32nd Annual INCOSE international symposium

hybrid event

Detroit, MI, USA
June 25 - 30, 2022

VIRGINIA TECH

Formalizing the Representativeness of Verification Models using Morphisms

Paul Wach – Presenter, PhD Candidate, VA Tech
Peter Beling – VA Tech
Alejandro Salado – U of Arizona

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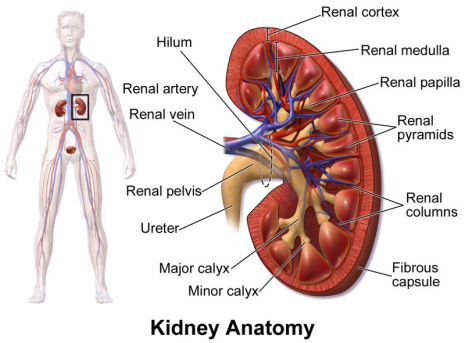
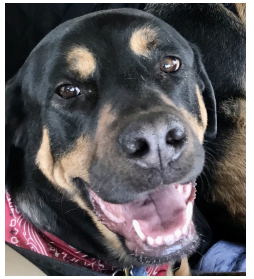


Kidney Anatomy

Paul Wach - Visual Bio



What do you think when you hear/read…?

Mass mock-up

Pedigree

Breadboard

Fidelity

Prototype

Final product

How do we determine validity of representativeness?

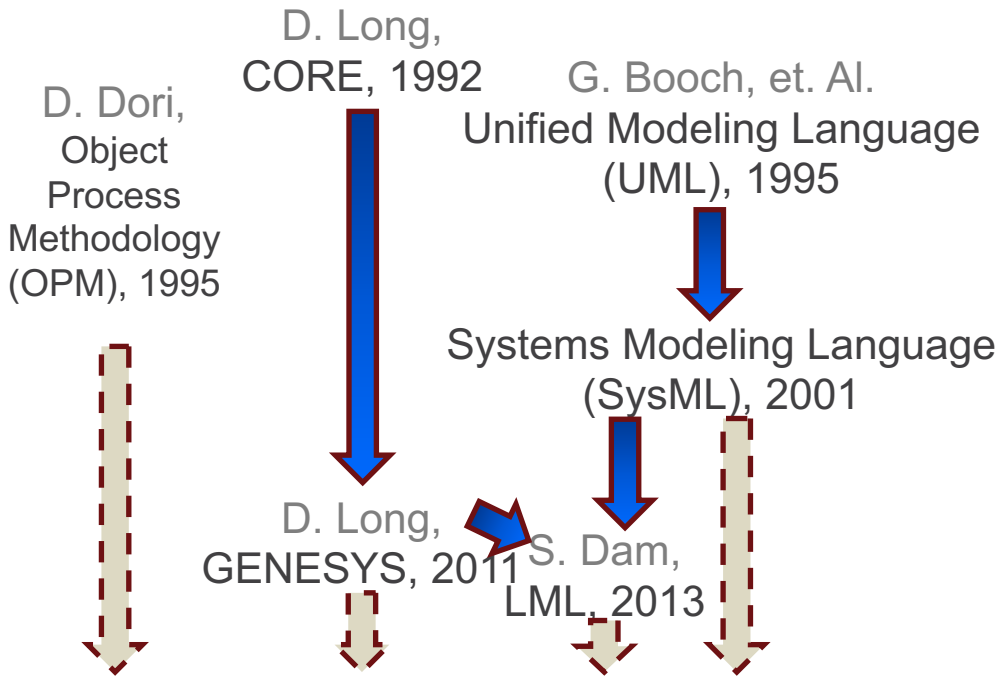
Verification

- …of adherence to system requirement
- …activity using a verification model (VM)
- A VM is an (often) abstract representation of the system design (or final product)

- Awareness of the correspondence between the VM and the justification of the ascertain of the adherence of the system design to corresponding system requirements

