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USING ONTOLOGIES IN CONCEPTUAL MODEL VALIDATION

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Using Ontologies in Conceptual Model Validation

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Thesis

- The ideal for VV&A of a model is to demonstrate that it is “**correct,**” or at least correct for some use.
- For extremely complex models, V&V may be essentially impossible, requiring the substitution of “**suitable**” for “correct.”
- For models of social interactions, e.g., war, peace keeping, nation building, etc., the theoretical basis of the social sciences does not support many decisions on “correctness.”
 - For these models, V&V concentrates on improving the users’ understanding of the model – its good and bad points.
 - One part of the **validation** process (of the **conceptual model**) devolves to an examination of the theoretical support that does exist.
 - The organizational support for this examination consists of an **ontology** of the Social Domain, which describes all of the possible elements that might be covered by a social model.

Some Definitions

- **M&S**

- **Model:** an abstraction of reality – can be mental, physical, computer code.
- **Simulation:** a model that addresses change over time – can be acted out manually or run on a computer.
- **Conceptual Model:** (general usage) the model that is intended to be implemented in computer code.

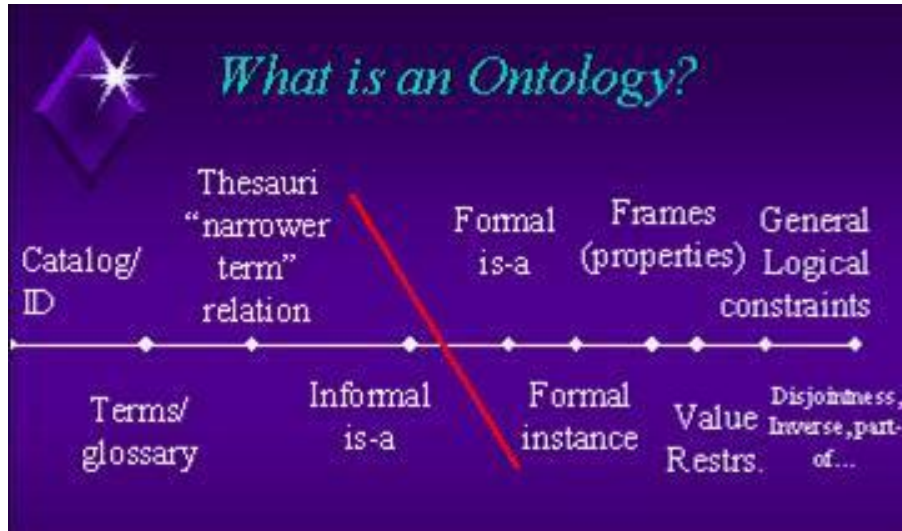
- **VV&A**

- **Verification:** is the process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques.
- **Validation:** is the process of determining the degree to which a model or simulation is an accurate representation of the real-world from the perspective of the intended uses of the model or simulation.
- **Accreditation:** is an official determination that a model is acceptable for a specific purpose.

- **Ontology**

- **Taxonomy:** a description of a domain characterized by a tree structure, each element having a single parent
- **Ontology:** a domain description in which each element may have multiple parents and which may incorporate other descriptive elements (properties, part-of relations, etc.)

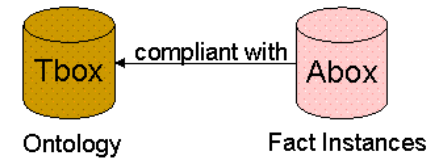
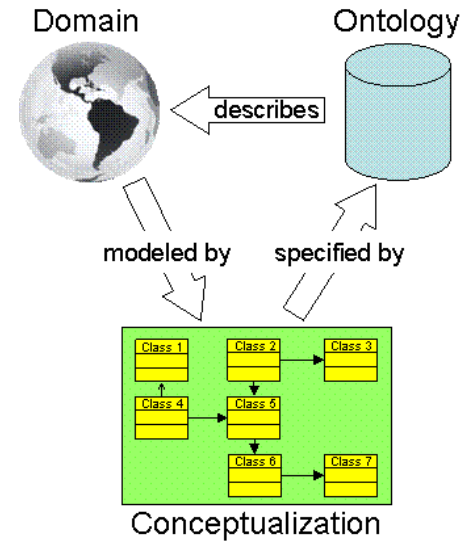
Ontology Concepts



