Irregular Warfare (IW) Metrics Ontology

HSCB Focus 2011

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Opinions expressed in this presentation are those of the authors and do not necessarily represent the position of DRC or TRAC.

Presentation Outline

- **Background**
  - **Army's Irregular Warfare Analytic Capability (IWAC)**
  - **HSCB Data Context**
  - **Lines of Effort (LOEs) and PMESII-PT State Variables**
  - **IWAC/TWG Data Representation Challenges**
- **IW Metrics Ontology Development Project**
  - **Irregular Warfare Metrics Ontology**
  - **Ontology Basics**
- **Ontology Development Process**
  - **Representing Metrics**
  - **Sample "Voter Turnout" Metric**
- **Results and Conclusions**

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IW Analytic Capability (IWAC) Program

- **Initiative led by the TRADOC Analysis Center (TRAC)**
- **Described in Tuesday afternoon presentation by Paul Works in Session 4 - Application of Social Cultural Methods, Models, and Tools (MMT)**
- **MMT aspect of IWAC primarily focused on the Irregular Warfare Tactical Wargame (IW TWG)**
- **IW TWG implemented as a composition of tool modules**
- **One of the tools is PAVE (supports planning, adjudication, visualization, environment) which uses Task-Event-Outcome (TEO) constructs**
- **TEOs utilize quantitative and qualitative data provided by CONUS analysts and forward data cells**

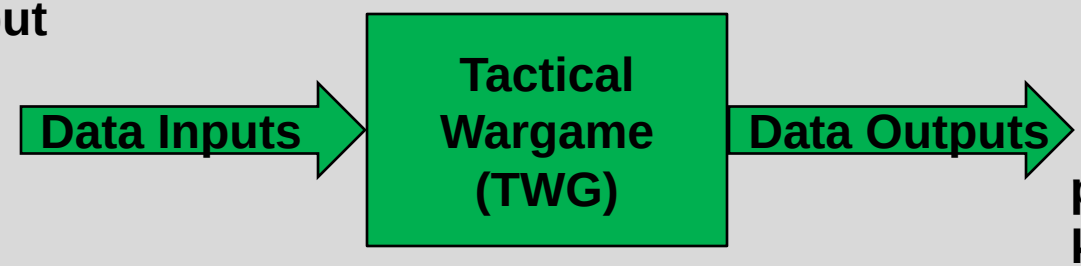
HSCB Data Context

Generic Case

Internal Data

TRAC Case

Some of the input data describes the state of the operational environment



Some outputs describe perceptions of population and key individuals

TEOs include data that define the odds of particular events and outcomes occurring

Lines of Effort (LOEs) and PMESII-PT State Variables

Lines of Effort (LOEs) within current focus:

- Establish Civil Security
- Establish Civil Control
- Support Host Nation Security Forces
- Support to Governance
- Restore Essential Services
- Support to Economic and Infrastructure Development

PMESII-PT state variable categories:

- Political
- Military
- Economic
- Social
- Information
- Infrastructure
- Physical environment
- Time

LOEs and PMESII-PT help categorize data in the IW domain.

IWAC/TWG Data Representation Challenges

- Describe desired end state of Lines of Effort (LOEs)
- Determine progress towards desired end state
- Describe current state of the operational environment
- Provide meaningful simulation outputs that indicate perceptions of key personnel and population
- Support multiple echelons (e.g., company, battalion)
- Use state information to affect TEO influencers
- Guide data collection efforts
- Support Verification, Validation, & Accreditation (VV&A) efforts