Systems Engineering Transformation

Modern MBSE: Descriptive



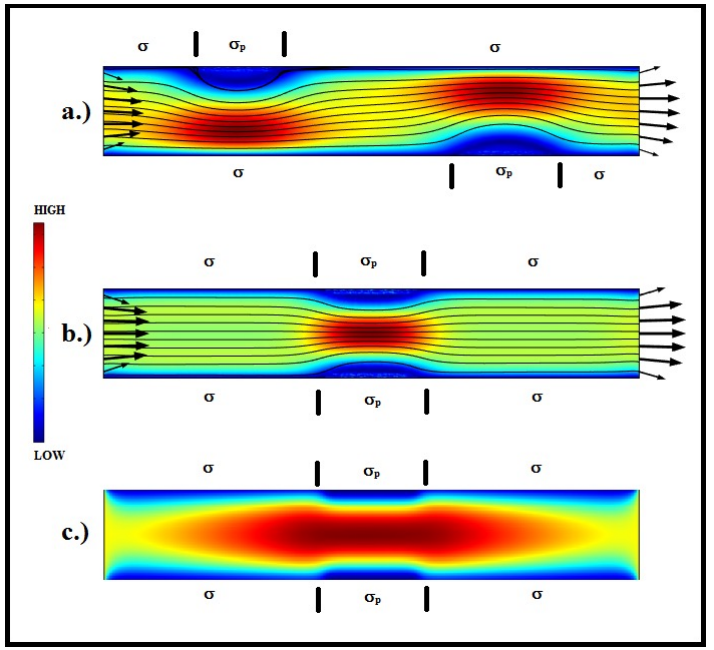
Systems Engineering is in the midst of a transformation

- The practice still largely remains document-based (DBSE)
- Despite model-based (MBSE) tools and methods existing since the early 1990s
- A systematic literature review of ~1,300 articles suggests that MBSE is serving as a conduit to enable transformation to the digital paradigm (Digital Engineering/DE)

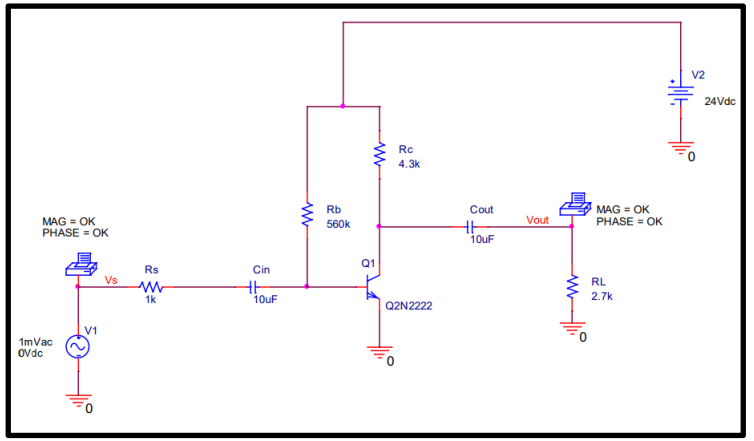
Trajectory of MBSE: Keystone enabler to engineer systems within the digital paradigm

Theory underpinning other domains

- Current forms of MBSE are descriptive and do not have theoretical foundations
- Other engineering domains have theoretical foundations upon which software platforms are implemented

