LOEs and the TRAC IW Metric Ontology

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BLUF

• Irregular Warfare Ontology
  – Controlled vocabulary of state variables
  – Basic relationships within Operational Environment
  – Implemented in Web Ontology Language (OWL)

• State variables (metric types) describe status of
  – Actions
  – Actors
  – Environment (natural & human, physical & mental)

• Ontology
  – Begins with taxonomy: PMESII + kinetics + natural environment
  – Allows metric types to be in multiple categories
  – “Comprehensive” list of ~400 metric types

• Association of metric types with LOEs
Concepts
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
Literature

• General concepts and relationships
  – Doctrine (e.g., Joint Pubs, Army FMs)
  – Workshops (MORS, NDU, HSCB)
  – Books, articles and presentations

• Initial sources for metrics and taxonomy
  – Hayes & Sands *Doing Windows*: 119
  – Interim Semi-static Stability Model (ISSM): 195
  – DIME/PMESII VV&A Tool: 285

• Confirmatory and Additional metrics and taxonomies
  – HSCB Taxonomy: 345
  – Metrics v3: 226
  – OCRS Matrix: 217
  – NDU Corruption Workshop: 131
  – IW Decomp 2009: 99
  – MPICE: 62
  – PRIME Taxonomy: 59
  – Hilson: 54
  – Others

• Total metric types 415
Metrics can be thought of as state variables that describe the Operational Environment.
Example Mapping of Political Environment to Associated Metric Types
Lines of Effort (LOEs)
## LOEs, Sub-Tasks, and Endstates

- Taken from FM3-24.2, pg 4-8, 21 April 09
- Sub-Tasks are Actions at a larger scale than our DIME+

<table>
<thead>
<tr>
<th>LOE</th>
<th>Subtasks</th>
<th>LOE Endstate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restore Essential Services</td>
<td>Restore Sewage Services, Restore Water Services, Restore Electrical Power and Services, Restore Academic Institutions, Restore Trash Services, Restore Medical Services</td>
<td>LOE Endstate 4: Essential services restored.</td>
</tr>
<tr>
<td>Support to Economic and Infrastructure Development</td>
<td>Provide Public Works Support, Provide Commerce Support, Provide Civilian Supply Support, Provide Civilian Health Support, Provide Agriculture Support, Coordinate Civic Assistance Programs</td>
<td>LOE Endstate 5: Economic foundation w/sufficient infrastructure established.</td>
</tr>
<tr>
<td>Support to Governance</td>
<td>Provide Public Administration Support, Identify and Recruit Leaders, Facilitate Local Government, Provide Cultural Affairs Support, Support and Secure Elections, Support HN Reforms</td>
<td>LOE Endstate 6: Functioning legitimate gov’t that does not require external support.</td>
</tr>
<tr>
<td>Conduct Information Tasks</td>
<td>Tell the Story to the U.S. Public, Marginalize Insurgent Influence, Isolate Population from Insurgent Forces, Provide Context for Host Nation Government Operations, Reinforce the Legitimacy of the Host Nation Government</td>
<td>LOE Endstate 7: Increased support to HN (local) government.</td>
</tr>
</tbody>
</table>
LOEs Selected for the Ontology

Rpt LOEs (DL6)

<table>
<thead>
<tr>
<th>LOEid</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOE01</td>
<td>Establish Civil Security</td>
</tr>
<tr>
<td>LOE02</td>
<td>Establish Civil Control</td>
</tr>
<tr>
<td>LOE03</td>
<td>Support Host Nation Security Forces</td>
</tr>
<tr>
<td>LOE04</td>
<td>Restore Essential Services</td>
</tr>
<tr>
<td>LOE05</td>
<td>Support to Economic and Infrastructure Development</td>
</tr>
<tr>
<td>LOE06</td>
<td>Support to Governance</td>
</tr>
</tbody>
</table>
LOEs → Metric Types

• Step 1: Identify DIME actions
  – FM 3-24.2 calls out subtasks for each LOE
  – Each subtask is clearly associated with one or more DIME actions
  – Several DIME actions are also implied (e.g., force security)

• Step 2: Identify DIME MoPs
  – Measures that are clearly associated with performing the given action, regardless of situation or modeling choices
  – Measures are inputs or direct outputs (e.g.,
    • $ invested
    • jobs created
    • number of diplomatic actions
    • road capacity built

• Step 3: Identify additional direct Metrics
  – Requires a model of what interacts with what
  – Include metric types that are directly affected by DIME MoPs

• Step 4: Work backward from LOE Endstates
  – Requires a model
  – Start with LOE Endstates and include metric types that directly effect them
  – Continue backward
Model of ~400 Metric Types + DIME Actions

1. Rebuild roads
2. Road capacity created
3. HN road capacity
2. Road jobs created
3. HN acceptable jobs
3. HN foreign investment

