DoDAF In-Depth

DoD CIO Architecture and Interoperability Directorate

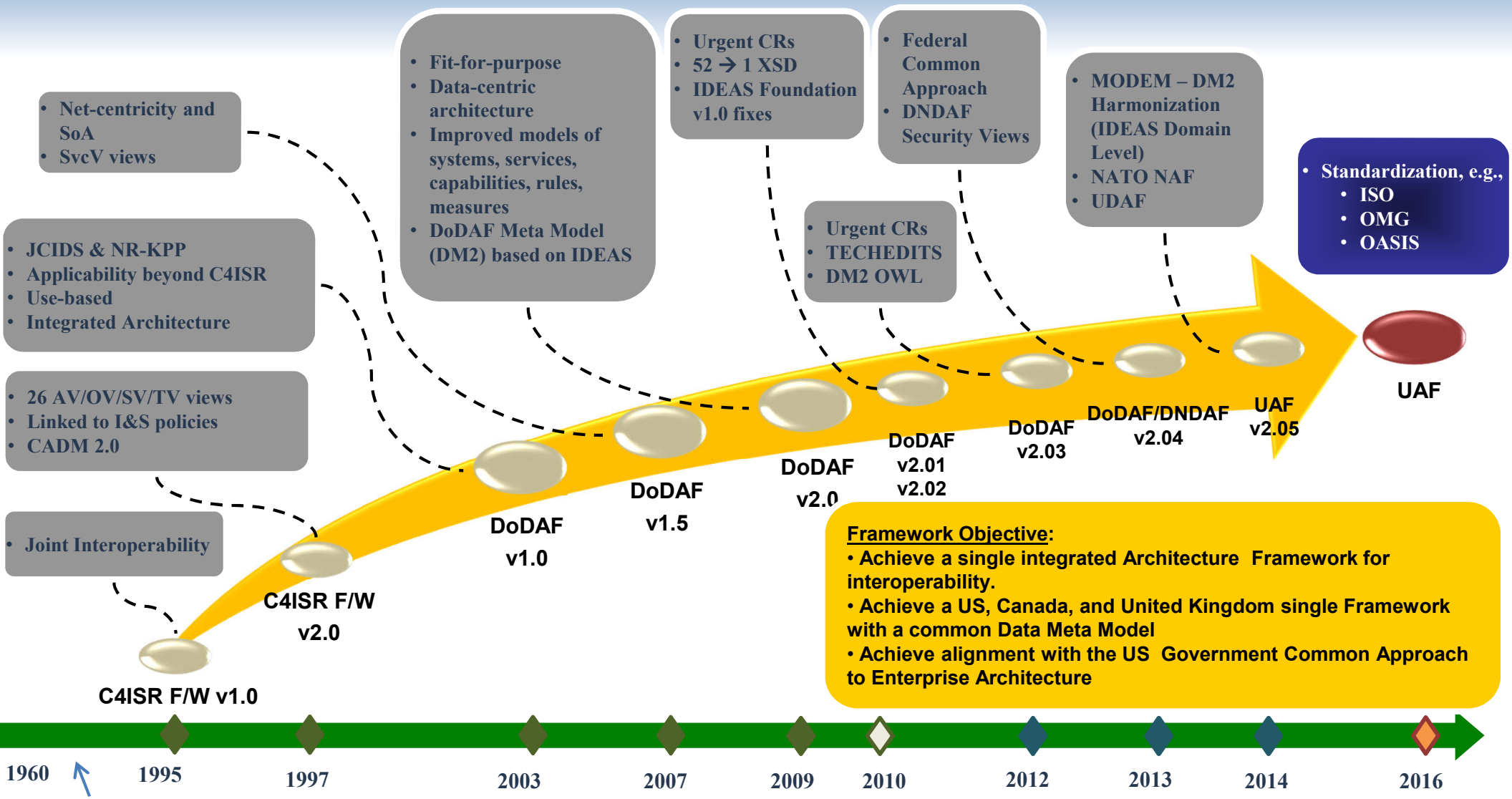
December 2013

Agenda

- Purpose and history
- DoDAF Basic Concepts
- Walkthrough of DoDAF Meta-Model (DM2)
- Walkthrough of DoDAF Model (View) Types
- DoDAF and Systems Engineering: Refinements Levels and Traceability

DoDAF Purpose and History

DoDAF Evolution



HIPO, SADT, Jackson-Mellor, IDEF, Mil-Std 490, BPR / FPI, etc.

DoDAF 2 Was Developed by DoD, not just DoD CIO

- DoDAF 2 Working Group met weekly for 3 years
- > 800 members
  - Operators
  - Engineers
  - Program managers
  - Industry
  - Tool vendors (including entire UPDM team)
  - Academia
  - Non-DoD Federal Government organizations

most DoD Components participated

- Operates according to an approved Configuration Mgmt Plan under authority of ASRG

Original and ongoing purposes

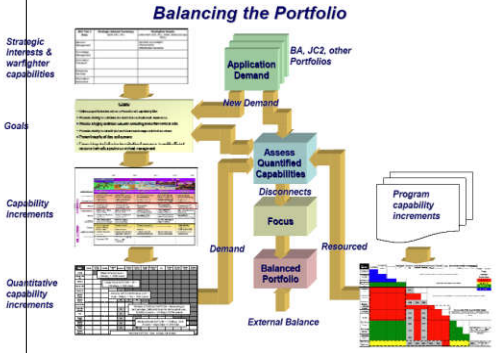
- Standardization of artifact names and expected content across Components
- Reuse of data across DoD's six core processes:
  - JCIDS
  - DAS
  - PPBE
  - CPM
  - SE
  - OPs
- Support enterprise analytics, e.g.,
  - Interoperability assessment (early in SDLC)
  - Portfolio Management
  - Capacity planning
  - AoA
  - Capability gaps and overlaps
- Line-of-sight from rqmts to implementations to resourcing

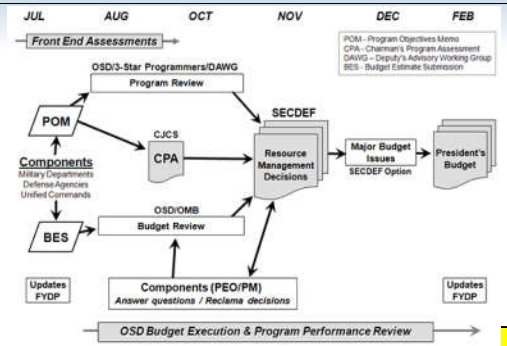
DoDAF Focus

Periodic (annual):

- PPBE
- CPM

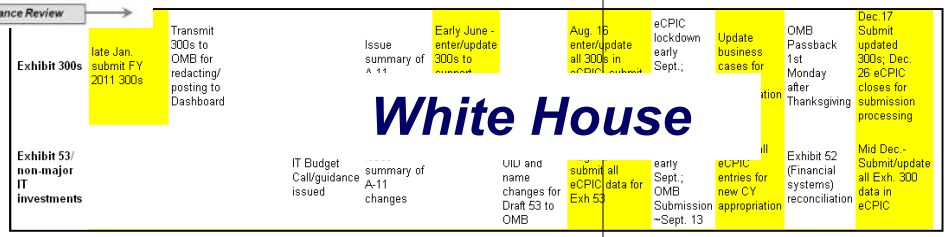
DoD





PPBE

CPM



White House

JCIDS

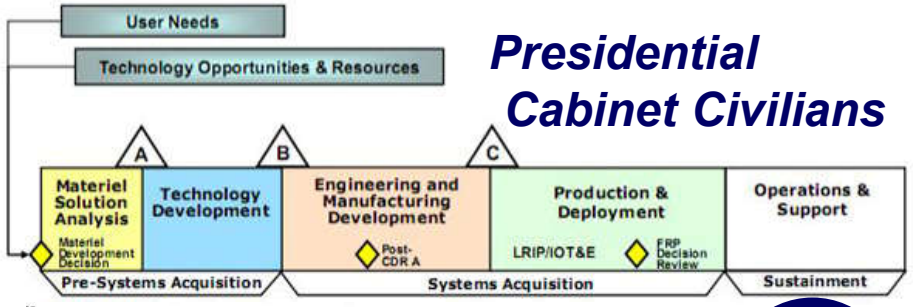
Military Staff
HQ (JCS)

Combatant Commands
Doctrine Commands
Training Commands

Event Driven:

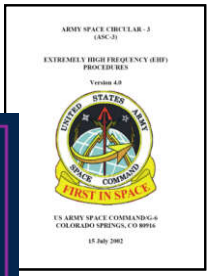
- JCIDS
- DAS
- SE
- OPS

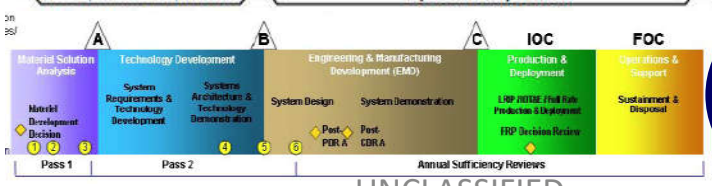
DAS



Presidential
Cabinet Civilians

OPS





SE

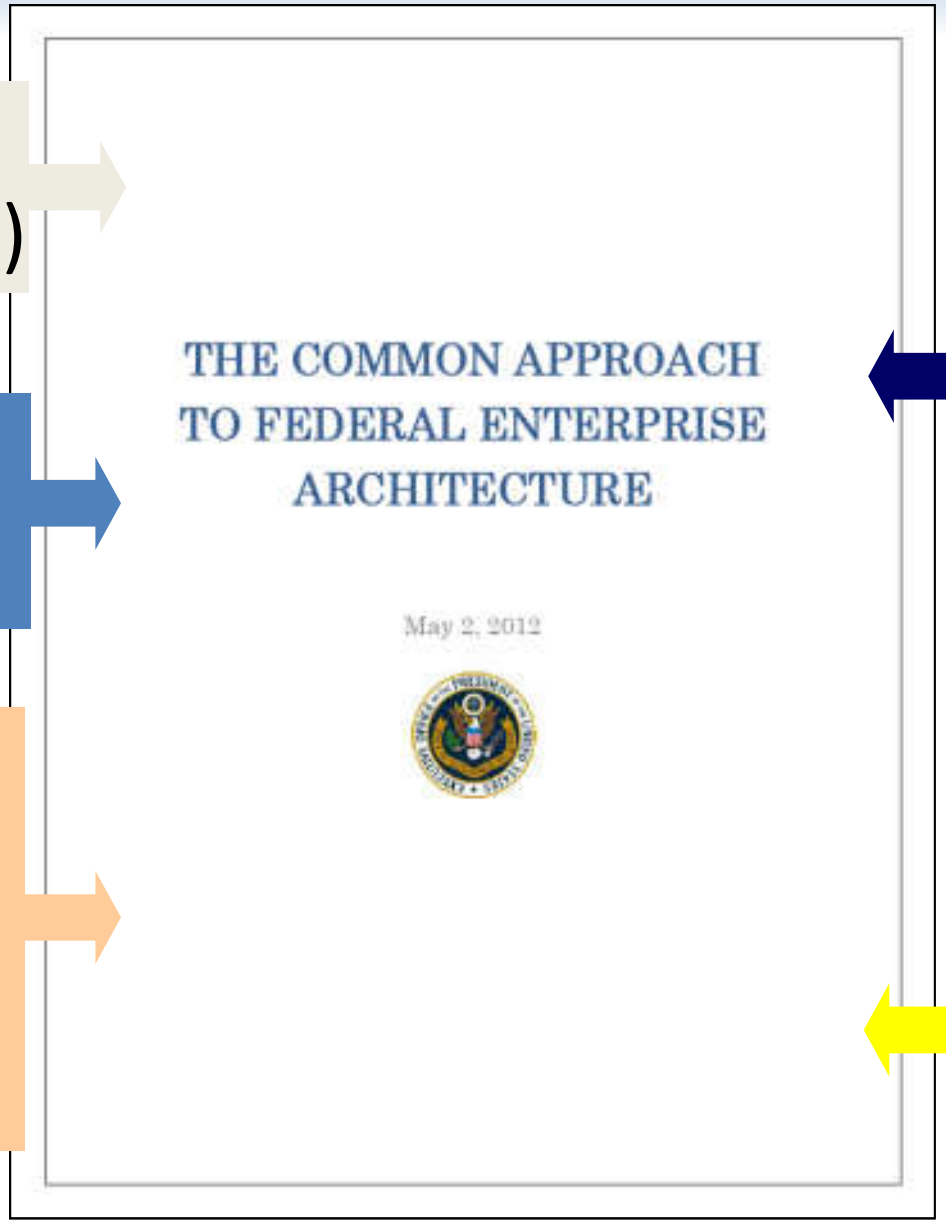
Acquisition
Organizations

Initiatives: Federal Government Common Approach

A. primary outcomes (4)

B. levels of scope (8)

C. basic elements of an EA program (8)



D. sub-architecture domains (6)

50 document artifacts

E. reference models (6)

CA Draft Artifact Working Group

Strategy Domain Artifacts		
S-1	Strategic Plan	DoDAF CV-1, 2, 3, 5, 6 (Capability Effects, Hierarchy, Schedules, Deployments, and Activities)
S-2	Concept Overview Diagram	DoDAF OV-1 (Operational Concept)
S-3	Capability Effects	DoDAF CV-1 (Capability Effects)
S-4	Capability Deployments and Dependencies	DoDAF CV-3, 4, 5 (Capability Schedules, Dependencies & Deployments)
S-5	Capability Hierarchies	DoDAF CV-2 (Capability Hierarchies)
S-6	Organization Chart	DoDAF OV-4 (Organizational Relationships)
S-7	SWOT Analysis	
S-8	Knowledge Management Plan	
S-9	Architecture Summary	DoDAF AV-1 (Executive Summary)
S-10	Architecture Dictionary	DoDAF AV-2 (Dictionary)
S-11	Balanced Scorecard (BSC)	Performance Measures Scorecard

Business Domain Artifacts		
B-1	Business Service Catalog	DoDAF SvcV-1 (Service Composition)
B-2	Business Service Capabilities	DoDAF CV-7 (Capabilities Services)
B-3	Business Case / Alternatives Analysis	OMB Exhibit 300
B-4	Business Value Chain	DoDAF OV-2 (Organizations and Resources)
B-5	Business Process Model	DoDAF OV-5a&b (Operational Activities), Operational Activity Diagram, Business Process Diagram
B-6	Business Process Services	DoDAF SvcV-5 (Service Operational Activities Support)
B-7	Business Process Sequences	OV-6c (Operational Activity Sequences)
B-8	Concept of Operations (CONOPS)	DoDAF OV-6c (Operational Activity Sequences)
B-9	Business Transition Plan	DoDAF PV-2 (Project Schedules), Business Operating Plan
B-10	Operational Performance Measures	DoDAF OV-6a (Operational Rules)
B-11	Project Plan	DoDAF PV-2 (Project Schedules) and PV-3 (Projects and Capabilities)

Convergence Approach for NAF

IDEAS Layered Approach

1. Foundation (upper ontology) ✓
2. Common patterns
3. Common architecture domain objects & relationships

1. Ontologic concepts and relationships
2. Commonly used patterns (e.g., resource flow, exchange)
3. Consensus concepts and relationships (e.g., person, organization, material)

X	X	X	X
NAF views	***national views***	***national views***	***national views***

Views for:

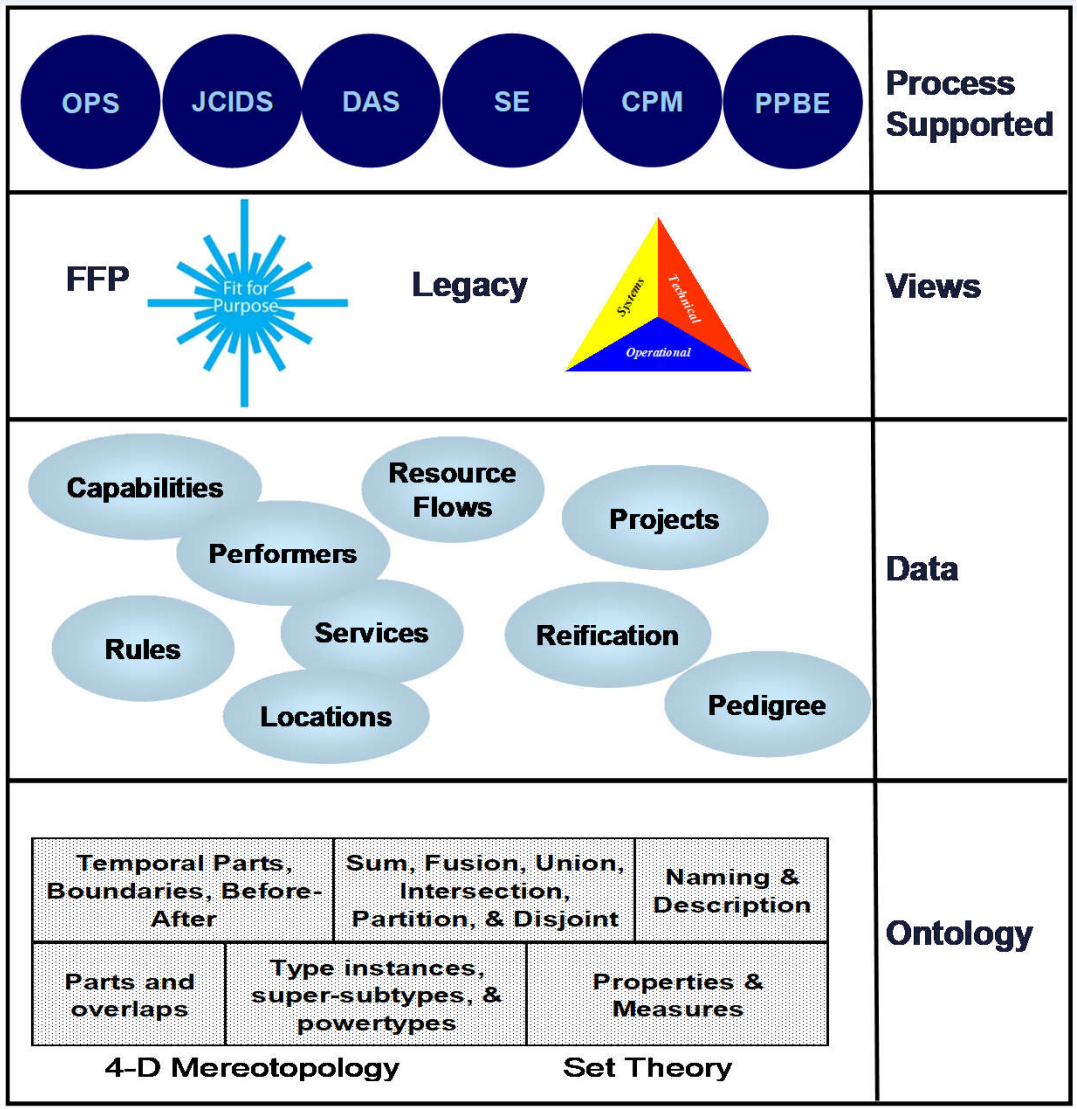
1. *NATO "core" architecture views*
2. *specific to needs and policies of individual nations*

DoDAF version 2.02, Change 1 Simplified Structure

- Vol. I - Normative
  - DM2 Conceptual Data Model (CDM) documentation
  - DoDAF Viewpoints & Models
- Vol. II - Normative
  - DM2 Logical Data Model (LDM) documentation
  - DoDAF Model Specs
  - DoDAF Glossary
  - SparxEA .EAP DM2 LDM file
- Vol. III - Normative
  - DM2 Physical Exchange Specification (PES) XSD file and documentation
  - SparxEA .EAP IDEAS Foundation file and documentation
- Vol IV – DoDAF Journal (information only)
  - DoDAF Informative material (e.g., 6-step, approximately 30 articles)
  - DM2 OWL-DL file and documentation
  - NOT under formal CM

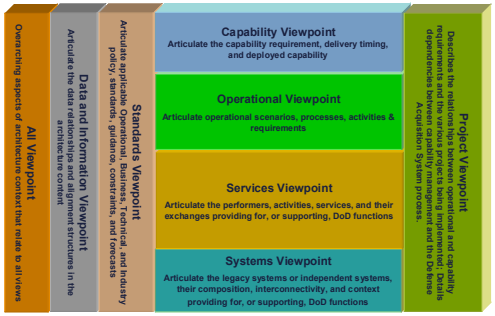
DoDAF Basics

Views, Definitions, and Metadata



The 52 DoDAF models use the concepts and concept relationships formalized in the DM2

- DoDAF Models



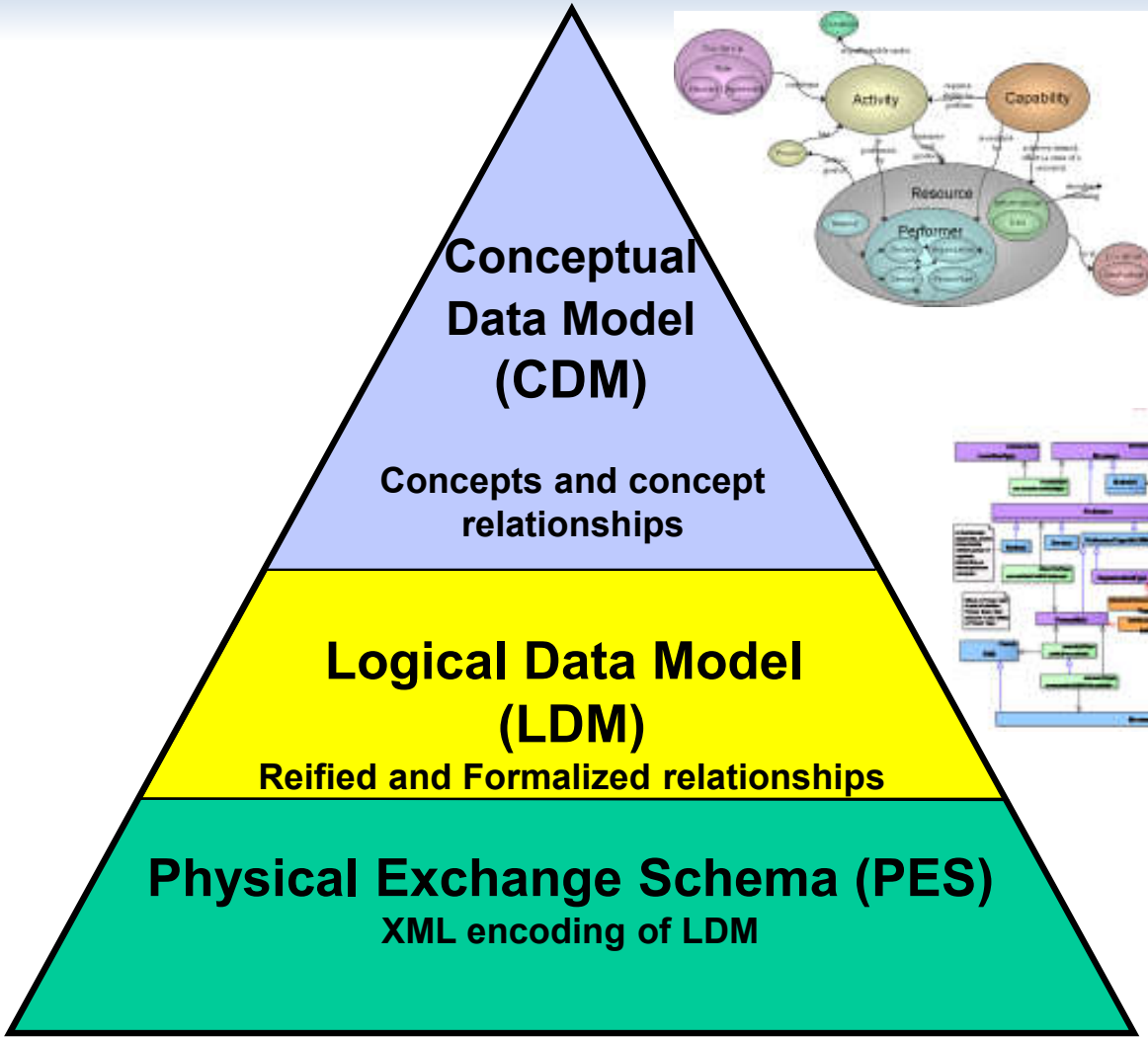
- DoDAF MetaModel (DM2)

DoDAF MetaModel (DM2)

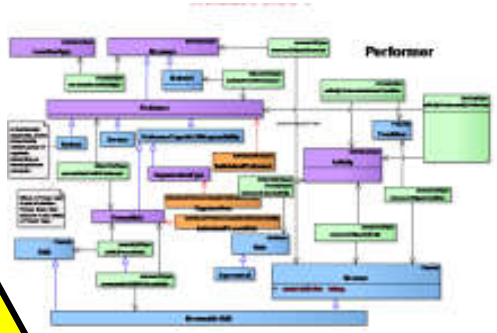
DoDAF Meta Model (DM2) Purposes

- Establish the constrained vocabulary for description and discourse about DoDAF models (formerly "products") and their usage in the 6 core processes
- Specify a way for federated EA data exchange between:
  - Architectural description development and analysis tools
  - architecture databases
  - other authoritative data sources
- Support discovery and understandability of EA data:
  - Discovery of EA data using DM2 categories of information
  - Understandability of EA data using DM2's precise semantics augmented with linguistic traceability (aliases)
- Increase the utility and effectiveness of architectural descriptions via a mathematical data model so they can be:
  - Integrated and cross-walked
  - Analyzed, evaluated, and assessed quantitatively

The DM2 Has Three Levels

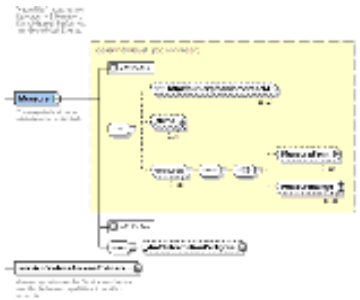


1. One page Powerpoint drawing
2. Two page high-level Glossary



1. Complete Glossary
2. IDEAS ontology foundation and common patterns*
3. DoDAF ontology domain extensions*
4. Explanatory documentation

**ontology model files adapted from UML tool*



1. XSD files (four)**
2. Usage documentation

*** auto-generated from the LDM*

Sources Used for DM2 and DoDAF Definitions

Models

- CADM 1.5
- IDEAS
- UPDM
- BMM
- Hay/Zachman
- ASM
- CRIS
- Conceptual CADM in DoDAF 1.0 / prototype CADM 2.0
- M3
- NAF Meta Model
- DoI Meta Model
- JC3IEDM
- GML
- UCORE 1.1
- GEIA 927
- AP233
- SUMO and ISO 15926 (via IDEAS)
- FEA Reference Models
- JFCOM JACAE