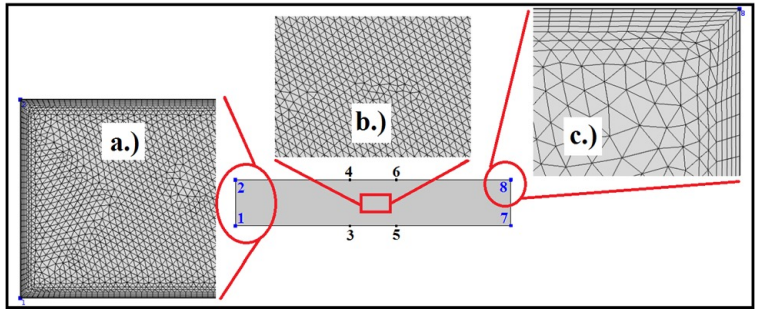


PSpice



https://engineering.purdue.edu/~ee255/lecturesupp_files/PSpice-Tutorial.pdf

<< Computational fluid dynamics



^ Finite element analysis ^

A. Wayne Wymore

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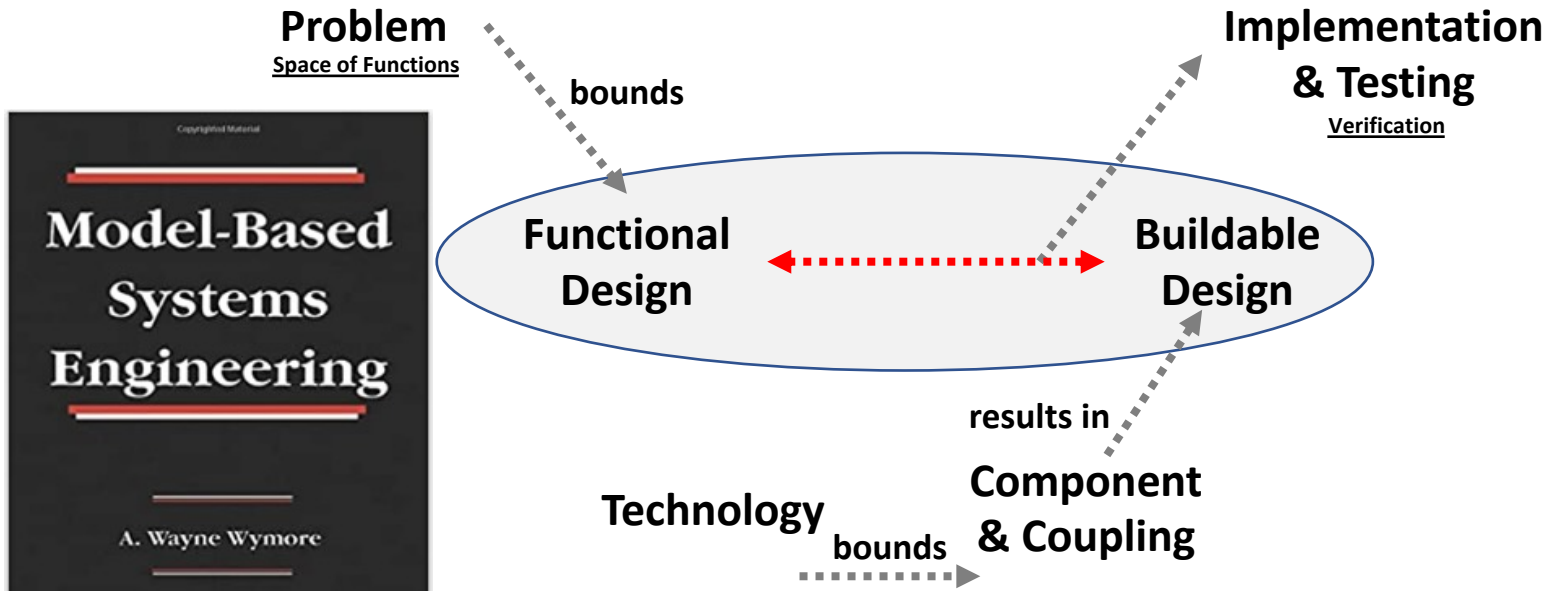
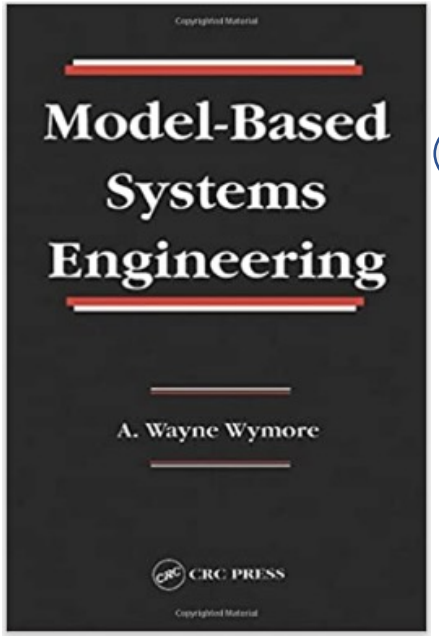
~Metamodel of T3SD





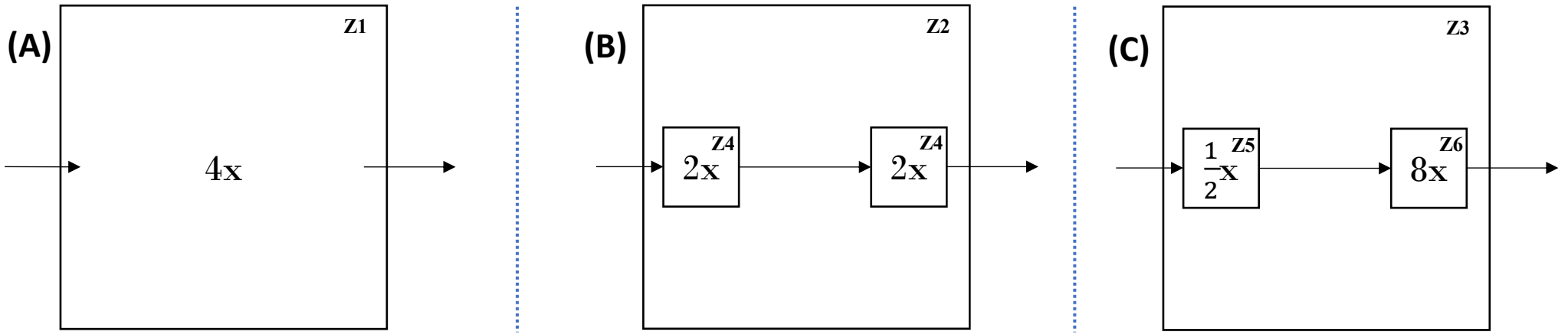
Wymorian Systems Theory:

- Mathematical Theory of Systems Engineering
- Theory of Modeling and Simulation
- Tricotyledon Theory of System Design (**T3SD**) aka **theory of MBSE**
- Theory of problem (formulation) spaces

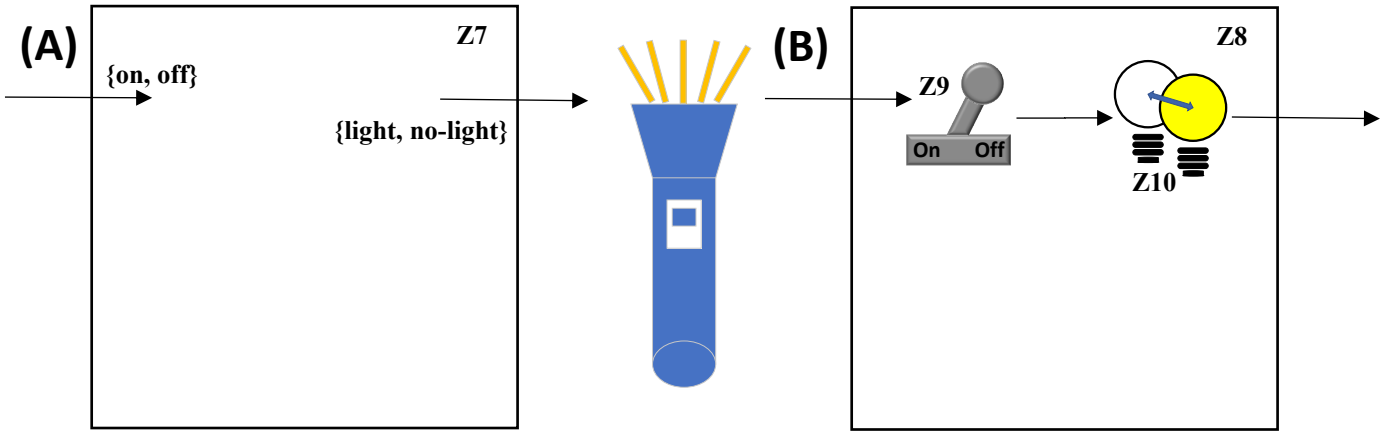
For verification models…