1. LOE 5 Endstate Economy & Infrastructure
2. HN Economy
2. HN Infrastructure

DIME Actions
## Metrics Mapped to LOEs

### Rpt Metrics by LOEs (DL7)

<table>
<thead>
<tr>
<th>Title</th>
<th>MetricClassName</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish Civil Control</td>
<td>AntiPopulationMovementActivitiesMoP</td>
</tr>
<tr>
<td></td>
<td>AntiTraffickingInPersonsActivityMoP</td>
</tr>
<tr>
<td></td>
<td>CivicEducationProjectsActivityMoP</td>
</tr>
<tr>
<td></td>
<td>CommandAndControlEstablishedMoP</td>
</tr>
<tr>
<td></td>
<td>CommunicationsEstablishedMoP</td>
</tr>
<tr>
<td></td>
<td>ConfidenceBuildingActivityMoP</td>
</tr>
<tr>
<td></td>
<td>DemobProcessProgressMoP</td>
</tr>
<tr>
<td></td>
<td>DischargedMilitaryJobsCreatedMoP</td>
</tr>
<tr>
<td></td>
<td>DischargedMilitaryTrainedProgressMoP</td>
</tr>
<tr>
<td></td>
<td>ExternalGovtAdvisorsMoP</td>
</tr>
<tr>
<td></td>
<td>ExternalJusticeAdvisorsMoP</td>
</tr>
<tr>
<td></td>
<td>FirstRespondersTrainedProgressMoP</td>
</tr>
</tbody>
</table>
Ontology Implementation
High Level Ontology Context

Operational Environment

- Taxonomy of operational environment elements (categories) (e.g., Governance within Political Environment)
- List of operational environment elements (DL1)

Catalog of Metric Types

- List of available metric types (e.g., FoodDistributedMoP)
- Instantiated from particular value within a defined area and timeframe (e.g., 500 metric tons of food distributed in Afghan province X between January 1, 2009 and December 31, 2009)

Metric Value

- Particular value within a defined area and timeframe (e.g., 500 metric tons of food distributed in Afghan province X between January 1, 2009 and December 31, 2009)

Lines of Effort

- List of actions (lines of effort) (e.g., Establish Civil Support)
- List of LOEs (DL6)

Mapping of metrics to operational environment elements (possibly more than one) (DL3)

Mapping of metrics to LOEs (possibly more than one) (DL7)
Metric Properties in Ontology File OF01

```
Metric

- Dublin Core Metadata Properties
- Metric Type Attributes (DL9)
  - describesOpEnvElt (in OF02)
  - impactedByLOE (in OF08)
  - versionInfo (OWL annotation property)
  - classificationLevel (annotation property)
  - associatedHSCBtaxonomyElement (annotation property)

<<instance>>

SampleMetricValue1

- Dublin Core Metadata Properties
- Metric Value Qualifiers (DL10)
  - subjectOrganization
  - subjectLocation
  - trustLevel
  - relatedCOCOM
  - unitOfMeasure
  - metricValue
  - relatedDoSRGionalBureau
  - relatedDoSFunctiOnalBureau
  - responsibleOrganization
  - collectionSystemUsed
  - sourceMetricValue
  - valueRepresentation
  - beginningDateTime
  - endingDateTime
  - valueDatatype
  - derivedMetric
  - dateCollected
  - transformedMetric
  - obtainedFrom
  - dateObtained
```
Ontology and Instance File Relationships

Legend

- Drafted / Exists
- Started / Prototyped
- Not Yet Started

Domain Ontologies

- Operational Environment Ontology (OF02)
- Metric Ontology (OF01)
- Line of Effort Ontology (OF08)

External Ontologies

- IES Ontology (OF06)
- Dublin Core (Metadata) Ontology (OF07)

Instance Files

- Sample Metric Values (IF01)

Sample Metric Values

- Metric Class
- Metric Attributes (class variable properties)
- Metric Qualifiers (instance properties)

Metrics for Metrics (e.g., Voter Turnout Metric class)

Operational classes
- Environment class
- Action class

Roads impact voter turnout

Roads impact voter turnout in

Fixed Distribution of Food

Food Distribution Op in

Afghan Province AF1 in

November 2009 was 35MT

Example:

- http://purl.org/dc/elements/1.1/
- http://example.com/example

Full Filename:

C:/BACKUP_LL/PM/ORLANDO PROJECTS/PMEI LOE METRIC ONTOLOGY WORK/ONTOLOGY DESIGN/TRAC ONT DESIGN 031511.VSD
OWL Encoding Evolution

Hartley Spreadsheets → IW Metrics Organization Database → DOAT Database Tool → OWL Ontology Files
Using the Ontology

• Create Use Cases
  – Use lists
    • List of Metric Types valuable in identifying what should be modeled
    • List of LOE related Metric Types valuable in identifying what data are needed for making decisions
  – Query ontology for …

• Use Use Cases
  – Identify what can be done with current capabilities
  – Identify what new capabilities are needed
  – Group capabilities by Use Case
  – Estimate costs for creating capability groups
  – Rank potential follow-on projects
From the hills of East Tennessee

Questions?