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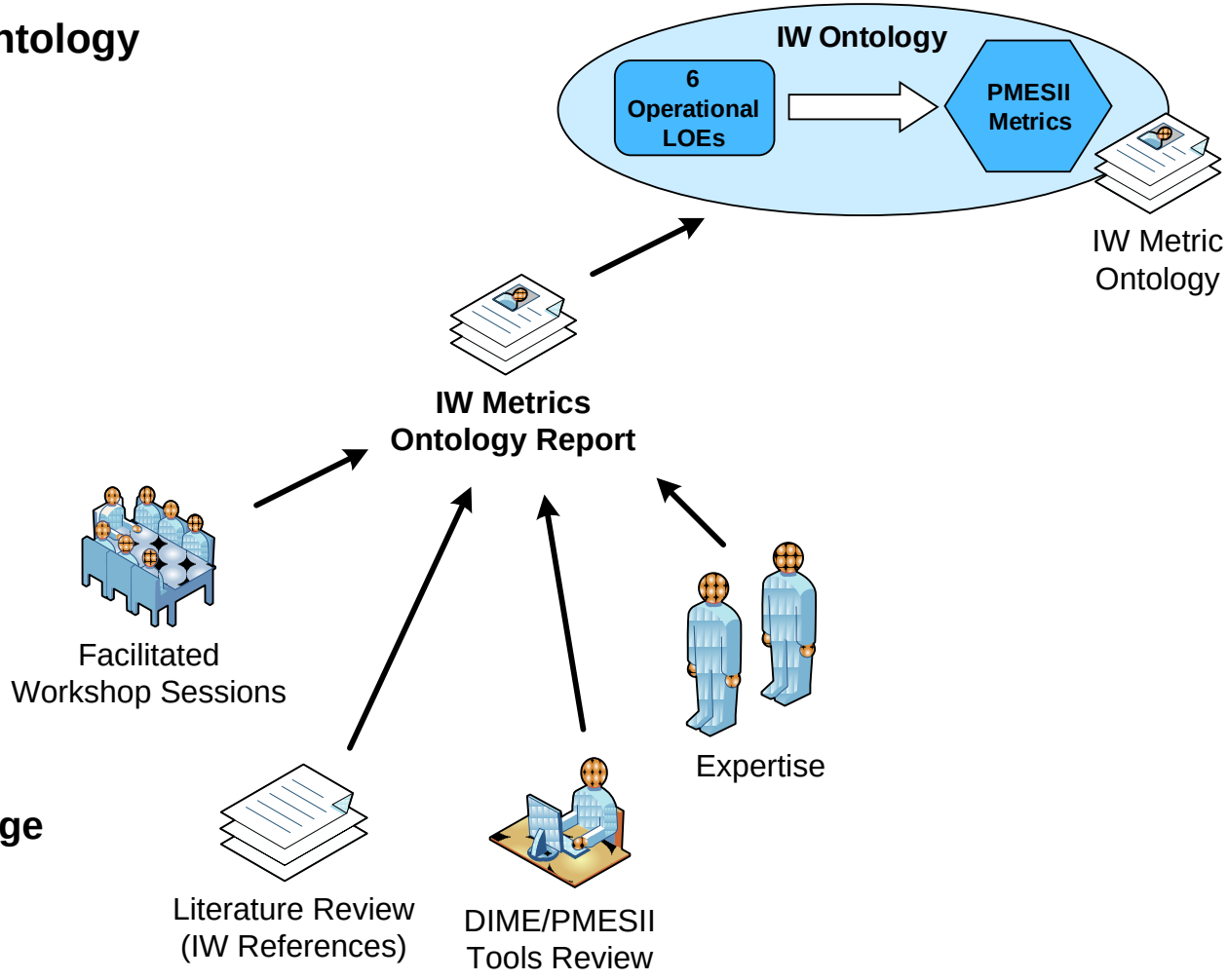
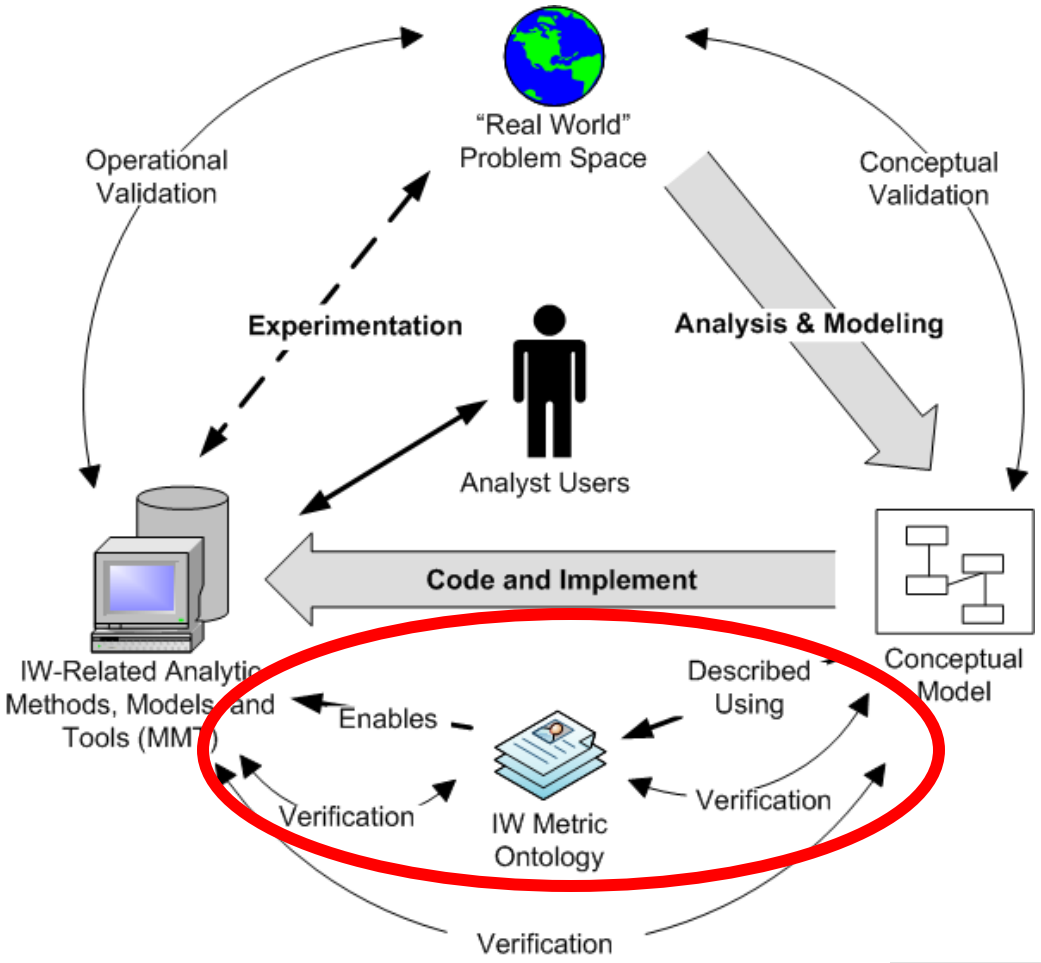
IW Metrics Ontology Development Project Activities and Deliverables