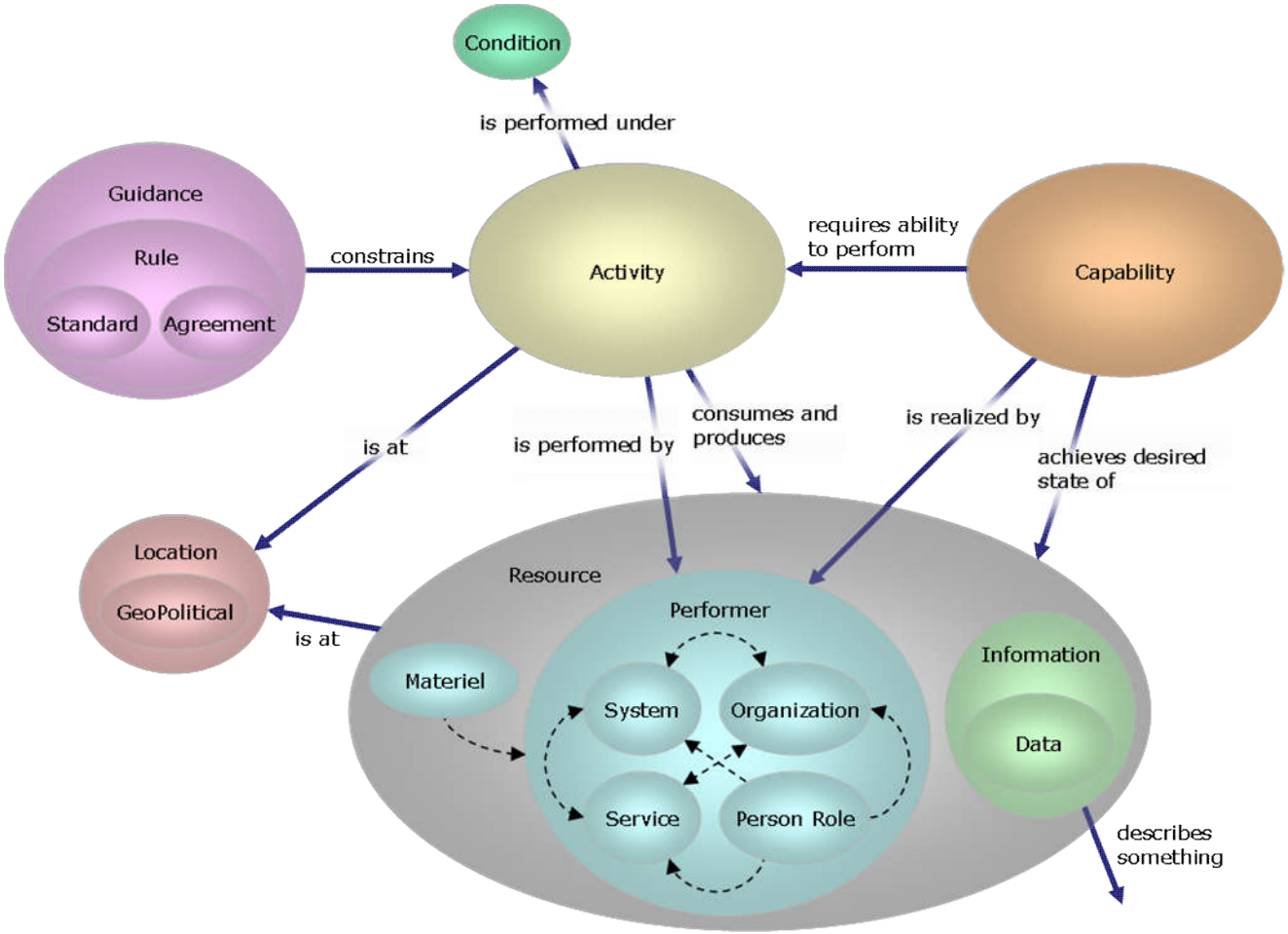
Definitions

- IEEE
- ISO
- W3C
- OMG
- EIA
- DODD & DODI
- JCS Pubs, especially CJCSI's
- Models in the Source_Candidates_071115.ppt
- DoDAF
- Other frameworks: Zachman, MODAF, TOGAF, NAF, ...
- FEA
- BMM
- WorldNet
- Wikipedia
- English dictionaries

DM2 Development and Maintenance Business Rules

- Scope
- Information Pedigree
- Security classification marking
- Term entry
- Aggregation rule
- Typed Relationships
- Implementation neutrality
- Definitions
- Aliases
- Extensions
- Research and reference information
- DoDAF WG share site
- Configuration Management
- Pilot and early adopter support

Conceptual Data Model = Concepts of the Six Core Processes*



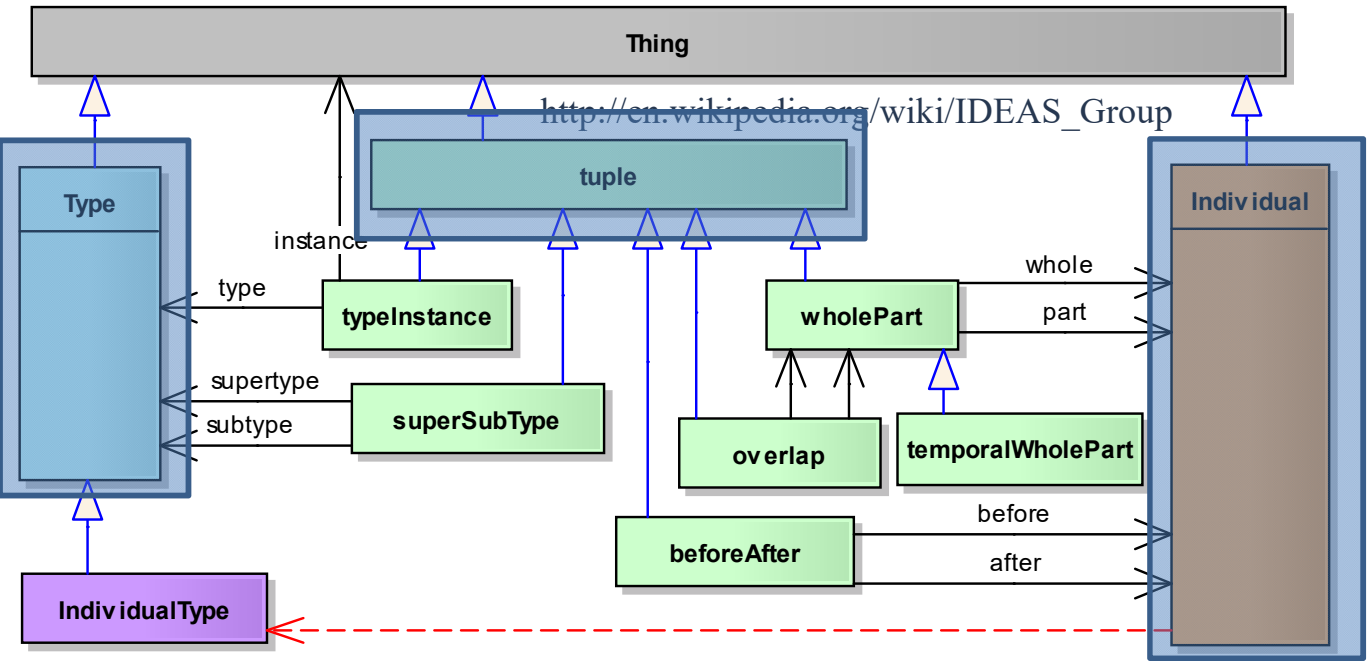
From the IDEAS Foundation:

- Everything has four dimensions
- Everything has temporal & spatial parts
- Everything has subtypes
- Everything has measures

DM2 Conceptual Data Model Glossary

- Activity: Work, not specific to a single organization, weapon system or individual that transforms inputs (Resources) into outputs (Resources) or changes their state.
- Resource: Data, Information, Performers, Materiel, or Personnel Types that are produced or consumed.
  - Materiel: Equipment, apparatus or supplies that are of interest, without distinction as to its application for administrative or combat purposes.
  - Information: The state of a something of interest that is materialized -- in any medium or form -- and communicated or received.
    - Data: Representation of information in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means. Examples could be whole models, packages, entities, attributes, classes, domain values, enumeration values, records, tables, rows, columns, and fields.
  - Performer: Any entity - human, automated, or any aggregation of human and/or automated - that performs an activity and provides a capability.
    - Organization: A specific real-world assemblage of people and other resources organized for an on-going purpose.
    - System: A functionally, physically, and/or behaviorally related group of regularly interacting or interdependent elements.
    - Person Role: A category of persons defined by the role or roles they share that are relevant to an architecture.
    - Service: A mechanism to enable access to a set of one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description. The mechanism is a Performer. The capabilities accessed are Resources -- Information, Data, Materiel, Performers, and Geo-political Extents.
- Capability: The ability to achieve a Desired Effect under specified (performance) standards and conditions through combinations of ways and means (activities and resources) to perform a set of activities.
- Condition: The state of an environment or situation in which a Performer performs.
- Desired Effect: A desired state of a Resource.
- Measure: The magnitude of some attribute of an individual.
- Location: A point or extent in space that may be referred to physically or logically.
- Guidance: An authoritative statement intended to lead or steer the execution of actions.
  - Rule: A principle or condition that governs behavior; a prescribed guide for conduct or action.
    - Agreement: A consent among parties regarding the terms and conditions of activities that said parties participate in.
    - Standard: A formal agreement documenting generally accepted specifications or criteria for products, processes, procedures, policies, systems, and/or personnel.
- Project: A temporary endeavor undertaken to create Resources or Desired Effects.
- Geopolitical Extent A geospatial extent whose boundaries are by declaration or agreement by political parties.

Leveraged International Defence EA Specification Ontology Foundation



- IDEAS:
  - –Upper level consistent with SUMO and ISO 15926
  - –Mathematics
    - type (~set) theory
    - 4D mereotopology
  - –None of these foundation properties are unusual; they are all used in reasoning everyday
- Rigorously worked-out common patterns are reused:
  - –Saved a lot of repetitive work – "ontologic free lunch"
  - –Result is higher quality and consistency throughout

Three types of Things:

1. Individuals – Things with spatio-temporal extent (not people)
2. Types – similar to sets
3. Tuples – ordered relations between Things

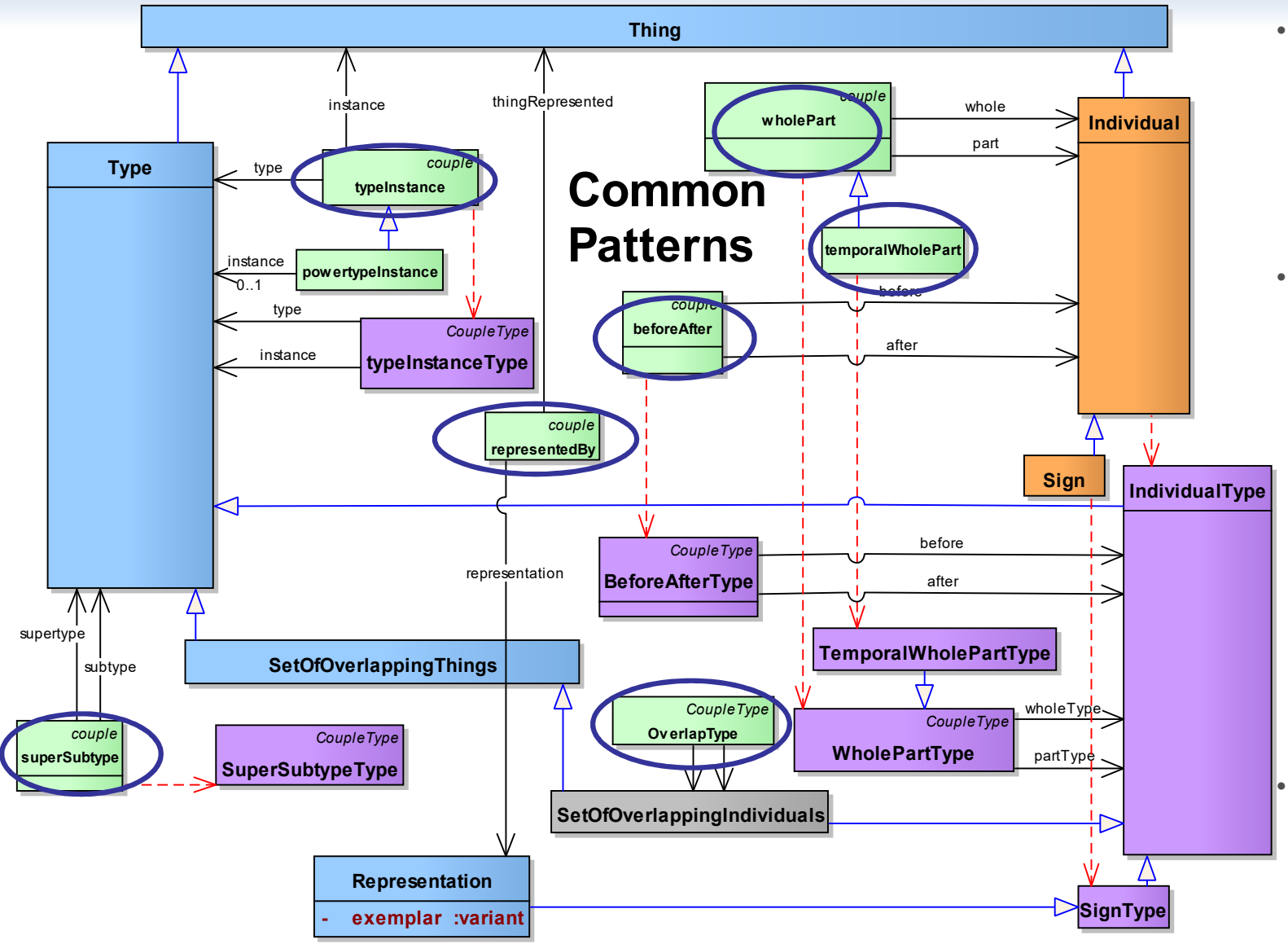
http://www.ideasgroup.org or
http://en.wikipedia.org/wiki/IDEAS_Group

The IDEAS Foundation is:

- Formal, higher-order, 4D, based on four dimensionalism
- Extensional (see Extension [metaphysics])
  - Using physical existence as its criterion for identity
  - Deals with issues of states, powertypes, measures, space -- what is truly knowable vs. what is assumed
  - signs and representations are separated from referents
    - The advantage of this methodology is that names are separated from things and so there is no possibility of confusion about what is being discussed.
- Well suited to managing change-over time
- Identifies elements with a degree of precision that is not possible using names alone
  - Comparing two Individuals, if they occupy precisely the same space at the same time, they are the same.
  - For two Types to be the same, they must have the same members
    - If those members are Individuals, their physical extents can be compared.
    - If the members are Types, then the analysis continues until Individuals are reached, then they can be compared.

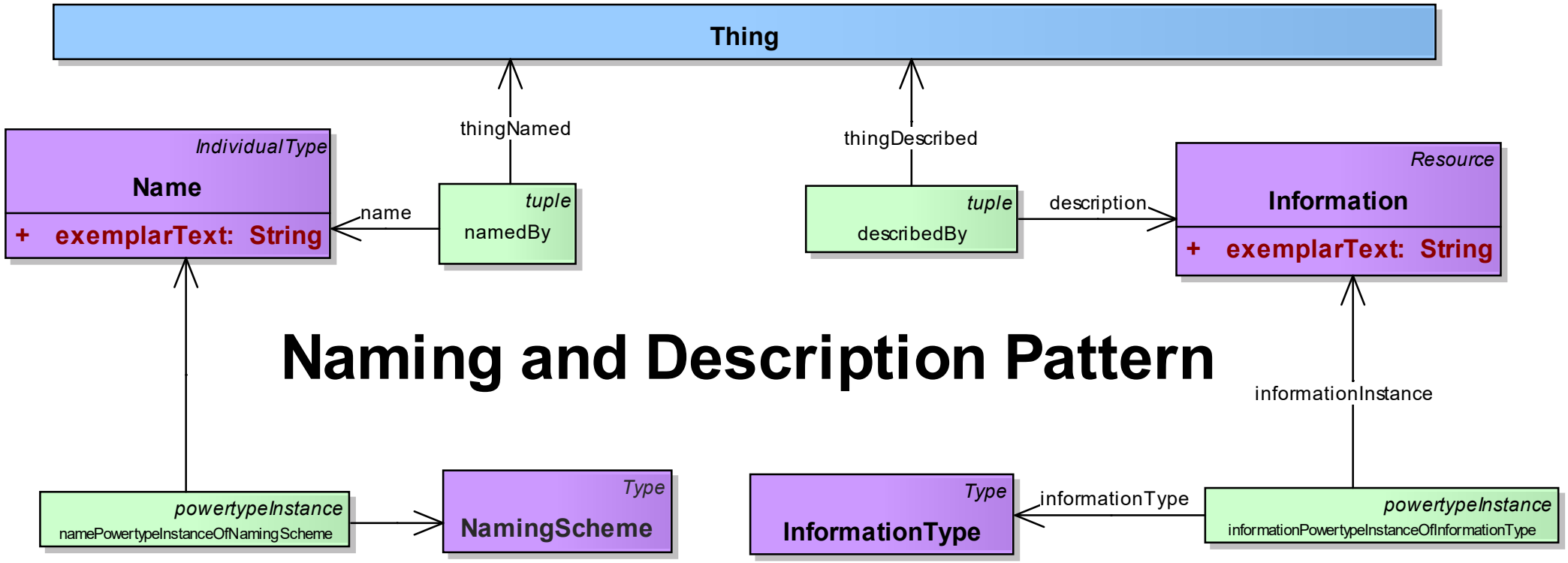
ideas group
international enterprise architecture exchange

Relationship types formalize important properties of the real world being modeled



- Set theoretic:
  - Super-subtype (categorization of Things); e.g., a type of system or service, capability, materiel, organization, or condition.
  - Type-instance, similar to "element of" in set theory
- Spatio-temporal parts and wholes (4D mereology):
  - Whole-part; e.g., components of a service or system, parts of the data, materiel parts, subdivisions of an activity, and elements of a measure.
    - Temporal whole-part (temporal states); e.g., the states or phases of a performer, the increments of a capability or projects, the sequence of a process (activity).
- Spatio-temporal boundaries and overlaps (4D mereotopology:
  - Overlap
  - Before-after (sequences)

Naming and Description Pattern



- Multiple names for same thing (aliases) – must tell Naming Scheme
- Information (formerly Information Element) linked to the Things it describes

Some points about the foundation:

- Types include sets of Tuples and sets of sets.
- Tuples can have other Tuples in their tuple places.
- There are three subtypes of Type: 1) Individual Type, sets whose members are Individuals (Things with spatio-temporal extent); Power Types, sets whose members are generated from a powerset on some other set; and 3) Tuples, sets of ordered relations between Things.
- The participants in a super-subtype relationship can be from the same class, e.g., the supertype can be an instance of Measure Type as well as the subtype. This allows for representation of as much of a super-subtype taxonomy as is needed.

Powertypes

- Power Type members are generated from some Type by taking all the possible subsets of the members of the Type. For example consider the Type whose members are a, b, c. The powerset would be:

$$\{a,b,c\},\{a,b\},\{a,c\},\{b,c\},\{a\},\{b\},\{c\},\{\varnothing\}$$

- Some of these subsets are not used by anyone, e.g., the full set, the null set, or just some random subset.

Interesting Instances of Powertypes

- Take the Individual Type AIRCRAFT, whose members include all the aircraft of the world. The powerset generated from this set would have:

$$\{a_1, a_2, ..., a_n\}, \{\varnothing\}$$

$$\{\text{F-15}_1, \text{F-15}_2, ..., \text{F-15}_{lastF-15built}\}$$

$$\{\text{F-15}_1, 747_1, ..., \text{Cessna}_1\}$$

  - The first two are not very interesting
  - The second one, which might be name F-15 Type, is quite useful.
  - The last example is not useful to most unless you are interested in the first (assuming the subscript 1 means first) of any particular aircraft type, e.g., if you were doing a study of first-off-the-line aircraft production lessons-learned.
- The usefulness of Power Types
  - they allow for multiple categorization schemes with traceability back to the common elements so that the relationships between multiple categorization schemes are known
  - multiple categorization schemes or taxonomies in EA because across a large enterprise it is not possible to employ a single categorization scheme, rather schemes vary depending on function.
    - For example, a weaponeer's classifies ordnance is naturally different from a logistician's, the former concerned with delivery means, lethality, etc. and the latter with weight, size, and other transportation issues.
- Note also that a powerset can then be taken of the powerset

Elements, Subsets, and Powersets

- "is-a" example:

$$\text{Aristotle is-a sapiens is-a species} \Rightarrow \text{Aristotle is-a species}$$

Appears to

- Using mathematical constructs:

$$\text{Aristotle} \in \text{sapiens} \wedge \text{sapiens} \in \text{species} \not\Rightarrow \text{Aristotle} \in \text{species}$$

- Powersets

$$\text{sapiens} \subset \text{homo} \subset \text{hominidae} \subset \text{primate} \subset \text{mammal}$$

$$\text{sapiens} \in \text{species}$$

$$\text{homo} \in \text{genus}$$

$$\text{hominidae} \in \text{family}$$

$$\text{primate} \in \text{order}$$

$$\text{mammal} \in \text{class}$$

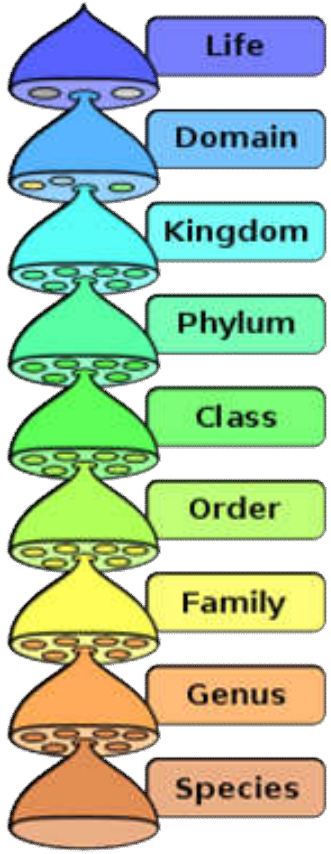
$$\text{species, genus, family, order, class} \subset \mathcal{P}(\text{animal})$$

$$\text{genus} = \mathcal{P}(\text{species})$$

$$\text{family} = \mathcal{P}(\text{genus})$$

$$\text{order} = \mathcal{P}(\text{familly})$$

$$\text{class} = \mathcal{P}(\text{order})$$



Properties

- Properties and attributes of classes

Define the powerset of A as the set of all subsets of A:

$$\mathcal{P}(A) = \{\{\ \}, \{a_1\}, \{a_2\}, ..., \{a_n\}, \{a_1, a_2\}, \{a_1, a_3\}, ..., \{a_1, a_n\}, ..., \{a_1, a_2, a_3\}, ...\}$$

Then:

$$B \subset A \Rightarrow B \in \mathcal{P}(A)$$

if $\mathbb{A} \subset \mathcal{P}(A) \ni \forall a_m \in A \exists A_i \in \mathbb{A} \ni a_m \in A_i$

then $\mathbb{A}$ is called a "property-of" A or A "has" $\mathbb{A}$

If $\mathbb{A} \equiv \{A_i\}, A_i \subset A \ni \mathbb{A}$ is a partition over A

then $\mathbb{A}$ is called a "unique property-of" A

Why Formal Ontology?

- Formalizes important properties of the real world being modeled
  - Categorization of things (type (~set) theory)
    - Things can be in many categories
  - Parts and wholes (mereology)
    - The parts don't have to be contiguous, e.g., parts of a squadron
  - Temporal states (4D mereology)
    - The objects have a lifetime (temporal extent) that can be broken into temporal states
  - Overlaps, spatial relationships (mereotopology)
  - Sequences, before-after (4D mereotopology)
- Establishes a criterion of identity -- If something has the same spatio-temporal extent as something else, they are the same
- Enables mathematical analysis of EA datasets using well-established set theoretic, geometric, and topologic mathematic "laws" and theorems, e.g.,
  - Commutivity and anti-commutivity, e.g., $A \cap B = B \cap A;\ a \bigcap b = b \bigcap a$
  - Symmetry and anti-symetry, e.g., $aPb \wedge a \neq b \Rightarrow \neg bPa; \qquad aBb \Rightarrow \neg bBa$
  - Reflexivity and irreflexivity, e.g., $A \subset A; \quad aPa; \quad \neg uBu$
  - Associativity $A \cup (B \cup C) = (A \cup B) \cup C; \quad A \cap (B \cap C) = (A \cap B) \cap C; \quad aO(bOc) = (aOb)Oc$
  - Transitivity $A \subset B \wedge B \subset C \Rightarrow A \subset C$
  - Many others, e.g., $a \in A \wedge A \subset B \Rightarrow a \in B$

    $\text{if } \{A_i\} \text{ forms a partition of A then } a \in A_j \Rightarrow a \notin A_k \forall j \neq k$

Benefits of adopting the IDEAS formal foundation and common patterns

- Agreed-upon analysis principles that provide a principled basis for resolving differences
- Model compactness through inheritance of superclass properties and rigorously worked-out common patterns.
  - Saved a lot of repetitive work – “ontologic free lunch”
  - Economizes implementations
  - Concentration of effort on a few common patterns results in higher quality and consistency throughout
- Improved ability to integrate and analyze multiple heterogeneous EA datasets to fulfill EA purposes
  - Depends on near-universal mathematics and science that all learn very similarly
- Mathematical rigor needed for precision Architectural Descriptions that can be analyzed and used in detailed processes such as Systems Engineering and Operations Planning.
  - Better ability to integrate and analyze EA data for EA purposes.

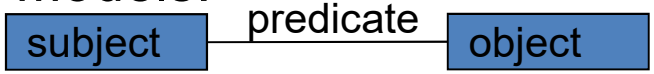
Why math? a spectrum of information sharing

Free-text — Human-interpretable only

Structured document — Human-interpretable but with a predictable organized arrangement

Database

Databases are semantically weaker than commonly understood, e.g., the fundamental concepts of Entity-Relationship and Class Models:



i.e., structured sentences => language-based

Mathematically structured

- Applicable mathematics:
  - Set or type theory
  - Mereology
  - Mereotopology
  - 4 dimensionalism
  - Predicate calculus
  - Logics: modal, Kripke, …
- Rules, operators:
  - Commutative, reflexive, transitive, …
  - Member-of, subset-of, part-of, …

Benefits of Rigorously Structured EA Data

- Databases are really just storage and retrieval with connections only for exactly matching pieces of information (e.g., "keys" or exactly matching strings).
- The nature and purposes of EA require more than just storage, retrieval, and exchange, e.g., integration, analysis, and assessment across datasets
- For example, the logical entailment of an EA dataset or collection of related EA datasets might reveal inconsistencies.
- EA entailment examples:
  - "F-16's can fly at least Mach y" ==> F-16C's can fly at least Mach y
  - "Ship's Self Defense System can parse and generate TADIL-J messages" and "SSDS is-part-of all CVNs" ==> CVN's can parse and generate TADIL-J messages
- Without the "intelligence" to perform entailment, data integrations, queries, and analysis algorithms miss connections.
- DM2's ontologic foundation supports entailment and other sorts of mathematical understanding of the data with membership (~ set theory) and 4D mereotopology (parts and boundaries).
  - These are so fundamental in human reasoning that it's hard to see that computers don't have it at all
  - Needed if we want to use them for something more than just storage and retrieval.
  - Has to be encoded it into them with formal methods

Initial work on mathematics of data modeling

- Set theory $\in, \subset, \cup, \cap, \ldots$
- 4-D (xyzt) mereology (and mereotopology)
  - Whole-part
    - Spatial
    - Temporal
  - Before-after
  - Overlap
- Predicate Calculus $\forall, \exists, \ni, \ldots$

Depends on near-universal mathematics and science that all learn very similarly

Formal Ontology Mathematics

- Set theory
- 4-D (xyzt) mereology (and mereotopology)
  - Whole-part
    - Spatial
    - Temporal
  - Before-after
  - Overlap
- Predicate Calculus $\forall, \exists, \ni, \ldots$
- Set theoretic, geometric, and topologic mathematic "laws" and theorems, e.g.,
  - Commutivity and anti-commutivity, e.g., $\in, \subset, \cup, \cap, \ldots$ $A \cap B = B \cap A;\ a \bigcap b = b \bigcap a$
  - Symmetry and anti-symetry $aPb \wedge a \neq b \Rightarrow \neg bPa; \quad aBb \Rightarrow \neg bBa$
  - Reflexivity and irreflexivity $A \subset A; \quad aPa; \quad \neg uBu$
  - Associativity $A \cup (B \cup C) = (A \cup B) \cup C; \quad A \cap (B \cap C) = (A \cap B) \cap C; \quad aO(bOc) = (aOb)Oc$
  - Transitivity $A \subset B \wedge B \subset C \Rightarrow A \subset C$
  - Many others $a \in A \wedge A \subset B \Rightarrow a \in B$

    if $\{A_i\}$ forms a partition of A then $a \in A_j \Rightarrow a \notin A_k \forall j \neq k$

These types of logics, calculii, theorems, etc. can be applied against datasets founded on formal ontologies such as the IDEAS Foundation

Examples of some set theoretic formalisms

Commutative and anti-commutative, e.g., $A \cap B = B \cap A$

Reflexive and irreflexive, e.g., $\mathrm{A} \subset \mathrm{A}$, $\mathrm{A} \subsetneq \mathrm{A}$

Associative, e.g., $A \cup (B \cup C) = (A \cup B) \cup C; \quad A \cap (B \cap C) = (A \cap B) \cap C;$

Transitive, e.g., $\mathrm{A} \subset \mathrm{B} \wedge \mathrm{B} \subset \mathrm{C} \Rightarrow \mathrm{A} \subset \mathrm{C}$

others:

$a \in A \wedge A \subset B \Rightarrow a \in B$

if $\{A_i\}$ forms a partition of A then $a \in A_j \Rightarrow a \notin A_k \forall j \neq k$

Examples of some mereotopologic formalisms

- Overlaps, spatial relationships (mereotopology)

Parthood $xPy \equiv x \text{ is a part of } y$

Proper part x is a proper part of y $x\langle P\rangle y \equiv xPy \wedge \neg yPx$

P and $\langle P\rangle$ are transitive : $xPy \wedge yPz \Rightarrow xPz$

$aPb \wedge a \neq b \Rightarrow \neg bPa;$

P is antisymmetric : $xPy \wedge yPx \Leftrightarrow x = y$

Overlap proposition $xOy \Leftrightarrow \exists z \ni zPx \wedge zPy$

Overlap operator : $x \bigcap y = z_o \ni z_oPx \wedge z_oPy \wedge \forall z_i \neq z_o, z_iPx \wedge z_iPy \Rightarrow z_iPPz_o$

Underlap $xUy \equiv \exists z \ni xPz \wedge yPz$

xOy and xUy are reflexive, symmetric, and intransitive

Overlap Associative $aO(bOc) = (aOb)Oc$

- Behaviors -- Sequences, before-after (4D mereotopology)

Before xBy is transitive : $xBy \wedge yBz \Rightarrow xBz$

Proper before is irreflexive $\neg u\langle B\rangle u$

Properbeforeisanti-commutative $a\langle B\rangle b \Rightarrow \neg b\langle B\rangle a$

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IDEAS Group

From Wikipedia, the free encyclopedia

The **IDEAS Group** is the International Defence Enterprise Architecture Specification for exchange Group. The deliv
data exchange format for military Enterprise Architectures. The scope is four nation (plus NATO as observers) and
DoDAF (USA), DNDAF (Canada) and the Australian Defence Architecture Framework. The initial scope for exchan
required to support coalition operations planning -

- Systems - communications systems, networks, software applications, etc.
- Communications links between systems
- Information specifications - the types of information (and their security classifications) that the comms architectu
- Platforms & facilities.
- System & operational functions (activities)
- People & organizations
- Architecture meta-data - who owns it, who was the architect, name, version, description, etc.