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BACKUP SLIDES
## Citations

<table>
<thead>
<tr>
<th>Source</th>
<th>Details</th>
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<tbody>
<tr>
<td>IWDcomp2009</td>
<td>IW Decomposition Analytic Strategy, TRAC, Overview Briefing for IW WG, 6 January 2009</td>
</tr>
<tr>
<td>Corruption</td>
<td>Dean S. Hartley III, &quot;Corruption in Afghanistan: Conceptual Model,&quot; 21 August 2010</td>
</tr>
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<td>Metrics v3</td>
<td>Metrics v3.xls from TRAC</td>
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<td>PRIME</td>
<td>PRIME Taxonomy from SRI</td>
</tr>
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<td>HSCB</td>
<td>HSCB Taxonomy from Gary Klein, Mitre</td>
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File Contents
## Operational Environment Elements (DL1)

### Rpt OpEnv (DL1)

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<thead>
<tr>
<th>PrintOrder</th>
<th>OpEnvAID</th>
<th>UniqueID</th>
<th>OpEnvName</th>
<th>ParentElement</th>
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<td>10</td>
<td>OpEnv001</td>
<td>OE</td>
<td>Operational Environment</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>OpEnv048</td>
<td>Env</td>
<td>Environment</td>
<td>OE</td>
</tr>
<tr>
<td>30</td>
<td>OpEnv015</td>
<td>Pol</td>
<td>Political Environment</td>
<td>Env</td>
</tr>
<tr>
<td>31</td>
<td>OpEnv049</td>
<td>Governance</td>
<td>Governance</td>
<td>Pol</td>
</tr>
<tr>
<td>32</td>
<td>OpEnv051</td>
<td>Politics</td>
<td>Politics</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>OpEnv052</td>
<td>Rule of Law</td>
<td>Rule of Law</td>
<td>Pol</td>
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<tr>
<td>34</td>
<td>OpEnv050</td>
<td>Overview</td>
<td>Overview</td>
<td>Pol</td>
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<tr>
<td>40</td>
<td>OpEnv013</td>
<td>Mil</td>
<td>Military Environment</td>
<td>Env</td>
</tr>
<tr>
<td>41</td>
<td>OpEnv039</td>
<td>Conflict</td>
<td>Conflict</td>
<td>Mil</td>
</tr>
<tr>
<td>42</td>
<td>OpEnv040</td>
<td>GovernmentMil</td>
<td>Government (Military)</td>
<td>Mil</td>
</tr>
<tr>
<td>43</td>
<td>OpEnv042</td>
<td>Security</td>
<td>Security</td>
<td>Mil</td>
</tr>
<tr>
<td>44</td>
<td>OpEnv041</td>
<td>MilitaryOther</td>
<td>Other (Military)</td>
<td>Mil</td>
</tr>
<tr>
<td>50</td>
<td>OpEnv009</td>
<td>Economy</td>
<td>Economic Environment</td>
<td>Env</td>
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</table>
## Metrics Types (DL2)

### Rpt Metrics (DL2)

<table>
<thead>
<tr>
<th>HartleySSrow</th>
<th>MetAID</th>
<th>UniqueID</th>
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<tbody>
<tr>
<td>Met194</td>
<td></td>
<td>CooperationBetweenHNMilitaryAndInterv</td>
</tr>
<tr>
<td>Met396</td>
<td></td>
<td>DamsCapacityAttackedMoP</td>
</tr>
<tr>
<td>Met398</td>
<td></td>
<td>DamsCapacityRebuiltMoP</td>
</tr>
<tr>
<td>Met399</td>
<td></td>
<td>DamsInvestmentMoP</td>
</tr>
<tr>
<td>Met050</td>
<td></td>
<td>DisarmamentActivityRating</td>
</tr>
<tr>
<td>Met255</td>
<td></td>
<td>MigrationMitigationActivityMoP</td>
</tr>
<tr>
<td>Met047</td>
<td></td>
<td>ConflictPropertyDestructionRate</td>
</tr>
<tr>
<td>Met046</td>
<td></td>
<td>ConflictCombatantDeathAndInjuryRate</td>
</tr>
<tr>
<td>Met045</td>
<td></td>
<td>ConflictCivilianDeathAndInjuryRate</td>
</tr>
<tr>
<td>Met352</td>
<td></td>
<td>SatisfactionOfPeoplesSpiritualNeeds</td>
</tr>
<tr>
<td>Met346</td>
<td></td>
<td>PerceptionByPeopleOfChangesInTheirSoci</td>
</tr>
<tr>
<td>Met022</td>
<td></td>
<td>NegotiationWBureaucraciesActivitiesMoP</td>
</tr>
<tr>
<td>Met400</td>
<td></td>
<td>DamsJobsCreatedMoP</td>
</tr>
<tr>
<td>4 Met160</td>
<td></td>
<td>GovtDecisionAuthRating</td>
</tr>
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</table>
# Mapping Operational Environment to Metrics (DL3)