- **Producing IW Metrics Ontology**
  - **linking LOEs**
  - **to PMESII Metrics**
- **Created through**
  - **Workshops**
  - **Literature review**
  - **Tools review**
  - **Expertise**
- **Developing**
  - **IW definitions**
  - **Ontology definitions**
  - **LOE definitions**
  - **PMESII definitions**
  - **Metric definitions**
  - **Operational knowledge**



TRAC contracted with DRC and Hartley Consulting to develop an IW Metrics ontology

IW Metrics Ontology Supports Conceptual Modeling

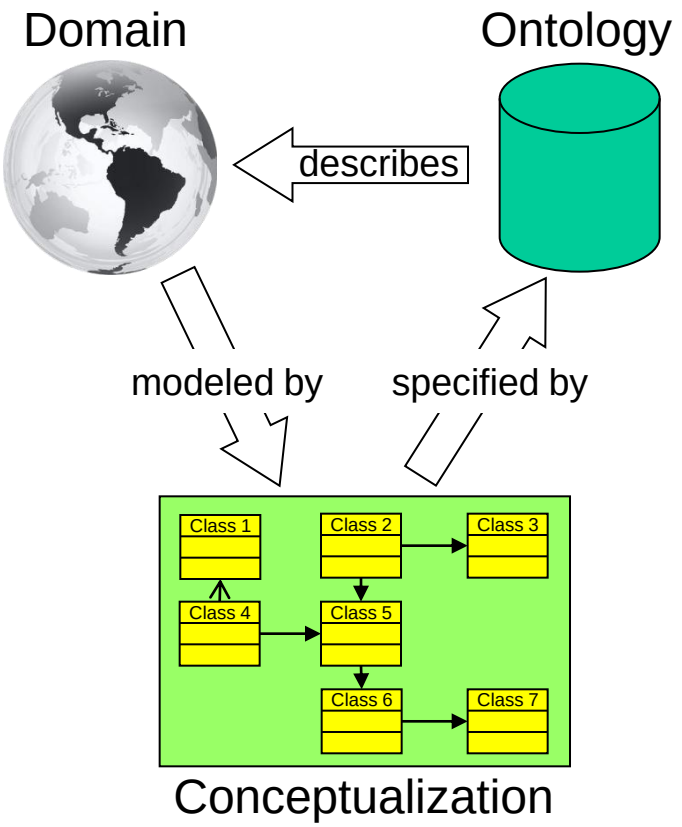


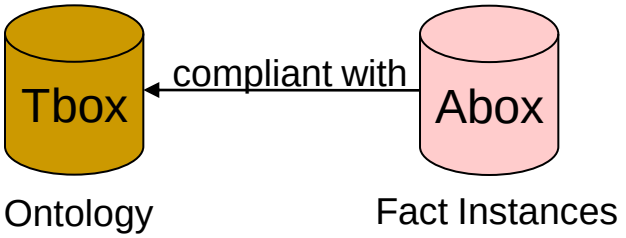
The IW Metrics Ontology helps structure a portion of the conceptual model.

Based on work by R.G. Sargent and others

What is an Ontology?

