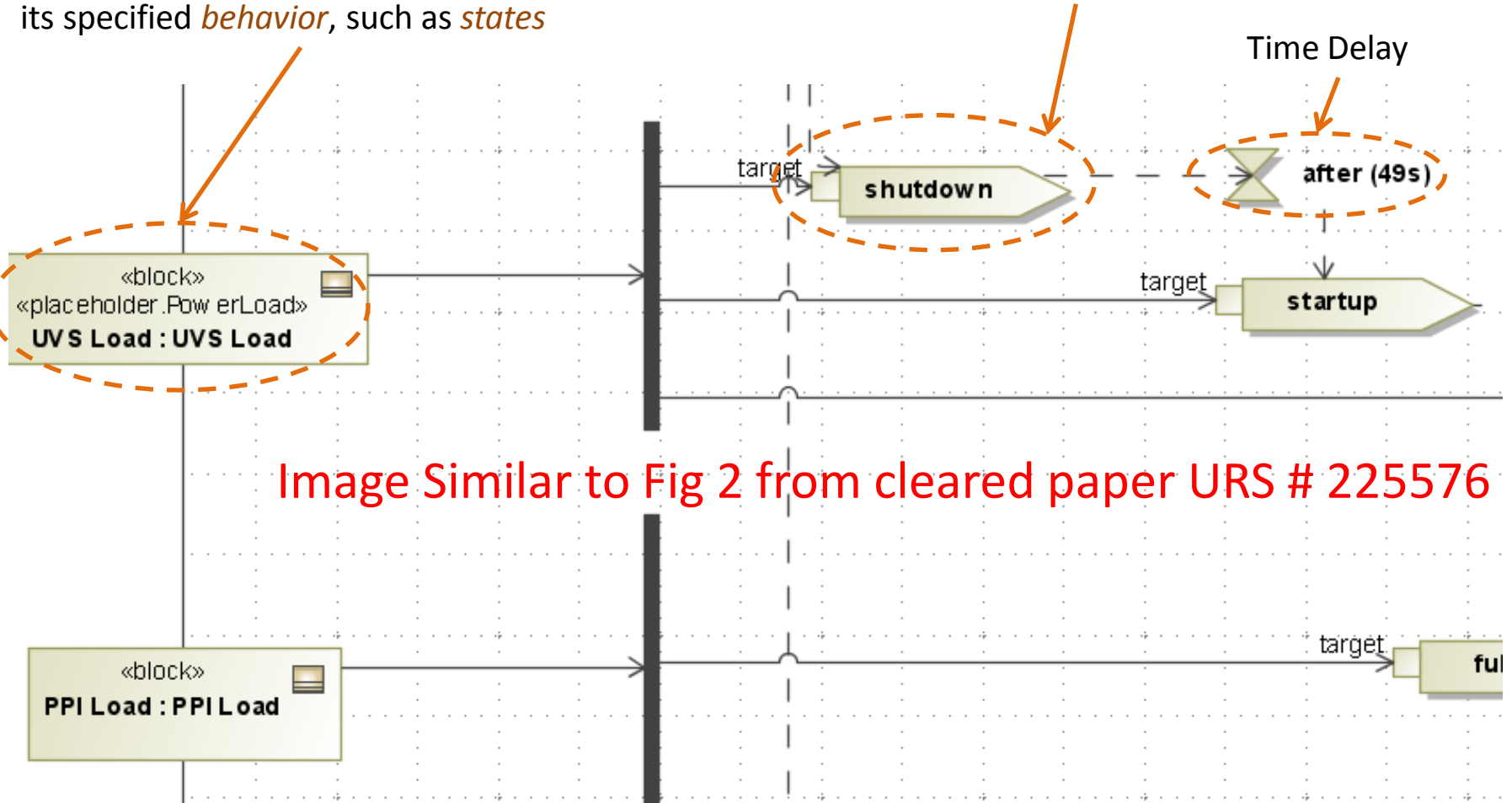
From Publically Available Eclipse 2009 presentation