## RptMetricsByOpEnvElt (DL3)

<table>
<thead>
<tr>
<th>Operational Environment Component</th>
<th>Metric Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Environment</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td>Political Environment</td>
<td></td>
</tr>
<tr>
<td>Governance</td>
<td>GovernanceRating</td>
</tr>
<tr>
<td></td>
<td>PoliticalLeadersTrainedProgressMoP</td>
</tr>
<tr>
<td></td>
<td>InternatnDiploActionsMoP</td>
</tr>
<tr>
<td></td>
<td>GovtSuppliesDeliveredMoP</td>
</tr>
<tr>
<td></td>
<td>GovtReformProgressMoP</td>
</tr>
<tr>
<td></td>
<td>GovtPersonnelEducatedProgressMoP</td>
</tr>
<tr>
<td></td>
<td>TransitionGovtCreationProgressMoP</td>
</tr>
<tr>
<td></td>
<td>ConstitutionReformProgressMoP</td>
</tr>
<tr>
<td></td>
<td>GovtDecisionAuthRating</td>
</tr>
<tr>
<td></td>
<td>GovtLeaderChangeRating</td>
</tr>
<tr>
<td></td>
<td>FirstRespondersTrainedProgressMoP</td>
</tr>
<tr>
<td></td>
<td>FirstRespondersJobsCreatedMoP</td>
</tr>
<tr>
<td></td>
<td>FirstRespondersActivityRating</td>
</tr>
<tr>
<td></td>
<td>ElectionsConductedProgressMoP</td>
</tr>
<tr>
<td></td>
<td>GovtDestabilizationActivityMoP</td>
</tr>
<tr>
<td></td>
<td>CentralAuthorityEffectivenessRating</td>
</tr>
</tbody>
</table>
Sample Metric Values (DL8)

<table>
<thead>
<tr>
<th>SMVAID</th>
<th>MetricType</th>
<th>MetricValue</th>
<th>Units</th>
<th>startingDateTime</th>
<th>endingDateTime</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FreedomRating</td>
<td>High</td>
<td>Scale</td>
<td>1/1/2010</td>
<td>12/31/2010</td>
<td>Florida</td>
</tr>
<tr>
<td>2</td>
<td>FreedomRating</td>
<td>Low</td>
<td>Scale</td>
<td>1/1/2010</td>
<td>12/31/2010</td>
<td>Libya</td>
</tr>
<tr>
<td>3</td>
<td>KeyLeaderPoliticalRating</td>
<td>Low</td>
<td>Scale</td>
<td>1/1/2010</td>
<td>12/31/2010</td>
<td>Libya</td>
</tr>
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</table>
## Metric Type (Attribute) Properties (DL9)

<table>
<thead>
<tr>
<th>Property Name in Ontology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>describesOpEnvElt</code></td>
<td>identifies the PMESII category by indicating the element of the Operational Environment being described</td>
</tr>
<tr>
<td><code>impactedByLOE</code></td>
<td>identifies an LOE whose execution impacts the values of metrics of this type</td>
</tr>
<tr>
<td><code>versionInfo</code></td>
<td>configuration management information (initially just a version number in a string)</td>
</tr>
<tr>
<td><code>classificationLevel</code></td>
<td>initially a string indicating level (e.g., “Unclassified”) (eventually BAH’s ISM3 ontology properties)</td>
</tr>
<tr>
<td><code>associatedHSCBtaxonomyElement</code></td>
<td>descriptor identifying associated HSCB taxonomy</td>
</tr>
</tbody>
</table>
## Metric Value (Qualifier) Properties (DL10)