The work has begun with the development of a formal ontology to specify the data exchange semantics. The W3C
Framework and Web Ontology Language (XML) will be the format used for data exchange. A demonstration of mult
scheduled for September 2007, based on exchanging process models for casualty tracking.

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1 The Need for Architecture Interoperability
2 Military Application
3 Ontology
4 Implementation
5 External links

ideas group — International Defence Enterprise Architecture Specification Group

BORO (TM) Process - Flowchart

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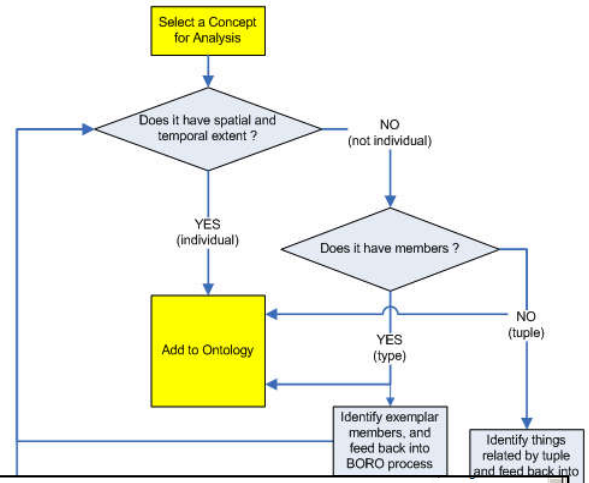

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BORO Method

From Wikipedia, the free encyclopedia

The introduction to this article provides **insufficient context** for those unfamiliar with the subject.
Please help improve the article with a good introductory style.

The **BORO Method** is a simple, repeatable process for developing formal ontologies. The **BORO**
extensional approach to ontology development. The advantage of BORO over other methods is th
physical reality means that, if followed to the letter, the method will always produce the same ont
same inputs. This makes it particularly powerful for comparing multiple data-sources for semantic
matches/mismatches and for re-engineering multiple legacy systems into a coherent whole (eithe
monolithic system, or as a method for designing federation of existing systems). Although BORO
ontology (information science) in the very strictest sense of the term, it does not produce the type
(information science) that computer scientists would use for reasoning and inference. Instead, BO
improve the quality of information and information models, to integrate multiple information source
semantics.

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1 History
2 Applications
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The BORO Program

Business Object Reference Ontology

Public Resources Website

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BORO Working Papers | BORO Technical Reports Articles and Papers | BORO - CEO Project reports | BORO Reference Ontologies | BOOK - Business Objects: Re-engineering for re-use

Resources available On-site

BORO Working Papers

Volumes

Volume A - The BORO Approach
Volume O - Ontology
Volume B - The BORO Business Object Ontology
Volume M - The BORO Methodology

BORO Technical Reports Articles and Papers

BORO - CEO Project reports

BORO book is downloadable from DoDAF WG site

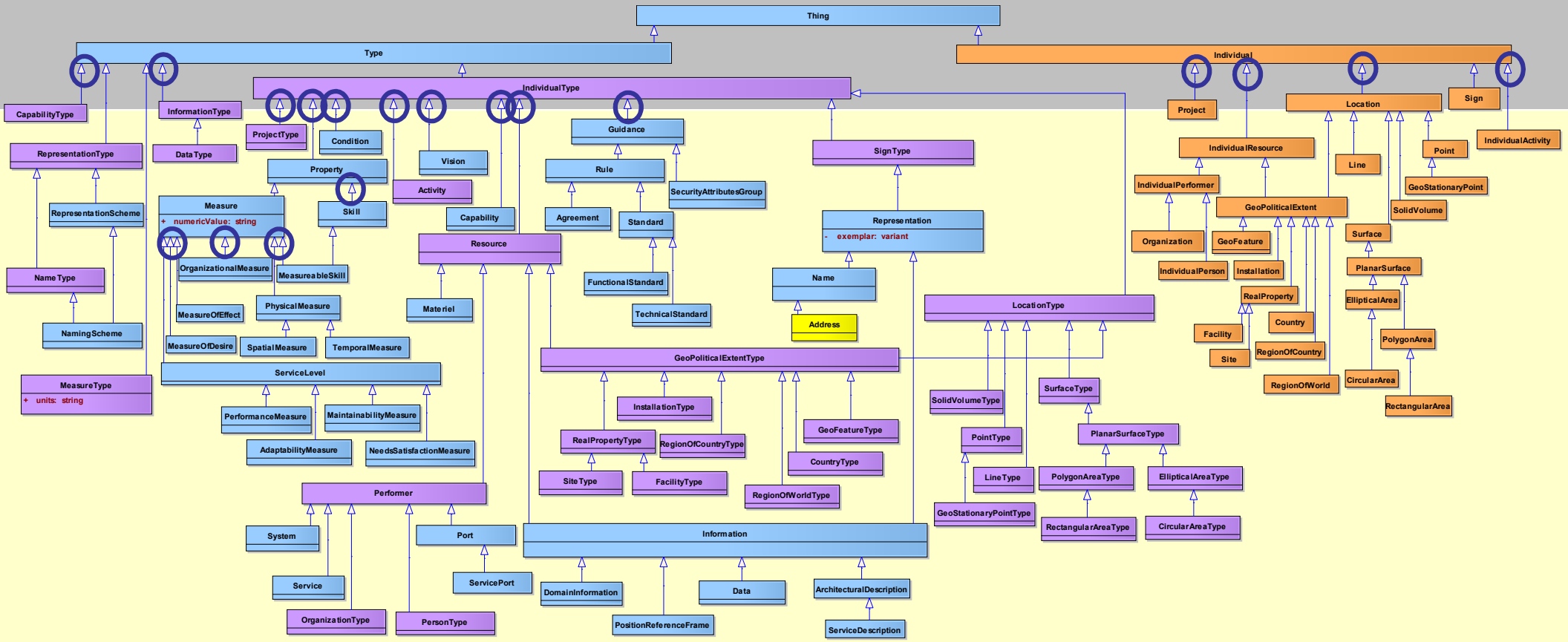
Walkthrough of the DM2 Logical Data Model Data Groups

DM2 LDM Semantically-related Clusters or Data Groups

1. ***Performers.*** Any entity—human things, automated things, and any assemblage of such things—that performs an activity and provides a capability.
2. ***Resource Flows.*** The behavioral and structural representation of the interactions between activities (which are performed by performers) that is both temporal and results in the flow or exchange of things such as information, data, materiel, and performers.
3. ***Information and Data.*** Representations (descriptions) of things of interest and necessary for the conduct of activities. Information is the state of a something of interest that is materialized—in any medium or form—and communicated or received.
4. ***Rules.*** How rules, standards, agreements, constraints, and regulations and are relevant to architectures. A principle or condition that governs behavior; a prescribed guide for conduct or action.
5. ***Capabilities.*** The ability to achieve a desired effect under specified standards of performance and specified conditions through combinations of ways (guidance and rules) and means (resources) to perform a specified set of activities.
6. ***Services.*** A mechanism to enable access to a set of one or more capabilities , where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description. The mechanism is a Performer. The capabilities accessed are resources, that is, information and data, materiel, performers, and geo-political extents.
7. ***Projects.*** All forms of planned activities that are responsive to visions, goals, and objectives that aim to change the state of some situation. A temporary endeavor undertaken to create resources or desired effects.
8. ***Organizational Structures.*** Representations of the organization types, organizations, and persons in roles that are within the scope of the described architecture.
9. ***Measures.*** All form of measures (metrics) applicable to architectures including needs satisfaction measures, performance measures, interoperability measures, organizational measures, and resource physical measures (e.g., mass). The magnitude of some attribute of an individual.
10. ***Locations.*** A point or extent in space that may be referred to physically or logically.
11. ***Pedigrees.*** The origin and the history of something; broadly, the DoDAF notion of *pedigree* encompasses the background and history of a resource.

DM2 Extends from IDEAS

IDEAS Foundation



DoDAF 2 Domain Concepts

Even Relationships Extend from IDEAS

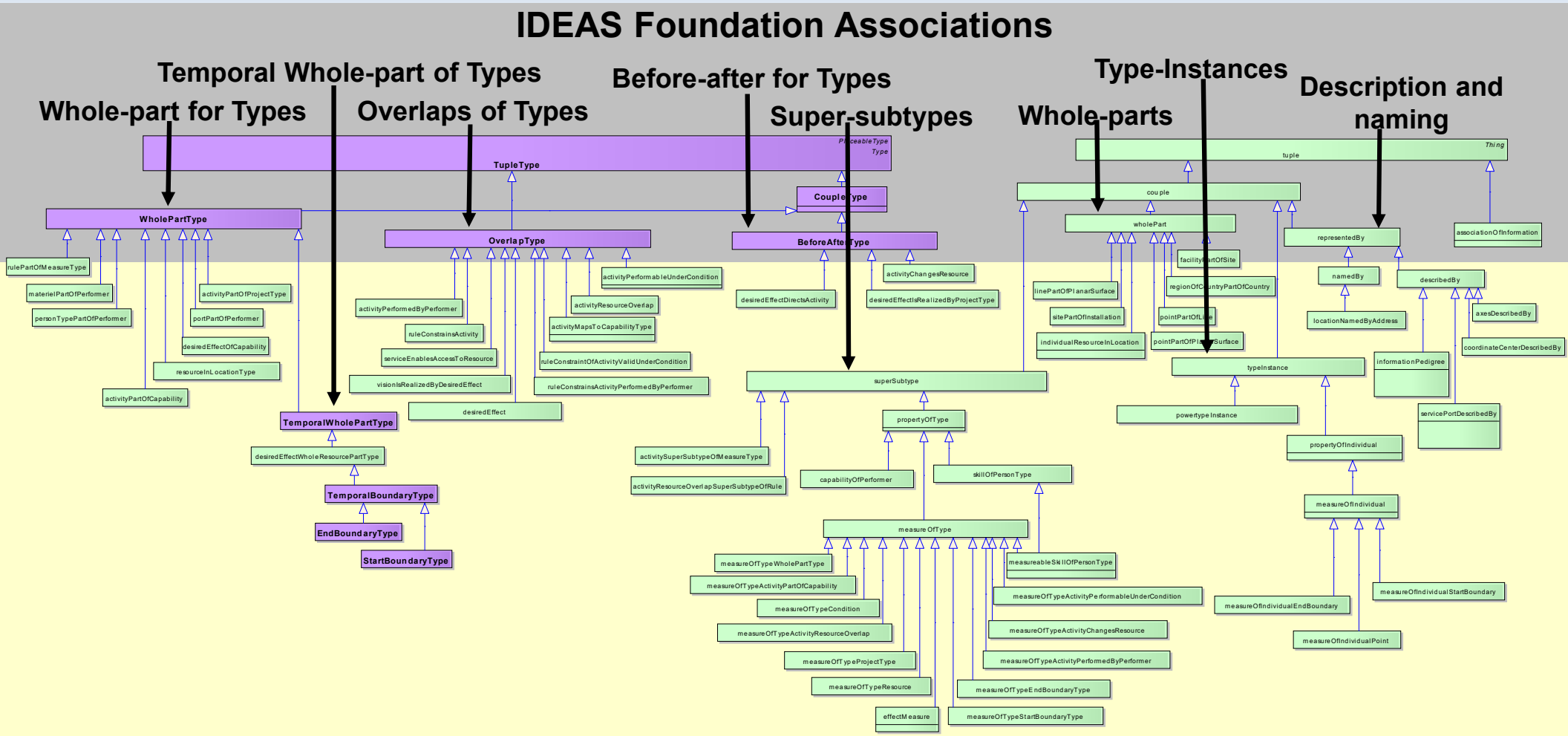
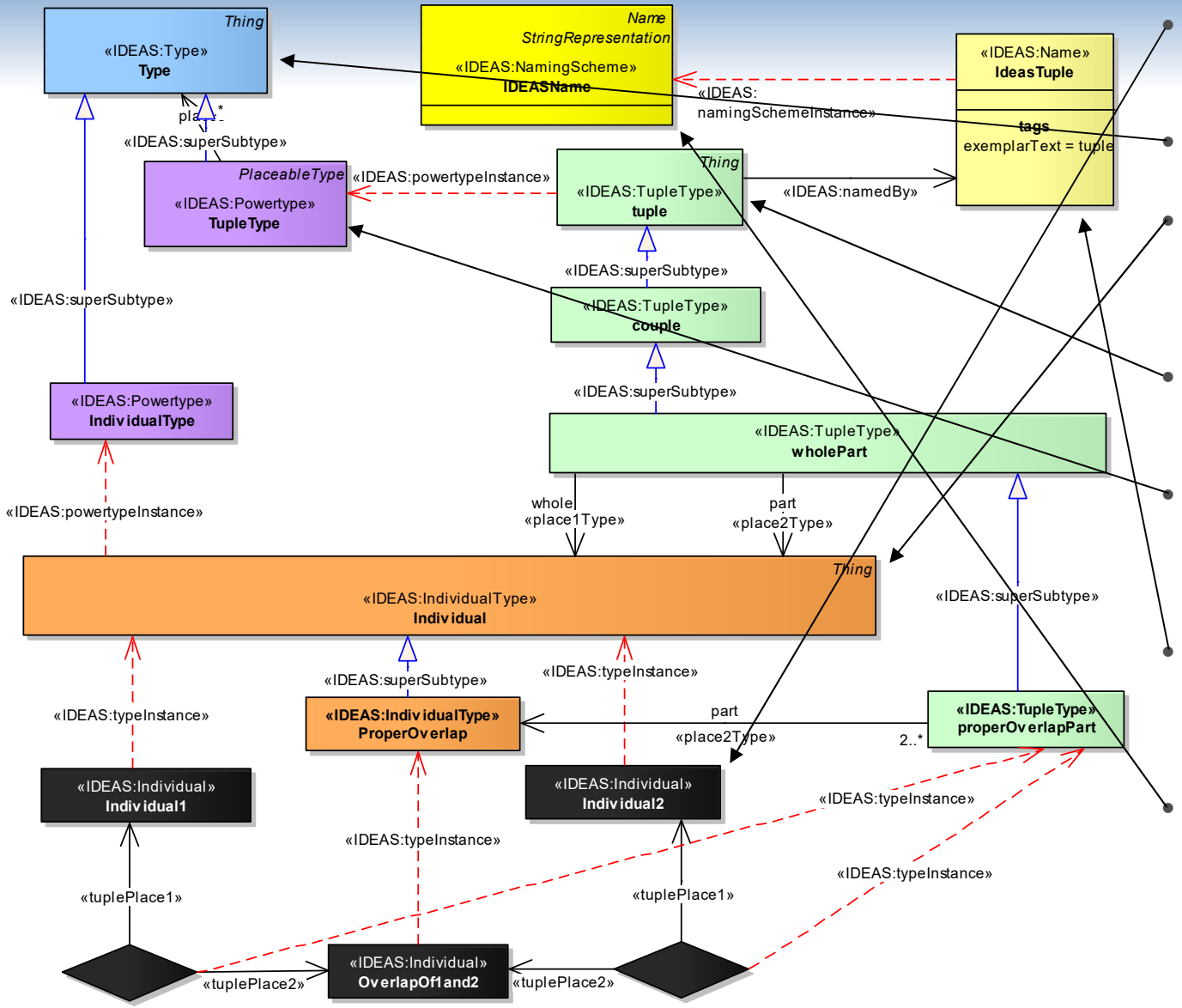


Diagram Conventions and Use of UML

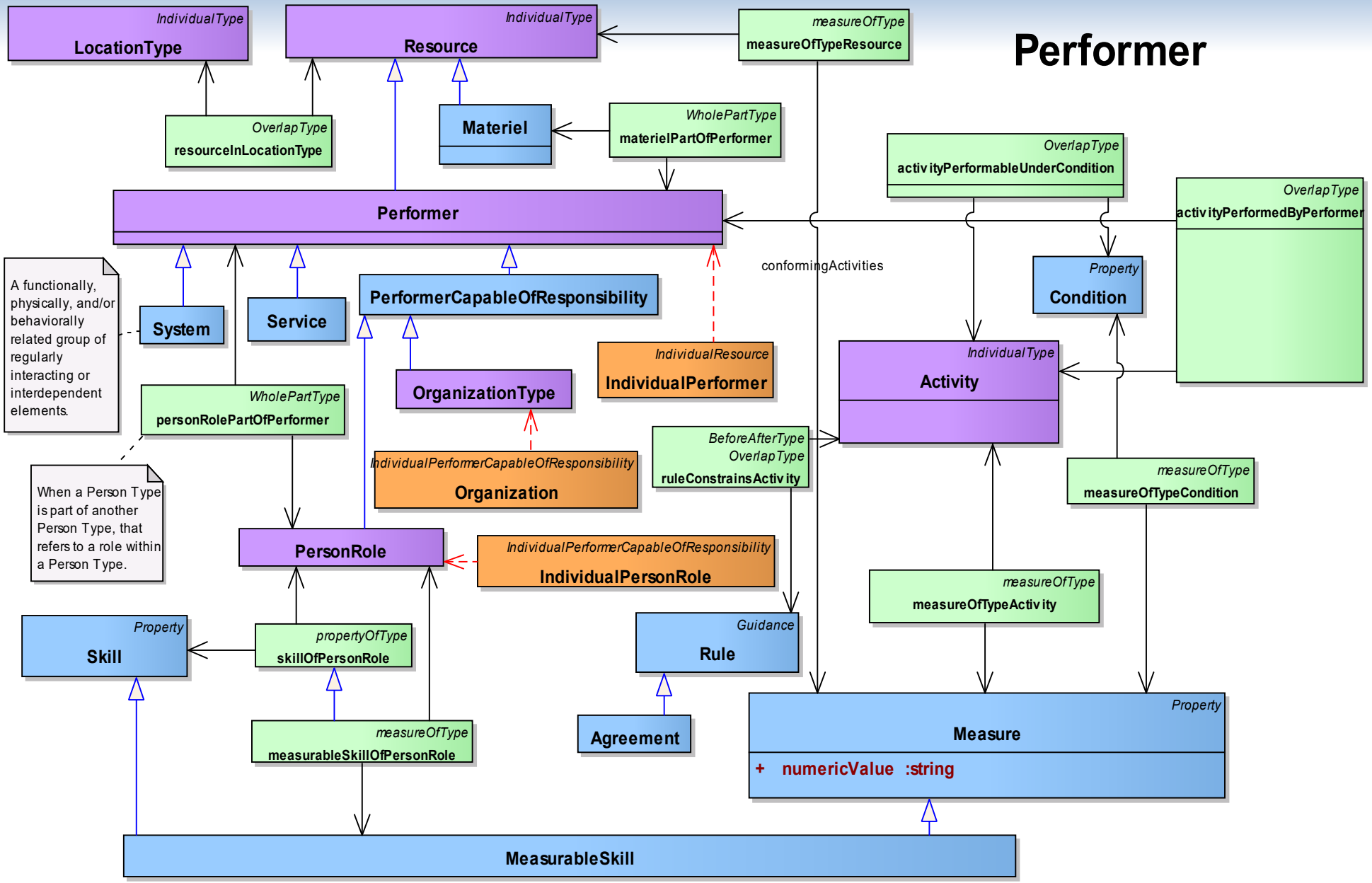


Individual -- An instance of an Individual - something with spatio-temporal extent
Type -- The specification of a Type
IndividualType -- The specification of a Type whose members are Individuals
TupleType -- The specification of a Type whose members are tuples
Powertype -- The specification of a Type that is the set of all subsets of a given Type
Name -- The specification of a name, with the examplar text provided as a tagged value
NamingScheme -- The specification of a Type whose members are names

Performer Data Group

- Central to the description of architecture
  - Performers are the “Who”
    - the “How” are assigned to Performers
      - Assignment involves tradeoffs, e.g., for performance and cost/benefit
      - Assignment results in allocated baseline and initial work breakdown structures
- Performers
  - Types: Organizations / Org Types, Person Role Types, Systems (humans and machines), and Services – or any combination thereof
  - Follow Rules in performing their Activities
  - Are at Locations
  - Have Measures

Performer Data Group Model Diagram



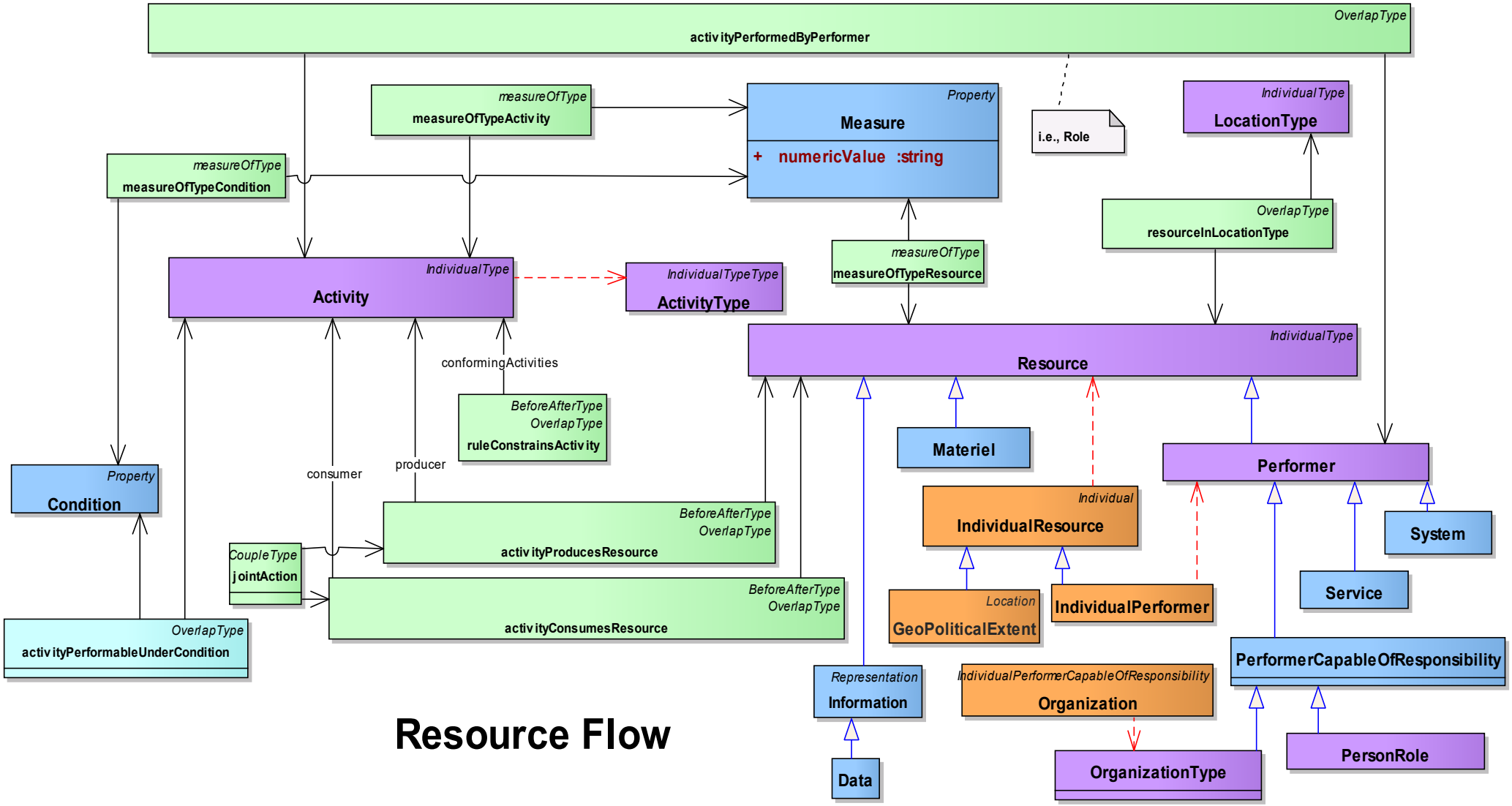
Performer Data Group Notes

- A performer may be:
  - A person in a role such as the roles described by the Amy's military occupational specialties (MOS). A person in a role includes materiel assigned and necessary to carry out the role (for example, see the Army's series of Common Tables of Allowances). A person in a role has temporal whole-parts (states) such as in-garrison or deployed; these temporal parts may have different materiel compositions and other associations.
  - A type of organization or a specific organization that has a mission.
  - A system in the general sense of any assemblage of components—machine and human—that accomplish a function.
  - A service, including software services and business services such as search and rescue.
  - Any combination of the above.
- The performance of an activity by a performer occurs in physical space and time. That is, at some place and time, the activity is performed. This is referred to as a spatial-temporal overlap, simply meaning that the activity and performer overlap in space and time. There are two ways in which a performer spatial-temporally overlaps an activity:
  - In the act of performing the activity. This sort of overlap may be expressed by saying that a performer is *assigned* to an activity.
  - As part of a larger process (aggregated activities). This sort of overlap may be expressed by saying that a performer is *allocated* to an activity. Allocation forms the initial stages of system or activity decomposition. Allocated performers are assigned to activities in the initial stages of defining performers.
- A standard, which is a sort of rule, constrains an activity in general and affects how performers carry out activities.
- A performer may be related to measures that bear on the performance of an activity (e.g., target tracking accuracy.) A performer may also be related to measures that bear on the performer itself (e.g., operational condition).
- A performer may be *at* a specific location designated by some set of coordinates within a coordinate system. A performer may also be *within* a more general location designated by an area, region, installation, site, or facility. Location type requirements and capabilities of a performer are captured and expressed via the activities that are performed under certain conditions (e.g., must be able to perform maneuver under desert conditions).
- Activities performed by a system can be called system or service functions (i.e., activities performed by a system). System or service functions are activities that are allocated to hardware, software, firmware, and persons in roles.
- In typical uses, activities are named by verbs and performers are named by nouns. This distinguishes *what* from *who* at the level of names. In typical specification activities, allocation to performers can take place at different levels of abstraction and at different levels of detail within a level of abstraction.
- Performers are represented in many places and stages in a detailed architectural description. A pure requirements architectural description would not show allocations to performers; this allocation would come later in the design process.

Resource Flow Data Group

- Resource flows model the flow of resources—materiel, information and data, geo-spatial extents, performers, and any combination thereof. Resource flows are key modeling techniques used to define interfaces and to assure interoperability between activities and their associated performers (e.g., systems and persons in roles). Resource flow models and associated analysis techniques reveal behavior such as:
  - The connectivity between resources.
  - Resource flow modeling provides an explicit means to describe the behavior of activities, systems, organizations and their composite effects on the overall enterprise.
  - The content of the information flowing between resources (e.g., interface definition).
  - The order or sequential behavior (parallel or serial) of the resources in relation to one another (e.g., project task execution and critical path).
  - The behavior of resource flow between or within organizations (e.g., work flow, information flow).
  - The changes in state during the spatial and/or temporal existence of the resource.
  - The rules that modify the behavior of the resource flow (e.g., business rules, controls, decisions).
  - The measures that define quality, constraints, timing, and other properties of the resource flow (e.g., quality of service (QoS), measures of performance, measures of effectiveness).
  - The flow of control orchestrating the behavior of a resource flow.