JEO: SysML-Simulink Power Simulation

Represents hardware in its entirety, including its *parameters values*, and its specified *behavior*, such as *states*

Represents a broadcast *trigger* to cause the hardware to *change state* and thus consume a different amount of power

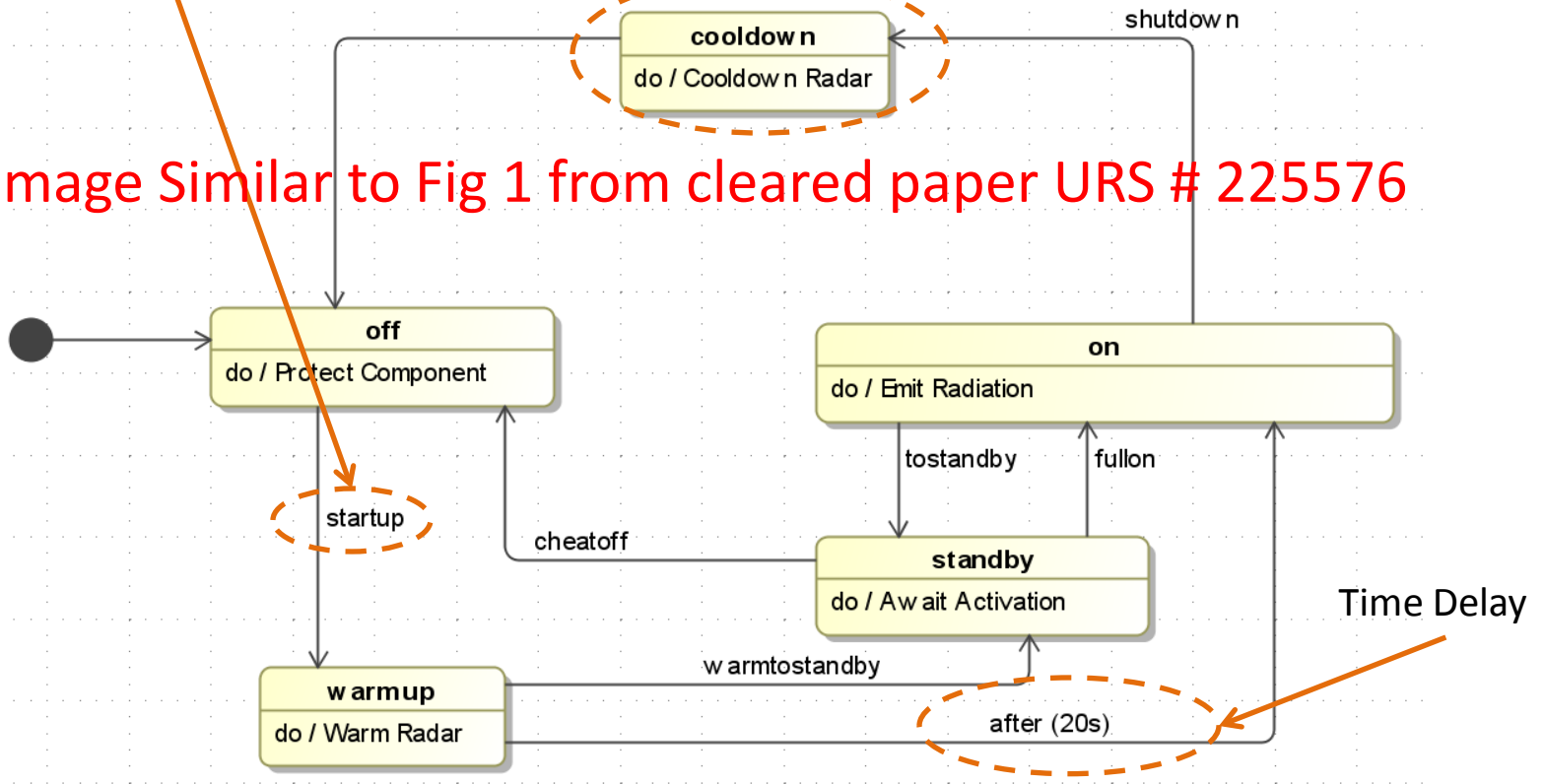


JEO: SysML-Simulink Power Simulation

The triggers from the last page are mapped to *transitions* between *states*

Each state contains a reference to what the *component should be doing* at this time, e.g., cooldown

