Exploration of Rosen's Modelling Relation and Category Theory

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An initial exploration. Any feedback or thoughts appreciated.

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Source: Rosen Modelling Relation and CT
On https://system.desc.systems

Rosen’s Modelling Relation (4 References).

Figure 2.3.1: Anticipatory Systems, Edition 1
Robert Rosen

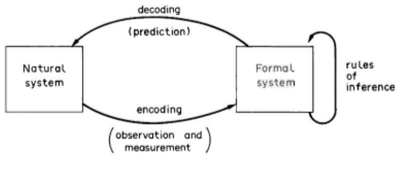
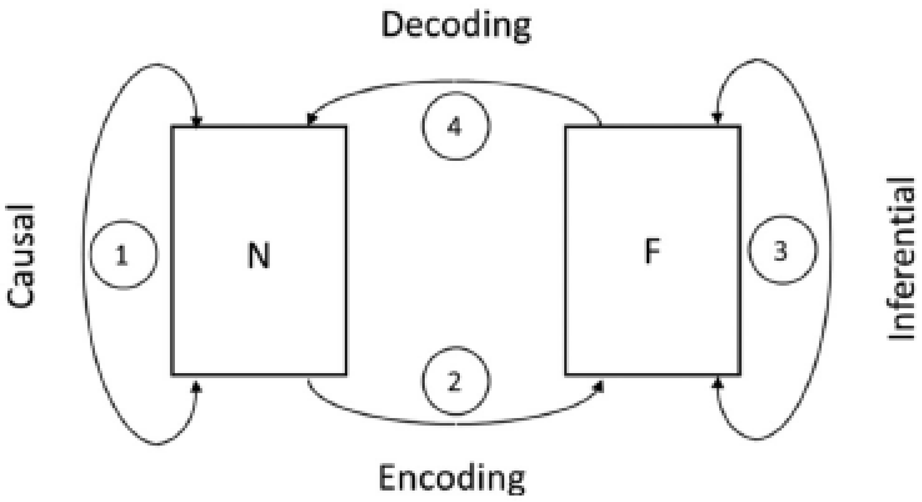


Fig. 2.3.1.

FIGURE 1 **Rosen's modelling relation**
From: Relational holon science and Popper's 3 worlds in engineering practice
David Blockley | Gary Smith |
Patrick Godfrey | John J. Kineman
Blue Text Added.

Congruence
Prediction based on model or simulation

N = Natural System



Category:
F = Formal System
Model of N

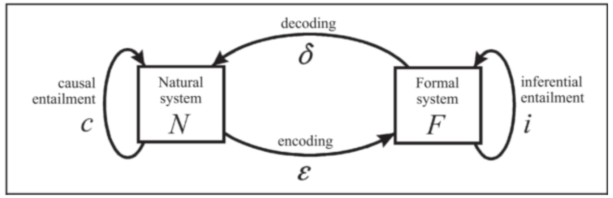
Congruence
Observation and Measurement

On Models and Modeling
Robert Rosen

Formal models were typically Mathematical models. Ensuring The results of the simulation matched The observations confirmed validity of The model conforming to the natural System.

FIGURE 2 **Prototypical Modeling Relation**
From: Robert Rosen’s Anticipatory Systems
A. H. Louie, 2010