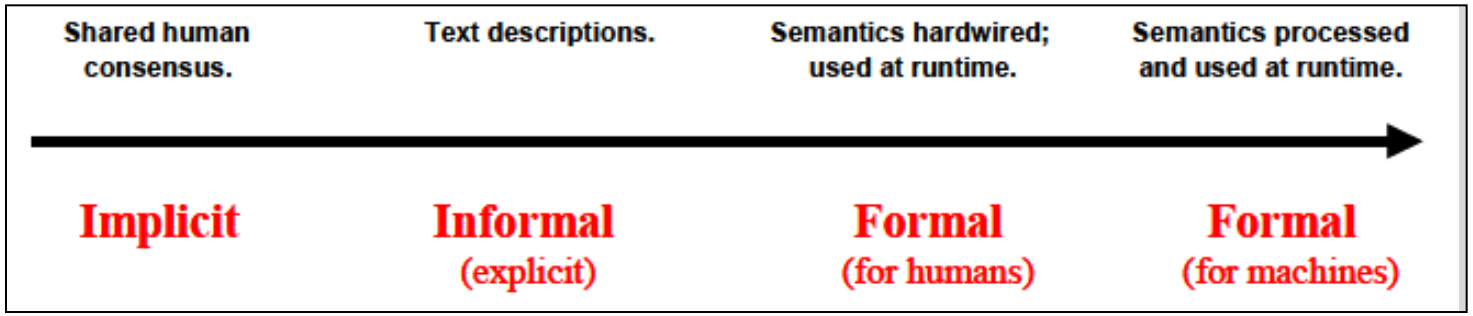
- **Gruber Definition**
  - **An ontology is a "formal specification of a conceptualization"**
  - **That is, a formally described, machine readable collection of terms and their relationships expressed with a language in a document file**
- **Computer science literature differentiates**
  - **Terminological components (Tbox)**
  - **Assertional components (Abox)**





Ontologies Provide Benefits

- Textual descriptions are ambiguous
- More formal representations enable more automated solutions
- Ontologies form a type of "compromise" between human readable text and computer processable data
- Relationships and restrictions between classes help support inferencing and "discovery" of additional facts



From: (Uschold, 2003)