Image Similar to Fig 1 from cleared paper URS # 225576



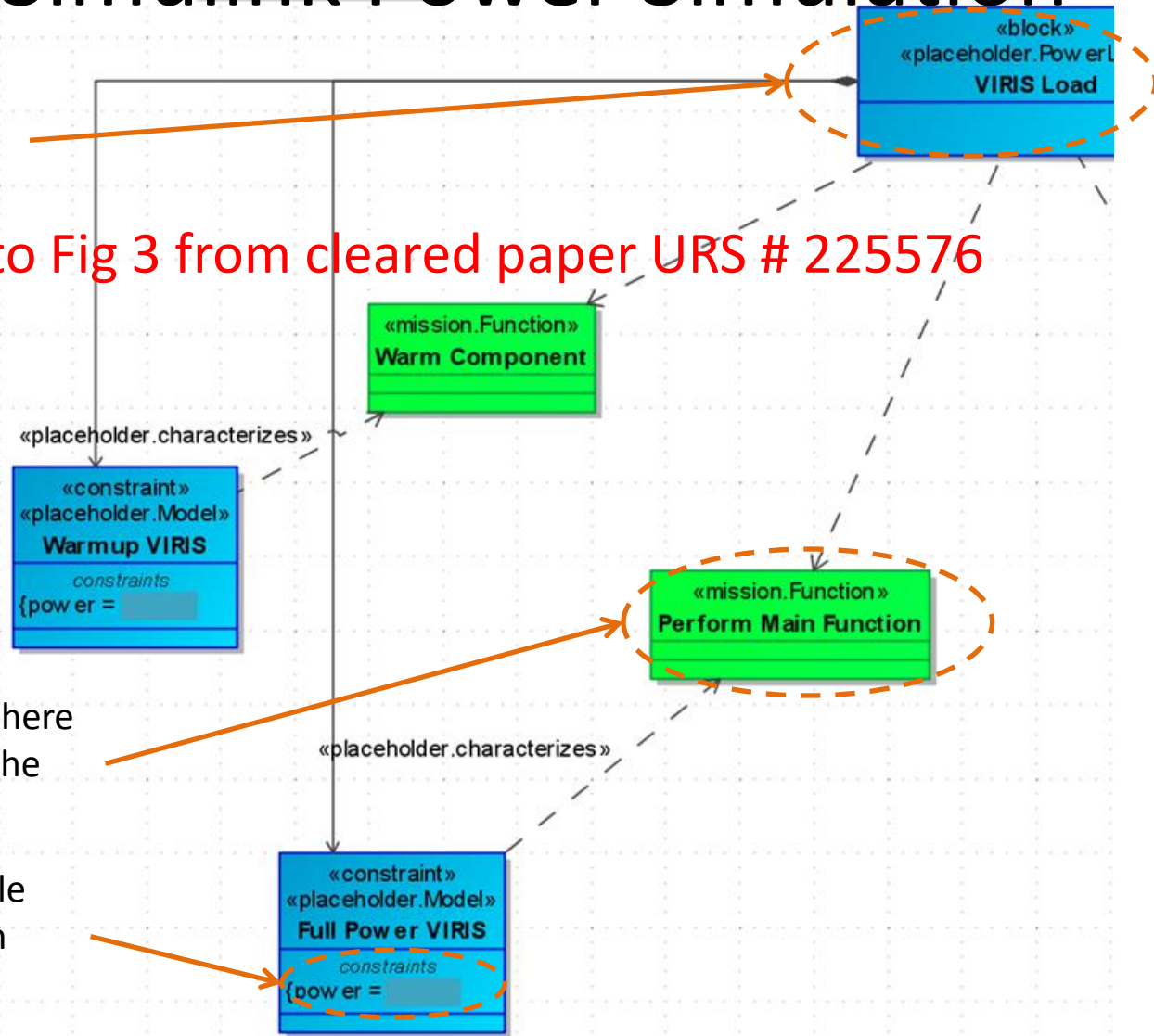
JEO: SysML-Simulink Power Simulation

The component definition is the key to orchestrating all of these views

Image Similar to Fig 3 from cleared paper URS # 225576

The functions performed appear here and are the same as those from the State Diagram

Finally, the power consumed while performing each function is given here, completing the map



Input Set : Definitional Parameters

Steady State Short Circuit Current : A

Open Circuit Voltage Annual Decline : Real

Steady State Resistance : Ω

Resistance Annual Increase : Real

CurrentYear : Real