Figure 2 The prototypical modeling relation



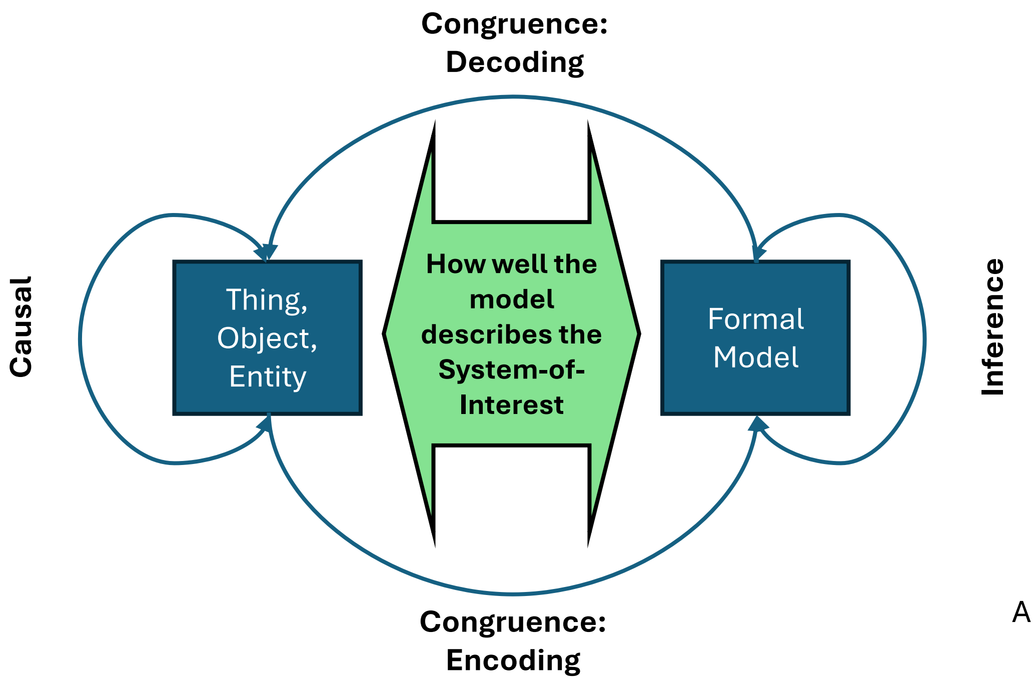
Using Rosen’s model

- **F = Formal System Model**
  - Formal system model is a conceptual model (or aligned mathematical model) of a Natural System.
  - The Formal System Model has a Congruence with the Natural System
  - The Formal System Model has elements and relationships that have a Congruence to the Entity, Thing or Object as a system-of-interest with type of traceability or mapping. The Congruence can be strong (as in Functor) or weak as in analogy or other mapping.
  - Relates to Epistemology
- **N = Natural System**
  - Natural System is an entity, thing, object as a system-of-interest in the natural world (Physical or Conceptual)
  - Through observations and experiments there is a Congruence that establishes a relationship between the Natural System and the Formal System Model. This can be weak or strong.
  - The observations and experiments can help create or improve a Formal Model.
  - Relates to Ontology
- **One Category (F) and Two Congruences (Encoding, Decoding) related to a system-of-interest**
  - This is described in Rosen’s book “Anticipatory Systems”, Edition 1 and the paper on models and modelling highlights the problems of misalignment of N as an entity, thing, object and the models F.

Rosen Model: Adapted for conversation

Rather than use the term “Natural System”,
The focus shifts to a physical or abstract:
System-of-Interest representing a
thing, object or entity.

Has named properties
or characteristics



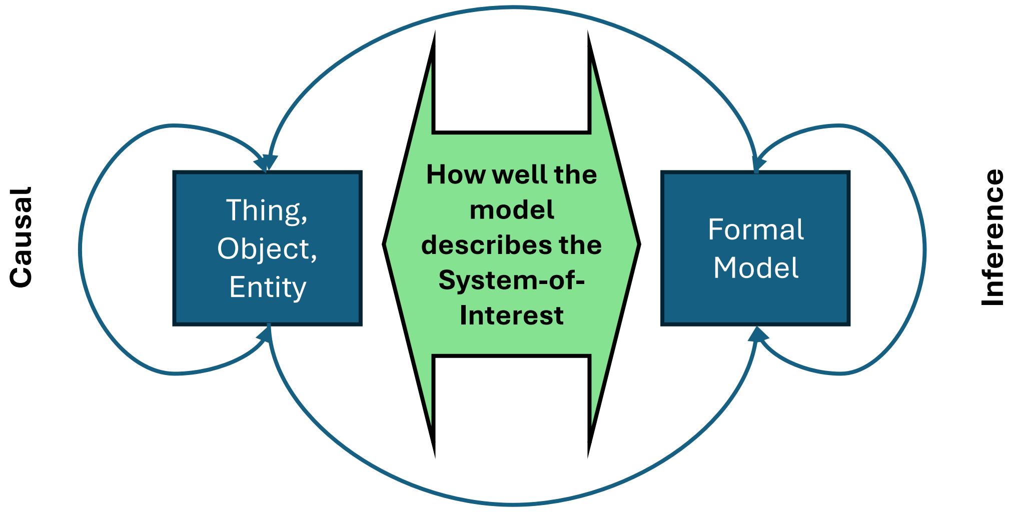
Focus on any type of model
About a system-of-interest

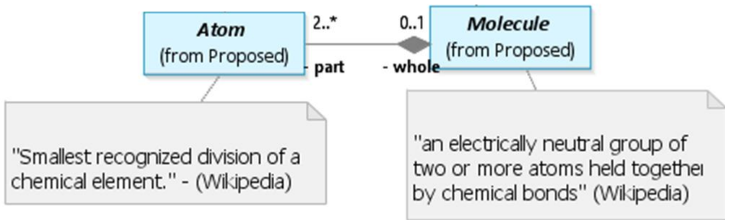
A focus on Ontology

A focus on Epistemology

Rosen Model: Water Molecule Example

System-of-Interest:
Water Molecule:
H_2O



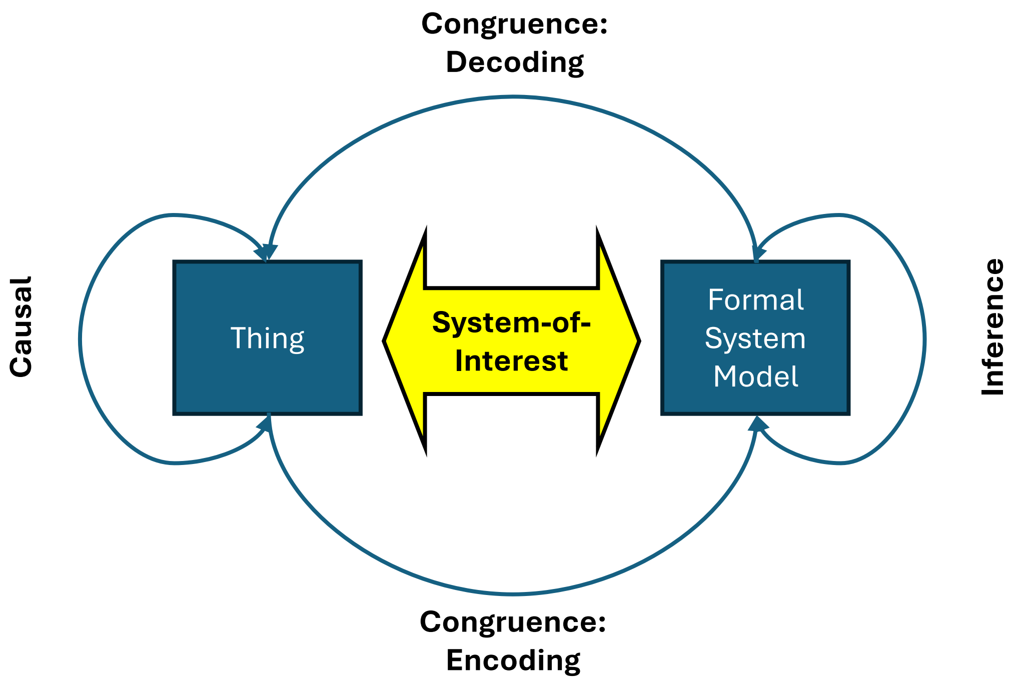


Tom Marzolf Model of a Molecule

H_2O can be modelled as a Molecule using the above model.

