Schema, Metamodels, and Ontologies, Oh My!
Moving from Ambiguity to Clarity, “One Idea in One Place”
**EXPLICIT > IMPLICIT**

**CLARITY > AMBIGUITY**

**ACCURACY || PRECISION**

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Ontology, Metamodel, and Schema

**Ontology**: a set of concepts and categories in a subject area or domain that shows their properties and the relations between them

Oxford Languages

**Metamodel**: a model which is intended to give an all-inclusive picture of a process, system, etc., especially by abstracting from more detailed individual models contained within it

Oxford Languages

**Schema**: the organization of data as a blueprint of how the database is constructed

Wikipedia
Setting the Right Context

HUMAN

MACHINE

SYSTEMS ENGINEERING

ENGINEERING SYSTEMS

FOUNDATION

EDUCATION

INTERCHANGE

INTEROPERABILITY

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Avoiding the Perils of the Extremes

“For every complex problem, there is an answer that is clear, simple, and wrong”

H.L. Mencken
Towards an Essential Systems Metamodel or Sparse Information Model or Minimal Systems Ontology or ...
Understanding the Systems Metamodel

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Understanding the Systems Metamodel

Color Code

- Requirement Element
- Functional Element
- Physical Element
- Interface Element
- Verification Element
- Other Element

Understanding the Systems Metamodel

- Decomposed by
  - Inputs / Outputs
  - Triggered by

- Includes
  - Exposes
  - Connected to

- Performs
  - Captures / Consumes
  - Produces

- Built from
  - Kind of

- Port
  - Exposes
  - Connected to

- Component
  - Built from
    - Kind of
  - Exposes
  - Connected to

- Link
  - Includes
  - Transfers

- Exit
  - Exits by

- Resource
  - Captures / Consumes
  - Produces

- Function
  - Decomposed by
  - Inputs / Outputs / Triggered by

- Item
  - Decomposed by

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Understanding the Systems Metamodel

Port

Component

Transition

State

Exit

Resource

Function

Item

Link

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transfers

includes

MBSE

Lightning Round

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Understanding the Systems Metamodel

Color Code:
- Requirement Element
- Functional Element
- Interface Element
- Physical Element
- Verification Element
- Other Element

Diagram:
- Component
  - Transition
    - triggered by
  - State
    - decomposed by
    - exhibits
  - Use Case
    - performs
    - involves / describes
    - specifies
    - includes / extends / kind of
  - Requirement
    - elicits
    - basis of / specifies
    - refined by
  - Port
    - connected to
  - Link
    - transfers
    - includes
  - Resource
    - captures / consumes / produces
    - decomposed by
  - Event
    - entered by / exited by
    - built from / kind of
    - exposes
    - entered by / exited by
    - built from / kind of
  - Function
    - elaborated by
    - decomposed by
  - Use Case
    - basis of / specifies
    - refined by
  - Requirement
    - elicits
    - basis of / specifies
    - refined by
  - Port
    - responsible for
  - Item
    - decomposed by

Additional Notes:
- www.incose.org/iw2021/
Understanding the Systems Metamodel
Understanding the Systems Metamodel

Color Code
- Requirement Element
- Functional Element
- Physical Element
- Interface Element
- Verification Element
- Other Element

Risk Rating Matrix

- Transition
- State
- Exit
- Function
- Use Case
- Component
- Requirement
- Port
- Verification Requirement
- Test Configuration
- Test Activity
- Link
- Item
- Event

- Enter by / exited by
- Decomposed by
- Includes
- Exposes
- Expects
- Performs
- Exits by
- Captures / consumes / produces
- Includes / describes
- Specifies
- Requires
- Verifies
- Expresses
- Responsible for
- Connected to
- Includes
- Assessed by
- Applied by
- Verifies
- Involves / describes
- Requires
- Includes
- Generates
- Results in
- Causes
- Risk
- Organization

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Understanding the Systems Metamodel
Developing a Better Metamodel

- Define your scope (engineering > modeling)
- Focus on the language of the domain
- Leverage both domain and language experts (but few heads are better than many)
- Manage the size (100 >> 1000 >> 10000)
- Emphasize interrelationships alongside concepts
- Begin with a proven base
Leveraging and Connecting Core, Tailored, and Domain-Specific

Tailored extensions
organizational or methodology
“special sauce”

Common core
applicable to any system

Domain-specific
driven by analytical, regulatory, or design-specific needs
Aligning across the Engineering Enterprise
Right Data, Right Place, Right Time, Right Presentation

- Program Mgt.
- Configuration Management
- Publications
- Training & Personnel
- Environmental
- Operations
- Maintenance
- Logistics
- Systems Engineering Team
- Customer
- Chief Engineer
- Hardware
- Software
- Safety
- Reliability, Availability, Maintainability
- Manufacturability

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Recognizing Roadblocks and Risks

- Overestimating current implementation
- Underestimating relationships
- Notation vs concept
- Amateur experts
- Emphasizing tools and artifacts
- Standards (proliferation)
- Reinventing the wheel
- Pursuit of perfection
- Attention Deficit Disorder
- Define and use
Aligning SE, MBSE, and Digital Engineering

Digital Engineering
critical enabler
for the modern engineering enterprise

MBSE
connective tissue of the Digital Engineering environment

Systems Engineering
technical connective tissue of the project team

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