Reference to Power Bus : Power Bus

state variables : Power Bus SV Set

Reference Bus Voltage : Reference Bus Voltage

Reference Bus Voltage Value : V

Isc : A

Rrtgss : Ω

RrtgAD : Real

VocAD : Real

Vbus : V

Yr : Real

«constraint»
«placeholder.Model»
Degradation Model : MMRTG Degradation Model

DF : Real

MMRTG State Variables : MMRTG State Variables

MMRTG Current : MMRTG Current Output

Current Output Value : A

MMRTG Degradation : MMRTG Degradation Factor

Degradation Factor Value : Real

SteadyStateShortCircuitCurrent : A

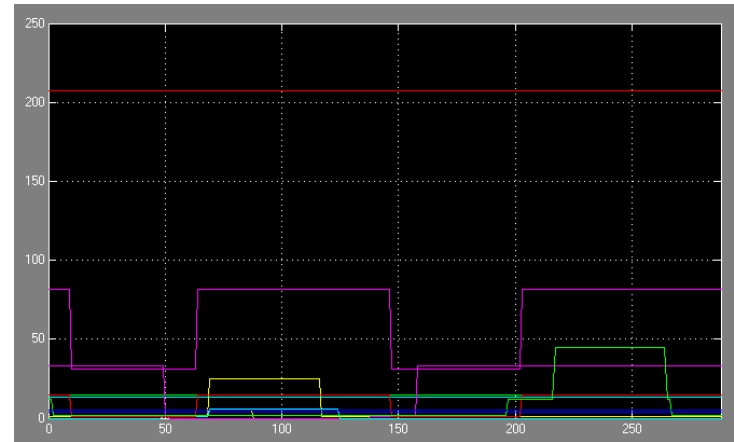
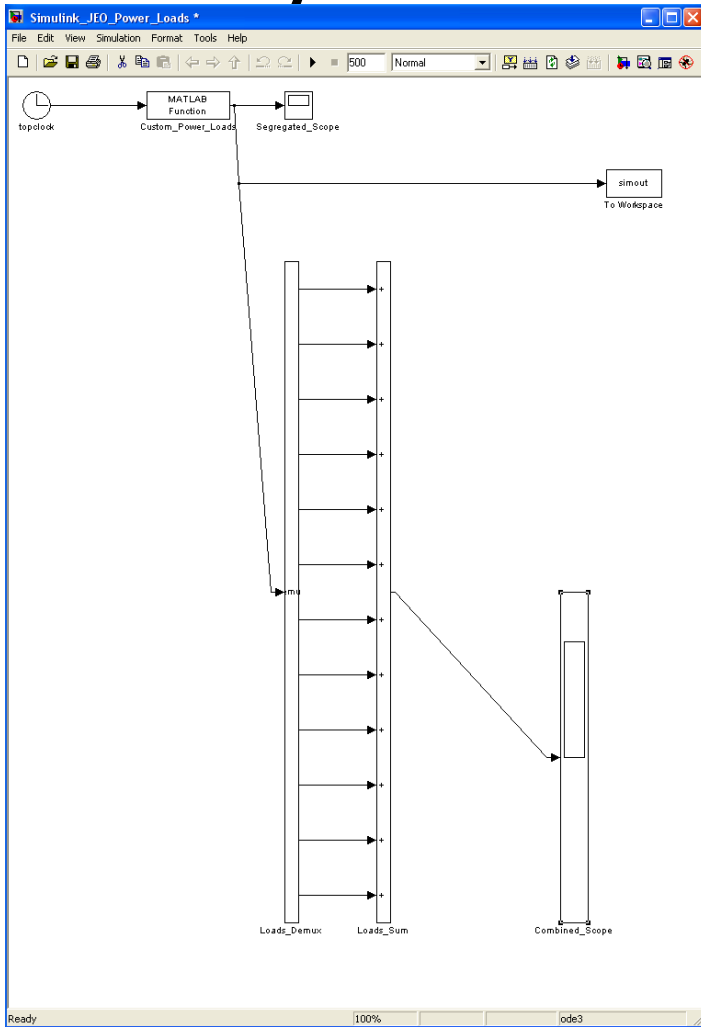
BusVoltage : V