Resource Flow Data Group Model Diagram

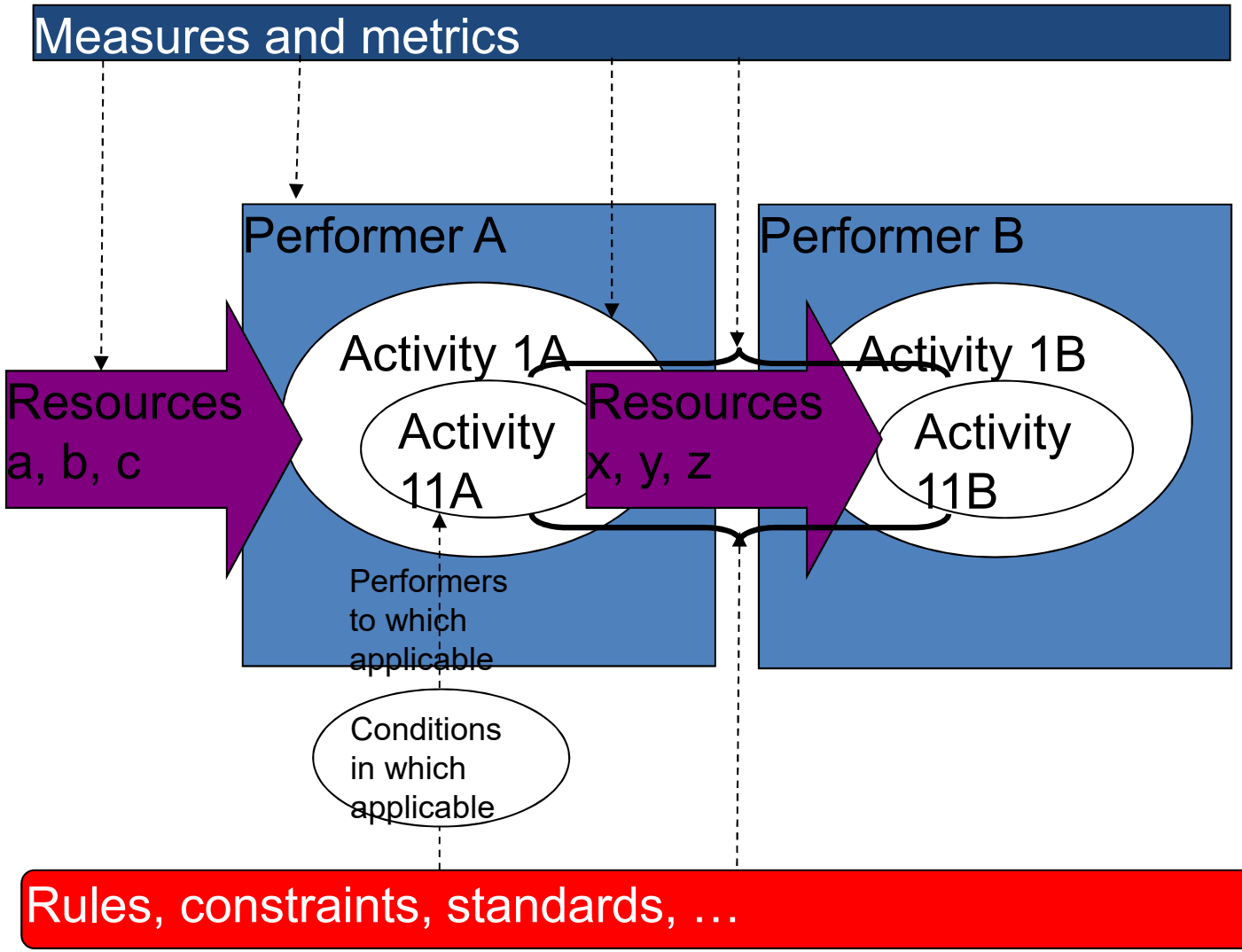


Resource Flow

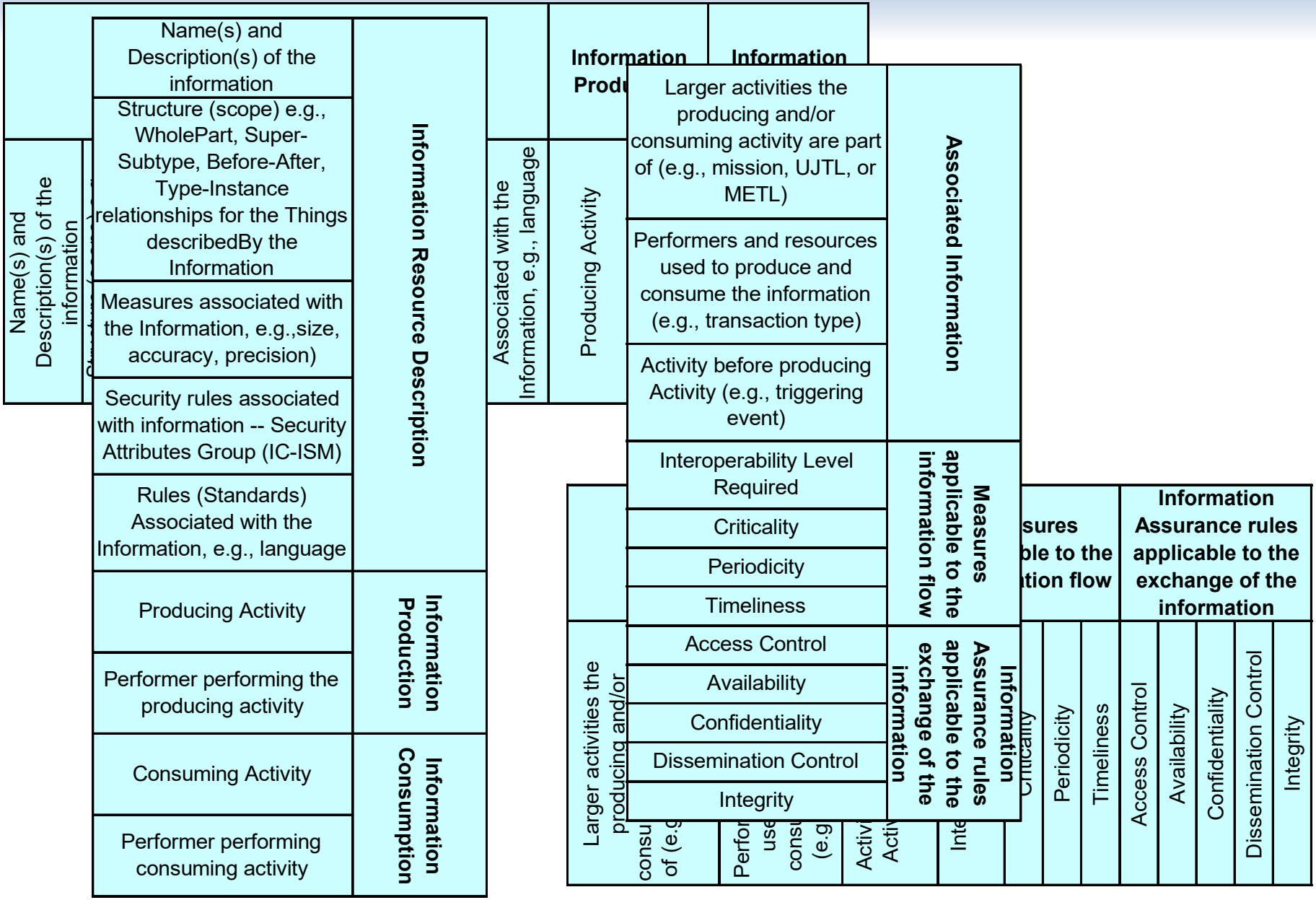
Resource Flow Data Group Notes

- DoDAF models the consumption and production—the flow—of any sorts of resources, not just flows of information and data exchanges. DoDAF may be used to model:
  - Materiel flows such as ammunition and fuel that are important for modeling the fire rate, logistics, and other aspects of a capability solution so it can be compared with other proposed solutions.
  - Persons in roles such as military occupational specialty (MOS) that allow representation of the training and education pipeline aspects of doctrine, organization, training, material, leadership and education, personnel, and facilities (DOTMLPF).
  - Performers such as organizations, persons in roles, and systems that are produced by a project's development activities. Among other possibilities, this allows an architect to model an acquisition project.
- All exchanges and flows are due to producing or consuming activities. Resource flows are activity-based, not performer-based, because a performer cannot produce or consume a resource other than by carrying out an activity. That is, a performer can only give or get a resource by carrying out an activity..
- The exchange or flow triple may have standards (rules) associated with it such as information assurance and security rules or, for data publication or subscription, data COI and web services standards.
- Rules and measures are applied to specific activities and their performers. Activities, systems, and persons in roles can be assigned to locations and further can be assigned conditions and constraints.
- The term flow implies that something (e.g., materiel, information) is moving from point A to point B, hence the use of the foundation concept of "overlap".
- The exchange or flow triple may be related to measures such as timeliness, throughput, reliability, or QoS.

Activity Model in DM2 Terminology



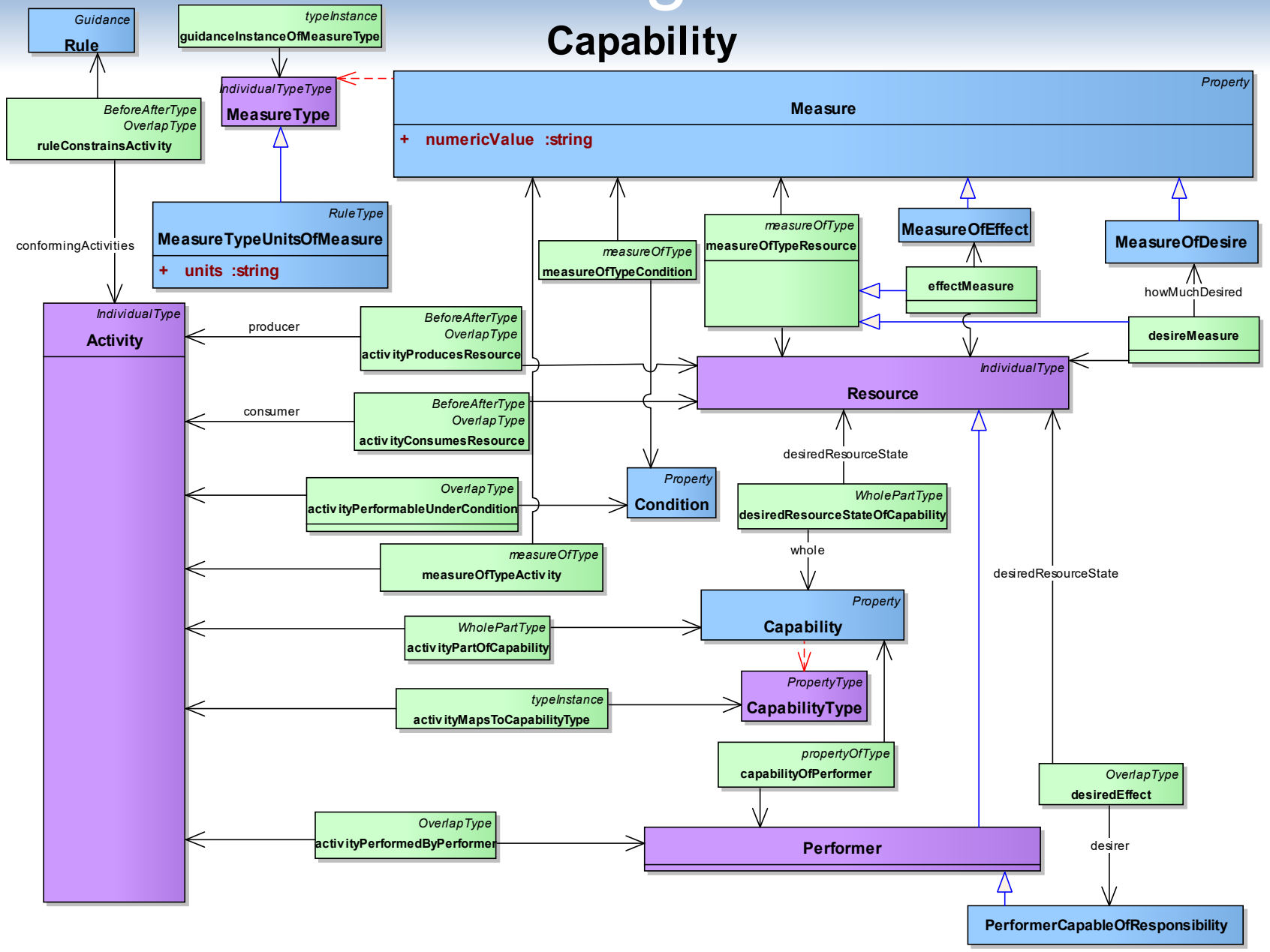
IER Table in DM2 Terminology



Capability Data Group

- The Capability Data Group provides information on the collection and integration of activities that combine to respond to a specific requirement.
- A capability, as defined here is “the ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks.”

Capability Data Group Model Diagram



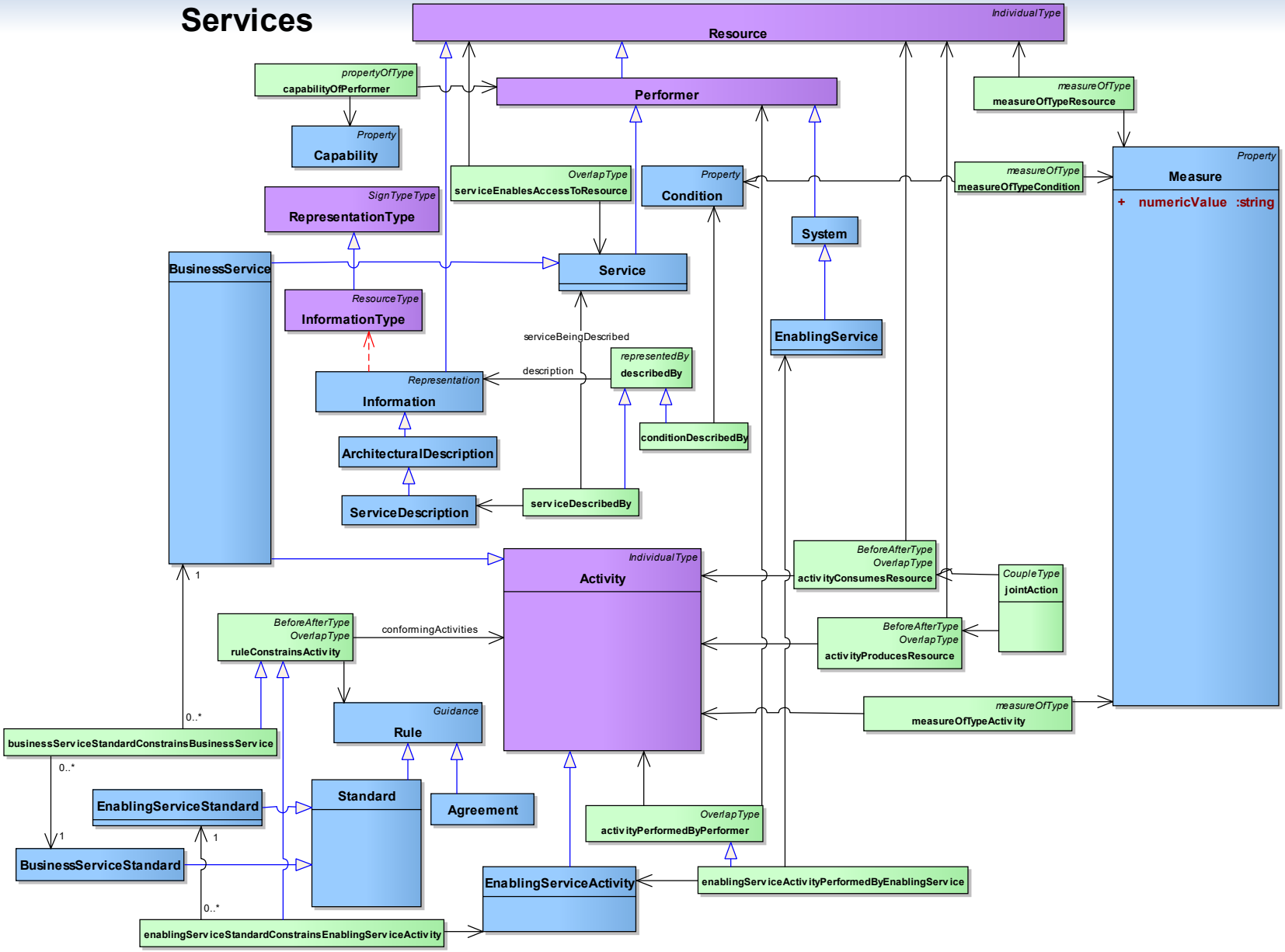
Capability Data Group Notes

- *Ways* are interpreted as guidance, rules, and standards. *Means* are interpreted as resources.
- Because a *desired effect* is a desired state of a resource (see Goals data group), a capability is about states—the persistence of current states and changes to future states—of resources.
- *Capabilities* link to *measures* through the *activities* they entail as parts and the *desired effects* sought.
- *Capabilities* relate to *services* via the realization of the *capability* by a *performer* that is a *service*. In general, a *service* would not provide the *desired effect(s)* but, rather, access to ways and means (*activities* and *resources*) that would.
- *Desired effects* are *resource states*. This simplification is enabled by the formal ontology on which the model is founded, specifically, 1) because the ontology is four-dimensional, all instances are spatio-temporal extents so a resource has a temporal extent and has possible future extents, and 2) because the ontology is meronymic, resources have wholes and parts so that a resource can be a complex aggregate of all types of things, in principle including Political, Military, Economics, Social, Infrastructure, and Information (PMESII).
- Desired *resource states* are ontologically synonymous with *goals*, *objectives,* and *outcomes*. Extensive research by the DoDAF working group that developed this model concluded that there was no objective distinction between the concepts because only subjective terms such as “more”, “greater”, “longer term”, “broader”, etc. were used to distinguish them. Since the foundation ontology is spatio-temporally mereologic, this distinction is not necessary.
- Desired *resource states* can be for *resource states* of adversarial or neutral parties as well as blue force. For example, for a Joint Suppression of Air Defenses (JSEAD) *mission*, the *desired effects* might include that the *resource state* of the target area’s air defenses reaches some desired *measures* of destruction, denial, disruption, degradation, and / or deception (D5). For a humanitarian assistance *mission*, the *desired effects* might include that the *resource state* for the victim population reaches nutrition, shelter, health, and low casualty rates.
- *Activities*, including *operational activities*, are ontologically synonymous with *Tasks*. The DoDAF capability modeling group could not determine an objective distinction.
- *Measures* enable modeling of the quantifiable aspects of the *desired effect* as well as the performance of *tasks* and the *conditions* under which they must be performed.
- In addition to *measures* associated with *task* performance, specified standards also imply conformance with *guidance*, *rules*, etc., shown as a constraint on the performance of the *tasks*.
- Conditions are modeled in accordance with the UJTL conditions and, therefore, measures are also associated with conditions.
- *Capability configurations* that might provide such a *capability* are modeled as *performers*, which are typically aggregates of air, space, and cyber assets that are located geo-spatially and that have *measures* associated with their overall performance and readiness as well as the individual elements that comprise them, including the personnel.

Services Data Group

- A service, in its broadest sense, is a well-defined way to provide a unit of work, through which a provider provides a useful result to a consumer. Services do not necessarily equate to web-based technology or functions, although their use in the net-centric environment generally involves the use of web-based, or network-based, resources.
- Functionally, a service is a set of strictly delineated functionalities, restricted to answering the *what-question*, independent of construction or implementation issues. Services form a layer, decoupling operational activities from organizational arrangements of resources, such as people and information systems. Finally, Services form a pool that can be orchestrated in support of operational activities, and the operational activities define the level of quality at which the services are offered.

Services Data Group Model Diagram



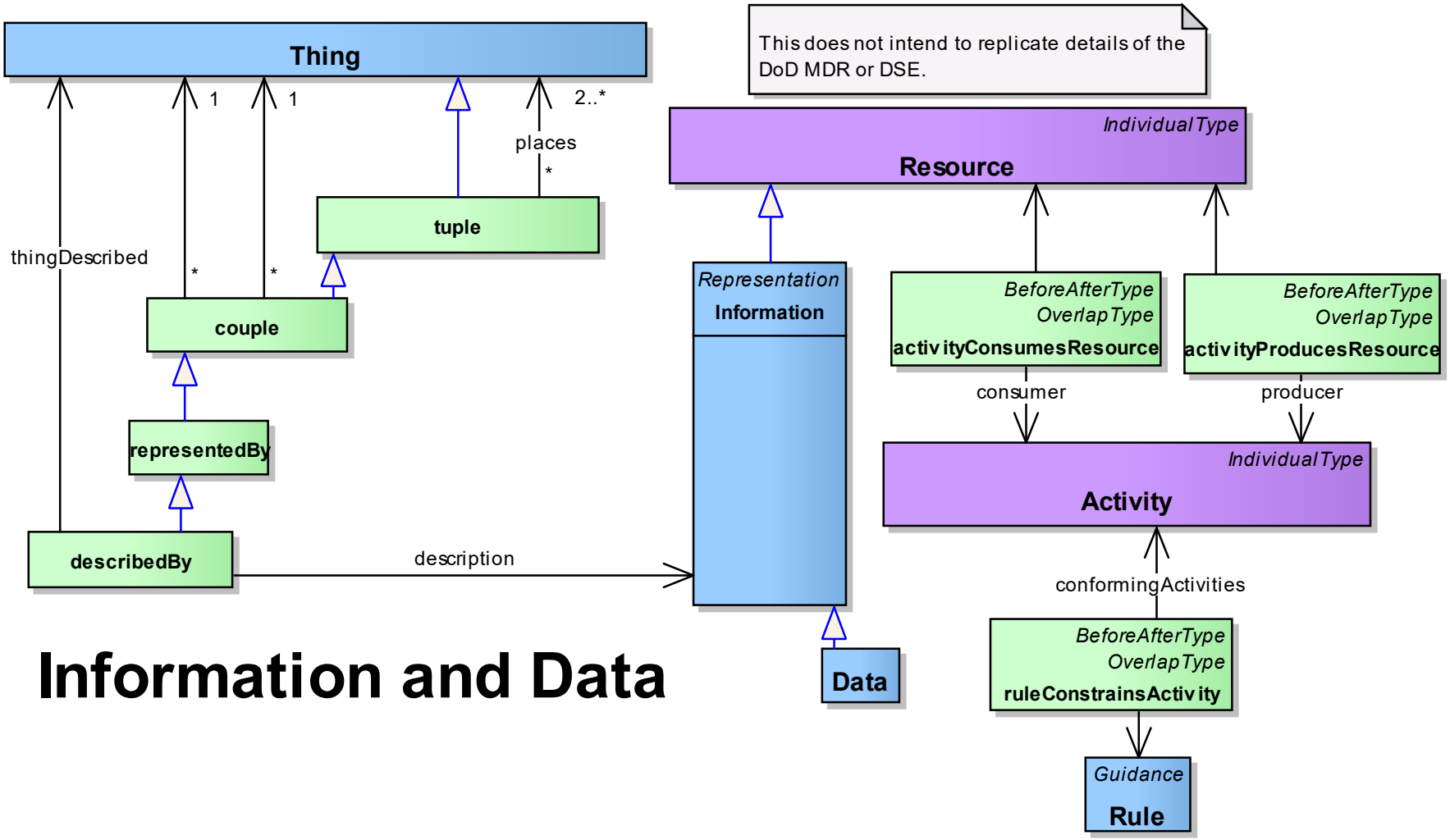
Services Data Group Notes

- Services are activities done by a service provider (performer) to achieve desired results for a service consumer (other performer). A service is a type of performer. This means that a service performs an activity and may thus provide a capability.
- Capabilities and services are related in two ways. One, the realization or implementation of a capability by a performer (usually a configuration of performers, including locations) may include within the configuration services (or service compositions) access other performers within the overall performer configuration. Conversely, the realization or implementation of a capability by a performer (configuration, including location) may provide the performers that are accessed by a service (or service composition).
- Services in DoDAF 2.0 include non-business services such as search and rescue services. This is important to keep in mind because much of the SOA literature looks only at information technology services.
- Although, in principle, anything has a description, the importance of self-description for discovery and use of services merits its call-out as a class. A service description provides whatever information is needed to use the service and no more. As such, it may include visible functionality, QoS, interface descriptions, data descriptions, and references to standards or other rules (service policy). A service description does not examine the inner workings of the service.
- Since service inherits whole-part, temporal whole-part (and with it before-after), service may refer to an orchestrated or choreographed service, as well as to individual service components.

Information and Data Data Group

- Information is the state of a something-of-interest that is materialized, in any medium or form, and communicated or received
  - emphasis is on the identification and description of the information in a semantic form (what it means) and why it is of interest (who uses it)
  - may entail some formality such as describing relationships between concepts, its purpose is to convey the interests in the operator, executive, or business person's frame of reference.
- Data is the representation of information in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means, and is concerned with the encoding of information for repeatability, meaning, and proceduralized use.
  - information descriptions are useful in understanding requirements, e.g., inter-federate information sharing requirements or intra-federate representation strategies, data descriptions are important in responsive implementation of those requirements and assurances of interoperable data sharing within and between federates.

Information and Data Data Group Model Diagram



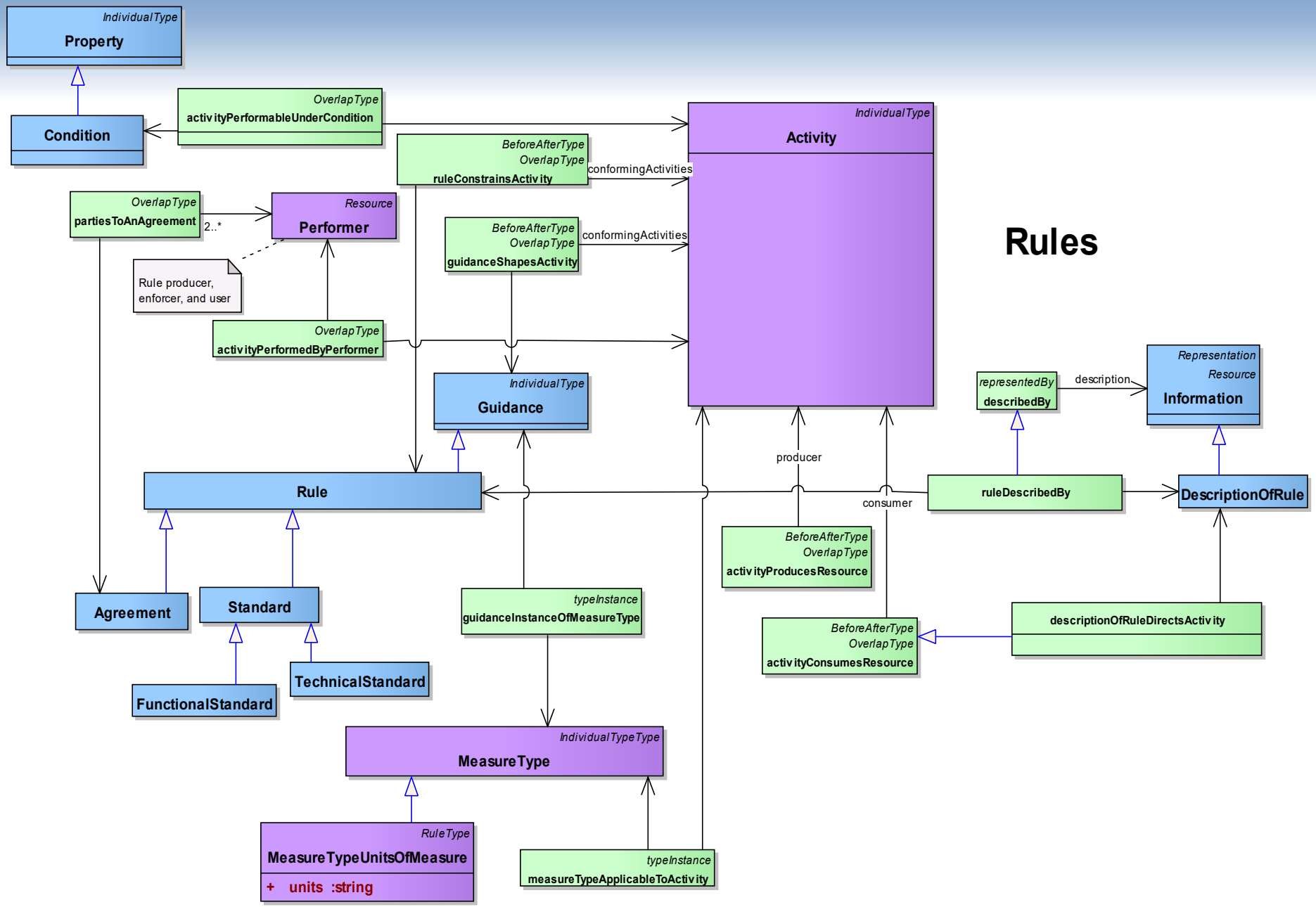
Information and Data Data Group Notes

- Key concept -- IInformation describes some Thing – material, temporal, or even abstract, such as a relationship (Tuple) or set (Type).
  - Since Information is a Thing, Information can describe other Information, e.g., metadata.
  - A Name is a type of Information in that it describes a Thing. A Name may be short or long – there is no restriction. So a textual description can be thought of a just a long Name. Information is more general than text strings and could be structured, formalized, or include other manners of description such as diagrams or images.
- Information, as a Resource Type, inherits whole-part, super-subtype, and before-after relationships.
- If Information is processable by humans or machines in a repeatable way, it is called proceduralized. Not all proceduralized information is necessarily computerized; forms are examples of data proceduralized for human repeatable processing.
- Data to be proceduralized has associations such as parts and types as well as other application specific associations. So for an Entity-Relationship model, Attributes are has associations with Entities and Entities are related according to verb phrases and cardinalities. In the physical schema, the fields are associated to datatypes.
- The representation for Data is not intended to cover all the details of, for instance, a relational data base management system (DBMS) underlying Meta-model, but just those aspects necessary to support the decision-making of the core processes.
- Architectural Descriptions describes architectures, often at different levels of detail (“reification”). See next slide.