<table>
<thead>
<tr>
<th>Property Name in Ontology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>subjectOrganization</td>
<td>organization being described by the metric value</td>
</tr>
<tr>
<td>subjectLocation</td>
<td>location being described by the metric value</td>
</tr>
<tr>
<td>trustLevel</td>
<td>trust level with 10 being absolute trust and 0 being no trust</td>
</tr>
<tr>
<td>relatedCOCOM</td>
<td>COCOM related to metric value</td>
</tr>
<tr>
<td>unitOfMeasure</td>
<td>initially a string identifying the units of measure for the metric value</td>
</tr>
<tr>
<td>metricValue</td>
<td>the metric value itself</td>
</tr>
<tr>
<td>relatedDoSRegionalBureau</td>
<td>name of related Department of State regional bureau</td>
</tr>
<tr>
<td>relatedDoSFunctinalBureau</td>
<td>name of related Department of State functional bureau</td>
</tr>
<tr>
<td>responsibleOrganization</td>
<td>organization responsible for geographic area</td>
</tr>
<tr>
<td>collectionSystemUsed</td>
<td>identification of system used to obtain data</td>
</tr>
<tr>
<td>sourceMetricValue</td>
<td>reference to another metric value used to derive the metric’s value</td>
</tr>
<tr>
<td>valueRepresentation</td>
<td>explanation of value meanings (e.g., data type or Likert scale from 1-5 with</td>
</tr>
<tr>
<td>beginningDateTime</td>
<td>Beginning of time period being described</td>
</tr>
<tr>
<td>endingDateTime</td>
<td>End of time period being described</td>
</tr>
<tr>
<td>valueDatatype</td>
<td>Indication of datatype used to describe metric value</td>
</tr>
<tr>
<td>derivedMetric</td>
<td>yes indicates the value was derived from other values</td>
</tr>
<tr>
<td>dateCollected</td>
<td>date that metric value was collected</td>
</tr>
<tr>
<td>transformedMetric</td>
<td>yes indicates that the metric value was a transformation of another metric value</td>
</tr>
<tr>
<td>obtainedFrom</td>
<td>initially a string indicating source of information (e.g., “Wikipedia”)</td>
</tr>
<tr>
<td>dateObtained</td>
<td>date on which metric value was obtained</td>
</tr>
<tr>
<td>Property Name in Ontology</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>contributor</td>
<td>An entity responsible for making contributions to the resource.</td>
</tr>
<tr>
<td>coverage</td>
<td>The spatial or temporal topic of the resource, the spatial applicability of the resource, or the jurisdiction under which the resource is relevant.</td>
</tr>
<tr>
<td>creator</td>
<td>An entity primarily responsible for making the resource.</td>
</tr>
<tr>
<td>date</td>
<td>A point or period of time associated with an event in the lifecycle of the resource.</td>
</tr>
<tr>
<td>description</td>
<td>An account of the resource.</td>
</tr>
<tr>
<td>format</td>
<td>The file format, physical medium, or dimensions of the resource.</td>
</tr>
<tr>
<td>identifier</td>
<td>An unambiguous reference to the resource within a given context.</td>
</tr>
<tr>
<td>language</td>
<td>A language of the resource.</td>
</tr>
<tr>
<td>publisher</td>
<td>An entity responsible for making the resource available.</td>
</tr>
<tr>
<td>relation</td>
<td>A related resource.</td>
</tr>
<tr>
<td>rights</td>
<td>Information about rights held in and over the resource.</td>
</tr>
<tr>
<td>source</td>
<td>A related resource from which the described resource is derived.</td>
</tr>
<tr>
<td>subject</td>
<td>The topic of the resource.</td>
</tr>
<tr>
<td>title</td>
<td>A name given to the resource.</td>
</tr>
<tr>
<td>type</td>
<td>The nature or genre of the resource.</td>
</tr>
</tbody>
</table>
## HSCB Taxonomy Items (DL4)

### Rpt HSCBTaxonomy (DL4)

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>HSCBID</th>
<th>NativeHSCBID</th>
<th>Taxon</th>
<th>Reference</th>
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<tr>
<td>A-D</td>
<td>HSCBTax001</td>
<td>1</td>
<td>Diplomatic Actions</td>
<td></td>
</tr>
<tr>
<td>A-D-01</td>
<td>HSCBTax002</td>
<td>1.1</td>
<td>Participate in Negotiations</td>
<td>[9] [5:1] [26]</td>
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<tr>
<td>A-D-02</td>
<td>HSCBTax003</td>
<td>1.2</td>
<td>Diplomatic or Quasi-Diplomacy</td>
<td>[9:2] [5:3] [26]</td>
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<td>A-D-03</td>
<td>HSCBTax004</td>
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<td>Establish Relations in Absence</td>
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<td>A-D-04</td>
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<td>Grant Diplomatic Recognition</td>
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<td>A-D-05.01</td>
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<td>Signing of Treaty or Coope</td>
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## Metrics to HSCB Taxonomy Mapping (DL5)

### Rpt XREF Metrics HSCB Taxonomy SS order (DL5)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>GovtDecisionAuthRating</td>
<td>E-P-02</td>
<td>Political Participation, Such as Voter Turnout</td>
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<tr>
<td>GovernanceRating</td>
<td>E-P-09</td>
<td>Governance Capacity (Governing Authority of)</td>
</tr>
<tr>
<td>FirstRespondersActivityRating</td>
<td>O-A-02.02</td>
<td>Local civil authorities (elected and traditional</td>
</tr>
<tr>
<td>GovtLeaderChangeRating</td>
<td>E-P-08</td>
<td>Regime/Head of Government Change</td>
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<tr>
<td>SocialServicesAdequacyRating</td>
<td>O-A-02.02</td>
<td>Local civil authorities (elected and traditional</td>
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<tr>
<td>GovtDecisionMakingRating</td>
<td>E-P-03</td>
<td>Competitive Multiparty Electoral System (Pre</td>
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<td></td>
<td>E-P-06</td>
<td>Separation of Powers (Presence/Absence/De</td>
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<tr>
<td></td>
<td>E-P-10</td>
<td>Legislative Activity</td>
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What is Ontology?
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)
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)
Semantic Spectrum

Pump: “a device for moving a gas or liquid from one place or container to another”

Shared human consensus.