OutputCurrent : A

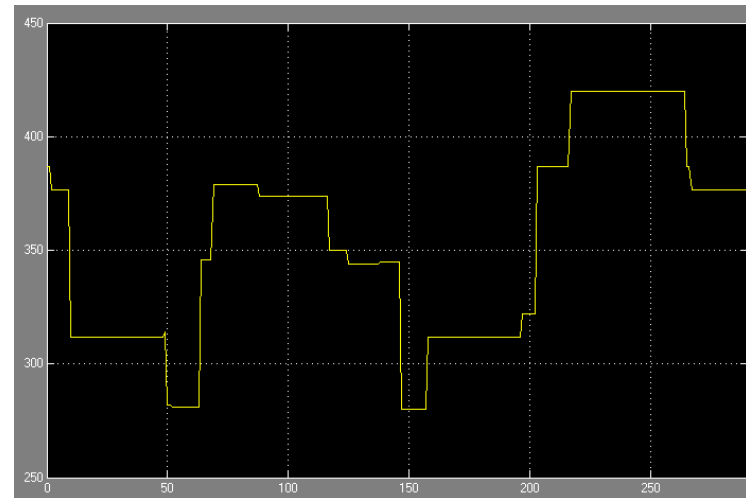
DegradationFactor : Real

«placeholder.Model»
«constraint»
voltage-current model : MSL MMRTG 2011 Voltage-Current Curve