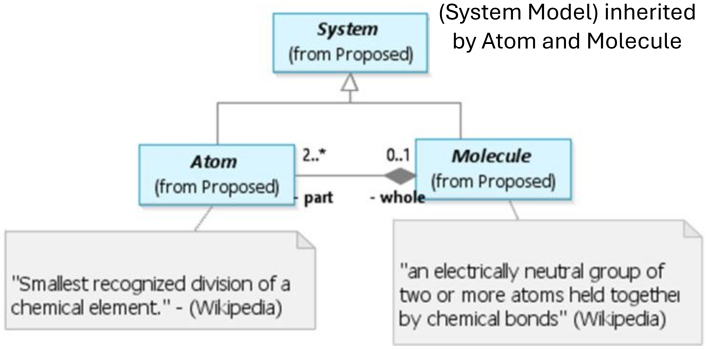
Rosen Model: Water Molecule as a System

System-of-Interest:
Water Molecule:
H_2O



A system “lens” to see an Entity, Thing or Object as a system.

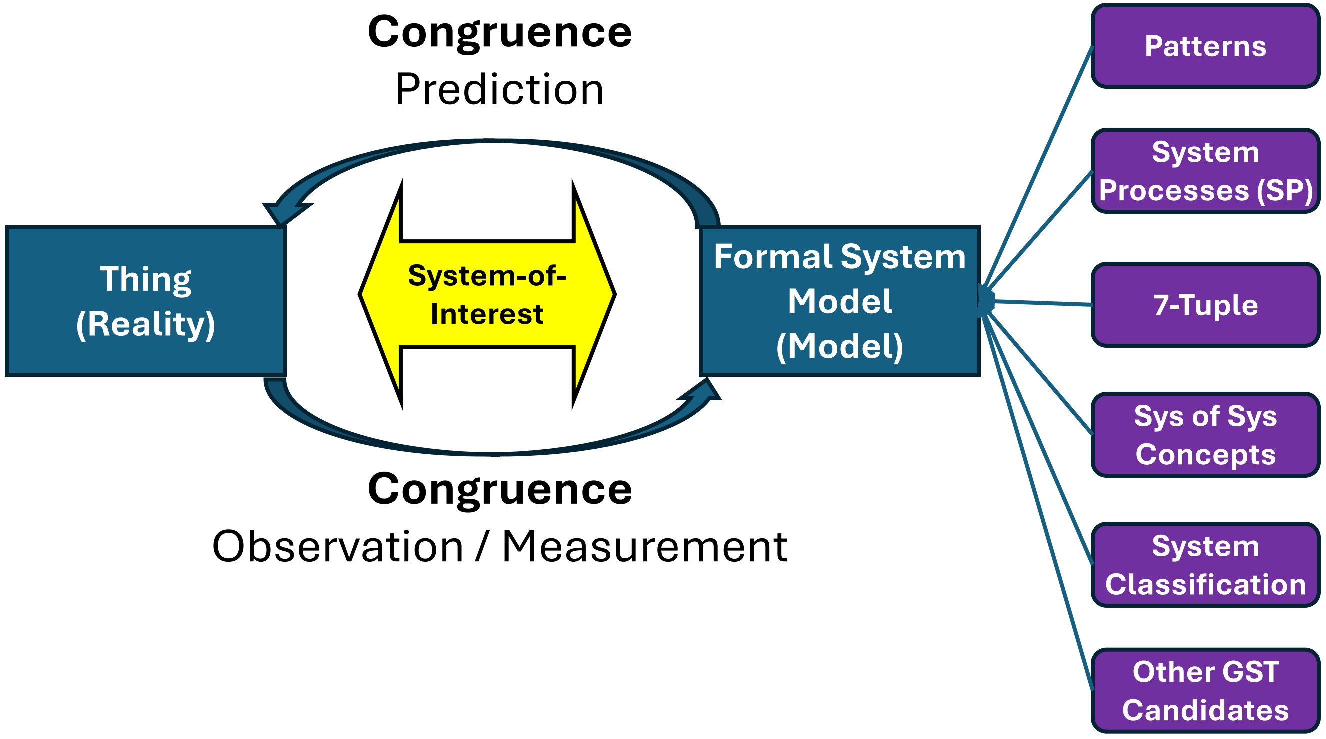
Definition of System (System Model) inherited by Atom and Molecule



Tom Marzolf Model of a Molecule as a system

H_2O can be modelled using the Molecule Model as a System.