McGuinness Spectrum

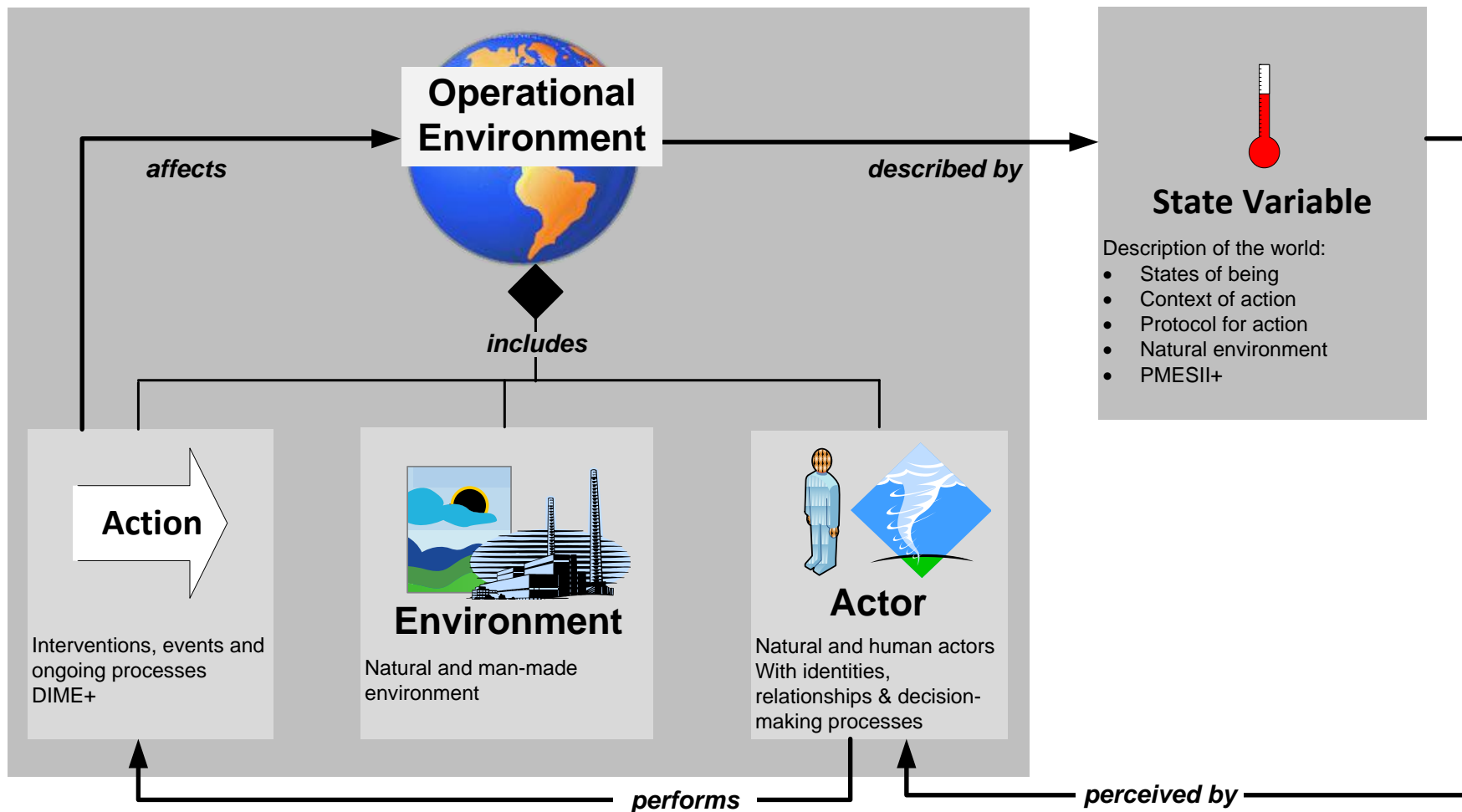
Ontology Languages

Applications	
OWL 2 Web Ontology Language	
RDF Schema	Individuals
RDF and RDF/XML	
XML and XMLS Datatypes	
IRIs and Namespaces	