Rules Data Group

- Rules are prescriptive sets of procedures regarding the execution of activities within an enterprise. Rules exist within the enterprise whether or not they are ever written down, talked about, or even part of an organization's consciousness. However, organizations often gather rules in a formal manner for specific purposes.
- Business rules are a type of rule that govern actions. Business rules are initially discovered as part of a formal requirement-gathering process during the initial stages of a project or during rigorous analysis of activities. In this case, the collecting of the business rules is coincidental to the larger discovery process of determining the workflow of an activity. Projects such as the launching of a new system or service that supports a new or changed business operation might lead to a new body of business rules for an organization that would require employees to conceptualize the purpose of the organization in a new way. This practice of coincidental business rule gathering is vulnerable to the creation of inconsistent or even conflicting business rules within different organizational units, or within the same organizational unit over time.
- A rule is not an activity—these two concepts are related but are very different. An *activity* is a transformation that produces new resources from existing resources. In contrast, a *rule* prescribes the ways that an activity may be carried out.

Rules Data Group Model Diagram



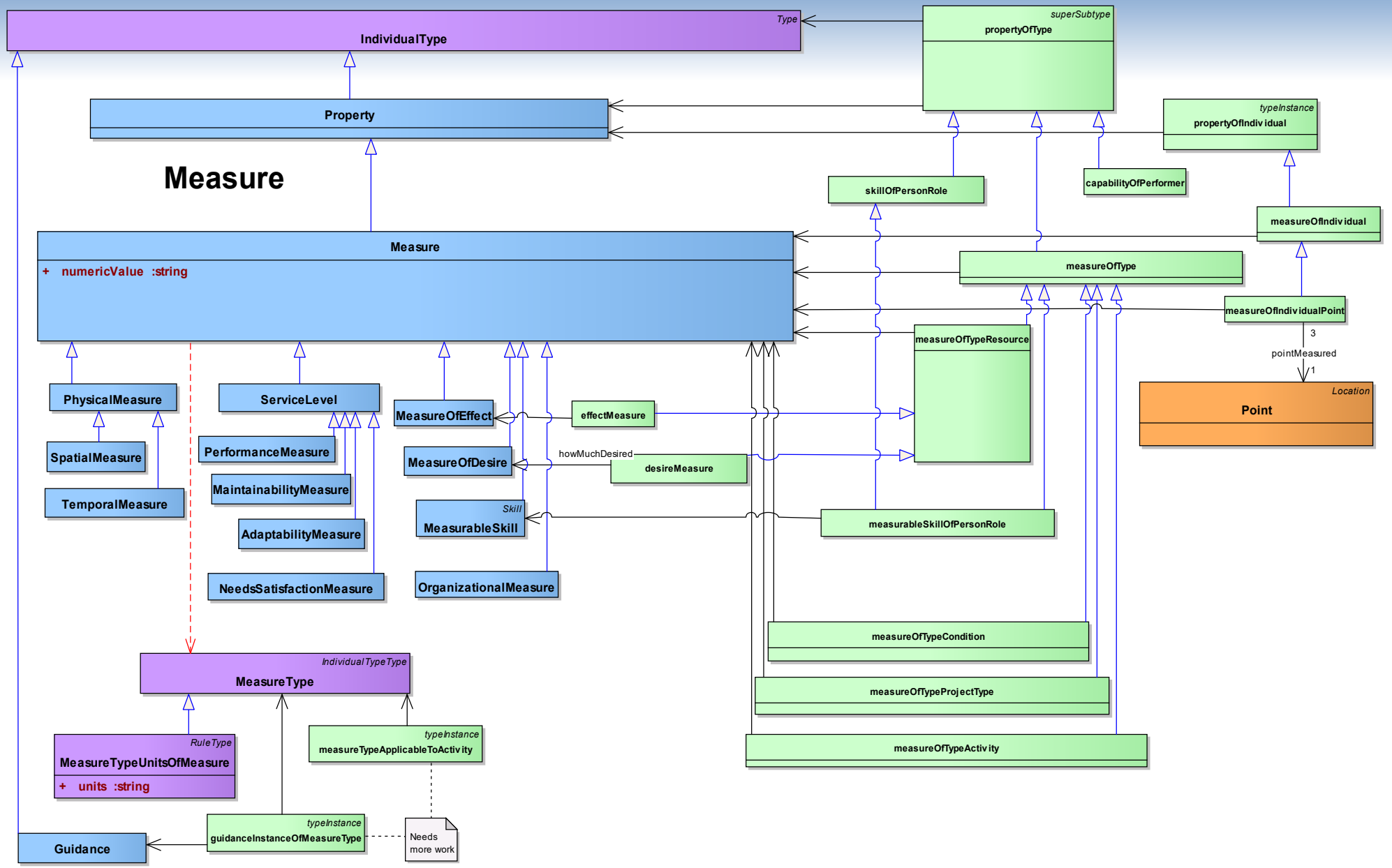
Rules Data Group Notes

- A Rule constrains Activities.
  - E.g., a speed limit rule constrains driving activity.
- Some seemingly static rules have the effect of limiting possible activities.
  - E.g., a rule that security fences must be 10 feet high constrains the activity of building security fences
- Constraints may apply or vary under certain conditions. For example, speed limits can be lower in poor weather conditions.
- Security classification, security marking, releasability, etc. are types of Guidance. Similarly; a Rule is a stronger form of Guidance.
- An important Constraint type is a Service Policy that constrains access to capability Performers.
- Doctrine, by definition, constrains military action.

Measure Data Group

- A measure is the magnitude of some attribute of an object. Measures provide a way to compare things, including projects, services, systems, activities, and capabilities. The comparisons can be among things at a point in time or among temporal parts of the same thing over time. For example, a capability may have different measures when looking at the current baseline and over increments toward some desired end-state.
- Many sorts of measures may be applied to architecture elements.

Measure Data Group Model Diagram



Measure Data Group Notes

- The key elements of the Measure Data group are Measure and Measure Type. Measure refers to the actual measure value and units. It relates to a Measure Type that describes what is being measured. Examples:

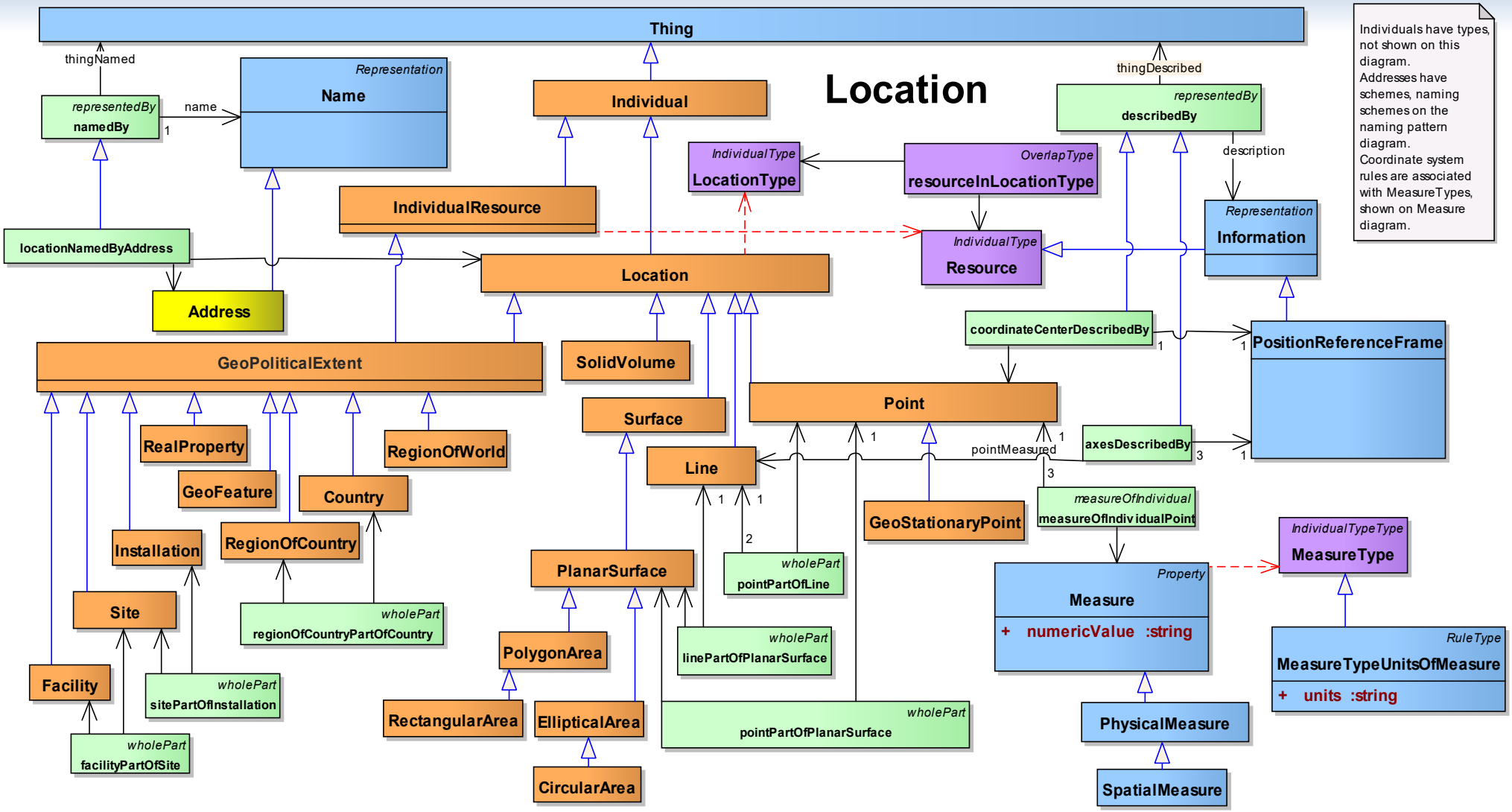
Measure	Measure Type
1 year	Timeliness
Mach 3	Rate
99 percent	Reliability
56K	BAUD
3 meters	Target Location Error (TLE) Accuracy
1,000 liters	Capacity
$1M	Cost
Level 3	Capability Maturity Model® Integration (CMMI) Organizational Level

- Formally, a Measure defines membership criteria for a set or class; e.g., the set of all things that has 2 kg mass. The relationship between Measure and Measure Type is that any particular Measure is an instance of all the possible sets that could be taken for a Measure Type.
- All Measure Types have a Rule that prescribes how the Measure is accomplished; e.g., units, calibration, or procedure. Spatial measures' Rules include coordinate system rules. For example, latitude and longitude are understandable only by reference to a Geodetic coordinate system around the Earth.
- As a Measure Type, cost can be captured in the architecture at different levels, based on the Process-owners requirements
- The upper part of the diagram depicts how Measures apply to architecture elements
- Measures can apply to relationships between objects; e.g., a Measure applied to a Performer performing an Activity

Locations Data Group

- A location is a point or extent in space.
- The need to specify or describe Locations occurs in some Architectural descriptions when it is necessary to support decision-making of a core process.
- Examples of core process analyzes in which locations might have a bearing on the decisions to be made include the following:
  - Base realignment and closure (systems engineering process).
  - Capability for a new regional command (JCIDS).
  - Communications or logistics planning in a mission area (operations process).
  - System and equipment installation and assignment of person roles to facilities (operations and systems engineering processes).

Location Data Group Model Diagram



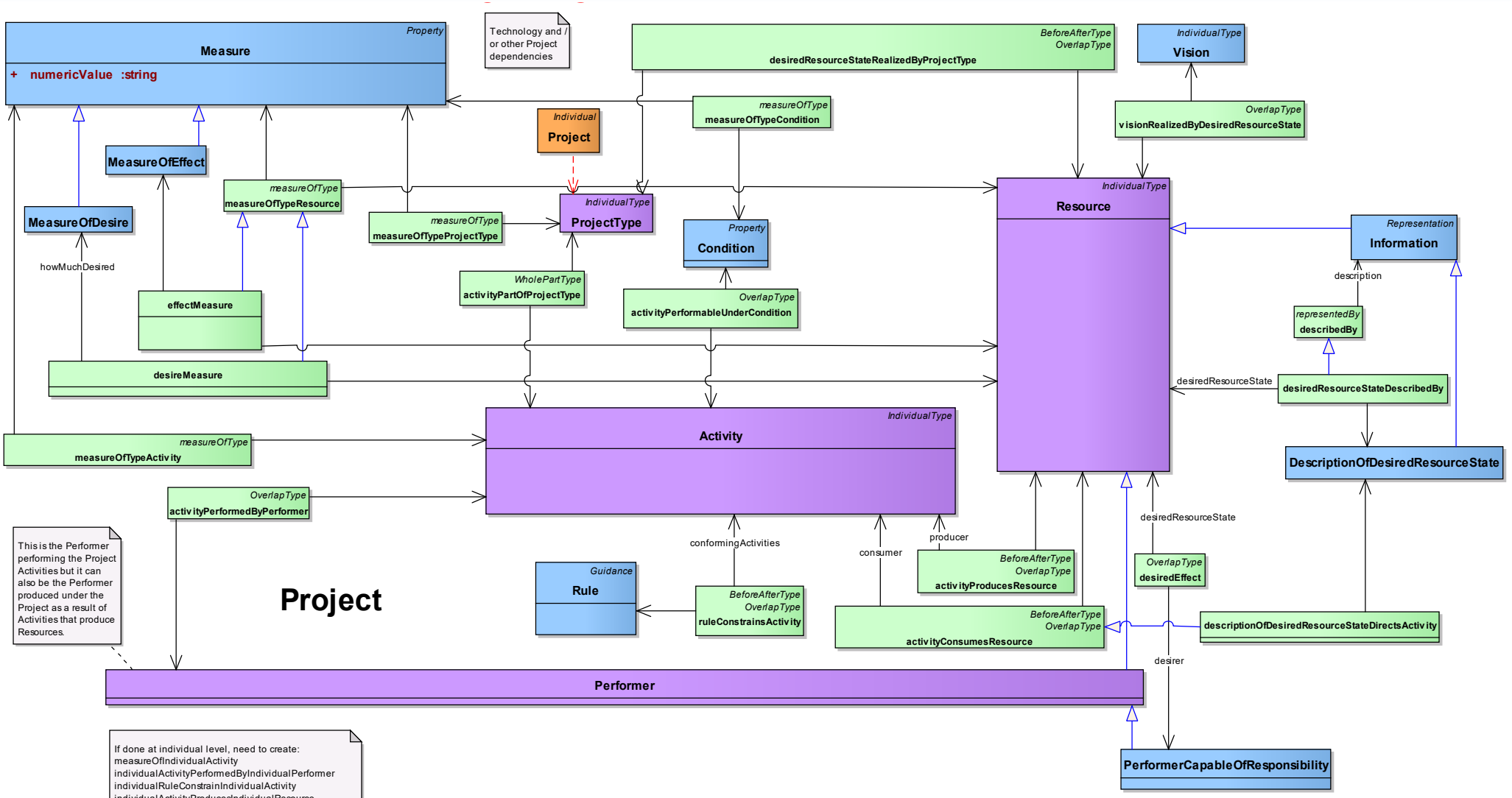
Locations Data Group Notes

- Addresses such as URLs, universal resource names (URNs), postal addresses, and data link addresses are considered names for locations. For example, a postal address is a naming system for the location of a building. A universal resource locator is a name for a server that is located somewhere on the web.
- The naming pattern works by identifying: 1) a name string, 2) the object being named, and 3) the type of name (e.g., postal address). Name here is used in the broadest sense, and a description is considered a long name.
- The lower left of the diagram is a model of types of location objects. These can be alternatively named using the naming pattern in the upper left and delineated using the Extent pattern in the lower right.
- Minimal parts of spatial extent (e.g., point, line, surface, solid volume) are detailed to satisfy various requirements within a federation. That is, some members of a federation may need to specialize spatial extents. Some common and simple parts are modeled, such as a line described by two points and a planar surface defined by a line and point.
- Facilities are types of locations. To describe the functionality of a facility, the activities performed by the performers located at the facility are described.
- Installation, site, and facility follow Army guidance from the Real Property Inventory Requirements. Similarly, a facility can be a linear structure, such as a road or pipeline.
- Geofeatures cover constructed control features, geophysical features, and meteorological and oceanographic phenomena.

Project Data Group

- A Project is a temporary endeavor undertaken to create Resources of Desired Effects
- Projects are relevant to all six core processes, e.g.,
  - The Primary Construct of the PPBE system is the Program Element (PE)
    - the basic building block of the Future Years Defense Program
    - describes the program mission and identifies the organization responsible to perform the mission
    - may consist of forces, manpower, materiel (both real and personal property), services, and associated costs, as applicable.2
  - Projects form the major elements of the DAS and are the key architectural construct within the PE is the Work Breakdown Structure (WBS).
  - The WBS is the primary instrument connecting an Architectural Description to the DAS and the PPBE processes.
    - A product-oriented family tree composed of hardware, software, services, data, and facilities. The family tree results from systems engineering efforts during the acquisition of a defense materiel item".
    - The WBS is the process necessary for subdividing the major product deliverables and project work into smaller more manageable components and it serves as a valuable framework for the technical objectives, and therefore it is product-oriented.
    - Just as the system is defined and developed throughout its lifecycle, so is the WBS.
      - In the early Project phases of concept refinement, system architecture, and technology development, the program WBS is usually in an early stage of development.
      - The results of the Analysis of Material Approaches and the Analysis of Alternatives (AoA) provide the basis for the evolution of the WBS at all stages of Project evolution.
      - As the architectural design of the project's product or service matures, so should the WBS.
    - The WBS is a primary tool in maintaining efficient and cost effective developments of products and services.
- A Project Plan contains the project WBS (including Tasks and responsible Organizations). The Project Data Group (PDG) contains the essential data required for defining a Project Plan, e.g., those required by DoD 5000.2:
  - Acquisition Strategy
  - Technology Development Strategy
  - System Engineering Plan.

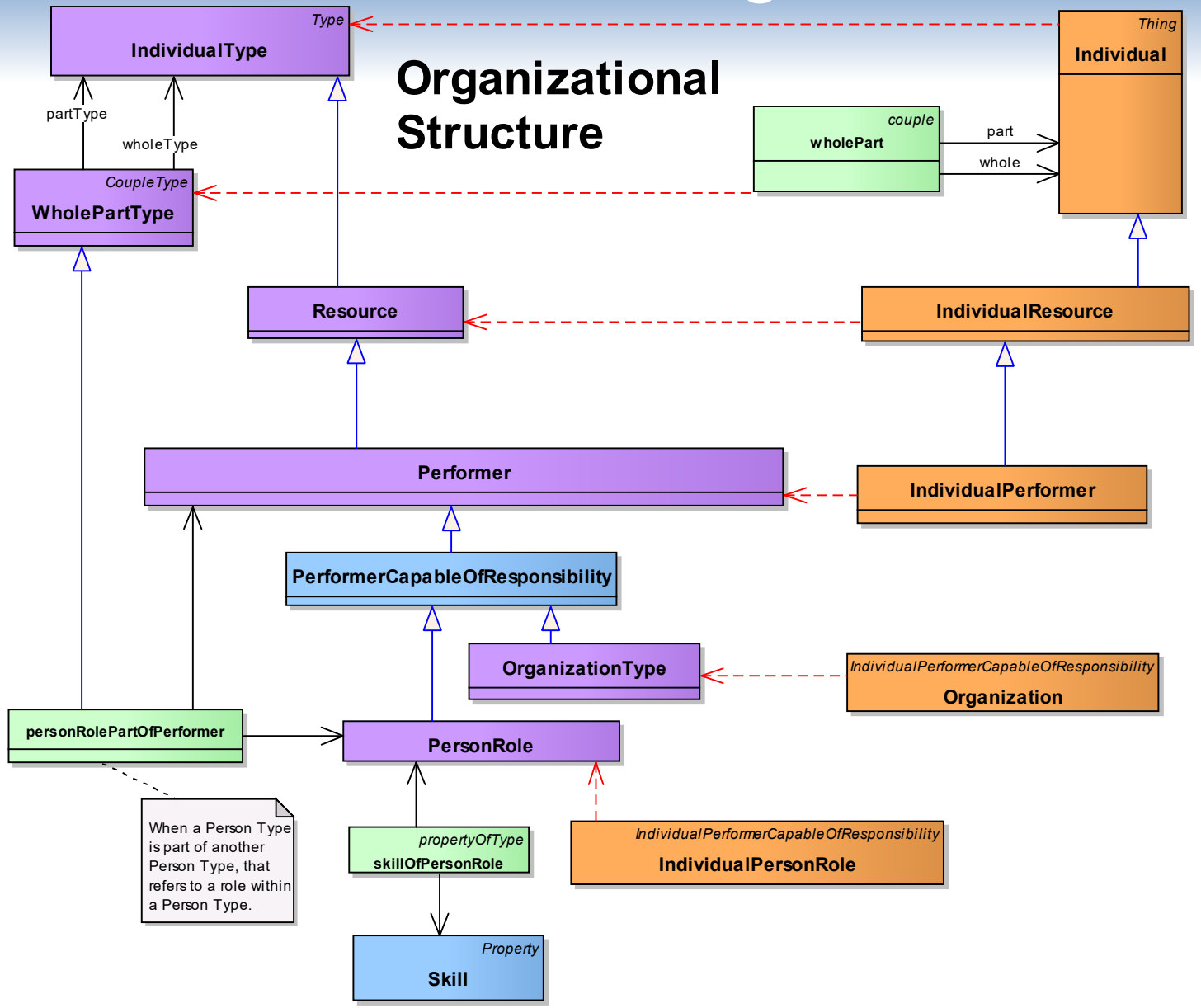
Project Data Group Model Diagram



Project Data Group Notes

- Like all concepts in the DM2, projects have whole-part, temporal whole-part, and super-subtype relationships so that major projects can have minor projects within them, projects can have time phases, and projects can be categorized.
- Because a project involves execution of activities, there is a flow of resources into the project's activities and a flow of products out of them, as described by the Resource Flows data group. So this model can describe a project that results in systems, services, persons in roles (e.g., by training), organizations (e.g., by organizational development), materiel, and locations (e.g., facilities, installations).
- Many kinds of measures may be associated with a project: measures of needs, of satisfaction, of performance, of interoperability, and of cost.
- Measures and rules can be assigned at all levels of the project decomposition.
  - Top-level measures and rules (conditions and constraints) could be assigned to the vision, goals, and objectives.
  - Lower-level measures and rules can then be derived and assigned to compliance criteria and to verification criteria. When part of a legal contract, policy, directive, formal agreement, or contractual instrument, rules state requirements for a project.

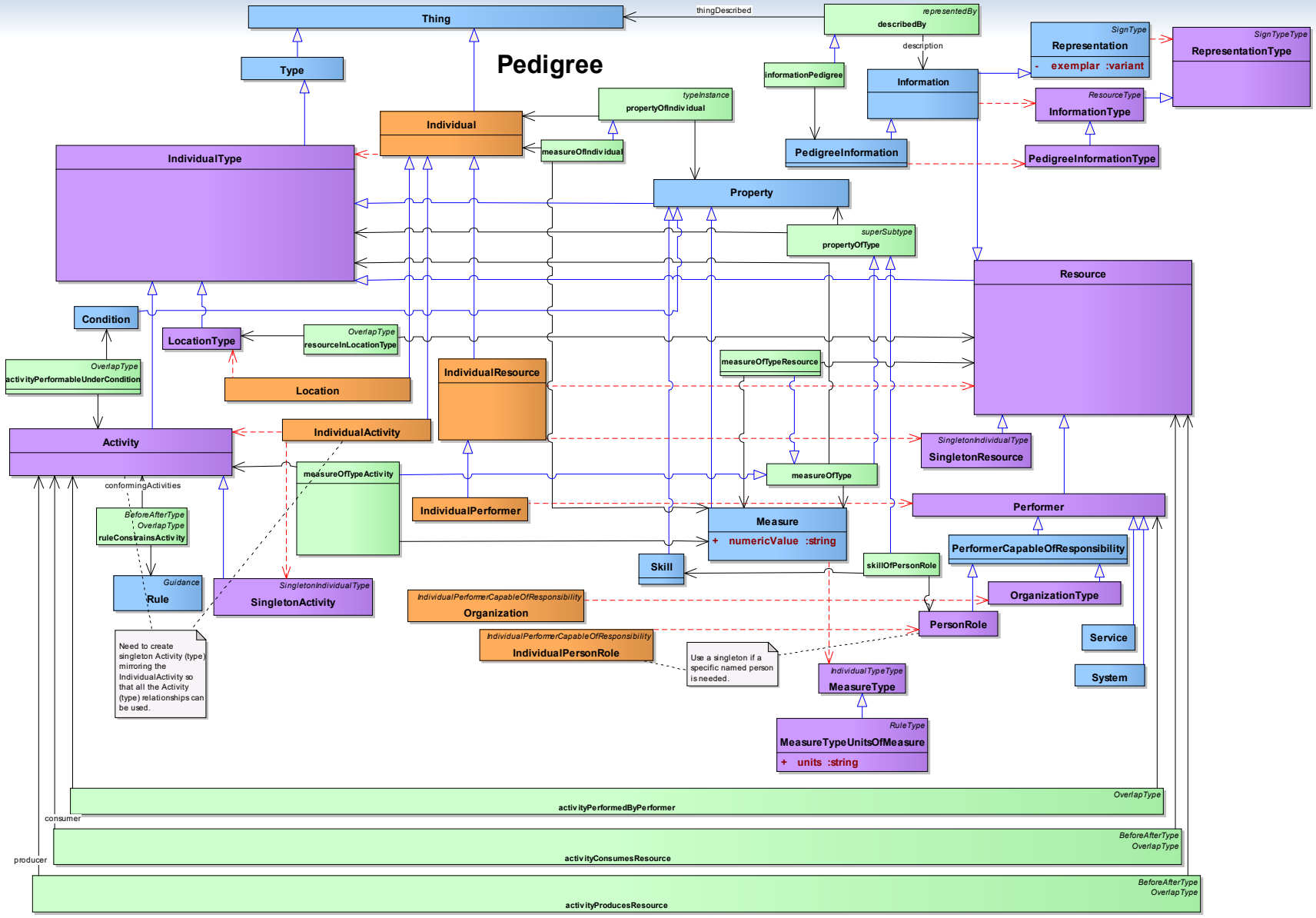
Organizational Structures Data Group Model Diagram



Pedigree Data Group

- The Pedigrees data group represents the workflow for a resource. It describes the activities used to produce a resource, in particular, a resource that is information about an architectural description or architectural data. Architectural descriptions are types of information: information describes some thing and architectural descriptions describe architectures. The production of architectural description information is particularly important for architectural descriptions. All aspects of the production workflow are describable with the Pedigrees data group, including:
  - resources consumed to produce a resource;
  - performers who act to produce a resource;
  - rules that constrain a producing activity;
  - measures applied to a producing activity and to resources consumed and produced; and
  - where a producing activity occurred.
- Architectural descriptions such as activity models are example of architectural descriptions that reified at many level of detail. In a typical development project, the architectural descriptions (contained in plans, specifications and/or “model based” Computer Aided Design Tools (CAD)) provide increasing levels of detail as the project progresses through the normal DoD Milestone process.