Rosen’s Modeling Relation: GST Candidates



Tyler

Lynn, Luke, Len

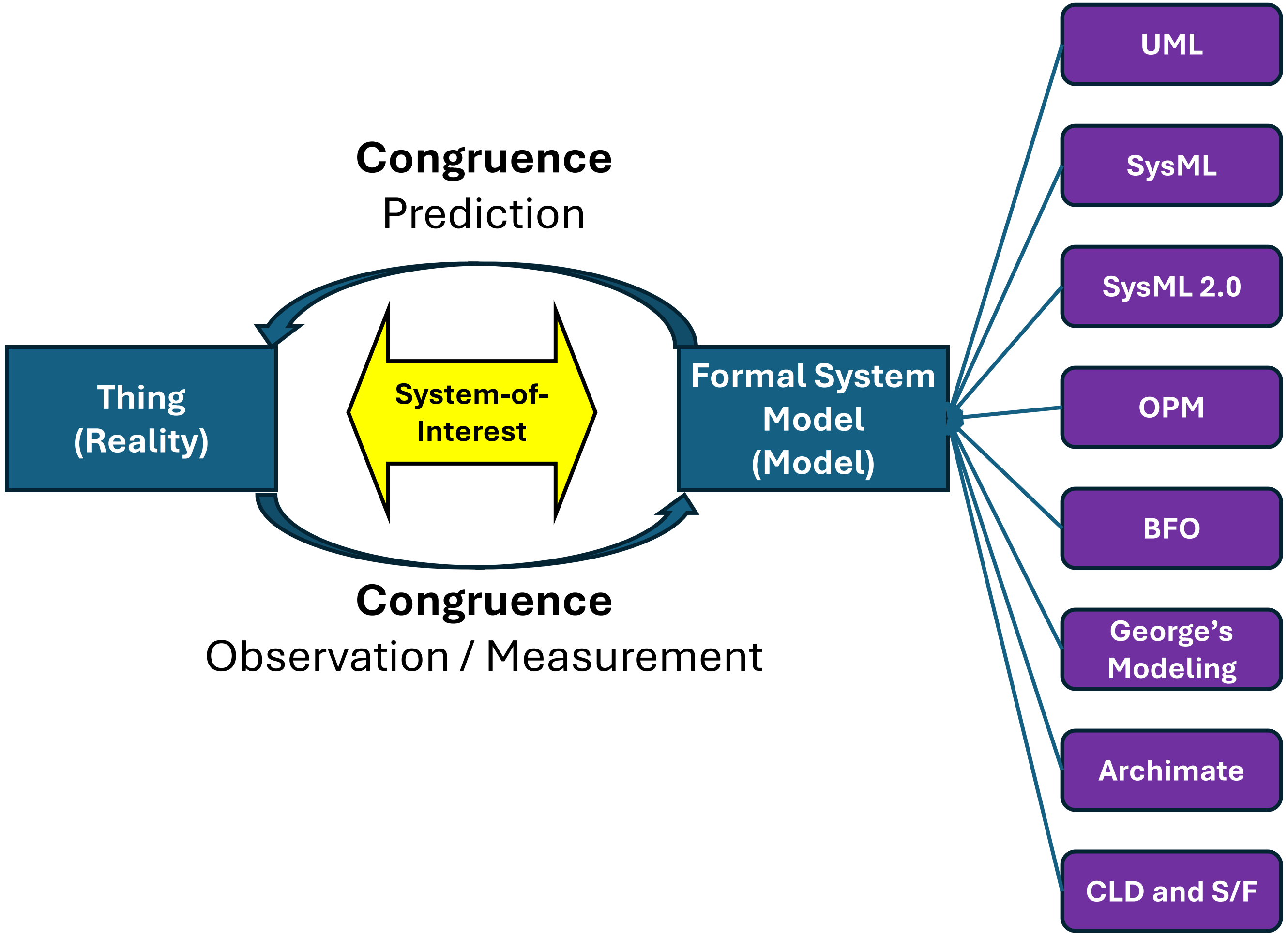
George

Ackoff, INCOSE, Boulding
LvB, Meadows, Bruce

Boulding, Ackoff, Checkland
George, Len, Miller, Tyler, Rob

Challoner, Kineman, Rose
Korn, B. Smith, Henshaw

Rosen’s Modeling Relation: Modeling Language



Structural and Behavioral Models

Based upon UML

New System Model Graphical And Text (not UML)