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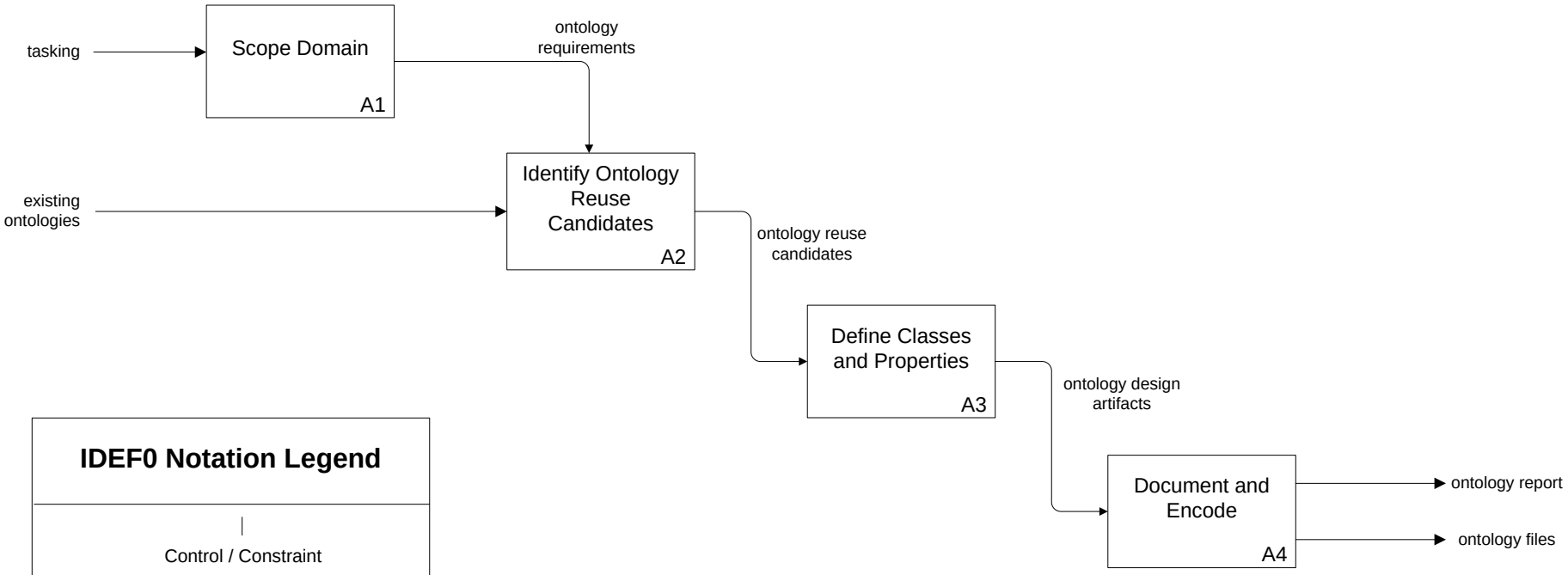
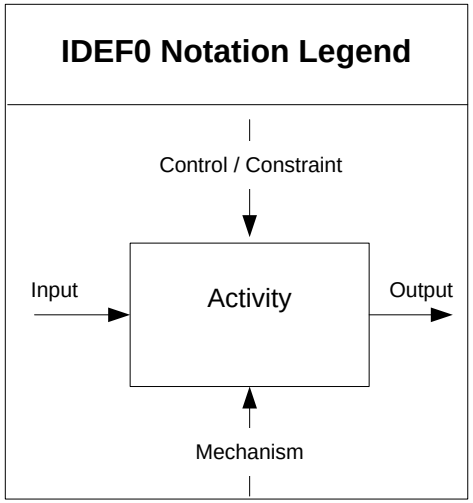
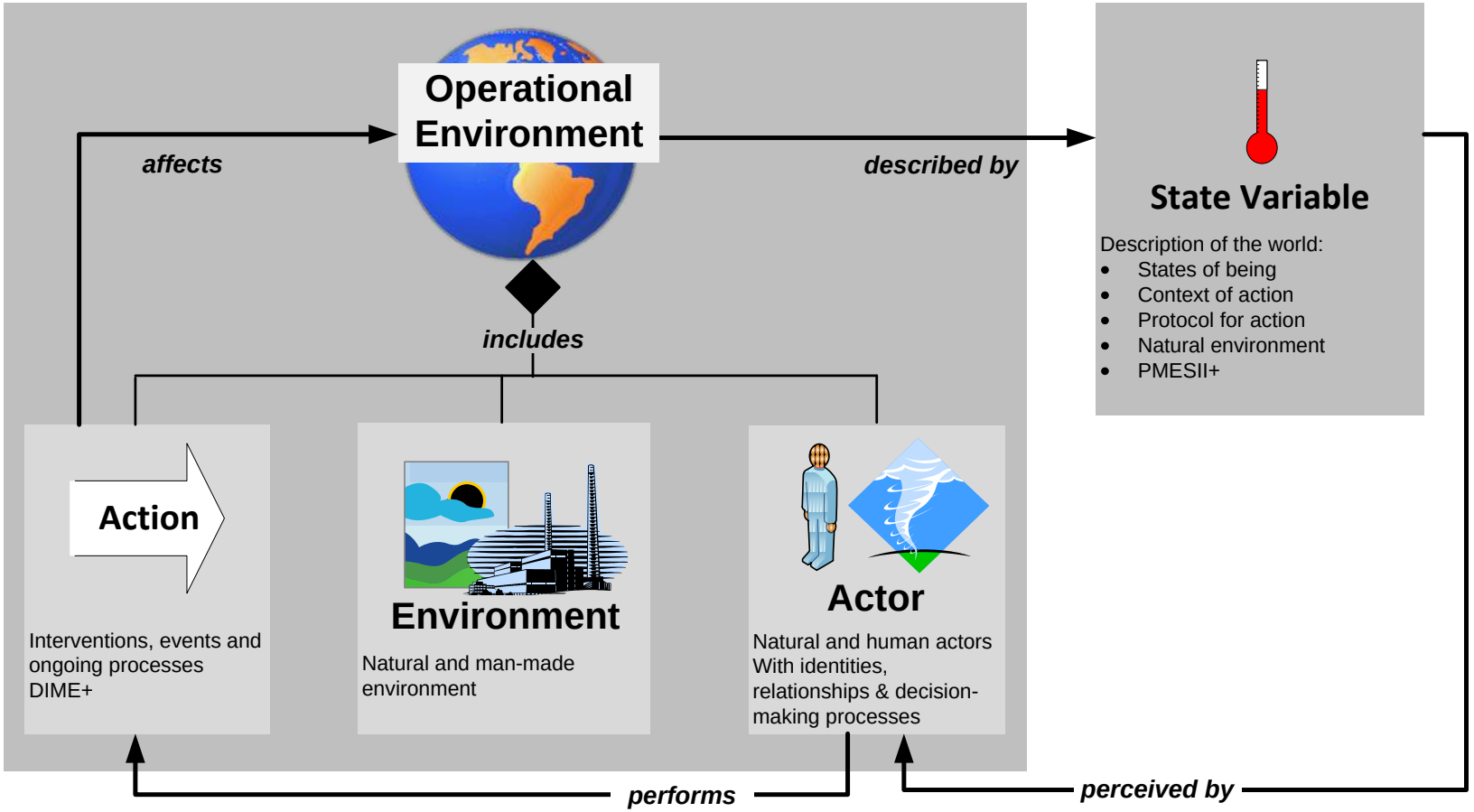
Ontology Development Process





The IW Metrics Ontology is being developed using a mature documented process.