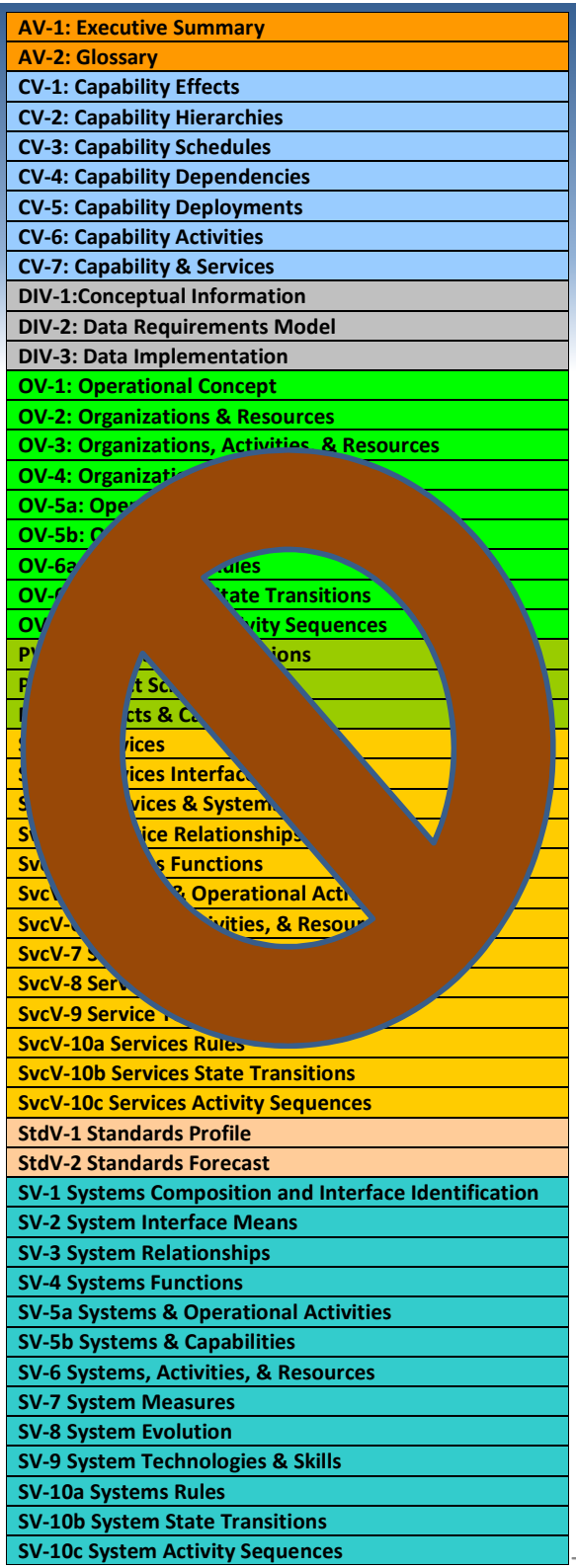
Pedigree Data Group Model Diagram



The Views and the meta-model (DM2)

Logical Organization of Architectural Descriptions ≠ the DoDAF List

- The DoDAF view nomenclature was NOT intended to imply development order or organization, e.g., there are cases where:
  - a number was assigned because others were already taken, e.g.,
    - SV-4
    - SV-7
  - the same information is just presented differently, e.g., SV-3 is just a summary of SV-1 (assigned before DoDAF 2's separation of presentation from data)
  - the information is traceability information, not actual architectural description, e.g., SV-5, CV-7
  - has been superseded by PV's, e.g., SV/SvcV-8&9



Possible Logical Organizations

Weapons System

- Operational Capabilities
  - High-Level Operational Concept (OV-1)
  - Capabilities (CV-1/6)
  - Capability Hierarchy (CV-2)
- Operational Analysis
  - Organizational Relationships (OV-4/6a)
  - Activity Hierarchy (OV-5a/6a)
  - Organizational and Task Resource Flows, Sequencing, and States (OV-2/3/5/6a/6b/6c)
  - Resource Description and Structure (DIV-1/xxx, OV-6a/StdV)
- Functional Architecture
  - Functionality Description (SV-4a)
  - Functional Performance (SV-7)
  - Functional Resource Flows, Sequencing, and States (SV-4/6/10abc)
  - Resource Description and Structure (DIV-2/xxx, SV-10a/StdV)
- System/Service Architecture
  - Functional Allocation (SV/SvcV-1/4)
  - System/Service Composition (SV/SvcV-1)
  - System/Service Performance (SVSvcV-7)
  - System/Service Interfaces (SV/SvcV-1/2/3)
  - System/Service Sequencing and States (SV/SvcV-10abc)
  - System Standards (SV/SvcV-10a/StdV)
  - Resource Description and Structure (DIV-3/xxx)
- Project and Deployment Plans
  - Executive Summary of Architecture Project (AV-1)
  - Project Timelines and Dependencies (PV-2)
  - Organizational Deployment of Capabilities (CV-5)
  - Capability Schedules (CV-3)
  - Capability Dependencies (CV-4)

FEA Common Approach

- Strategic
  - OV-1, CV's
- Business Services
  - OV's, SvcV-1
- Data and Information
  - DIV-1/2, OV-2/3/5, SV/SvcV-4, StdV's
- Enabling Applications
  - SvcV's, functional / logical SV's
- Host Infrastructure
  - SV's
- Security
- OV-6a, SV/SvcV-10a, StdV's

Note:

- ***Everything should have traceability to requirements, not just special case of SV-5 and CV-7***
- ***All Resources should be structurally described, not just Information and Data***
- ***All Resources, Capabilities, and Activities have measures, not just Systems***
- ***Everything has temporal state, phase, etc., not just StdV's***

Draft Artifact Working Group Strategic Plan Examples (6 of 11)

PRM	Performance Reference Model	Descriptions	Other Framework Names
S-1	Strategic Plan	A description of the organization's vision, strategic objectives, a prioritization of the desired outcomes from achieving those objectives, the measurements that will demonstrate achievement, and the resources to be used to achieve them	DoDAF CV-1, 2, 3, 5, 6 (Capability Effects, Hierarchy, Schedules, Deployments, and Activities)
S-2	Concept Overview Diagram	The high-level graphical/textual description of the operational concept.	DoDAF OV-1 (Operational Concept)
S-3	Capability Effects	Supports the Strategic Plan by defining effects caused by activities conducted for capabilities and measures for these effects	DoDAF CV-1 (Capability Effects)
S-4	Capability Deployments and Dependencies	Supports the Strategic Plan by defining schedules for the deployment of capabilities in terms of timelines, organizations, and locations and dependencies among effects caused by capabilities	DoDAF CV-3, 4, 5 (Capability Schedules, Dependencies & Deployments)
S-5	Capability Hierarchies	Presents one or more hierarchies of capabilities and the types of hierarchical relationships between these capabilities	DoDAF CV-2 (Capability Hierarchies)
S-6	Organization Chart	Presents the composition and relationships among organizational performers	DoDAF OV-4 (Organizational Relationships)

Draft Artifact Working Group
Business Services Examples (8 of 11)

BRM	Business Reference Model	Descriptions	Other Framework Names
B-1	Business Service Catalog	Presents the business services, taken from the BRM, that are provided within the scope of the architecture and may also indicate business services that are consumed or used internally within the architecture	DoDAF SvcV-1 (Service Composition)
B-2	Business Service Capabilities	A mapping between the business services and the capabilities that these services support	DoDAF CV-7 (Capabilities Services)
B-3	Business Case / Alternatives Analysis	A summary of the planning, budgeting, acquisition, and management of federal capital assets sufficient to determine if investment funding should be recommended or continued	OMB Exhibit 300
B-4	Business Value Chain	Describes the information or resource flows between organizational performers	DoDAF OV-2 (Organizations and Resources)
B-5	Business Process Model	Presents the hierarchical structure of organizational activities and activities performed by organizational performers to consume and produce resources	DoDAF OV-5a&b (Operational Activities), Operational Activity Diagram, Business Process Diagram
B-6	Business Process Services	A mapping of business services provided by business processes.	DoDAF SvcV-5 (Service Operational Activities Support)
B-7	Business Process Sequences	Supports the CONOPS by presenting sequences of activities performed by organizational performers	OV-6c (Operational Activity Sequences)
B-8	Concept of Operations (CONOPS)	Organizes Business Processes Sequences into scenarios	DoDAF OV-6c (Operational Activity Sequences)

Draft Artifact Working Group Applications Examples

ARM	Applications Reference Model	Descriptions	Other Framework Names
A-1	Application Inventory	A registry of applications and services, the system functions or service activities they perform, and, optionally, prioritized or ranked.	
A-2	Application Service Matrix	Interface relationships between services and applications	DoDAF SvcV-3a&b (Service Interfaces to Services and Systems)
A-3	Application Performance Matrix	The measures (metrics) of applications	DoDAF SV/SvcV-7 (System and Services Measures)
A-4	Application Interface Diagram	The identification of application resource flows and their composition	DoDAF SV-1 (System Composition and Interfaces)
A-5	Application Interface Matrix	The interface relationships among systems	DoDAF SV-3 (System - System Interfaces)
A-6	Application Data Exchange Matrix	The details of resource flows among systems; the activities performed; the resources exchanged; and the attributes (rules and measures) associated with these exchanges	DoDAF SV/SvcV-6 (System and Service Resource Flows)
A-7	Application Communication Diagram	The means by which resource flows between applications occur	DoDAF SV/SvcV-2 (Systems and Services Interface Means)
A-8	Event Sequence Diagram	A sequence of triggering events associated with resource flows and systems	DoDAF SV/SvcV-10c (System and Service Activity Sequences)
A-9	State-Transition Diagram	The states systems transition to in response to events	DoDAF SV/SvcV-10b (System and Service State Transitions)
A-10	Software License Inventory	A list of Commercial-off-the-Shelf (COTS) assets with details about each (installation date, original cost, condition and such).	
A-11	System/Application Evolution Diagram	The planned incremental steps toward migrating a suite of systems and/or applications to a more efficient suite, or toward evolving a current system or application to a future implementation	DoDAF SV/SvcV-8 (System and Service Evolution)

Draft Artifact Working Group Infrastructure Examples

IRM	Infrastructure Reference Model	Descriptions	Other Framework Names
I-1	Asset Inventory	A list of assets with details about each (installation date, original cost, condition and such)	Asset register
I-2	Network Diagram	Describes the means by which resource flows between systems occur	DoDAF SV/SvcV-2 (Systems and Services Interface Means)
I-3	Enterprise Service Bus Diagram	TBD	
I-4	Hosting Concept of Operations	Presents the high level functional architecture, organization, roles, responsibilities, processes, metrics and strategic plan for hosting and use of hosting services	
I-5	Technical Standards Profile	Collects the various systems standards rules that implement and sometimes constrain the choices that can be made in the design and implementation of an architecture	DoDAF StdV-1 (Standards Profile)
I-6	Technology Forecast	The emerging technologies, software/hardware products, and skills that are expected to be available in a given set of time frames and that will affect future infrastructure development	DoDAF SV/SvcV-9 (System and Service Technology and Skills)

Walkthrough by a logical organization:

Operational Capabilities

Operational Analysis

Functional Architecture

System/Service Architecture

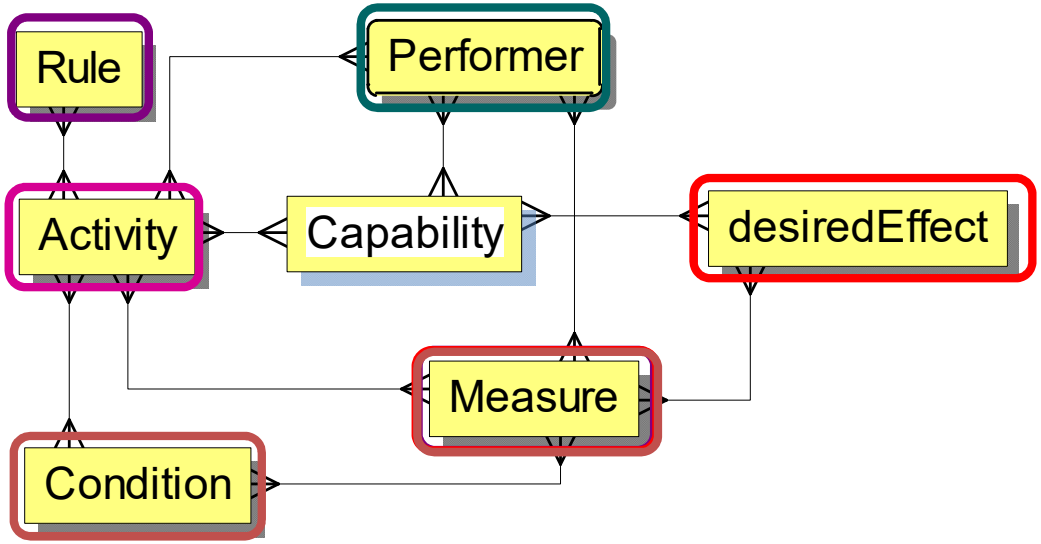
Operational Capability

- Definitions:
  - "The ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks."*
- Six components:
  1. desired effects,
  2. measures associated with the effects,
  3. tasks to be performed,
  4. standards of performance (metrics) for the tasks,
  5. conditions under which the tasks must be performed, and
  6. measures associated with the conditions.
- These are modeled in the DoDAF capability model as shown in the next slide

* Joint Chiefs of Staff; Joint Capabilities Integration and Development System (JCIDS); CJCSI 3170.01H; January 2012

Capability Data Group and the Capability Views

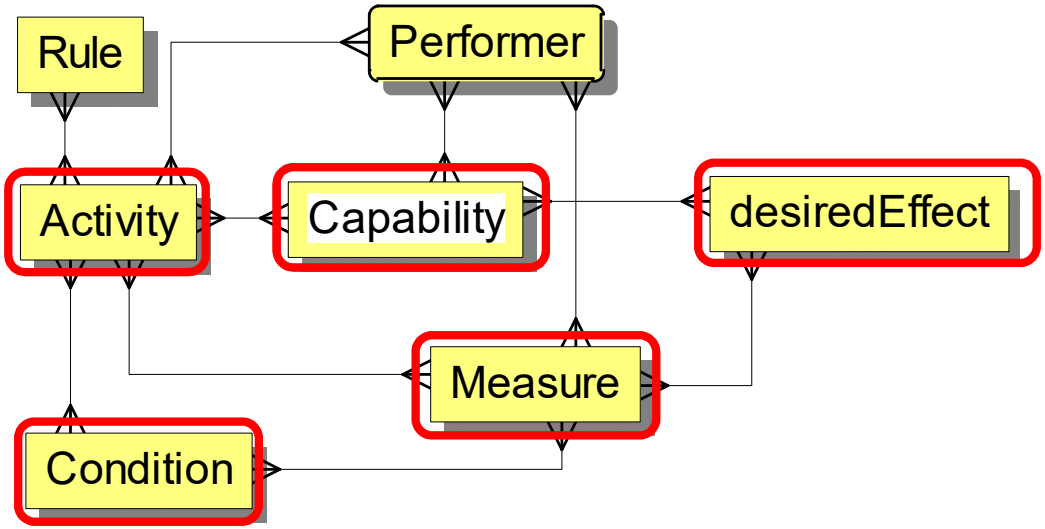
- "The ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks."*



JCA's, UJTL/Service tactical Tasks with Measure Types and Conditions can be applicable

Core Components of Capability that are in every CV

- CV-1 Vision
- CV-2 Capability Taxonomy
- CV-3 Capability Phasing
- CV-4 Capability Dependencies
- CV-5 Capability To Organizational Development Mapping
- CV-6 Capabilities to Operational Activities Mapping
- CV-7 Capabilities to Services Mapping



CV-1 Vision

- **CV-1 Vision**
- CV-2 Capability Taxonomy
- CV-3 Capability Phasing
- CV-4 Capability Dependencies
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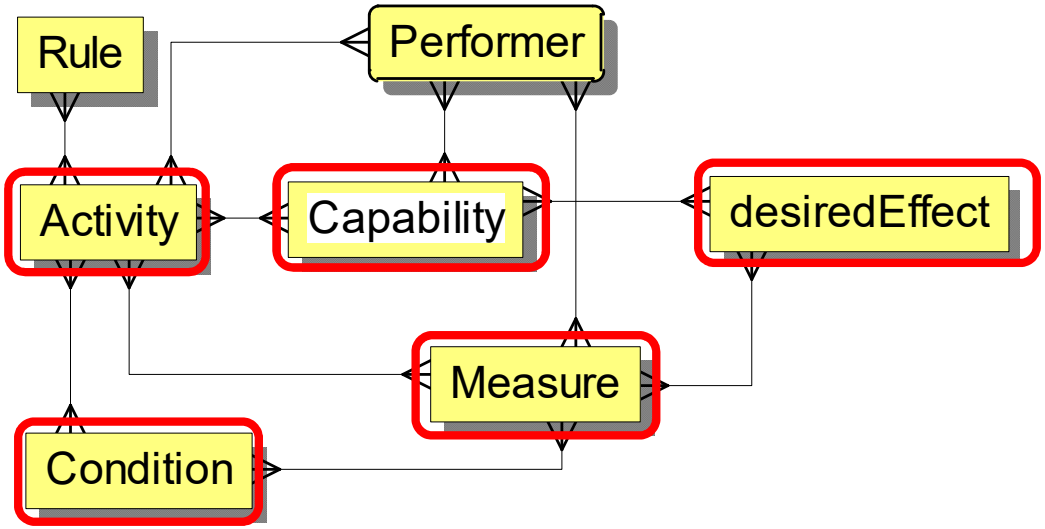


Narratives and graphics are probably present too, but these are minimal elements to talk about "capability" architecturally.

CV-2 Capability Taxonomy

CV-1 Vision

CV-2 Capability Taxonomy

CV-3 Capability Phasing

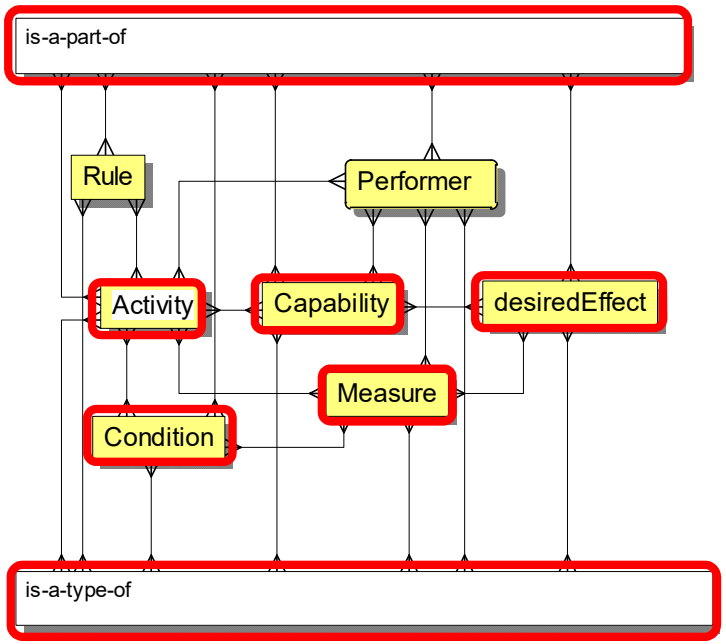
CV-4 Capability Dependencies

CV-5 Capability To Organizational Development Mapping

CV-6 Capabilities to Operational Activities Mapping

CV-7 Capabilities to Services Mapping

i.e., adds wholePart, superSubtype, and typeInstance relationships



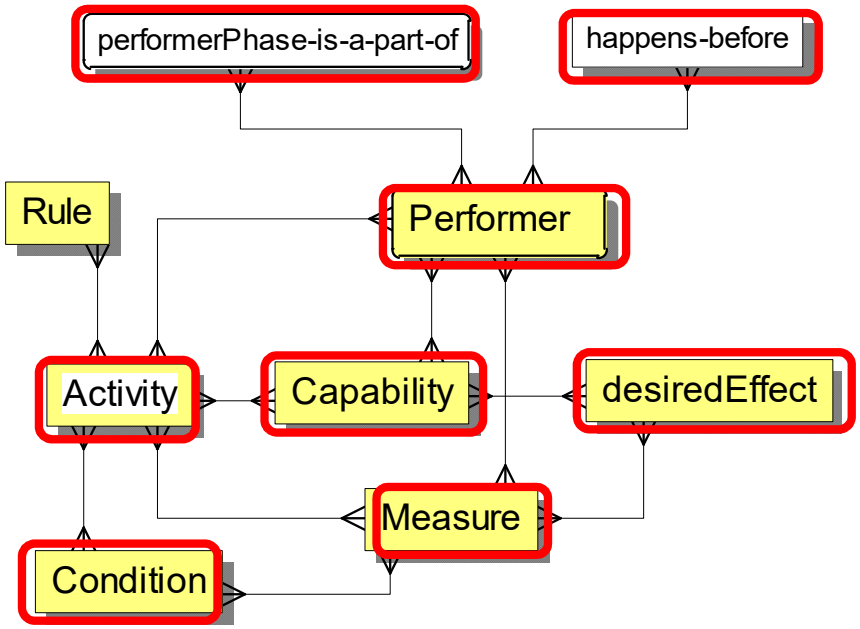
We don't usually show these because they are inherited from the DM2 ontology foundation.

CV-3 Capability Phasing

CV-1 Vision | CV-2 Capability Taxonomy | **CV-3 Capability Phasing** | CV-4 Capability Dependencies

CV-5 Capability To Organizational Development Mapping | CV-6 Capabilities to Operational Activities Mapping | CV-7 Capabilities to Services Mapping

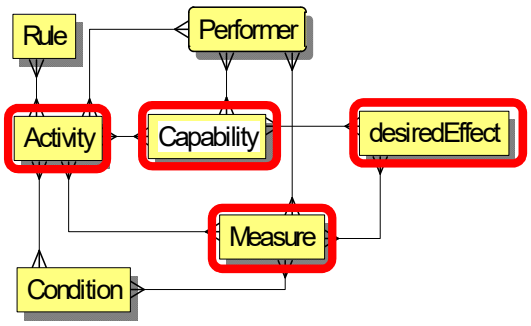
i.e., adds the phases of the Performers (aka Means, Capability Configurations) and their sequencing.



CV-4 Capability Dependencies

CV-1 Vision | CV-2 Capability Taxonomy | CV-3 Capability Phasing | **CV-4 Capability Dependencies**

CV-5 Capability To Organizational Development Mapping | CV-6 Capabilities to Operational Activities Mapping | CV-7 Capabilities to Services Mapping



Same core elements with several kinds of dependencies.

DataDependency	Resource consumed by Performer	1. Resource consumed by Performer 2. dataAssociation
FunctionalDependency	A constraint on, or dependence of, a function on one or more outside influences, conditions, functions, triggers or events.	Composite of Activity with Constraint or dependence on one or more Conditions, Activities, triggers (composite of Activity and Event), Events.
ScheduleDependency	Schedule dependencies deal with Resources that an Activity requires in order to proceed.	Before after relationships between Activities and Resources
TechnicalDependency	A Constraint on an Activity related to Performer(s) or Resource(s) needed.	Rule to Performer Resource - Performer overlap Resource consumed by Performer

Dependencies in DoDAF

DataDependency	Resource consumed by Performer	1. Resource consumed by Performer 2. dataAssociation
FunctionalDependency	A constraint on, or dependence of, a function on one or more outside influences, conditions, functions, triggers or events.	Composite of Activity with Constraint or dependence on one or more Conditions, Activities, triggers (composite of Activity and Event), Events.
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CV-5 Cap to Org Development

CV-1 Vision

CV-2 Capability Taxonomy

CV-3 Capability Phasing

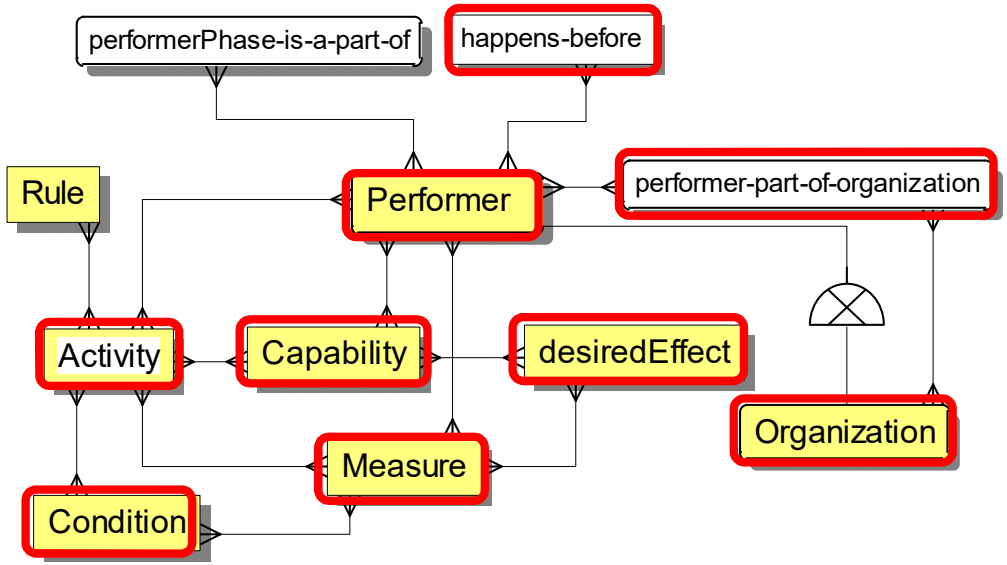
CV-4 Capability Dependencies

CV-5 Capability To Organizational Development Mapping

CV-6 Capabilities to Operational Activities Mapping

CV-7 Capabilities to Services Mapping

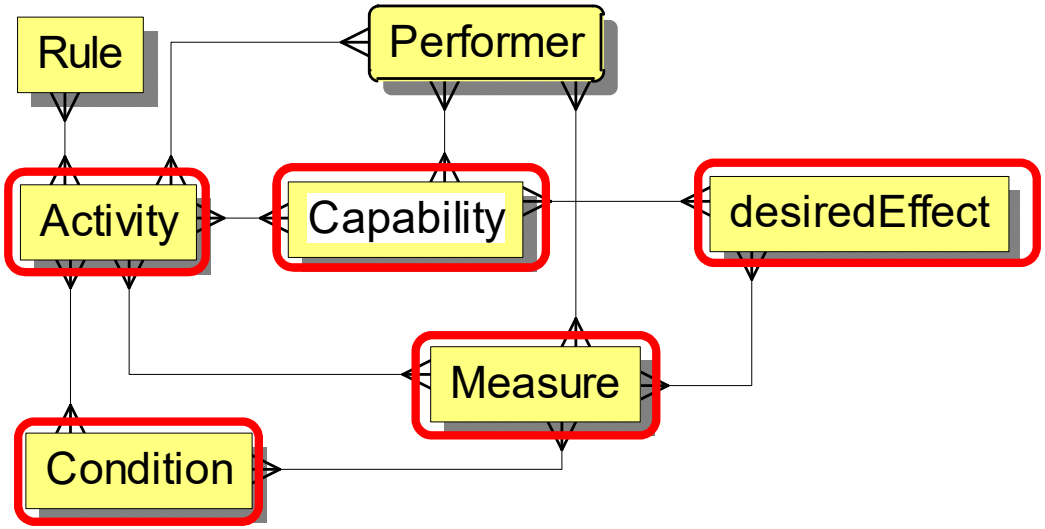
Similar to phasing (CV-3) but with time Organizations receive Performers.



CV-6 Capability/Activities

- CV-1 Vision
- CV-2 Capability Taxonomy
- CV-3 Capability Phasing
- CV-4 Capability Dependencies
- CV-5 Capability To Organizational Development Mapping
- **CV-6 Capabilities to Operational Activities Mapping**
- CV-7 Capabilities to Services Mapping

Nothing beyond core, i.e., unnecessary view. DoDAF Working Group has recommended its removal.