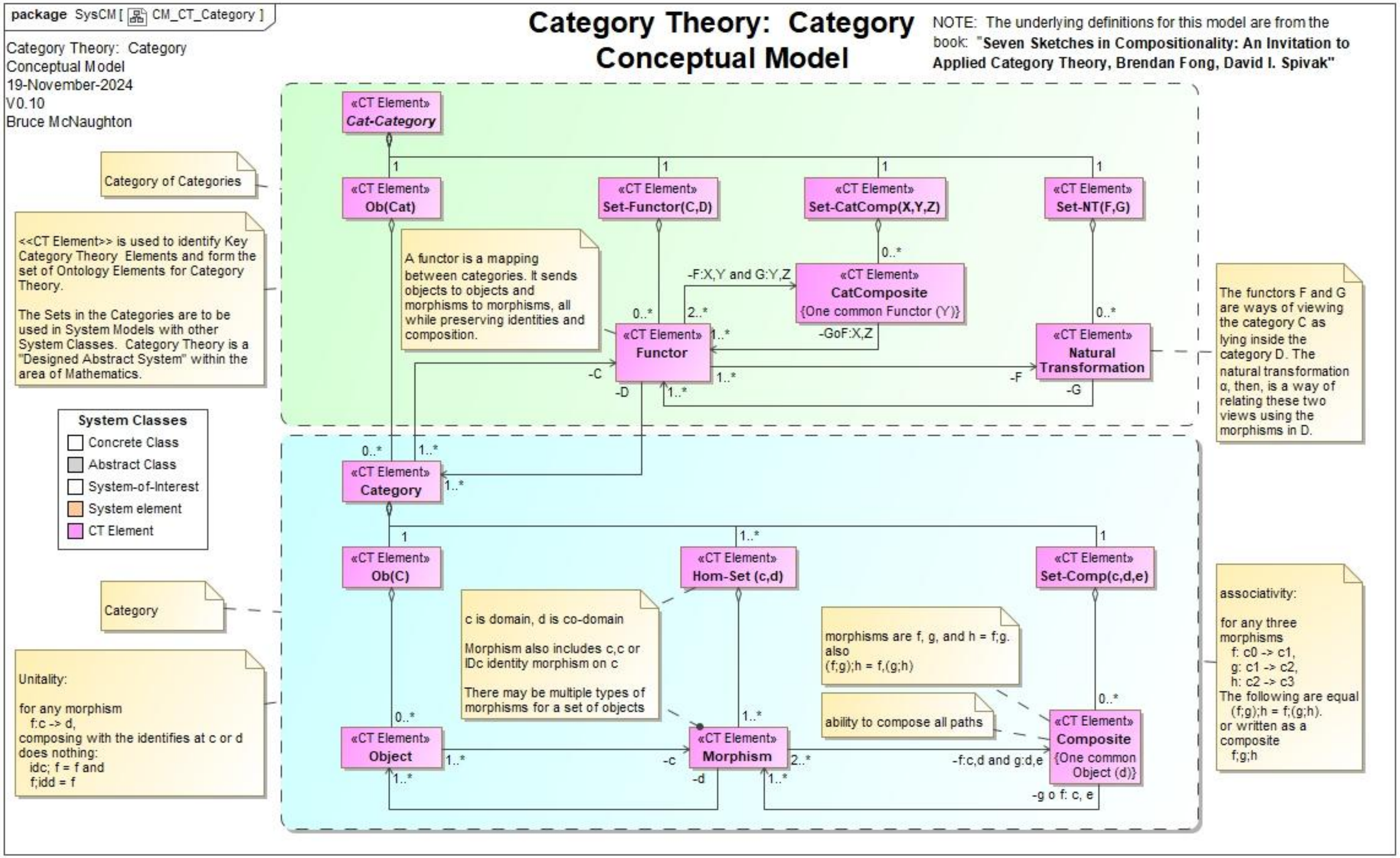
Object Process Methodology Similar to UML

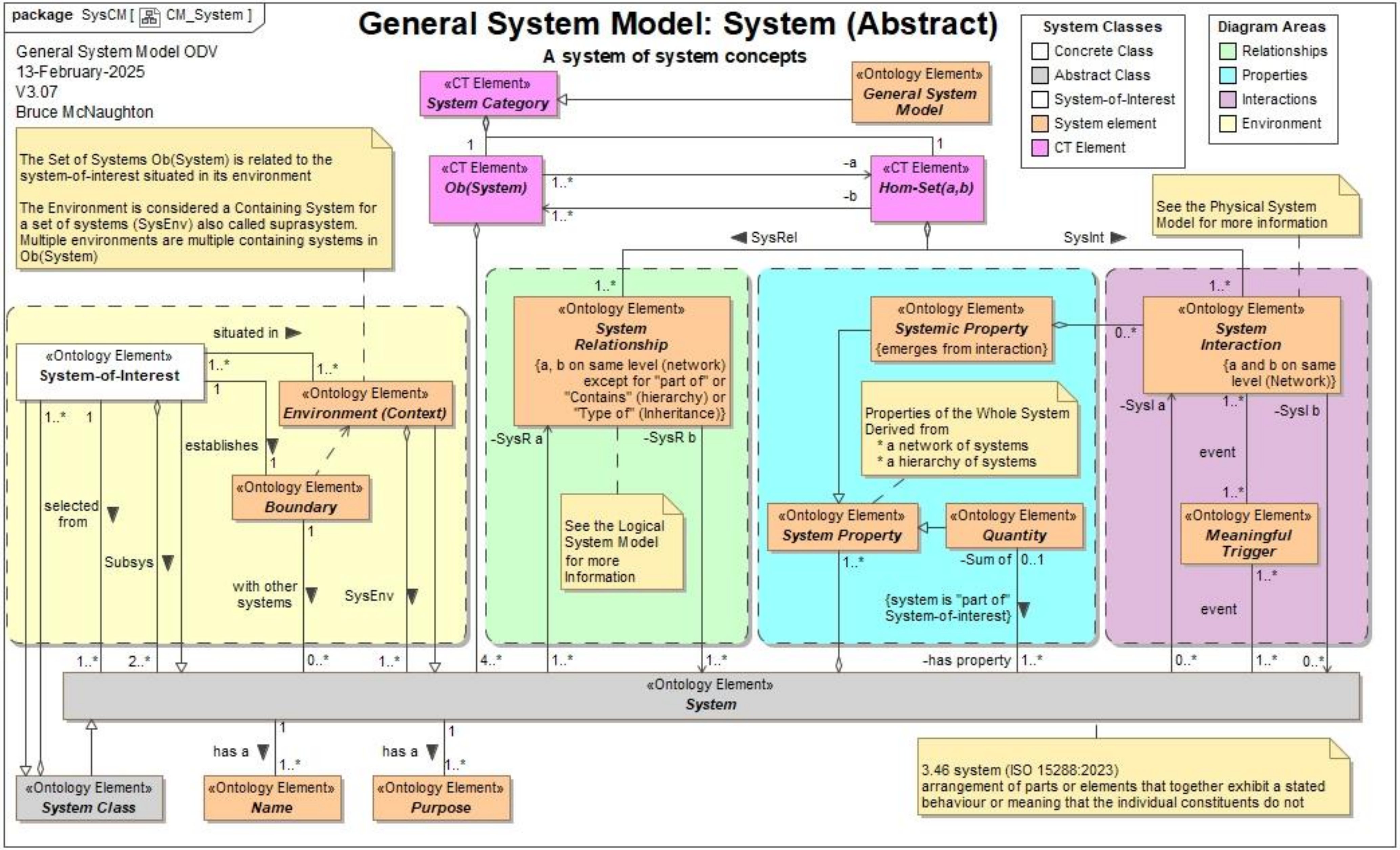
Ontology building (OWL and RDL provide tools)