Scope Domain - Context Diagram

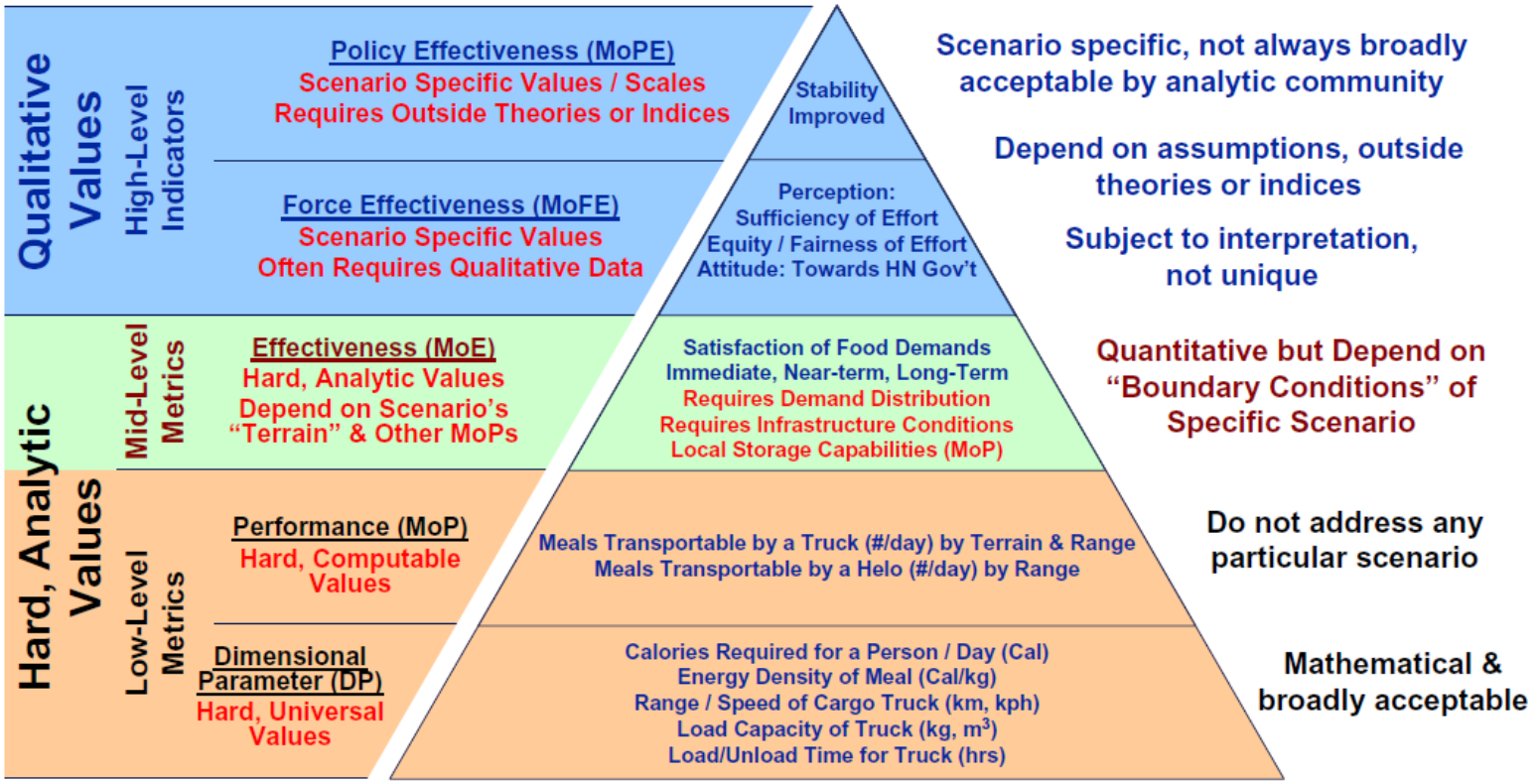


Metrics can be thought of as state variables that describe the Operational Environment.

Identify Reuse Candidates

- **Leverages Dr. Dean Hartley's work on the ISSM and VV&A Tool (see HSCB Focus 2011 presentation on "VV&A for Human Social Culture Behavior Models: The DIME/PMESII Model VV&A Tool") (Hartley, 2006) (Hartley, 2009)**
- **TRAC and ERDC work on Infrastructure and Essential Services (IES) ontology**
- **Navy-led effort to specify requirements for modeling DIME actions and PMESII effects (Young et al, 2009)**
- **Measuring Progress in Conflict Environments (MPICE) metrics framework for assessing conflict transformation and stabilization (Dziedzic et al, 2008)**
- **Office of the Coordinator for Reconstruction and Stabilization (OCRS) Matrix (DoS, 2005)**

Hierarchy of Measures – Types of Metrics



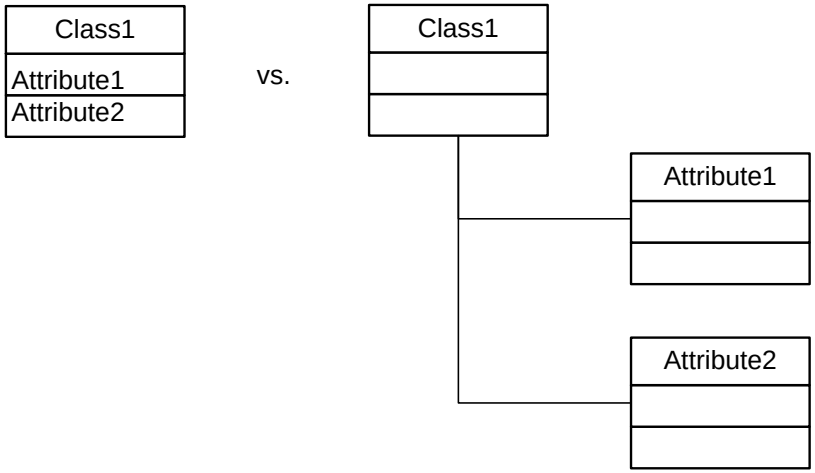
Low-Level Metrics Alone Fail to Capture the Impact of Activities on the Broader Mission Objectives the "So What?" Impact