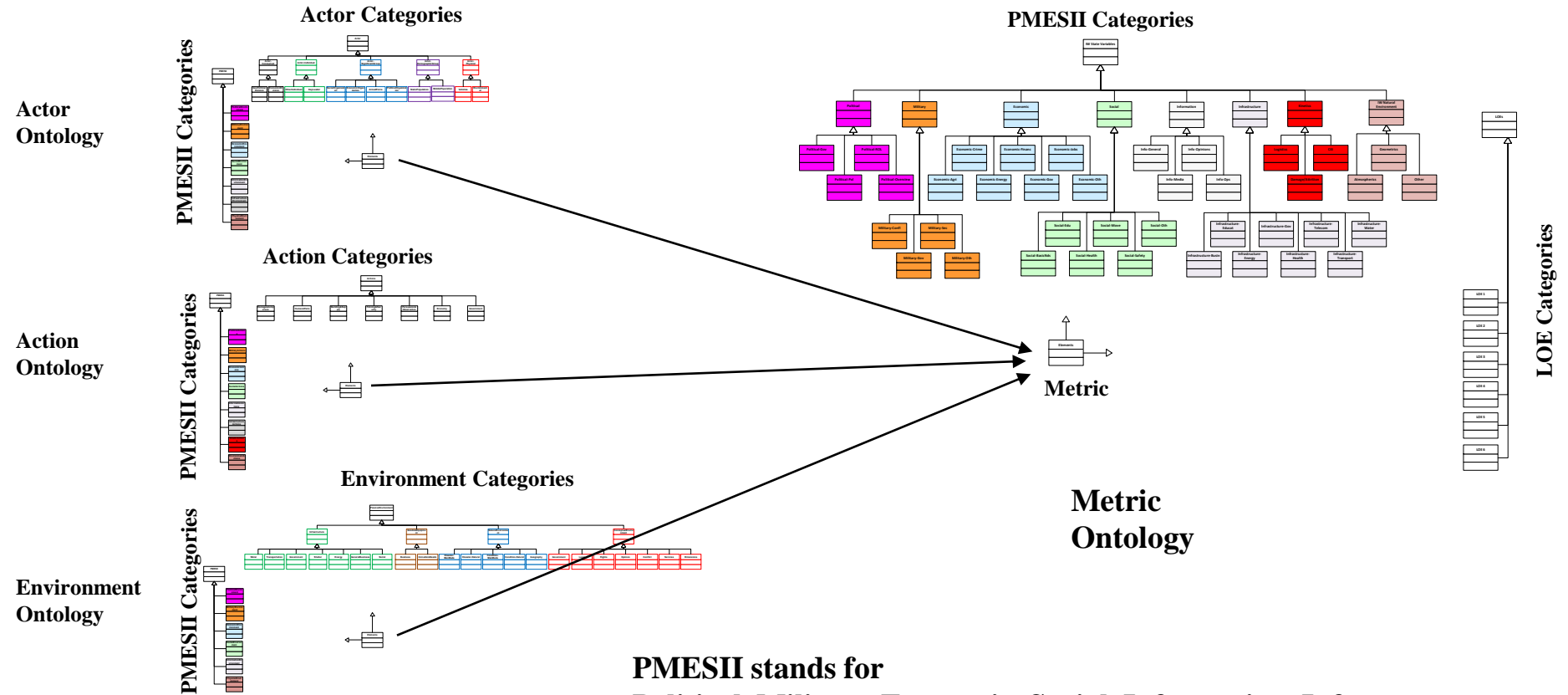


General Social Models

High Level Conceptual Diagram

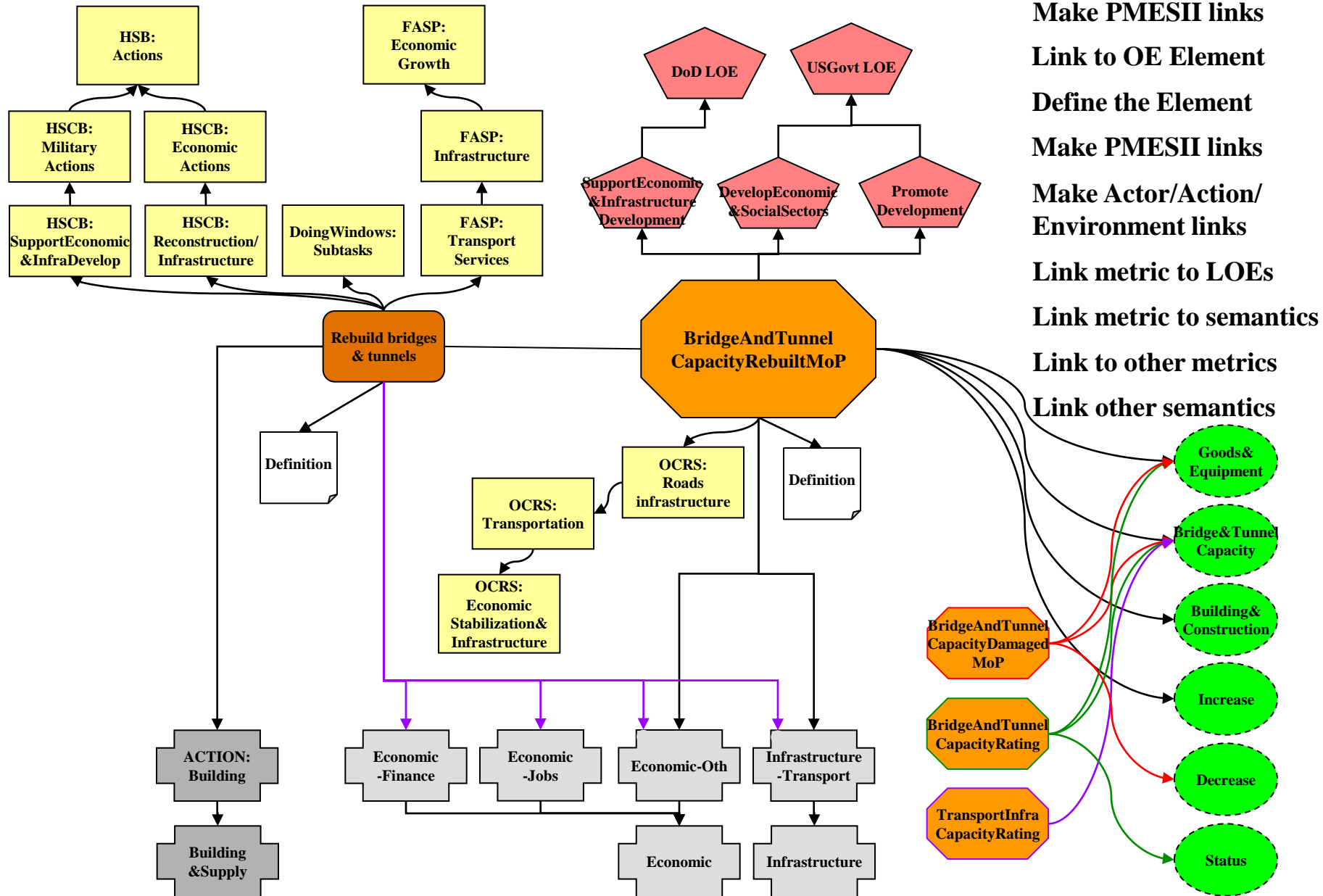


Populating the Conceptual Diagram



**PMESII stands for
Political, Military, Economic, Social, Information, Infrastructure,
Top levels of a taxonomy of metrics for the social domain**