***Start thinking in terms of morphisms**

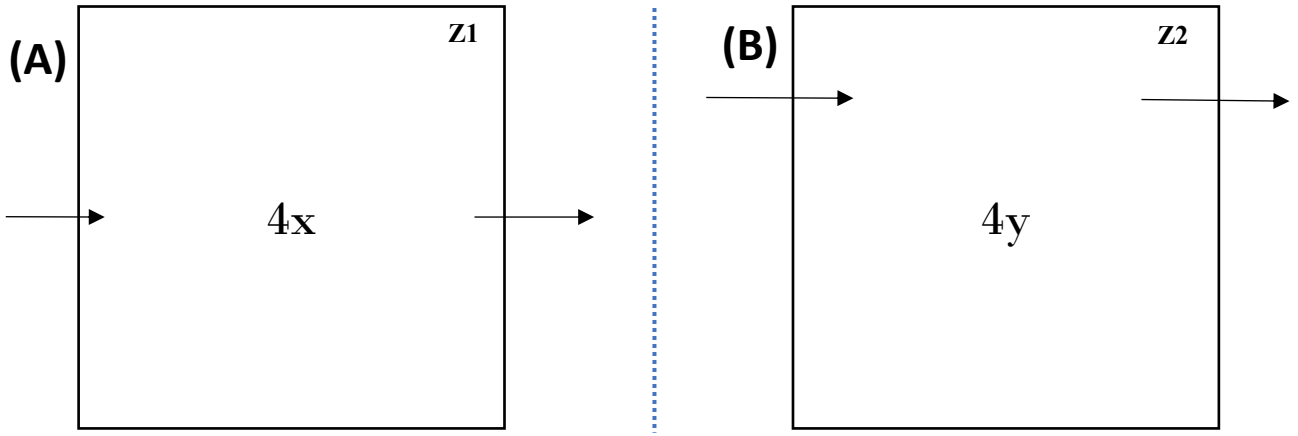
Homomorphism



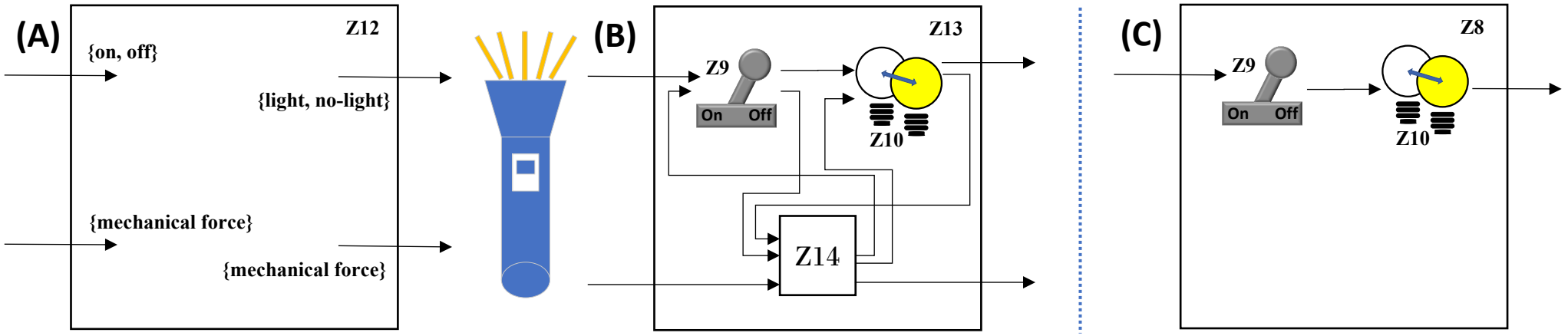
Homomorphism



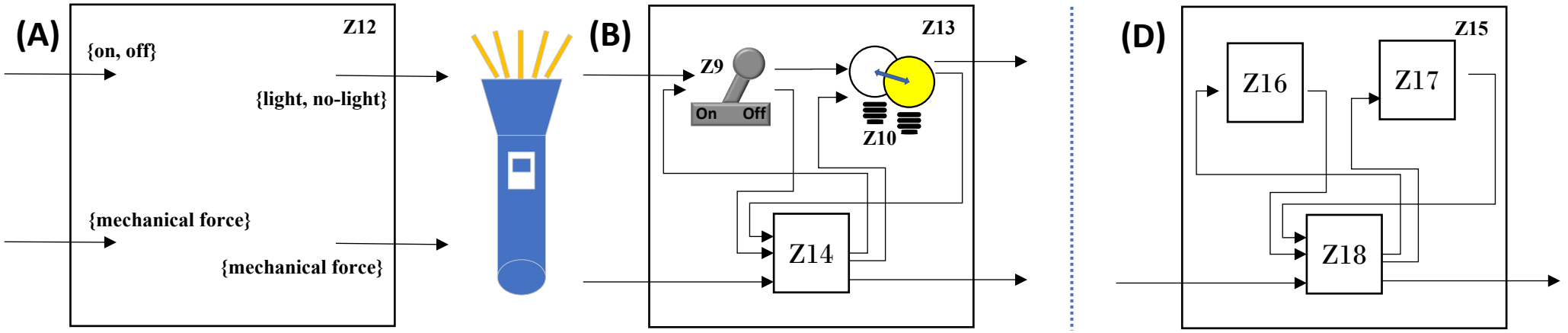
Isomorphism



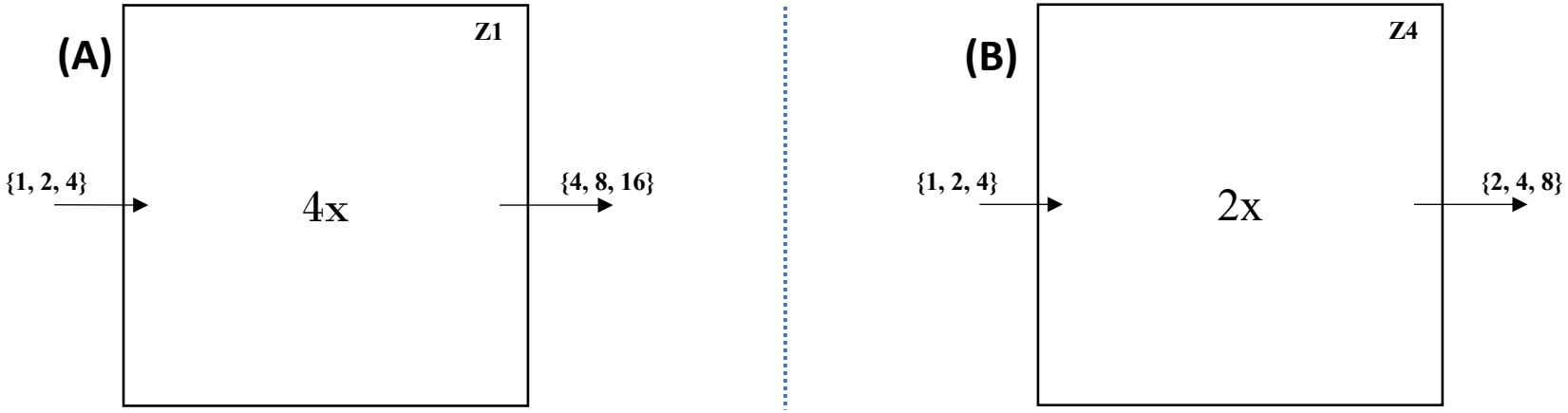