From:
(Young et al, 2009)

Describing a Metric

Attributes of a Metric:

- **Name**
- **Definition**
- **Units**
- **Geographic association**
- **Author**
- **References**
- **Time-based**



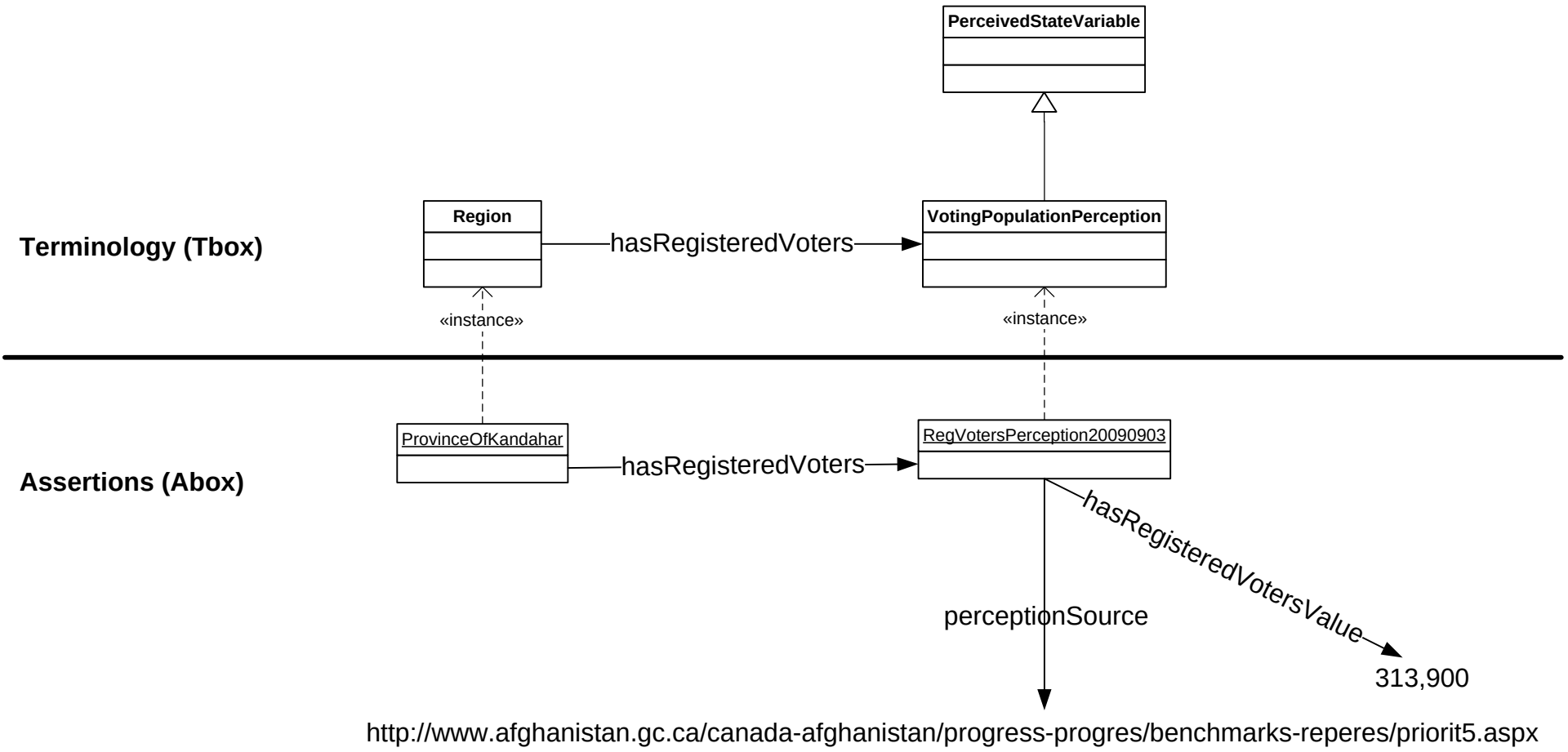
- **Metrics become "first class" reusable well-defined objects in their own right that belong to classes and not just attributes of a objects being described (less tightly coupled)**
- **Assertions can be made to describe the attributes of a particular metric value**

Sample Metric – "Voter Turnout"

- **Example values/instances of the example metric:**
  - **35% nationwide for Afghanistan's election held on August 20, 2009 for the election of president and 420 provincial council seats according to a Washington Times website article on August 21, 2009 which was accessed on-line on 12/30/2010**
  - **9% for Helmand Province in Afghanistan's national election held on August 20, 2009 for the election of president and 420 provincial council seats based on:**
    - **1,000,000 registered voters reported by National Democratic Institute for International Affairs (NDIIA) on their website on 10/1/2009**
    - **90,000 votes cast according to Afghan election officials' press release on 11/1/2009**

Metrics may be described directly or derived from other metrics.