Symbolic modeling

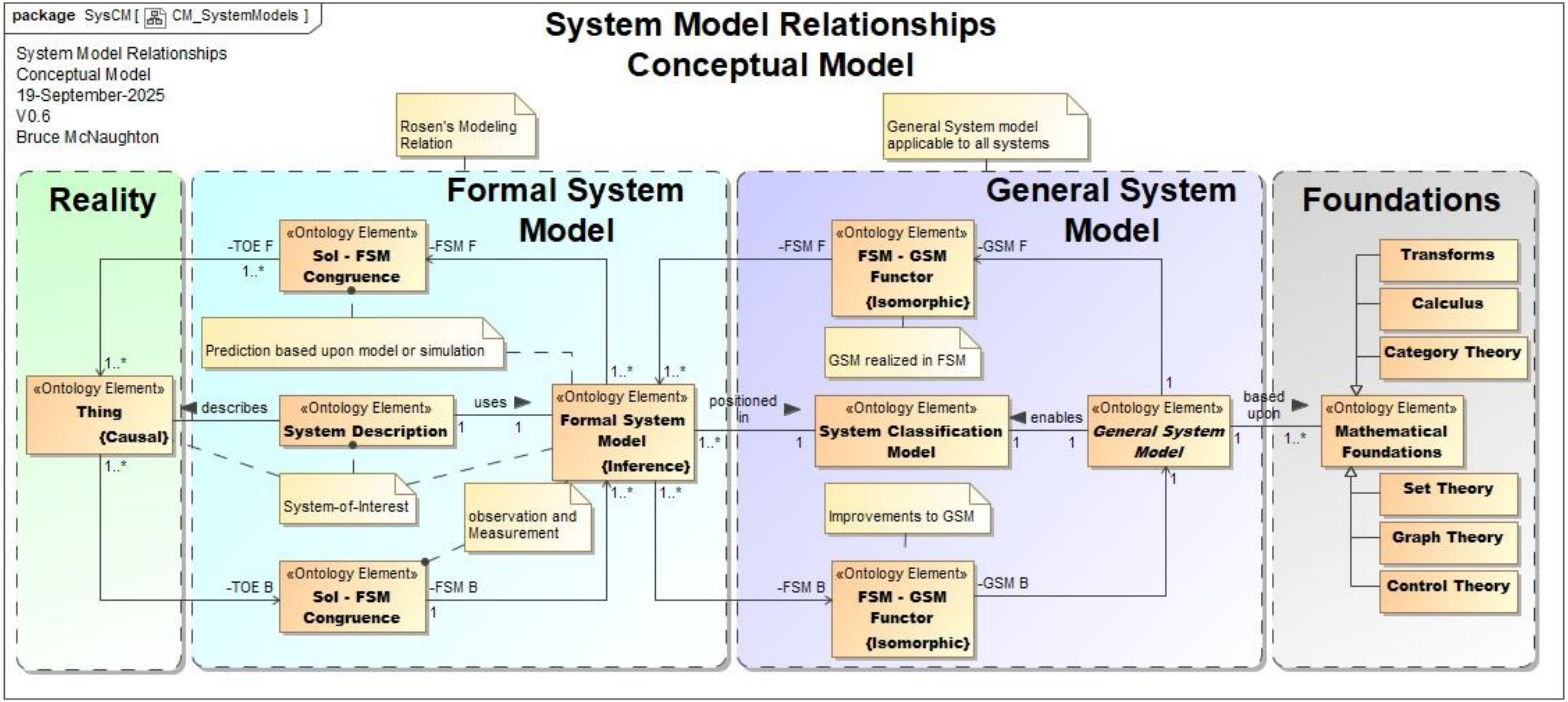
Enterprise Architecture Modeling (visual / data)

Causal Loop Diagram (CLD)
Stock and Flow Diagram (S/F)