Coupled system morphism



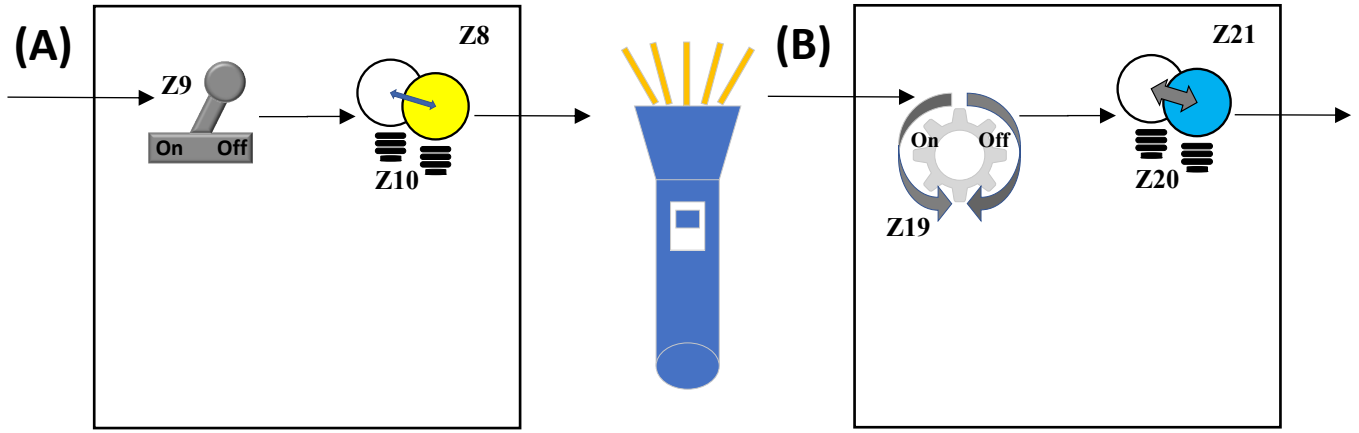
Coupled system morphism



Parameter morphism



Parameter morphism



Force: 0.5 N → Torque: 0.5 Nm

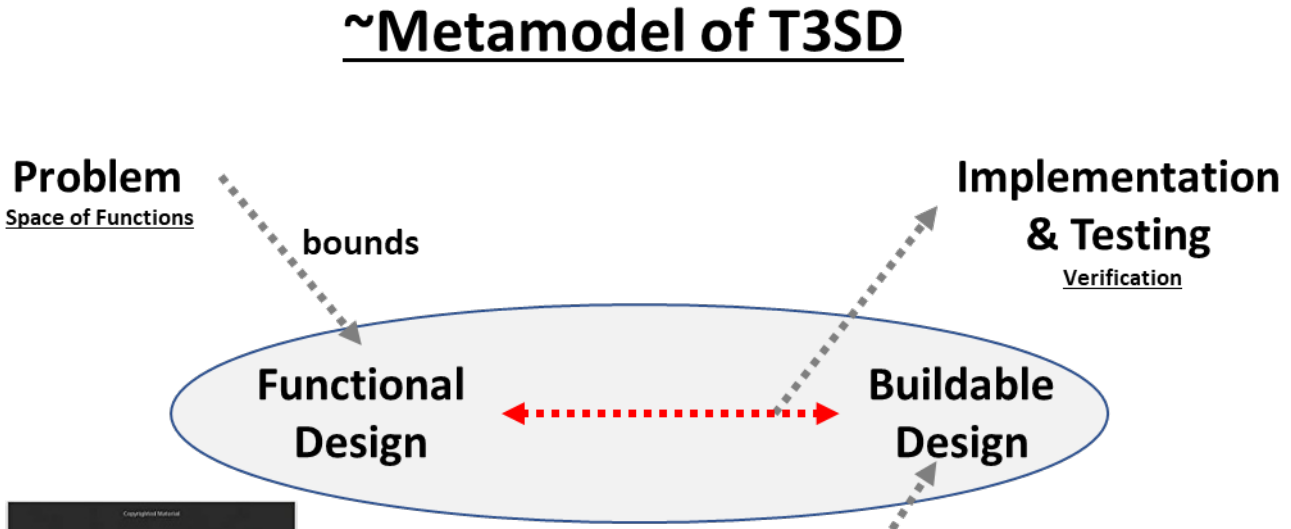
Color: yellow
Wavelength: 570–590 nm
Lumen: 1000