Text descriptions.

Semantics hardwired; used at runtime.

Semantics processed and used at runtime.

Implicit

Informal (explicit)

Formal (for humans)

Formal (for machines)

From: (Uschold, 2003)
Knowledge Representation Spectrum

Naming the Problem

- End-state goals
- Status vector
- Actions to change status
- Interactions of above

- Describe with taxonomy
- Add properties

- Interactions are a model
Ontology Concepts

- Information representation
  - Class
  - Property
  - Individual
- Relations between representations
  - Is an instance of (membership)
  - Has value for
  - Restrict (helps define class)
- Relations within representations
  - Synonymy (similar or identical)
  - Antonymy (contrast or dichotomy)
  - Hyponymy (is-a)
  - Meronymy (part-of)/ Holonymy (contains)
Ontology Elements

- State variables describe the Operational Environment
  - Actors
  - Actions
  - Environment
- Some terms are overloaded
  - “Train teachers”
    - Action
    - State variable giving the current status of the action
  - “Migrants”
    - State variable describing the extent of existence of migrants
    - Actor (if so modeled)
  - “Epidemic”
    - State variable describing the extent of the epidemic
    - Action
    - Actor (if so modeled)
  - “Flood/Tsunami”
    - Environmental element
    - Action (if so modeled)
    - State variable describing the status of the action
    - Actor (if so modeled)
Ontology Languages

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

<table>
<thead>
<tr>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWL 2 Web Ontology Language</td>
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<tr>
<td>RDF Schema</td>
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<td>Individuals</td>
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<td>RDF and RDF/XML</td>
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<tr>
<td>XML and XMLS Datatypes</td>
</tr>
<tr>
<td>IRIIs and Namespaces</td>
</tr>
</tbody>
</table>

Derived from: (Lacy, 2005)
The issue of identifying these very few “basic” principles, now often referred to as foundational ontologies (FOs) (or top, or upper ontologies; see Figure 1) (Gangemi et al. 2002), meets the practical need of a model that has as much generality as possible, to ensure reusability across different domains (Smith and Welty 2001).

From: (Navi, 2004)
Ontology Development Process
Ontology Development Process

A1. Scope Domain

A2. Identify Ontology Reuse Candidates

A3. Define Classes and Properties

A4. Document and Encode

IDEF0 Notation Legend

- Activity
- Input
- Output
- Mechanism
- Control / Constraint

ontoloogy requirements

ontology reuse candidates

ontology design artifacts

ontology report

ontology files
Describing the Elements
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
Representing Perceived Metrics

Terminology (Tbox)

Assertions (Abox)

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

How do we know what happened?

• Indicators … are not effects
• Better to be observable than not, but “not seen” does not mean “not there”
• Inference from indicator to effect is “reverse direction”

Source: (Dr. Maris “Buster” McCrabb’s “Effects-based Operations: An Overview”)
Observable Metrics for Deriving LOE Endstate

Goal

MoPE = LOE Endstate

High-level metrics impacting goal

MoFE 1

Metrics depending on DIME actions and other state variables

MoE 1 MoE 2 MoE 3 MoE 4

MoP 1 MoP 2 MoP 3 MoP 4 MoP 5

DIME actions

MoPs based only on DIME

The other state variables

DP 1 DP 2 DP 3

Dime 1 Dime 2

Mission

Derived from

LOE

Observable metrics

DIME action metrics

Required to compute goal value
How are State Variables Calculated?

• Some state variables may be observed directly
• Most state variables will be calculated
  – Some state variables will be calculated from a single indicator/metric
  – Many state variables will be calculated from several indicators/metrics
• Most indicators/metrics will require reformatting
• Example: “Agriculture Sector Strength”
  – Indicator: Crop Production
  – Indicator: Meat Production
  – Combination: (CP+MP)/2
  – Scaling
Crop Production

- Metric: Hectares of permanent crops per 1000 people
- Data from 175 countries
- Scaling equation to yield nearly normal distribution
  - $\text{ScaledCrops} = 2 \times (\log_{10}(\text{hectares per K people}) - 1.1)$
Meat Production

• Metric: Annual metric tons of meat per person
• Data from 150 countries
• Scaling equation to yield nearly normal distribution
  – ScaledMeat = 2*(log10(MetTonspercapita)+1.9)
Agriculture Sector Strength

- First step
  - \( \text{AvgCrops\&Meat} = \frac{(\text{ScaledCrops} + \text{ScaledMeat})}{2} \)

- Second step: Calculate current figure for the country (use equations)
- Third step: Find the difference in standard deviations of the current figure from the international mean (a + or – number). Use this to represent the estimate of the current Agriculture Sector Strength
- Note: this is a model, not a fact
How are DIME Variables Calculated?