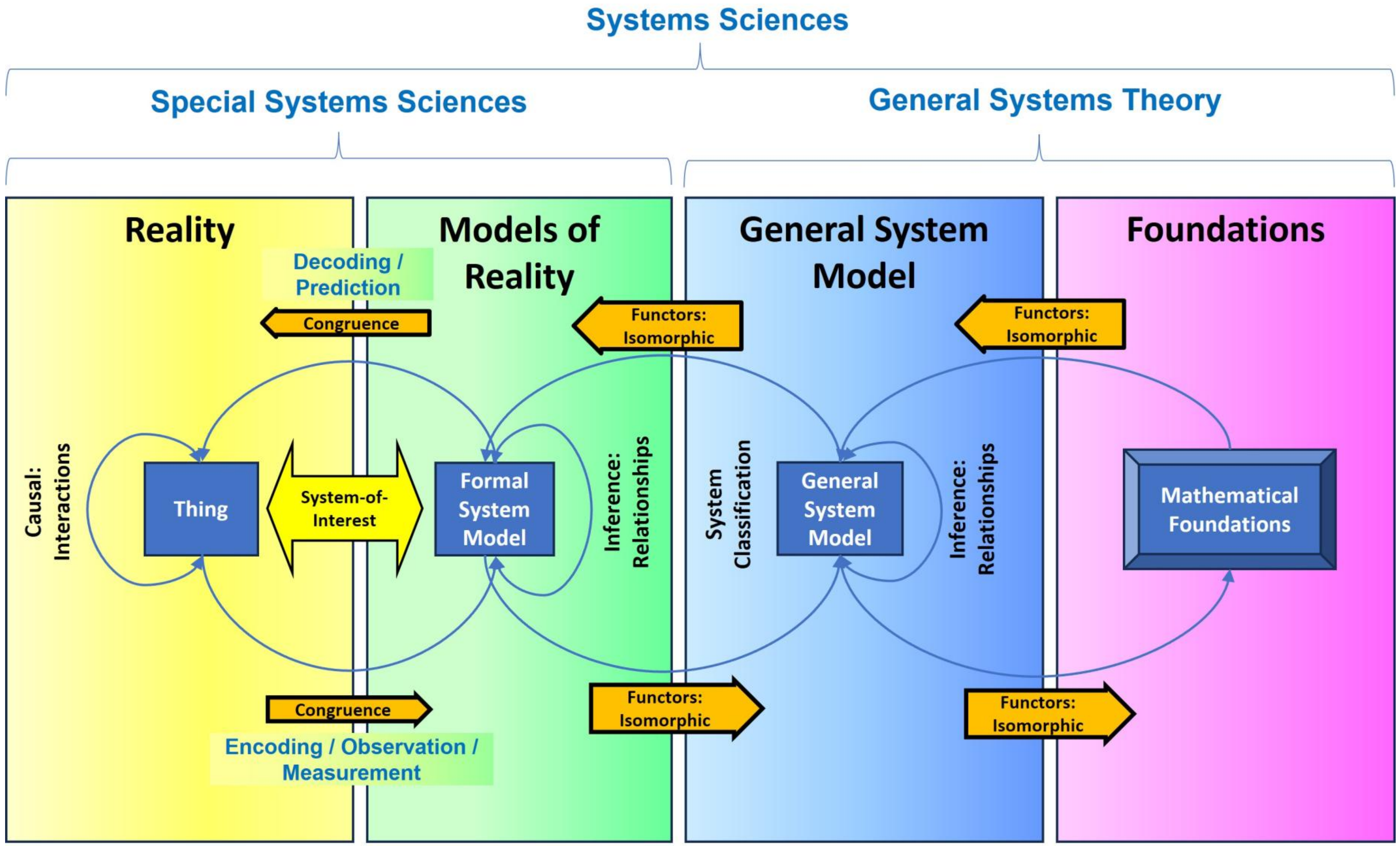

package SysCM [CM_CT_Category]
Category Theory: Category Conceptual Model
NOTE: The underlying definitions for this model are from the book: "Seven Sketches in Compositionality: An Invitation to Applied Category Theory, Brendan Fong, David I. Spivak"
Category Theory: Category
Conceptual Model
19-November-2024
V0.10
Bruce McNaughton
Category of Categories
<<CT Element>> is used to identify Key Category Theory Elements and form the set of Ontology Elements for Category Theory.
The Sets in the Categories are to be used in System Models with other System Classes. Category Theory is a "Designed Abstract System" within the area of Mathematics.
System Classes
Concrete Class
Abstract Class
System-of-Interest
System element
CT Element
Category
Unitality:
for any morphism
f:c -> d,
composing with the identifies at c or d does nothing:
idc; f = f and
f;idd = f
«CT Element» Cat-Category
«CT Element» Ob(Cat)
«CT Element» Set-Functor(C,D)
«CT Element» Set-CatComp(X,Y,Z)
«CT Element» Set-NT(F,G)
A functor is a mapping between categories. It sends objects to objects and morphisms to morphisms, all while preserving identities and composition.
-F:X,Y and G:Y,Z
«CT Element» CatComposite {One common Functor (Y)}
-GoF:X,Z
«CT Element» Functor
«CT Element» Natural Transformation
-C
-D
-F
-G
The functors F and G are ways of viewing the category C as lying inside the category D. The natural transformation α, then, is a way of relating these two views using the morphisms in D.
«CT Element» Category
«CT Element» Ob(C)
«CT Element» Hom-Set (c,d)
«CT Element» Set-Comp(c,d,e)
c is domain, d is co-domain
Morphism also includes c,c or IDc identity morphism on c
There may be multiple types of morphisms for a set of objects
morphisms are f, g, and h = f;g. also (f;g);h = f,(g;h)
ability to compose all paths
«CT Element» Object
«CT Element» Morphism
-c
-d
-f:c,d and g:d,e
«CT Element» Composite {One common Object (d)}
-g o f: c, e
associativity:
for any three morphisms
f: c0 -> c1,
g: c1 -> c2,
h: c2 -> c3
The following are equal
(f;g);h = f;(g;h).
or written as a composite
f;g;h