CV-7 Capability/Services

CV-1 Vision

CV-2 Capability Taxonomy

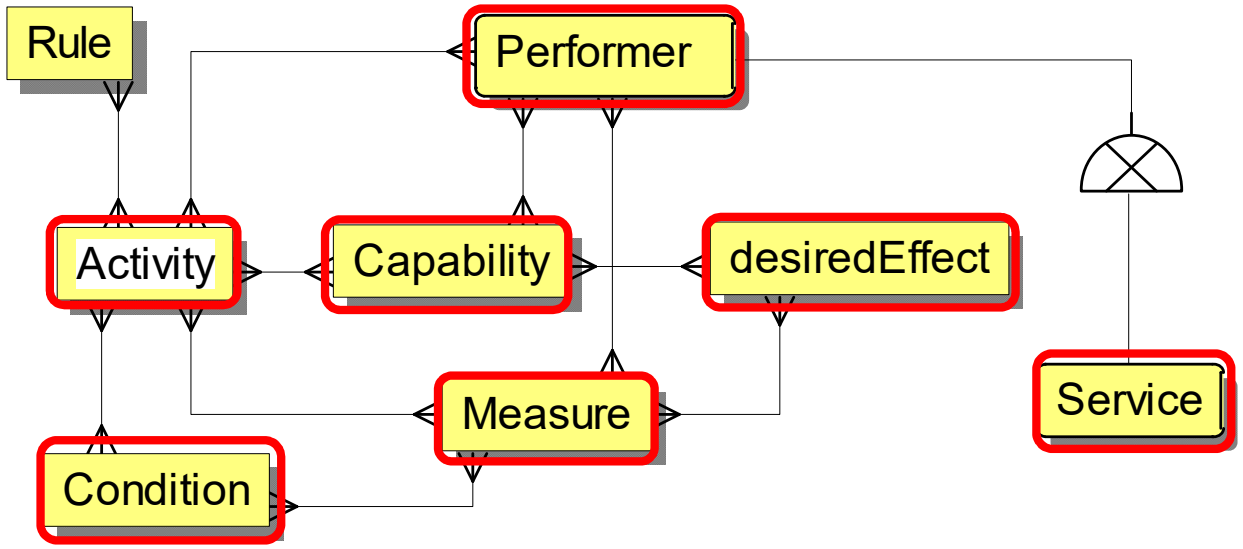
CV-3 Capability Phasing

CV-4 Capability Dependencies

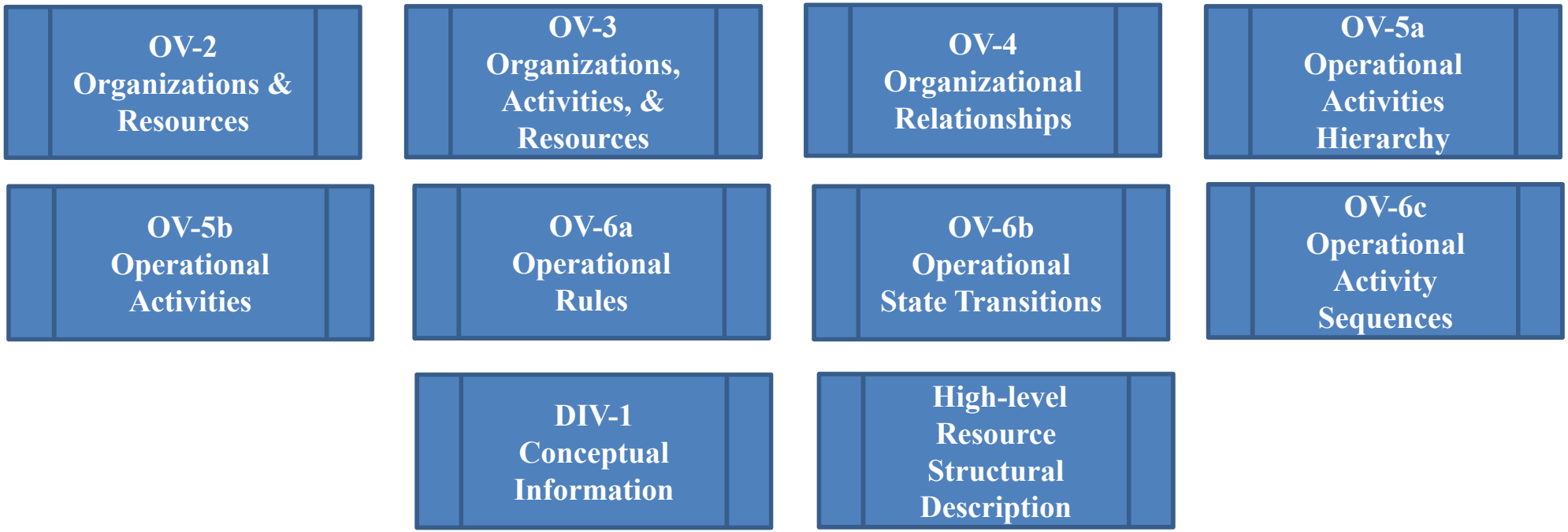
CV-5 Capability To Organizational Development Mapping

CV-6 Capabilities to Operational Activities Mapping

CV-7 Capabilities to Services Mapping

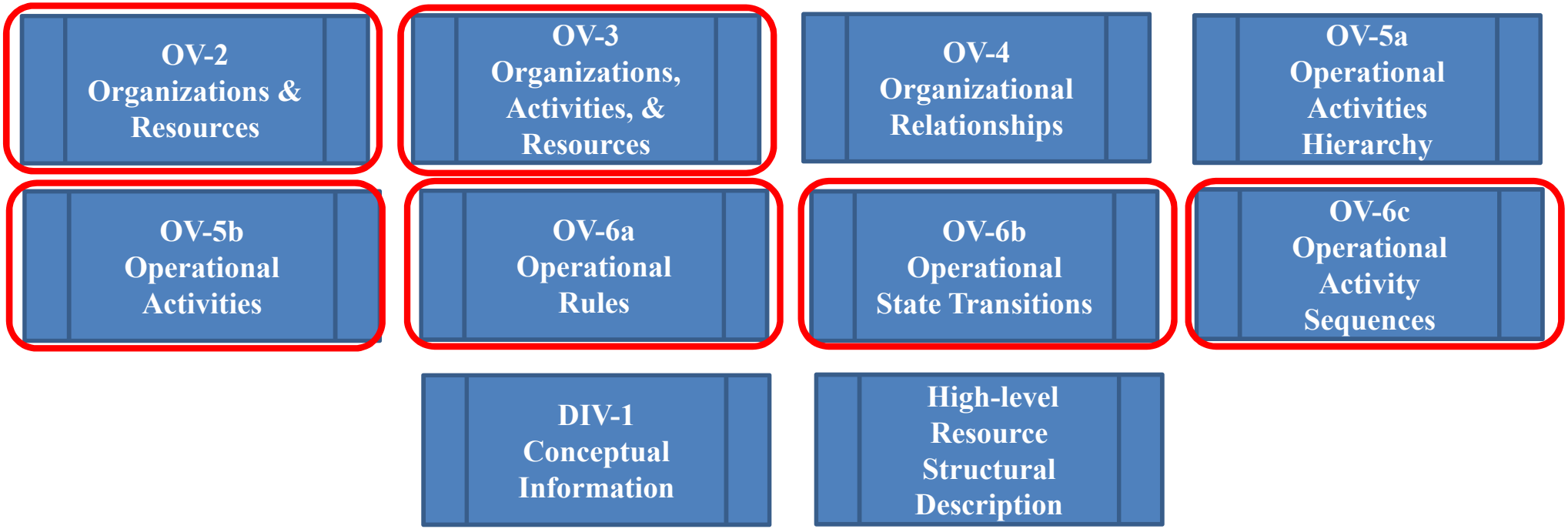


Operational Analysis

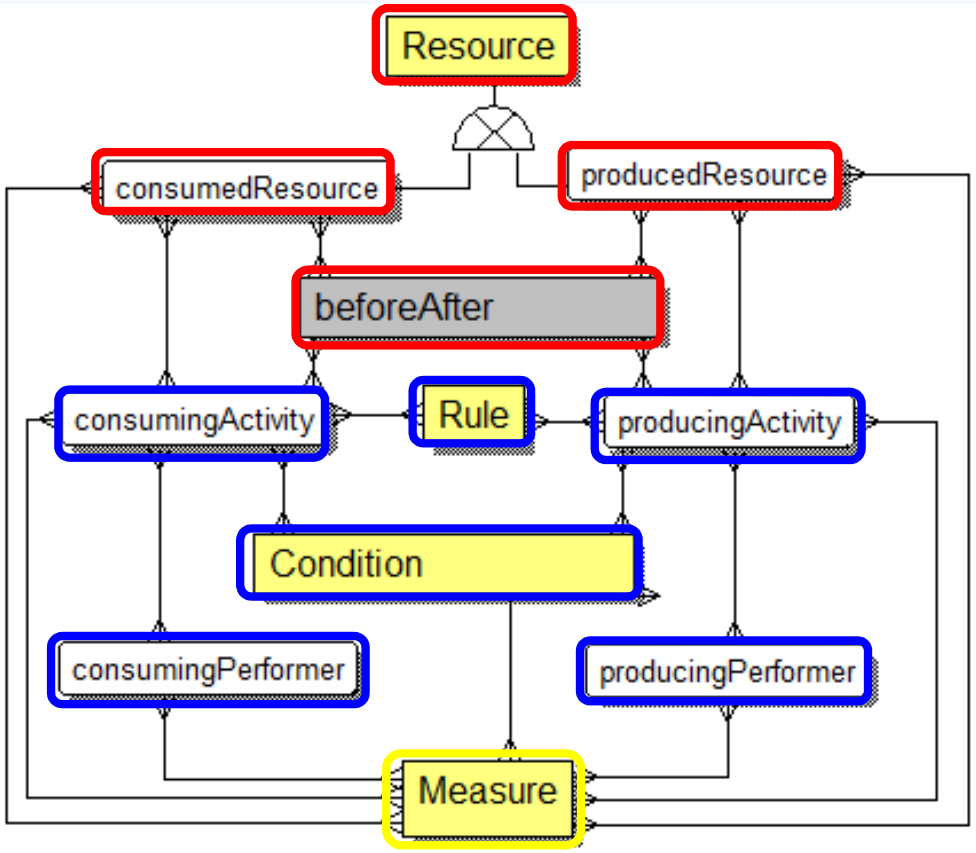


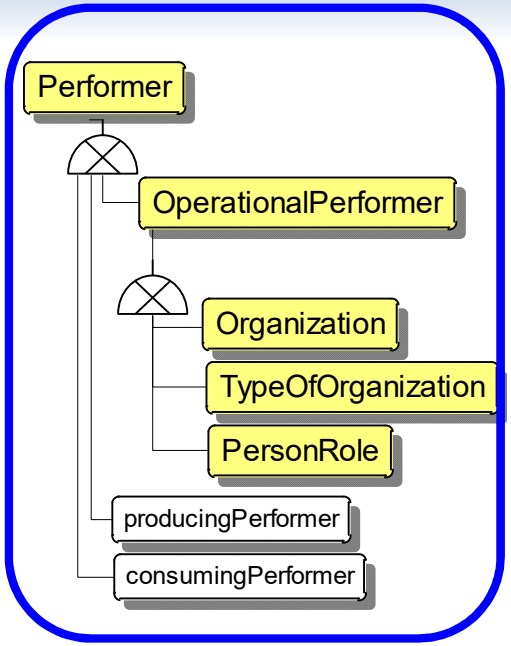
- Sometimes called:
  - Requirements analysis
  - Business process modeling
- Two basic view types (see following slides)
  - Resource and/or temporal flow
  - Structure and/or same-type relationships

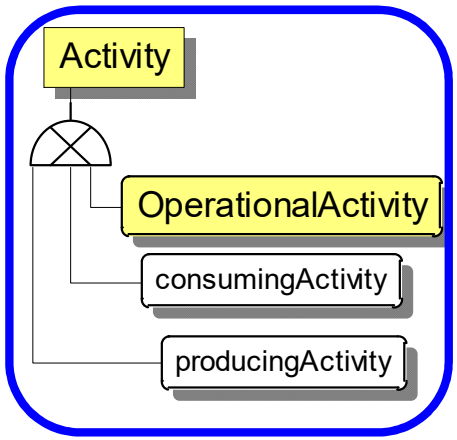
Operational Resource and/or Temporal Flow

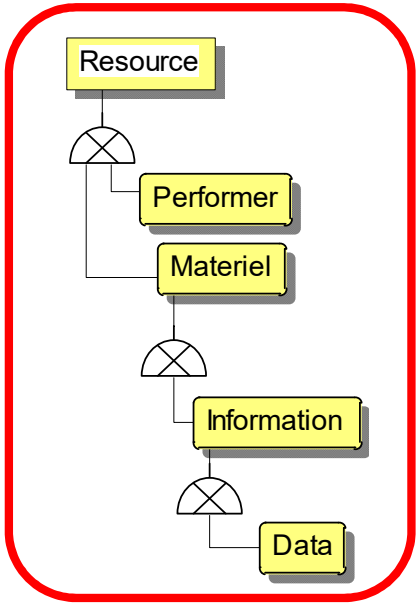


Operational Resource and/or Temporal Flow





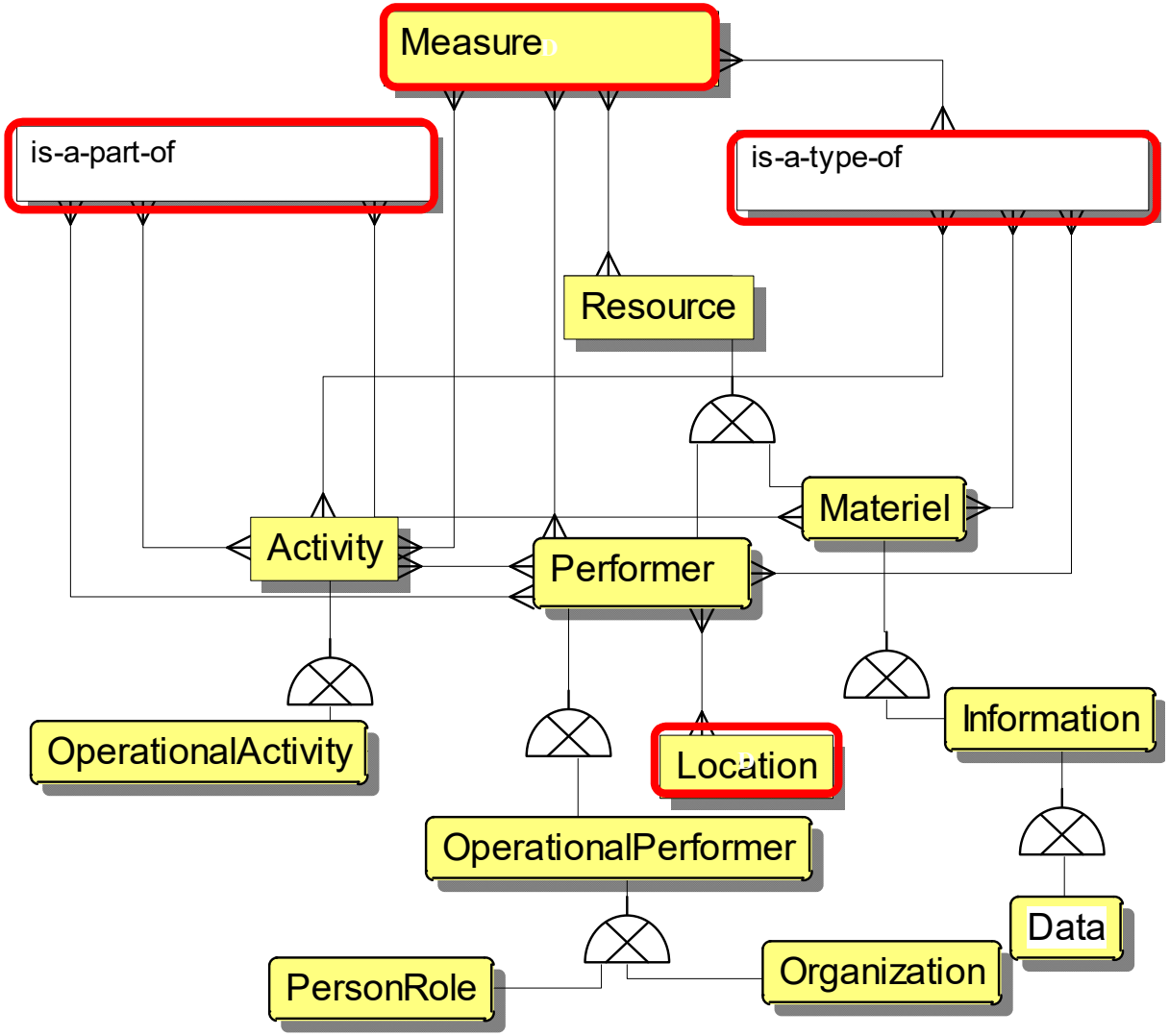




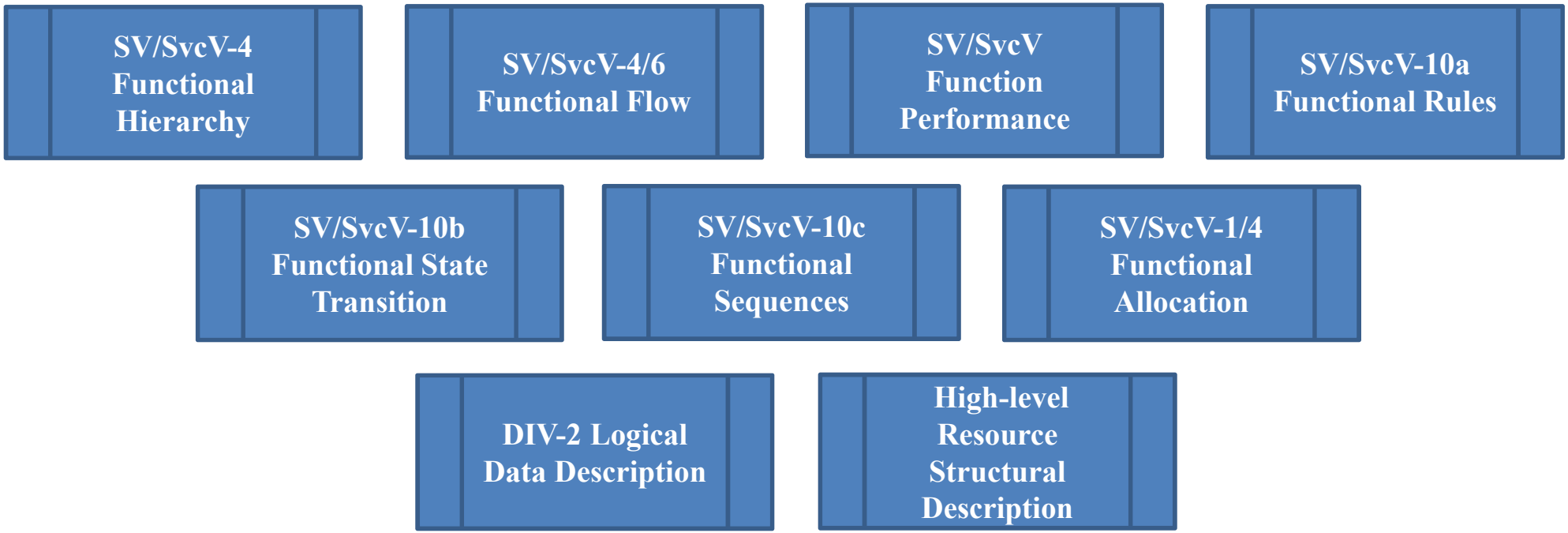
Resource flow that is specific to Operational, vice Functional, Service, or System Resource Flows

Operational Structures and Relationships

Operational Structures and Relationships



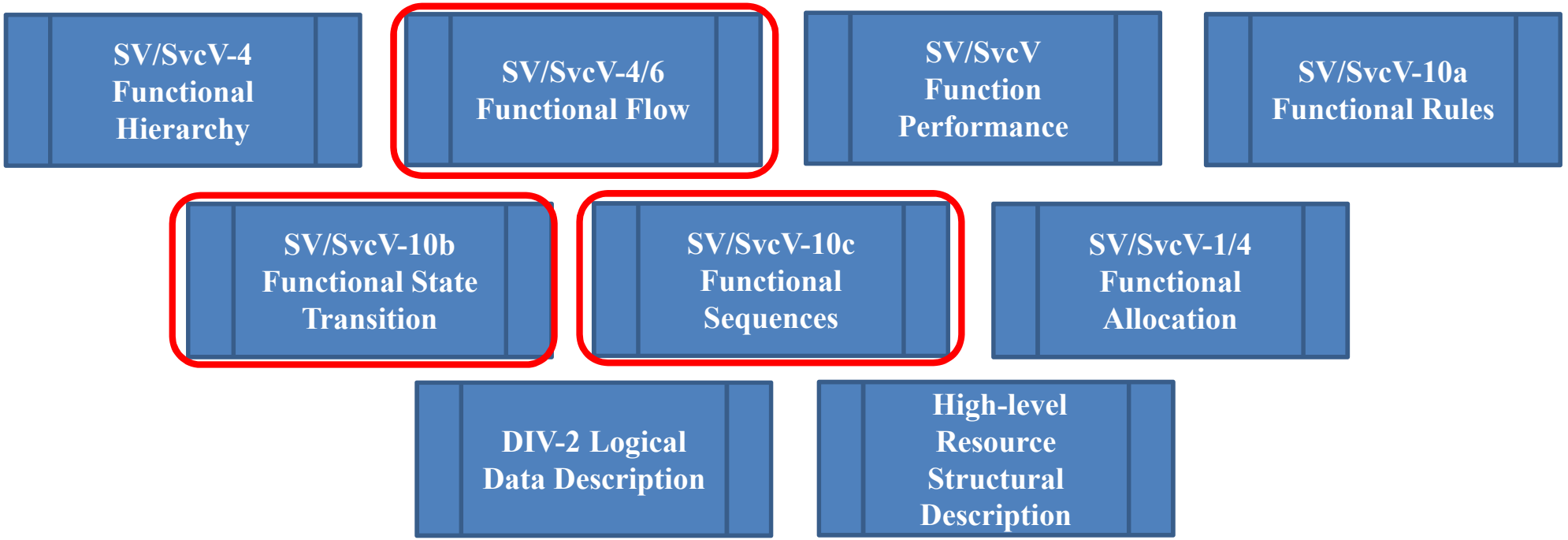
Functional Architecture



- Sometimes called pre-allocated
- Sometimes called “logical”
- Joint Common System Functions List (JCSFL) can be used

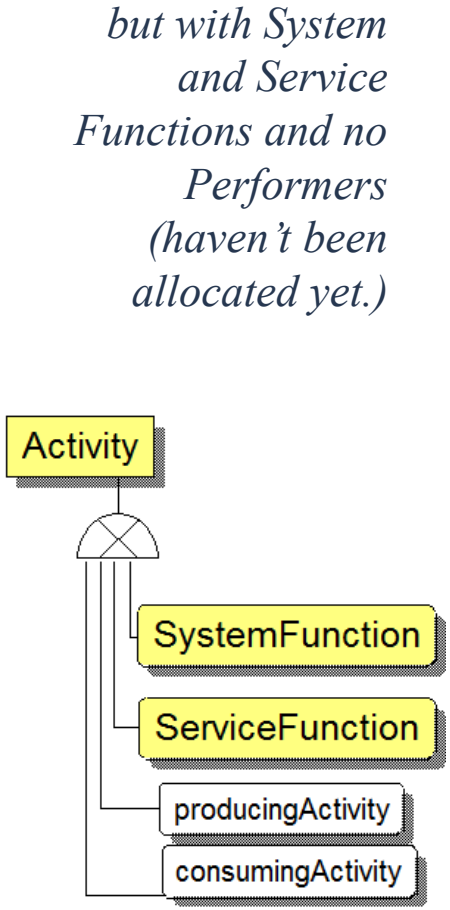
- Documented in:
  - Functional Requirements Document
  - Functional Specification
  - A-Specification or SSS (sometimes)

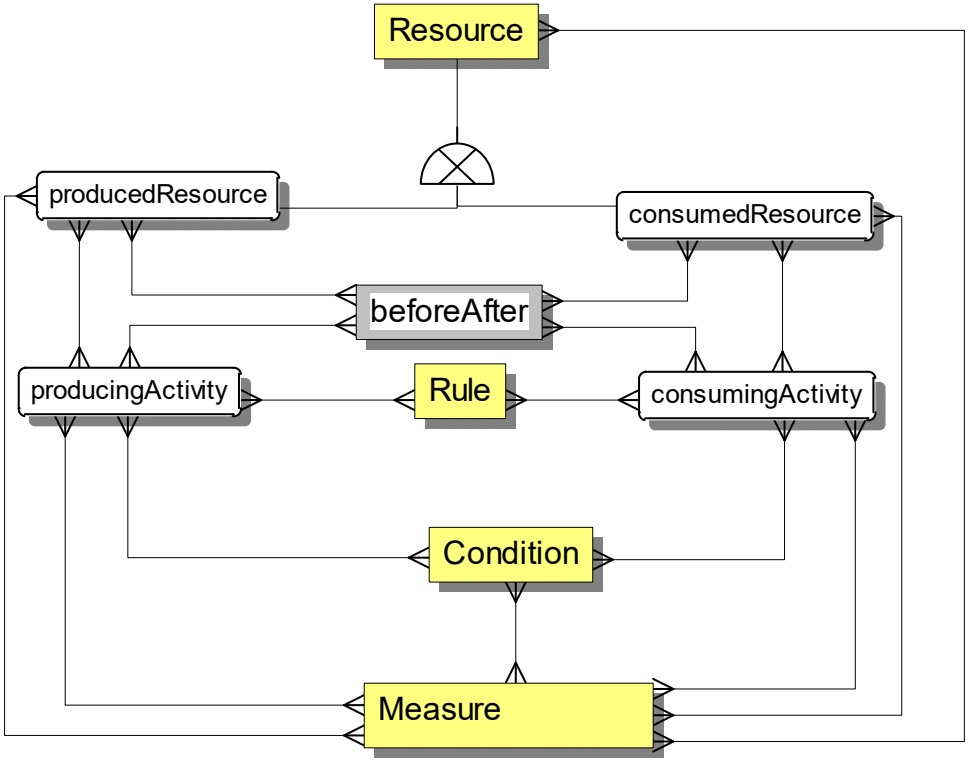
Resource Flow and/or Temporal Sequence

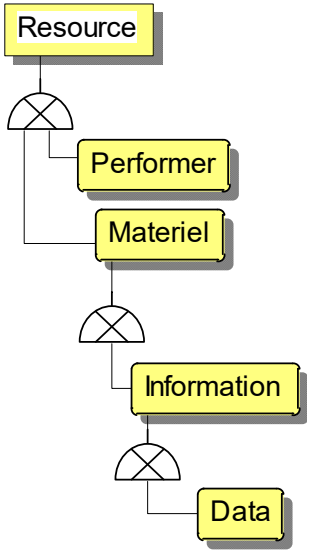


Resource Flow and/or Temporal Sequence

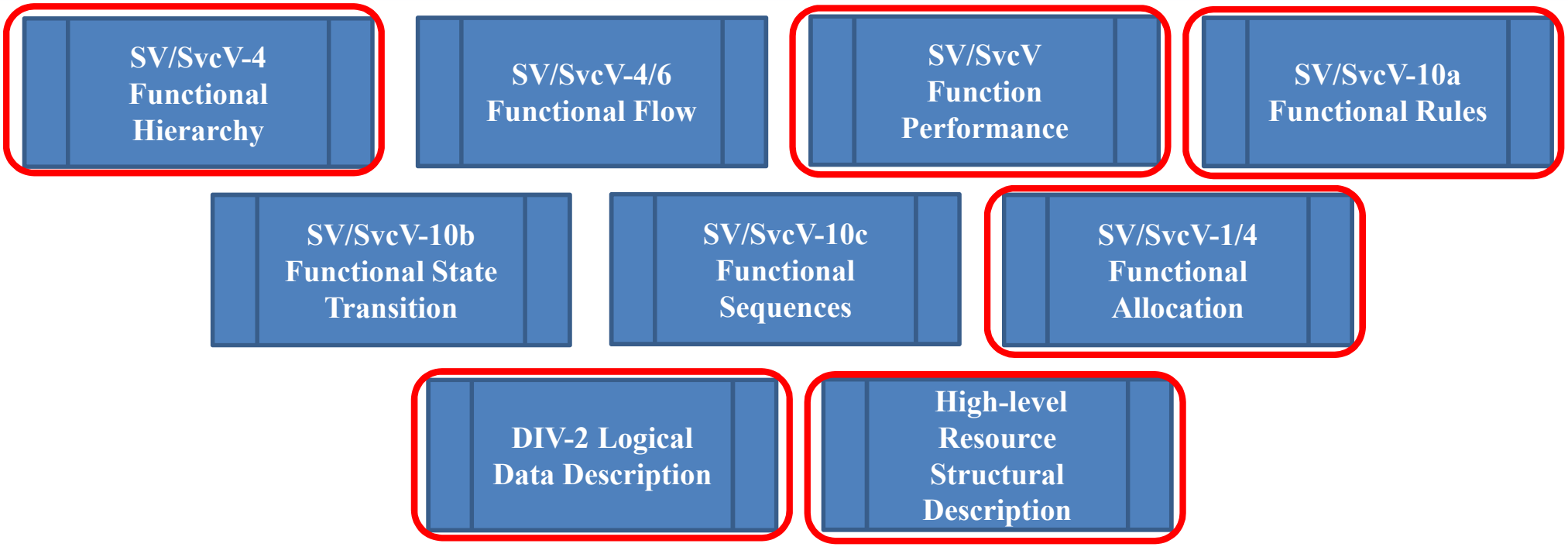
Similar to before but with System and Service Functions and no Performers (haven't been allocated yet.)