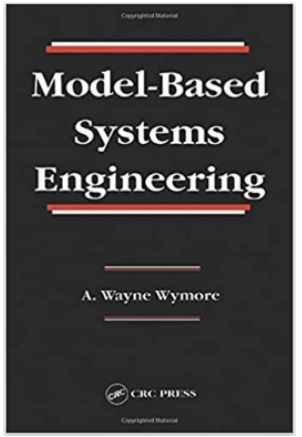
→

Color: blue
Wavelength: 450–495 nm
Lumen: 200

Start thinking in terms of morphisms

- …for verification models
- Transition from implicit to explicit
- Verification is about confidence





Paul Wach – paulw86@vt.edu

Thank You! Questions?

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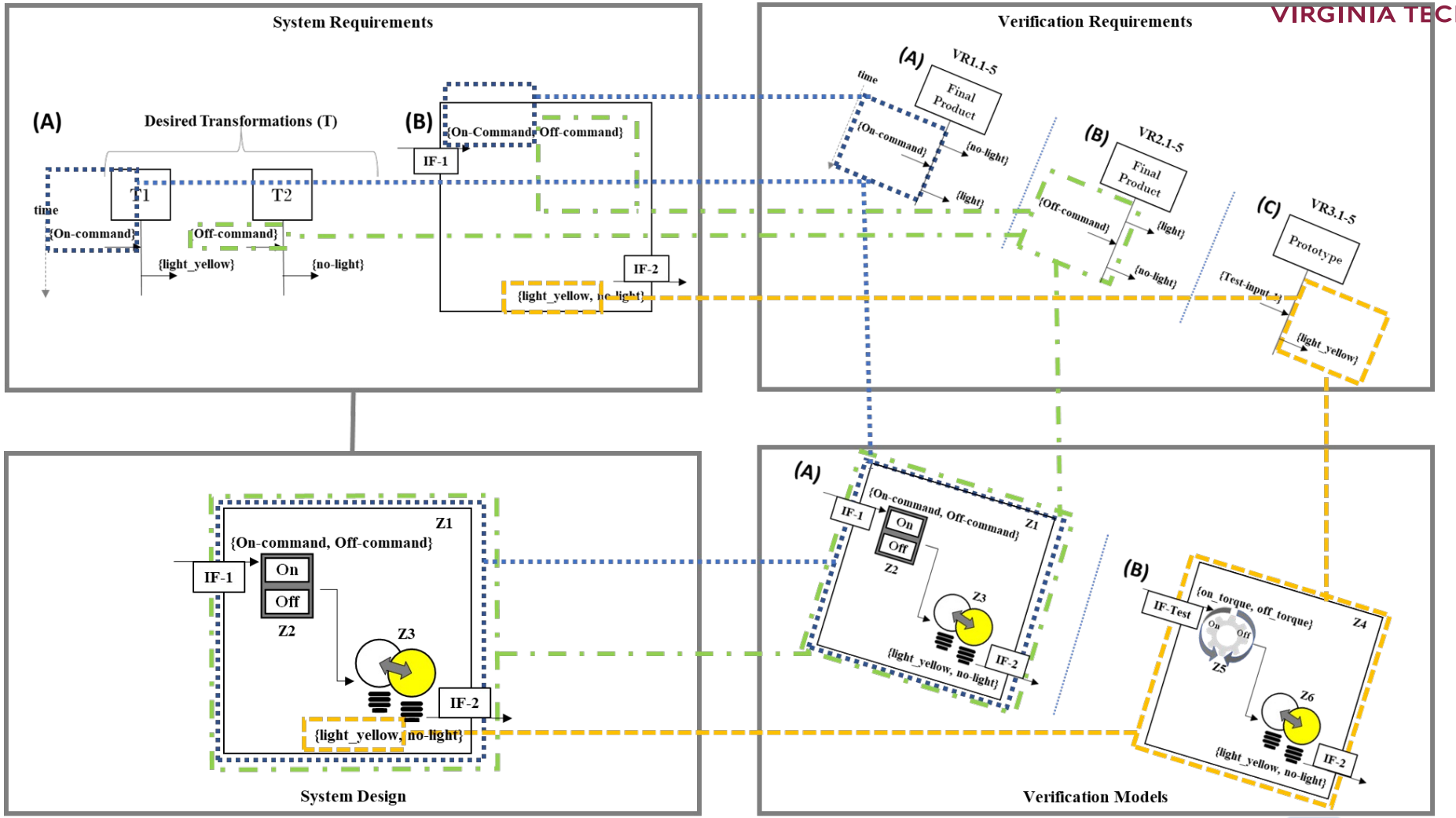
Currently Exploring