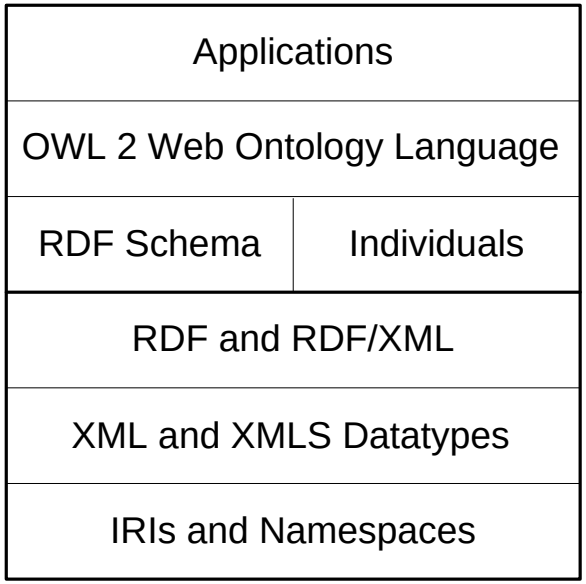
Representing Derived Metrics



UML can be used to describe relationships between classes, properties, individuals/instances, and property values

Encoding the Ontology

- **Concepts derived from Description Logics**
- **Represents an evolution (not revolution) in representing information**
- **Web Ontology Language – OWL standardized by W3C**



Derived from:
(Lacy, 2005)

The Web Ontology Language – OWL builds on widely accepted standards for information representation.

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Conclusions / Lessons Learned

- **IW, metrics can be categorized using PMESII-PT variables**
- **PMESII-PT variable values are valuations – "[the state of] corruption is bad"**
- **Generalization/specialization "Is-A" relationships can be used to organize the types of state variables into taxonomies**
- **Aggregation relationships can be used to group state variables into collections**
- **ISSM and other efforts provided a useful starting point for developing the ontology**

Ontology Design Decisions

- **Metric values are individuals/instances of metric classes**
- **Class variables (properties) are needed in addition to instance properties**
- **N-ary relationship required to fully specify a metric value**
- **Ontology alignment maps help isolate the dependencies on external ontologies**
- **Metrics categories (e.g., PMESII-PT, LOEs) can be represented informally (as string properties rather than as classes)**

Summary

- **TRAC is leading the Irregular Warfare Analytic Capability (IWAC) initiative that includes developing and executing the Tactical Wargame (TWG)**
- **Lines of Effort (LOEs) and PMESII-PT state variables can be used to help characterize the IW domain**
- **The TWG has HSCB data challenges**
- **An IW Metrics ontology is being developed to address some of those issues using researchers and workshops**
- **The ontology provides benefits including helping support VV&A**
- **The ontology is being developed using mature documented processes that involves**
  - **Carefully scoping the IW Domain**
  - **Identified reuse candidates as starting points**
  - **Designing classes and properties within multiple ontology files**
  - **Encoding the ontology using Web Ontology Language - OWL and documenting the results in a formal report**
- **In addition to the ontology, the effort is generating insights into representing the state of the Operational Environment**

Questions?

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References

- Dziedzic, Michael, Barbara Sotirin, and John Agoglia, (2008) Measuring Progress in Conflict Environments (MPICE): A Metrics Framework for Assessing Conflict Transformation and Stabilization, Version 1.0. US Institute for Peace, Washington, DC.
- Hartley, Dean S. III, (2006) Operations Other Than War (OOTW) Flexible Asymmetric Simulation Technologies (FAST) Prototype Toolbox: ISSM v4.00 Analysts' Guide. DRC, Orlando, FL. 2006.
- Hartley, Dean S. III,(2009) DIME/PMESII VV&A Tool (Software). Hartley Consulting, Oak Ridge, TN. 2009.
- Lacy, Lee W. (2005) OWL: Representing Information Using the Web Ontology Language.
- Office of the Coordinator for Reconstruction and Stabilization, (2005) "Post-Conflict Reconstruction Essential Tasks." US Dept of State, Washington, DC. 2005. http://www.crs.state.gov/index.cfm?fuseaction=public.display&id=10234c2e-a5fc-4333-bd82-037d1d42b725
- Uschold, Michael (2003) “Where are the Semantics in the Semantic Web?”, AI Magazine.
- Young, William C. and Jerry R. Smith, (2009) "Requirements for Modeling DIME Actions and PMESII Effects" presented at FOCUS 2010 Conference.