- DIME variables are both action variables and state variables
- As state variables, DIME variables represent the state of the action
- As action variables, DIME variables directly impact the environment, changing some state variables
- DIME variables are represented
  - Usually in two parts, an amount of work and an amount of work needed, that can be converted into a fraction
  - Sometimes as a fraction of completion, that can be scaled
  - Sometimes as a scaled variable, e.g., -3 to +3, representing “horrible” to “fantastic” total capability achieved
- Choosing the proper denominator is critical
- E.g., Electricity Production
Rebuilding Electrical Production

• In Iraq, electrical production capacity was destroyed in the war
• Reconstruction requirements were massive and required intermediate goals
• A construction project might involve building a megawatt generator
  – Beginning the project would involve purchasing materials and hiring and paying people
  – During the project, more materials would be purchased and people would continue to be paid
  – At completion, increased electricity would be produced, no new materials would be purchased and people would be laid off
• Project DIME variables
  – A DIME variable could be created that consisted of fraction of the project completed
  – Alternatively, a DIME variable could be created that consisted of amount of electrical production generated versus total capacity of the project
• A broader view would consider all construction projects in a phase
  – Create a DIME variable consisting of total work/total phase work
  – Create a DIME variable consisting of total electrical production/total electrical production desired from the phase
• A still broader view would consider all construction to restore production to pre-war levels
• The broadest view would consider all construction to create capacity that brings Iraq into a better than 3rd world status
• Note that
  – Red forces might destroy some work in progress, what does this do to DIME variables?
  – Red forces might destroy some electrical production capacity that was undamaged or completed in a previous project, what does this do?
• Which DIME variables are appropriate?
Prices as Metrics

• Price is determined by Supply, Demand, particular item, & other factors
• For an item, Supply & Demand are usually dominant
  – Price is proportional to Demand/Supply
  – Examples
    • Reduction in drug supply
      – Crop eradication
      – Drug interdiction
      – Capture or killing drug operatives
      – Raises price – Metric says price increase is good
      – May increase violent competition
    • Reduce demand
      – Education of buyers
      – Law enforcement against buyers
      – Lowers price – Metric says price decrease is good
      – May reduce competition as high price producers leave market
• Do both
  – Conflicting Metric interpretation
• Measuring Supply and Demand directly is preferable – just harder
Context Diagram made Concrete

You (the Actor)
Cook (the Action)
a Turkey in an Oven (collectively, the Environment)
and decide when to take it out with State Variables:
Example: Cooking a Turkey

Action: Put in Oven
Indicator: Cooking Time

Process: Cook

Indicator: Meat Temperature

MoM: Turkey is done

Action: Take out of Oven
How Do We Get This Picture?

- Taking a raw turkey and putting it in the oven (almost always) results in “turkey is in oven”-state: fact
- Cooking the turkey (almost always) results in “turkey in oven is browner”-state: fact
- Taking a “cooked” turkey out of the oven (almost always) results in “brown turkey out of oven”-state: fact
- Desired Measure of Merit is “turkey is done”-state: given
- Connections among
  - “cooking time” and “turkey is done”
  - “meat temperature” and “turkey is done”
  - “cooking time” and “meat temperature”
  - model – subject to verification & validation
- Most MoMs are not directly observable, require models using observable indicators
- More complex MoMs use models with sub-MoMs and many indicators
Modeling Alternatives

• **Case 1: Situational Awareness**
  – Monitor the indicators, when they say “go”, intervene and eat the turkey
  – Requires analysis to develop a model of the relationship between the indicators and the MoM
  – The resultant model is (relatively simple), connecting observations of reality with the inferred MoM value

• **Case 2: Simple Control Theory Model**
  – Set the temperature, timer & thermometer, monitor for deviations. If the guests are late, turn down the temperature setting. If the guests are early and hungry, turn up the temperature setting.
  – Develop model of the relationships among the controls and the indicators, as well as a model between indicators and MoM
  – The resultant model is more complex than in Case 1; however, it still has simplifications. E.g., in IW case, Red actions and their results can be treated as indicators

• **Case 3: Complex Model**
  – Compute which controls actions will give the best results as the situation changes.
  – The relationship models need to be more complex and accurate, taking into account actor and action interactions and dynamics.
  – The resultant model is very complex.
Sources of Concepts
Why We Need Authoritative References and Resources

• Ground concepts in vetted terms and definitions whenever possible
• Vetted terms and definitions have evolved from collaborative development and review
• Support provenance / pedigree of information in the ontology
Descriptive Requirements (Actions, Effects, and Overarching)

Source: Smith, Young (2009) Requirements for a Government Owned DIME/PMESII Model Suite” (N81)
We get our initial meronymy connections here, but not our hyponymy connections.
The Conflict Ecosystem

Operator’s View

• Performing tasks is a science – achieving desired effects is an art.
• The commander’s CONOPs contains the broad flow of tasks to assigned units intended to achieve the desired effects and the required endstate. It is a theory that is tested in execution against an adversary and his CONOPs.