JEO: SysML-Simulink Power Simulation



Individual Contributions

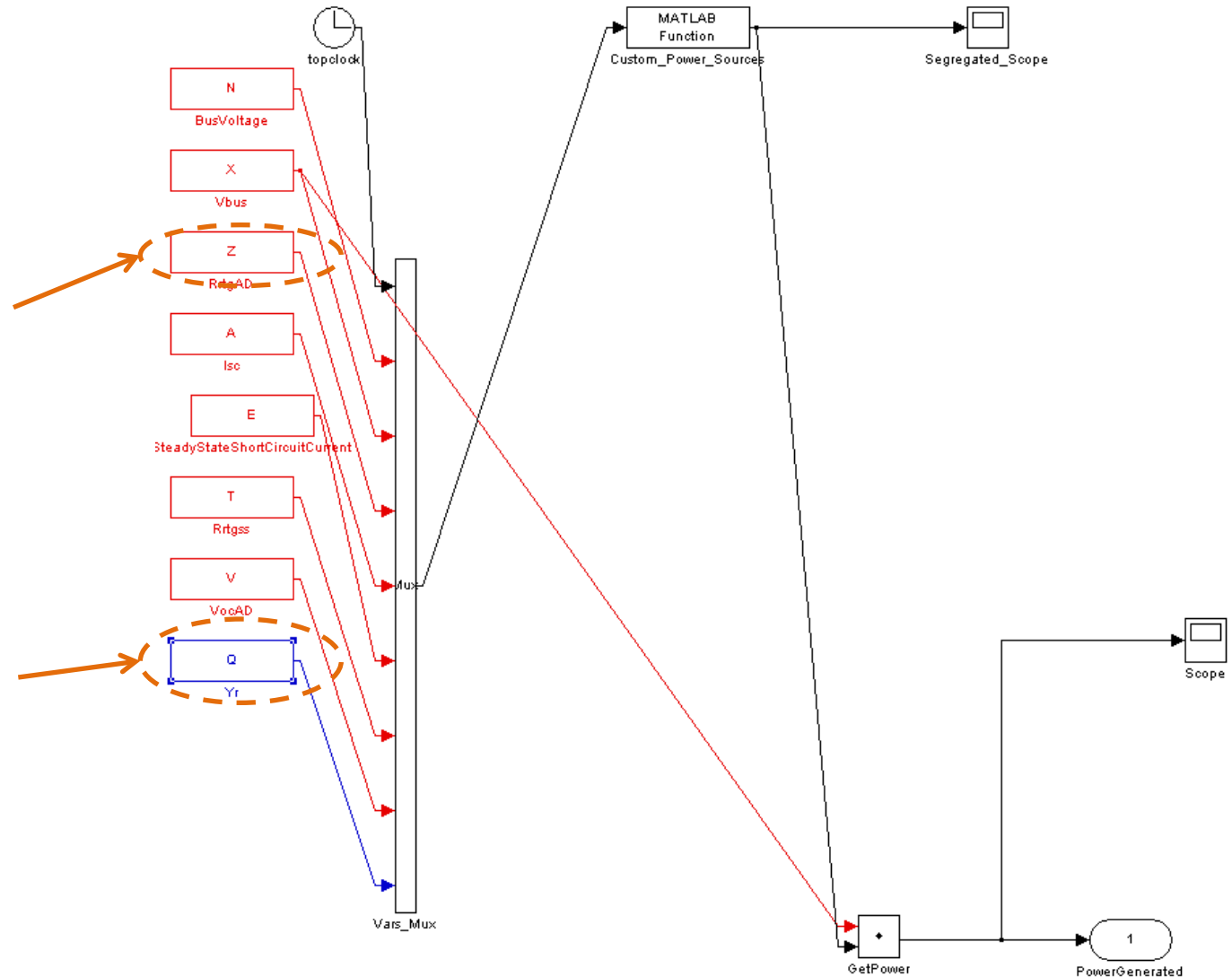


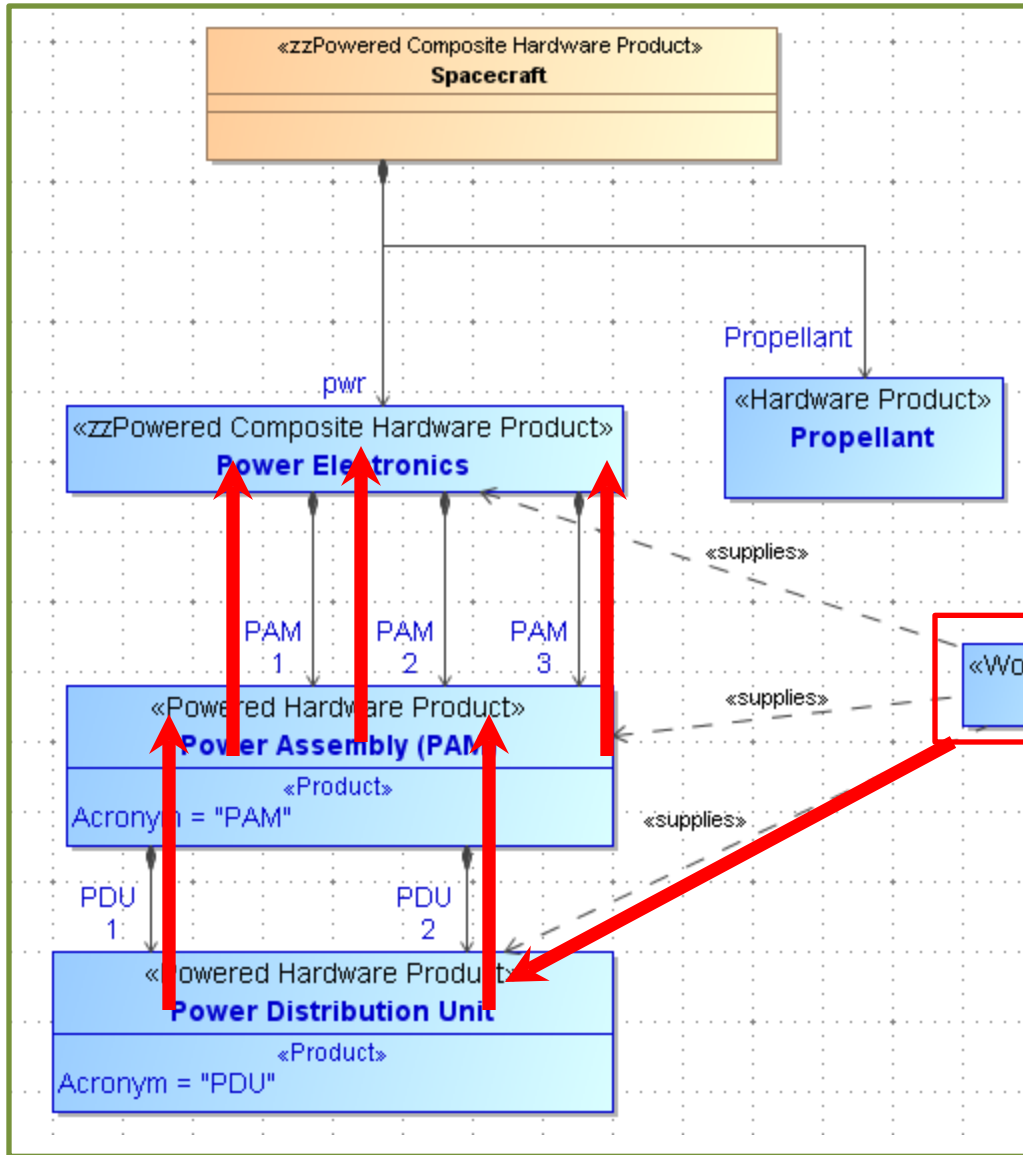
Power From Aggregate Loads

JEO: SysML-Simulink Power Simulation

Simulink Generation chain automatically identifies variables given values in the SysML model (treated as “givens”)...

...as well as those without values, that the user is encouraged to modify





Work MEL Rollup looks for leaves and then gets count by looking up composition tree (e.g, 6 PDUs in this case)

Composition MEL Rollup moves from top to bottom

What Does Transformation Buy?

- “Strong” transformation, where new models automatically spring entirely from older ones based only on definitions
- But “weak” transformation is still very useful, because it bootstraps information from old models into new ones
 - Synchronized by construction
 - Leverages redundancies for efficiency rather than getting bogged down in continuous synchronization and consistency efforts

Lessons Learned

- Good systems model is inherently multidisciplinary
 - Strong generalist with analytic skills
 - Specialist with discipline knowledge
- Requiring the systems engineer to provide data for execution by subsystem led to higher quality technical interactions than “give me your document”
- Computational sophistication runs into difficulties with human verification (how to “prove” that it is working) and validation
- It takes a lot of work to get a good system model – but much of this work is in **really** understanding the interfaces and approach (real systems engineering, not document shuffling)
- Be VERY careful to get your scope understood and locked in early or the model will run away from you!

Important Steps Forward

- Need to enlarge the QVTo community of practice if we intend to go forward with it as a technology
- Need to adapt transformation from a computer science “dark art” into systems-compatible thinking
- Start to categorize general classes of analyses to help with reusable transformation patterns
 - E.g., Geometric Finite-Element, Time Marching (ODE, Discrete Event), Parametric Web