Example Ontology Links



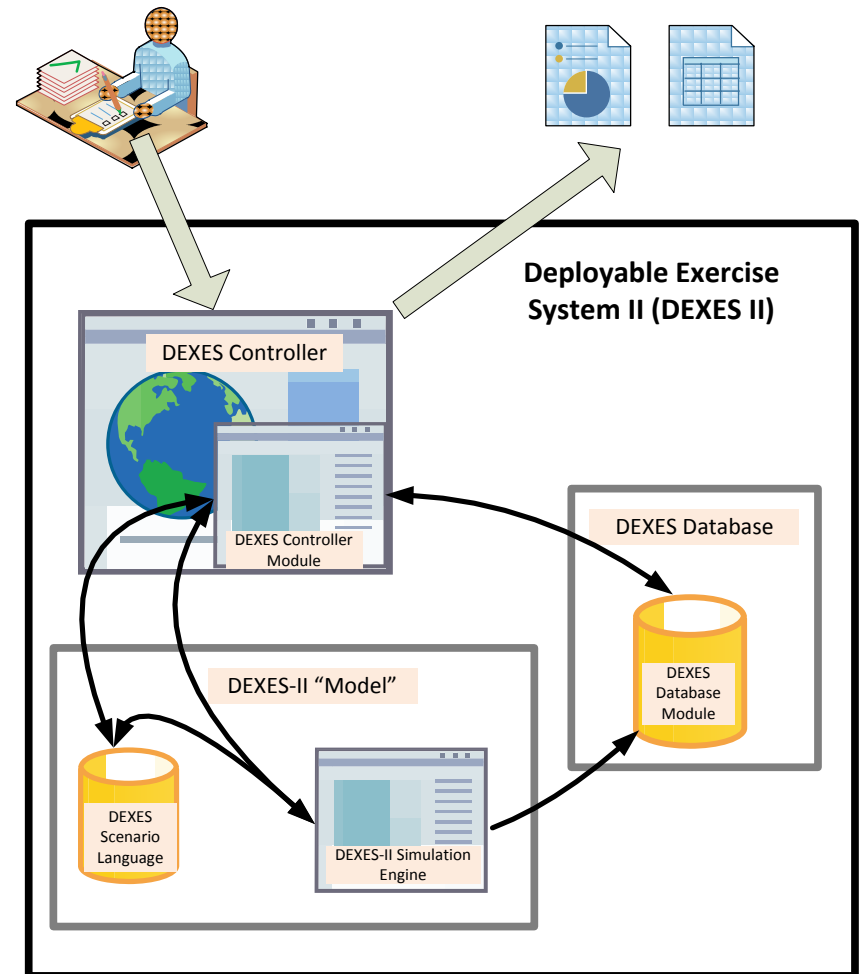
Social Ontology

- **633 Metric Classes**
- **Linked to 545 Operational Environment Elements**
 - **83 Actors, with actor ontology**
 - **313 Actions, with action ontology**
 - **165 Environment Elements, with environment ontology**
 - **Several in multiple categories**
- **Each class and element is linked to one or more subcategories of the PMESII+ paradigm (political, military, economic, social, information, infrastructure, kinetics, environment)**
- **Definitions include links to 13 sources (lists, taxonomies, ontologies)**
- **Each metric class is (potentially) linked to one or more Lines of Effort (LOEs) from one or more of the several LOE Owners (e.g., US Govt, US DoD, Afghan National Police)**
- **Each metric class is linked to one or more semantic terms to allow computer inferencing**
- **For VV&A purposes, these are collapsed into 408 elements**

System Diagram

3 Models, 4 Modules

- **The Deployable Exercise System II (DEXES-II) is an example of a social model**
- **Part of the VV&A process is “Defining the System”**
- **This involves identifying each part by defining the names and version numbers, defining the “part-of” relationships, and defining the connections within the system**



Theories

- Another part of the VV&A process is defining the theories
- Each theory, social, physical, or human expertise stand-in, must be defined, given citations, and rated as to approximate level of validity