Source: (Kiefer, 2004)

24 Jan 2011

IW Metrics Ontology
Data Architect’s View

- State = set of elements + their attributes at a moment in time
- Actions change state by changing attributes (if conditions permit)
- A State Engine increments time; examines all elements and attributes; triggers actions and reactions whose state conditions are met; degrades or prohibits actions as limited by states; tests susceptibility state conditions of objects and, if met, changes attributes as a result of actions & reactions.

Source: (Kiefer, 2004)
## Potential Sources for Ontology Elements

<table>
<thead>
<tr>
<th>Citation</th>
<th>Reference</th>
</tr>
</thead>
</table>
Doctrine

Strategic/Operational Level
- US Government COIN Guide
- IW Joint Operating Concept
- JP 3-24
- Joint Doctrine Pub 3-40
- FM 3-0
- FM 3-24
- FM 3-07

• Tactical Level
  - FM 3-24
  - FM 3-07
  - FM 3-07.1
  - FM 3-24.2
  - CALL Leader’s Handbook 07-27
  - CALL PRT Playbook

From: (Azimuth, 2010)
IW Metrics Lexicon

- JP 1-02, DOD Dictionary of Military and Associated Terms, 12 April 2001, as amended through September 2010
- Some terms identified as part of Capabilities Based Planning
- Some terms identified as part of MORS workshops
- Other terms will be defined as part of ontology development effort
CBP Data Architecture Primitives

- Element: a physical or mental thing that exists. (noun)
- Attribute: a quantitative or qualitative characteristic of an element or its actions. (adjective or adverb)
- Action: A behavior by an element that changes the state of any element. (verb)
- State: the set of attributes an element possesses at a point in time.

From: (Kief, 2004) derived from (Dubois, 1997)
CBP Terminology for Operators

- **Mission**: purpose (objectives and endstate) assigned to the commander.
- **Endstate**: set of conditions, behaviors, and degrees of freedom that defines achievement of the commander's mission.
- **Effect**: a change in a condition, behavior, or degree of freedom.
- **Capability**: *The ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks*".
- **Task**: an action or activity (derived from an analysis of the mission and concept of operations) assigned to an individual or organization to provide a capability.
- **CONOPS**: overall picture and broad flow of tasks assigned to subordinates/supporting entities within a plan by which a commander maps capabilities to effects to accomplish the mission for a specific scenario.
- **Scenarios**: assumptions about the political-military context, including the adversaries, friendlies, and neutrals.
- **Conditions**: variables of the operational environment including scenario that affects task performance.
- **Standards**: quantitative or qualitative measures for achieving the levels of performance of a task.

From: (Kief, 2004) and updated at (MORS, 2007)
CBP Terminology for Data Architects

- Classes: physical/mental (all), agent/object (elements only)
- State: the set of attributes an element possesses at a point in time
- Capability: the set of all actions that an agent element may take as permitted by its state.
- Susceptibility: the set of all actions that can change an attribute of an object element as permitted by its current state.
- Condition: a range of states that affects performance of an action or an action’s impact on changing an attribute.
- Standard: the proficiency and sufficiency specified for performance of a task.
- Effect: a state change
- Endstate: the state that defines achievement of the commander’s mission.
- Metric: quantitative measure associated with an attribute.

From: (Kief, 2004)
Bibliography – Books (1 of 2)

Bibliography – Books (2 of 2)


Bibliography – Papers and Presentations

• Albe2003.pdf Power to the Edge
• Bach2007.pdf A Toolkit for Building Hybrid, Multi-resolution PMESII Models
• Cana2010.pdf Canada's Engagement in Afghanistan Quarterly Report
• Chal2009.pdf Tipping Sacred Cows - Moral Potential Through Operational Art
Bibliography – Papers and Presentations

- Mand2008.pdf  The Ontology of Counterinsurgency
- The listing immediately above is what I came up with based on my reading of the manual.
- The listing immediately above is listed online as the APA citation.
- Mans2007.pdf  Linking Doctrine to Action: A New COIN Center-of-Gravity Analysis
- Available online at: [http://www.dtic.mil/jointvision/ideas_concepts/ebo.ppt](http://www.dtic.mil/jointvision/ideas_concepts/ebo.ppt)
- Note: the hyperlink above would not work for me. This listing was available under ‘Internet Resources’ at [http://www.au.af.mil/au/aul/bibs/ebo.htm](http://www.au.af.mil/au/aul/bibs/ebo.htm) a January 2008 Maxwell AFB, AL, site.
- Smit2009 PPT.pdf  Requirements for a Government Owned DIME/PMESII Model Suite