- How “should” verification models be derived?
  - Currently exploring the framing of verification within the context of systems theoretic morphism

Verification is about confidence

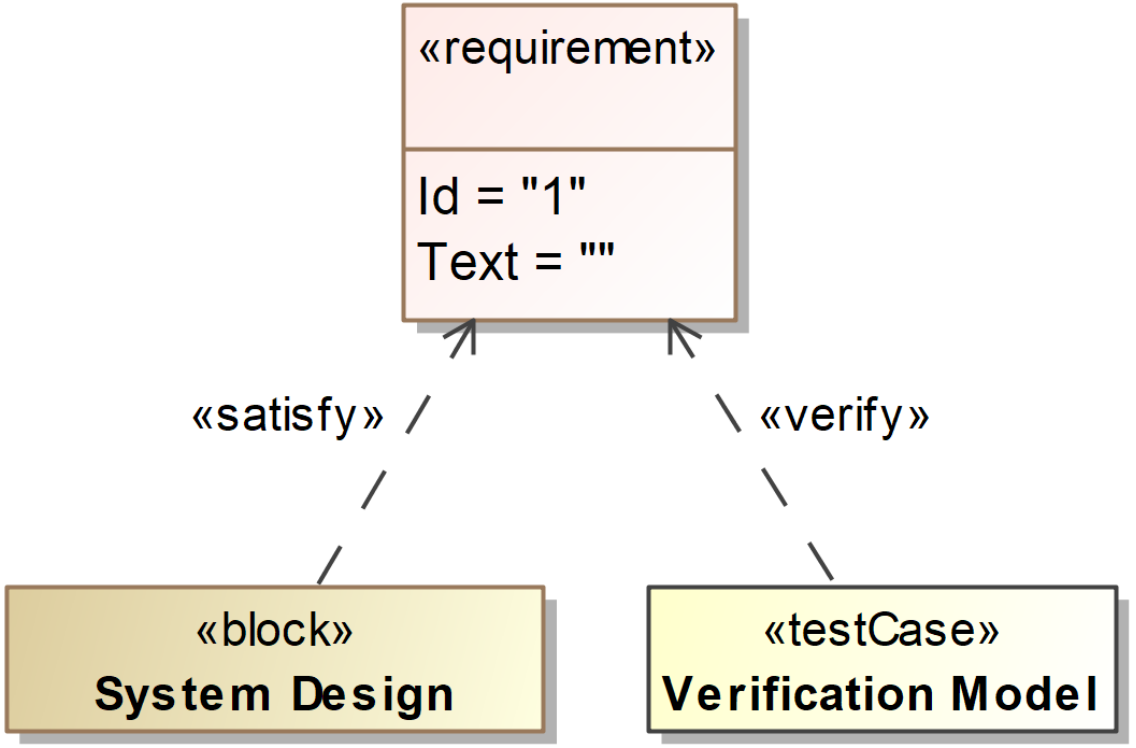
Research uses **systems theory** to frame the **argument** for **confidence** in the **systems design** adherence to **system requirements** through an **analogous verification model** observed within the context of the **verification requirements**.

***Start thinking in terms of morphisms**



A look at SE model-based practice

- Does the “satisfy” relationship mean that the system design actually satisfies the requirement?
- Does the “verify” relationship provide exclusion criteria for acceptability of verification models?
- What is the theory underpinning these relationships?



Systems Theory Perspective: System and System Requirements

- An **open system** is defined as a transformation of *inputs* into *outputs* transferred through *interface(s)*

- All system requirements can be modeled as **desired** transformations of *inputs* into *outputs* through **desired** *interfaces*
  1. Functional: what the system must do
  2. Performance: how well the system must perform its functions
  3. Resource: what the system may consume to perform its functions at the required performance
  4. Environment: settings or contexts in which the system must perform its functions