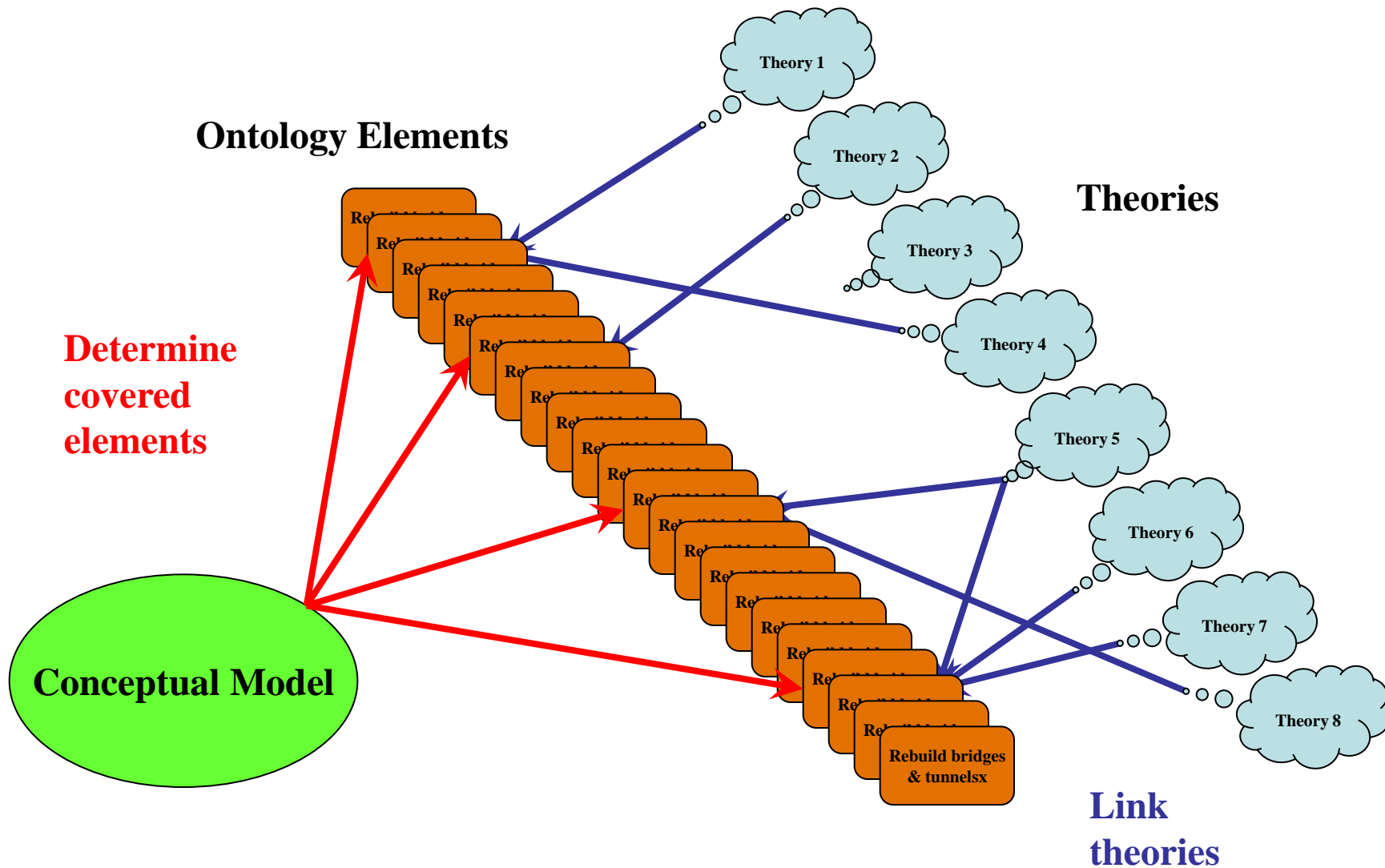
Theory Validity Abbreviation	Theory Validity Description	Theory Validity Value
Nil	Uncodified	0
Nil+	Codified but amorphous	0.5
WAG	Wild Assed Guess	1
WAG+	WAG plus some science	1.5
SWAG	Scientific WAG	2
SWAG+	SWAG with some review	2.5
PeerRvw	Peer reviewed theory	3
PeerRvw+	Well reviewed theory	3.5
Accepted	Generally accepted theory	4
Proved-	Close to proven theory	4.5
Proved	Scientifically proved theory	5