package SysCM [CM_System]
General System Model: System (Abstract)
A system of system concepts
General System Model ODV
13-February-2025
V3.07
Bruce McNaughton
System Classes
Concrete Class
Abstract Class
System-of-Interest
System element
CT Element
Diagram Areas
Relationships
Properties
Interactions
Environment
«CT Element» System Category
«Ontology Element» General System Model
«CT Element» Ob(System)
«CT Element» Hom-Set(a,b)
The Set of Systems Ob(System) is related to the system-of-interest situated in its environment
The Environment is considered a Containing System for a set of systems (SysEnv) also called suprasystem. Multiple environments are multiple containing systems in Ob(System)
See the Physical System Model for more information
SysRel
SysInt
«Ontology Element» System-of-Interest
situated in
«Ontology Element» Environment (Context)
establishes
«Ontology Element» Boundary
selected from
Subsys
with other systems
SysEnv
«Ontology Element» System Relationship {a, b on same level (network) except for "part of" or "Contains" (hierarchy) or "Type of" (Inheritance)}
-SysR a
-SysR b
See the Logical System Model for more Information
«Ontology Element» Systemic Property {emerges from interaction}
Properties of the Whole System Derived from
* a network of systems
* a hierarchy of systems
«Ontology Element» System Property
«Ontology Element» Quantity
-Sum of
{system is "part of" System-of-interest}
-has property
«Ontology Element» System Interaction {a and b on same level (Network)}
-SysI a
-SysI b
event
«Ontology Element» Meaningful Trigger
«Ontology Element» System
«Ontology Element» System Class
has a
«Ontology Element» Name
«Ontology Element» Purpose
3.46 system (ISO 15288:2023) arrangement of parts or elements that together exhibit a stated behaviour or meaning that the individual constituents do not

Foundations to Reality using Category Theory



Foundations to Reality

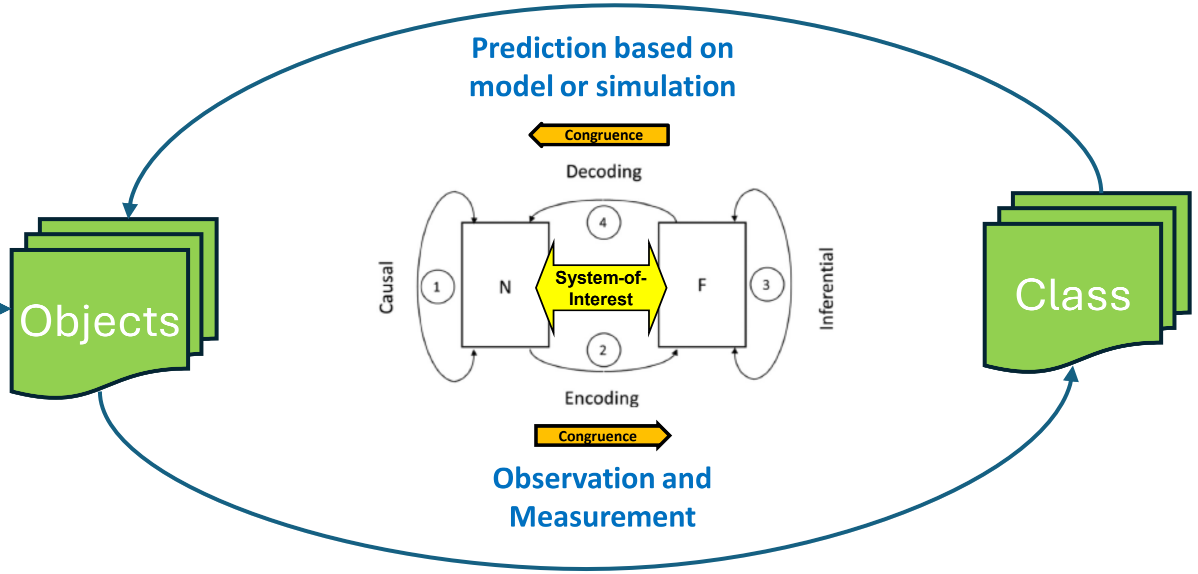


UML and Modeling Relation

Matlab, Simulink, open Modelica capabilities:
Simulate Behavioural diagrams based in UML (activity, sequence, state machine)
Provide discrete, stochastic and continuous simulation.

Behavioral Models (Activity, Sequence, etc) connected with Matlab or Simulink provide a means to check / predict the behavior of the objects

Behaviorial Diagrams (Activity, state machines or Sequence Diagrams) are used to model performance.
These models can be connected with MATLAB or SIMULINK to carry out performance models.



Object Diagrams are Structural Models used for instantiation of a class model

Atom may be an Abstract Class while an Oxygen Atom is an Instance of the Atom Class with typical numbers of protons, neutrons, and electrons.

Classes formed through observation and measurement of objects to define Attributes and Functions

Class Diagrams are Structural Models

To identify attribute and function names (ontology)

Classes may be Abstract or Concrete

Abstract Classes require object re-definition to form an instance

Conclusions: So far .. More to come.

- **Entity, Thing, Object as a System-of-Interest**
  - The focus for scientific understanding and learning is an Entity, Thing, Object as a system-of-interest.
  - An Entity, Thing or object has characteristics / properties that can be observed / named.
  - These characteristics / properties may not be described in system terms (e.g. may not have inherent named system concepts).
- **Models are used to understand an Entity, Thing, Object as a system-of-interest**
  - Models reflect our understanding (Knowledge) of an Entity, Thing, Object as a system-of-interest
  - Models can be improved (we now have a Subatomic way to understand Molecules and Atoms)
  - In most cases, models are not the Entity, Thing, Object. The Map is not the Territory.
  - Classifications of Entities, Things, Objects as a system-of-interest is another type of model.
- **System Models are used to understand an Entity, Thing, Object <u>as a System-of-Interest</u>**
  - Using a common language and representation
  - Definition of System and an associated General System Model are key.
  - Isomorphic to a General System Model based upon Math Foundations
  - Using a formal set of tools and techniques (math, modelling, etc).
  - Along with a system classification model.