- **Subject Matter Expert: Loren Cobb, CMVValue=2.5**
- **Subject Matter Expert: DEXES Experience, CMVValue=3.0**
- **Social/economic/political content areas**
 - **Demographic dynamics, cmv = 4.0**
 - Age-specific birth rate: gamma distribution centered at age ten, Valkovics, 1983; Kendelski, 1988
 - Age-specific mortality rate: union of infant mortality and adult mortality, logistic model of Thatcher with a modification for infant mortality
 - **Migration and refugee dynamics, cmv = 1.5**
 - **Educational system, cmv = 2.5**
 - Flow model of movement of students into, through, and out of education system, Cobb, 1999
 - **Public health (epidemics), cmv = 3.5**
 - Full spatial version of the standard “S-I-R” model, here Hoppenstaedt discretized integro-differential equations. S=susceptible, I=infections, R=recovered.
 - **Governance and corruption, cmv = 2.0**
 - **Public opinion dynamics, cmv = 3.0**
 - **Developmental economics, cmv = 3.0**
 - **Juvenile gangs and organized crime, cmv = 2.0**
 - **Ethnic relations, cmv = 2.5**

Perform the Static Conceptual Model Validation

- The final part of the conceptual model validation process is linking the ontology elements that are used in the model (covered) to the theories.
- Each ontology element is considered:
 - Is it relevant to the model and its use? [yes or no]
 - Is it covered by the model? [implemented in some fashion]
 - Which theory or theories are used in the implementation?
 - This information is entered into the VV&A Tool.

Validation Process

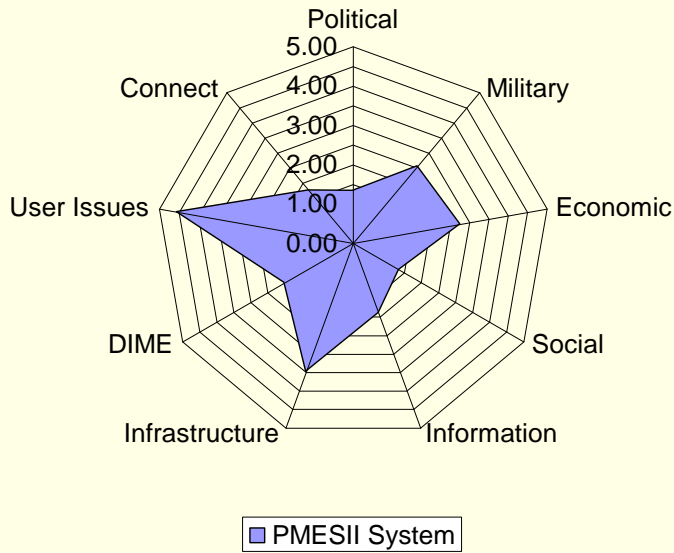


Perform the Static Conceptual Model Validation

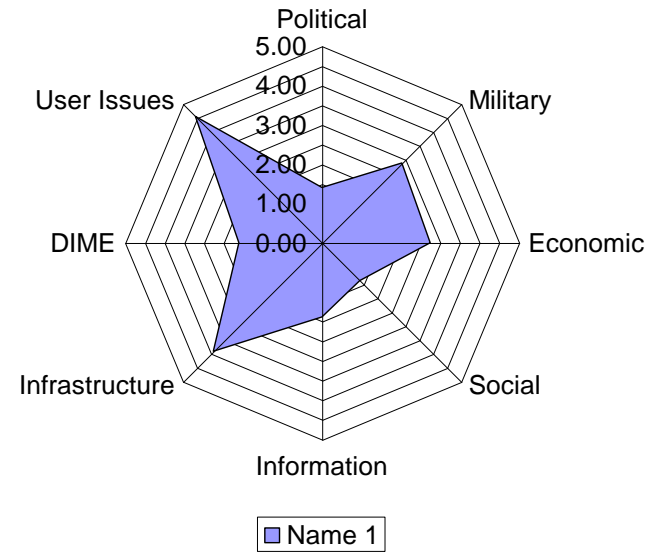
- The final part of the validation process (for this presentation) is linking the ontology elements that are used in the model (covered) to the theories.
- Each ontology element is considered:
 - Is it relevant to the model and its use? [yes or no]
 - Is it covered by the model? [implemented in some fashion]
 - Which theory or theories are used in the implementation?
 - This information is entered into the VV&A Tool.
- Various charts and reports are generated:
 - The following charts show gross averages at the PMESII level of the theory validity coverage.
 - Other more detailed charts are available and required for full understanding
 - Detailed reports describe each and every connection between the elements and the theories.

Sample Charts for Validation Visualization

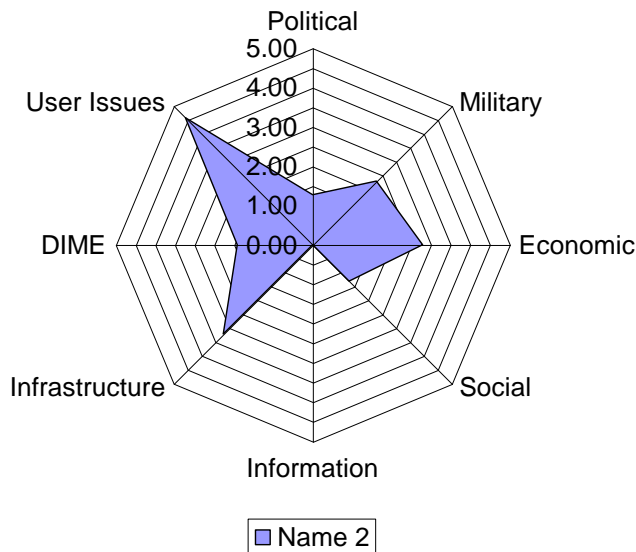
System Validation Metrics



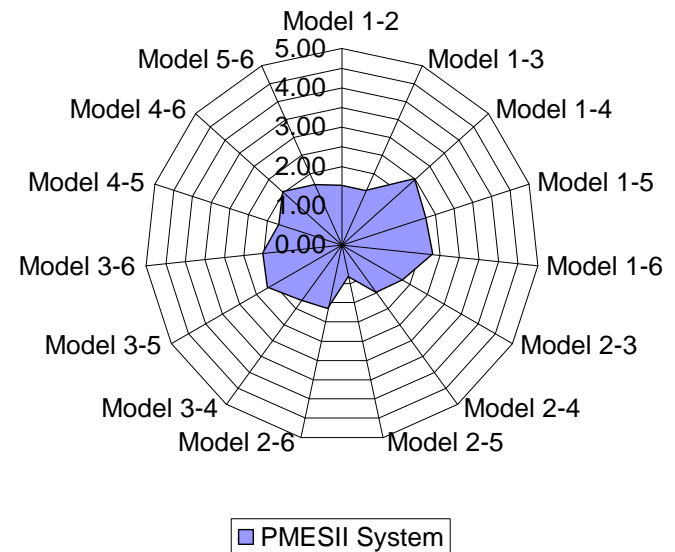
Model Validation Metrics



Model Validation Metrics



Inter-Model Connections



Summary

- **Social Ontology**

- Provides an organizational structure for defining the coverage of a model
- Provides a meaningful connection between the model and the theories it uses

- **Benefits**

- Defines the domain coverage of the model
- Defines the theories underpinning the model
- Defines the maximal theoretical validity of the model
- Supports better understanding (validation) of the nature of the conceptual model that underlies the computer system

From the hills of East Tennessee

Questions?



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