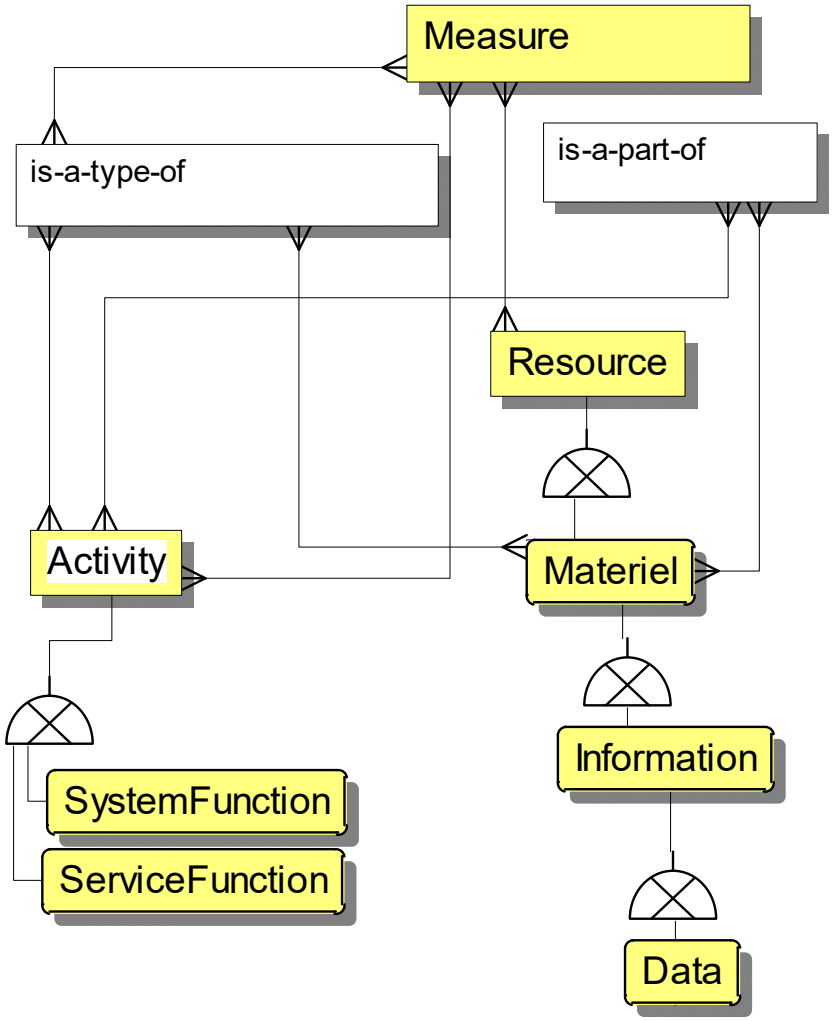


Structure and Same Type Relationships

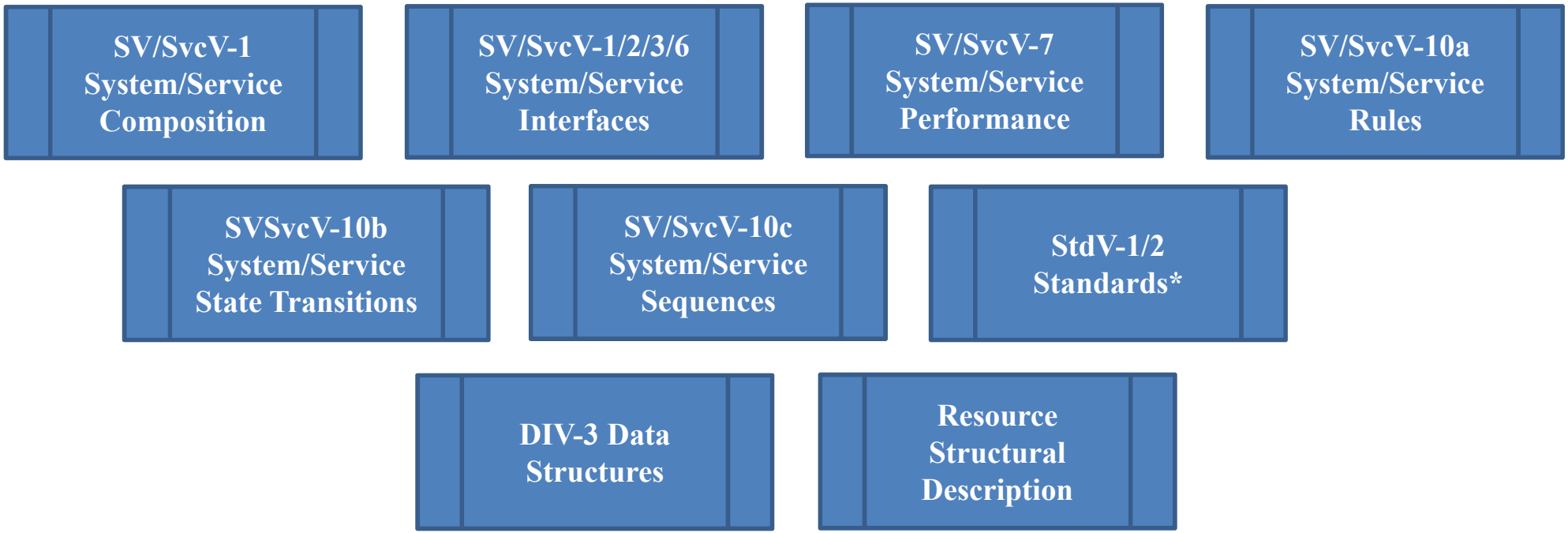


Structure and Same Type Relationships

No Performers or Locations in Functional Architecture. (Allocation hasn't occurred yet.)



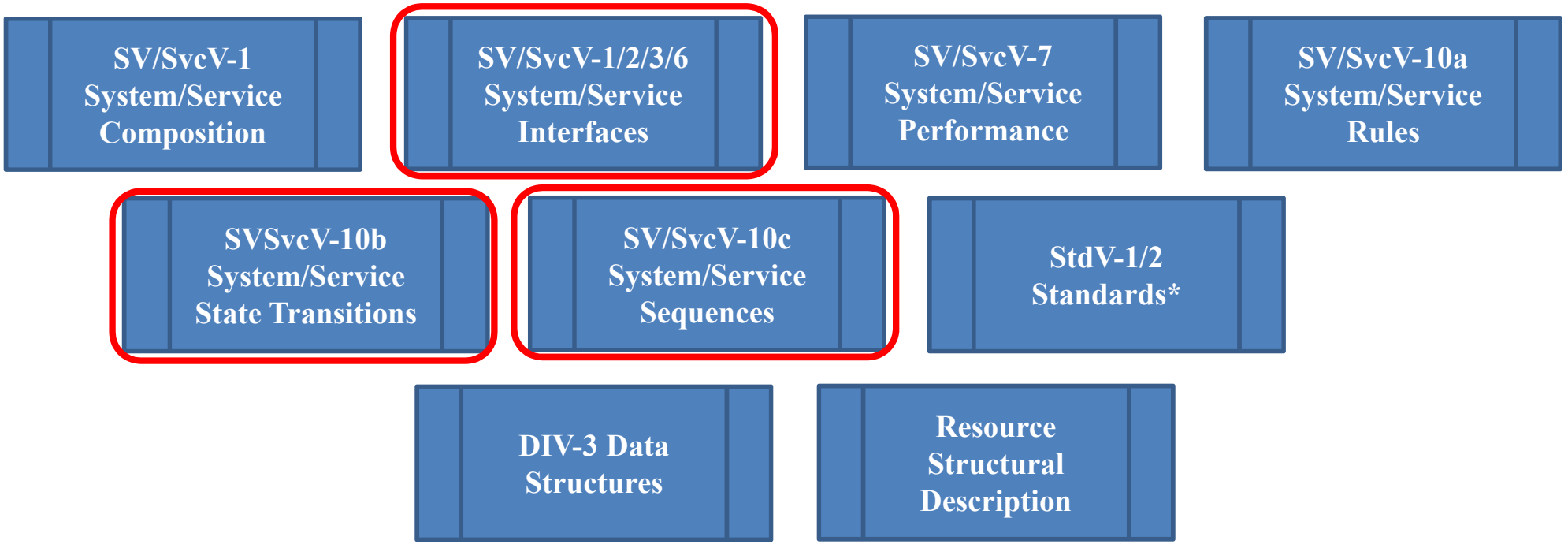
System and Service Architectures



- Documented in:
  - A/B/C Specification
  - SSS/SSDD/SRS/SDS
  - Technical Requirements Document
  - System Requirements Document
  - System Design Specification
  - Interface Requirements Specification
  - Interface Design Description
  - Interface Control Document
  - Human Systems Interface Specifications*

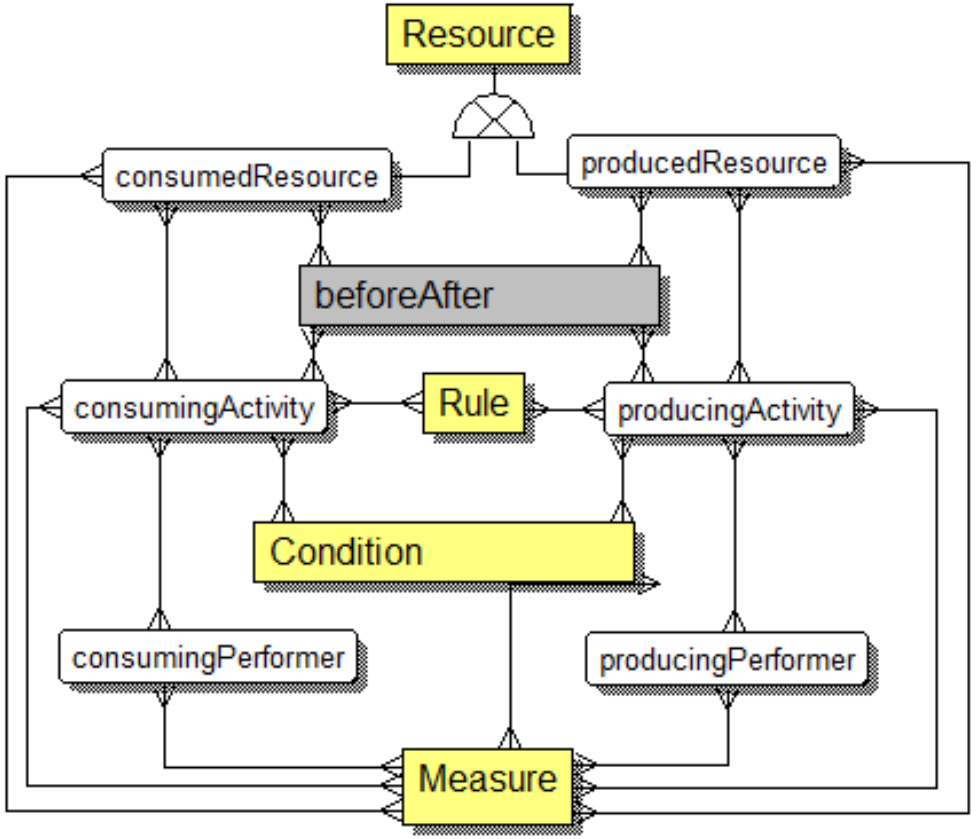
** In DoDAF 2, operators are part of the system or service*

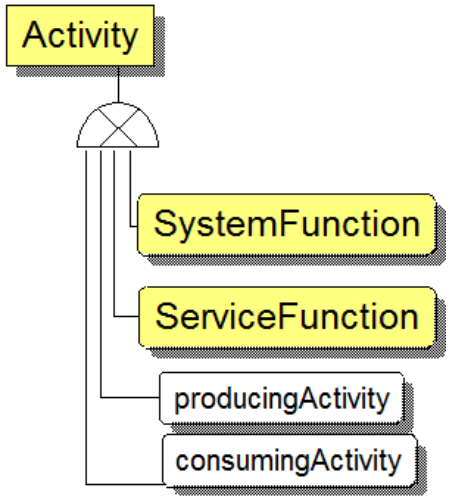
Resource Flow and/or Temporal Sequence

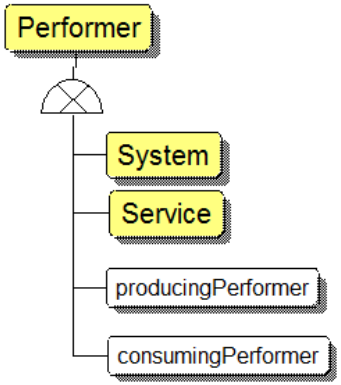


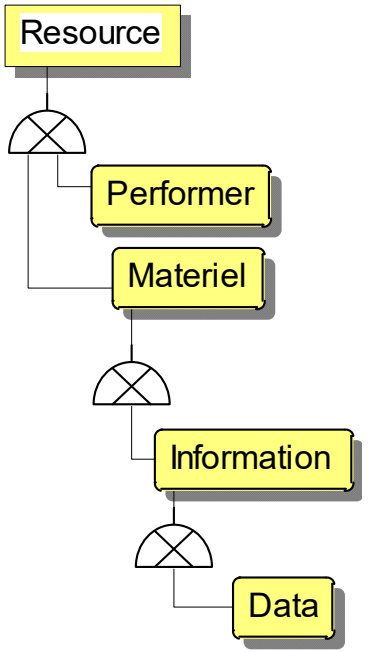
Resource Flow and/or Temporal Sequence

Similar to before but with System and Service Performers.

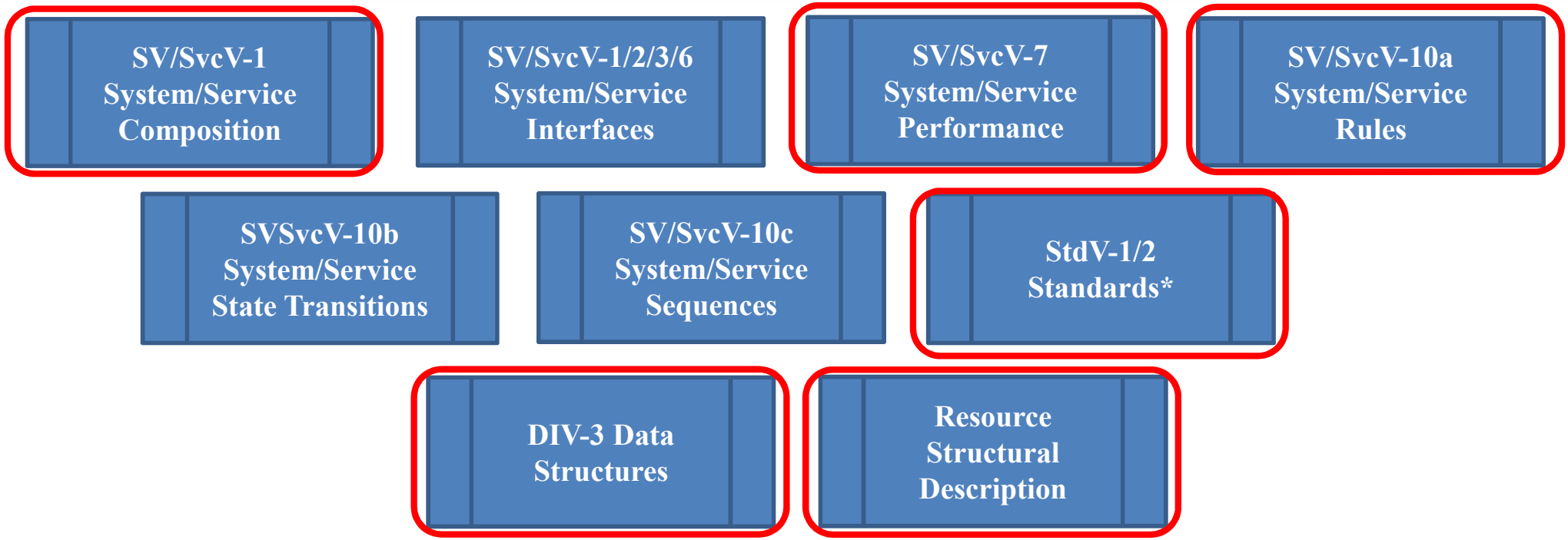




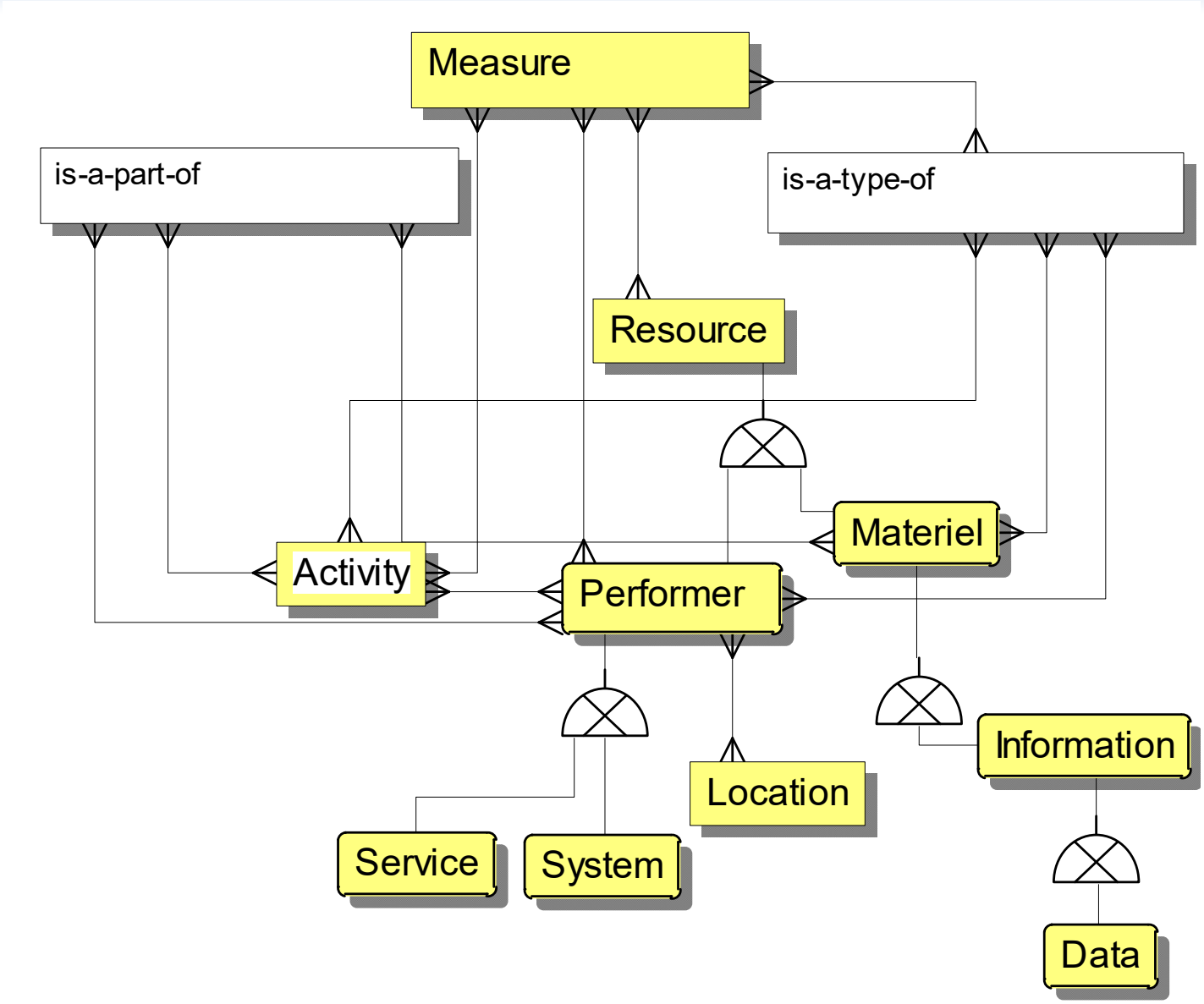




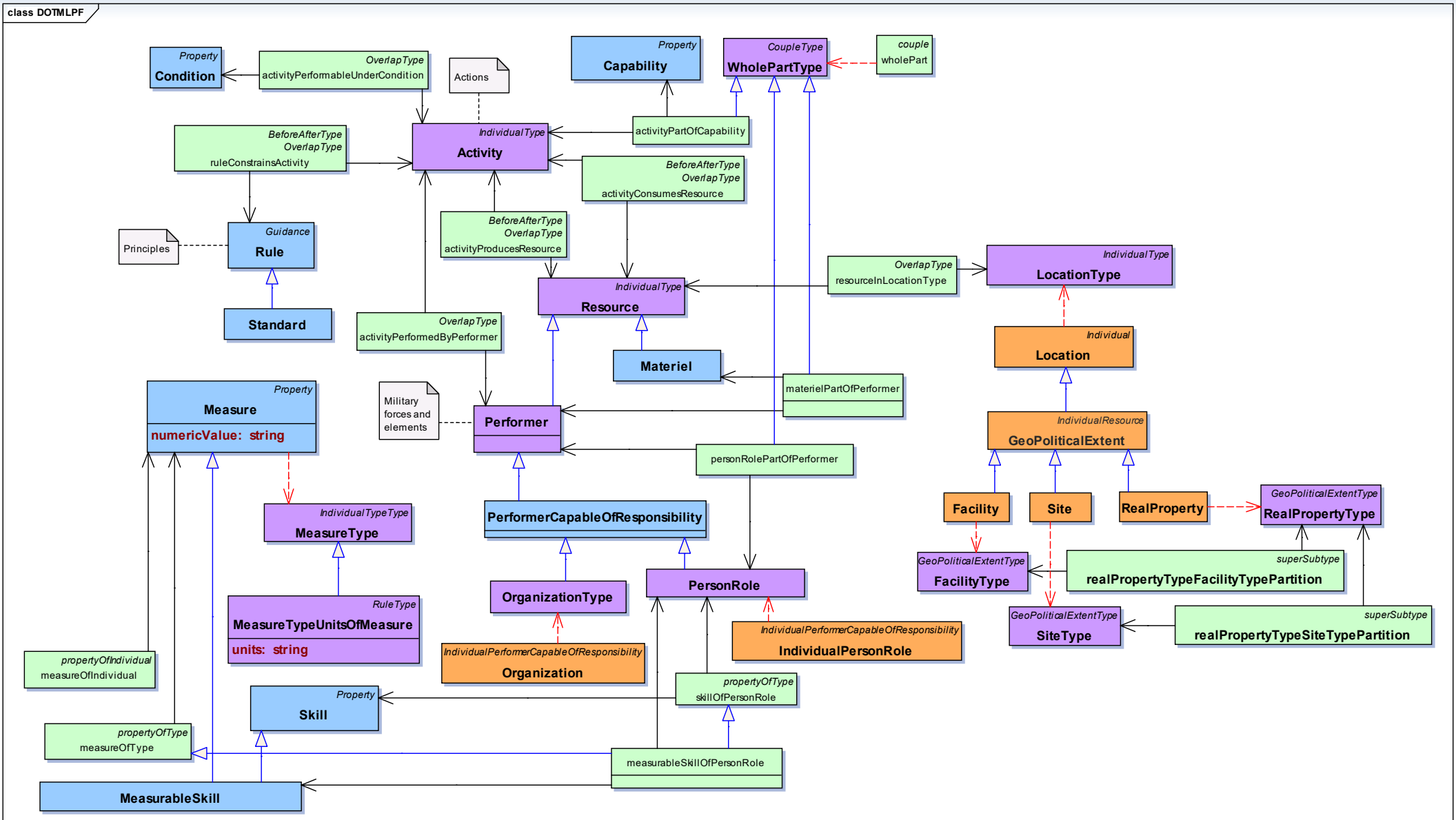
Structure and Same Type Relationships



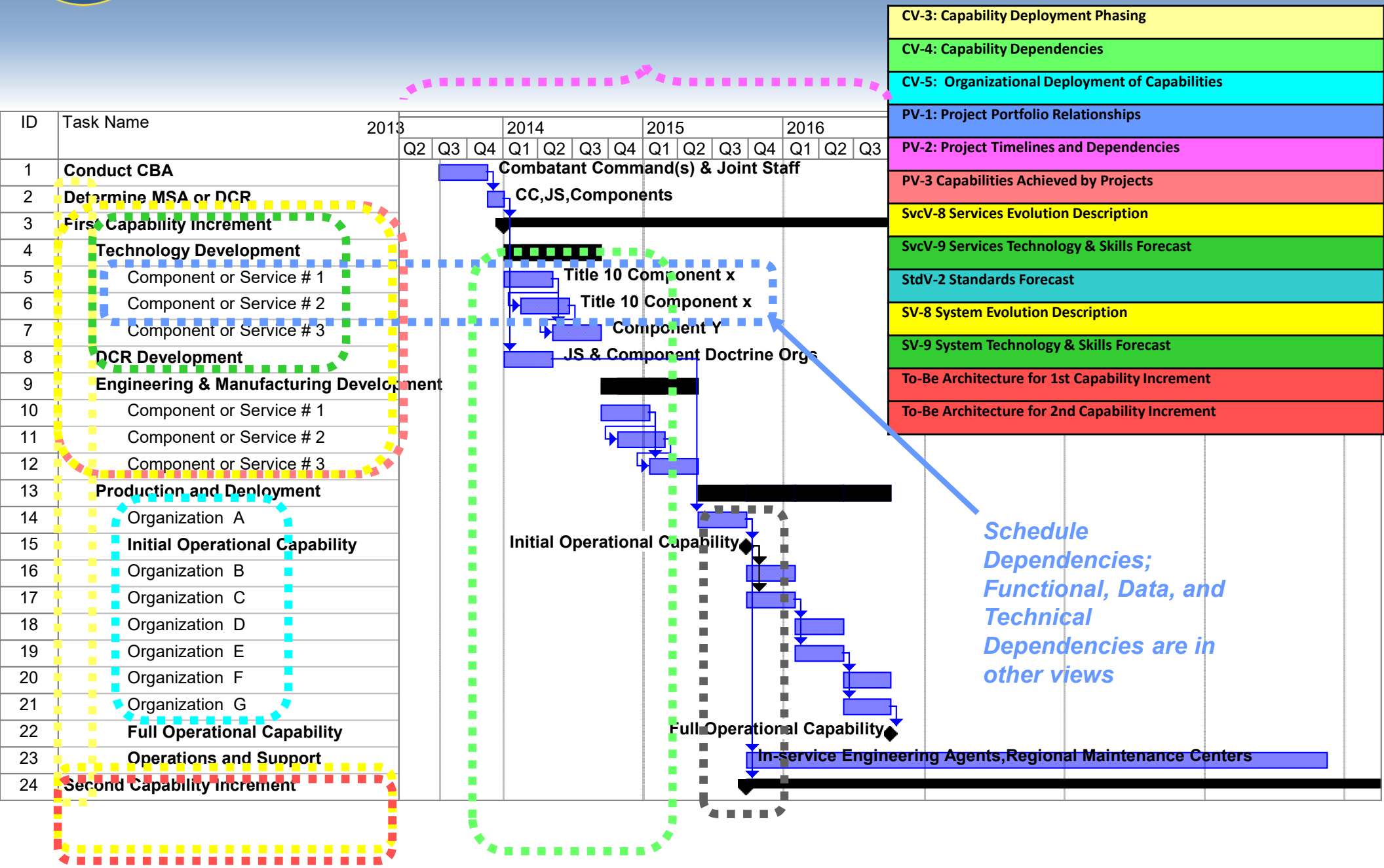
Structure and Same Type Relationships



DOTMLPF

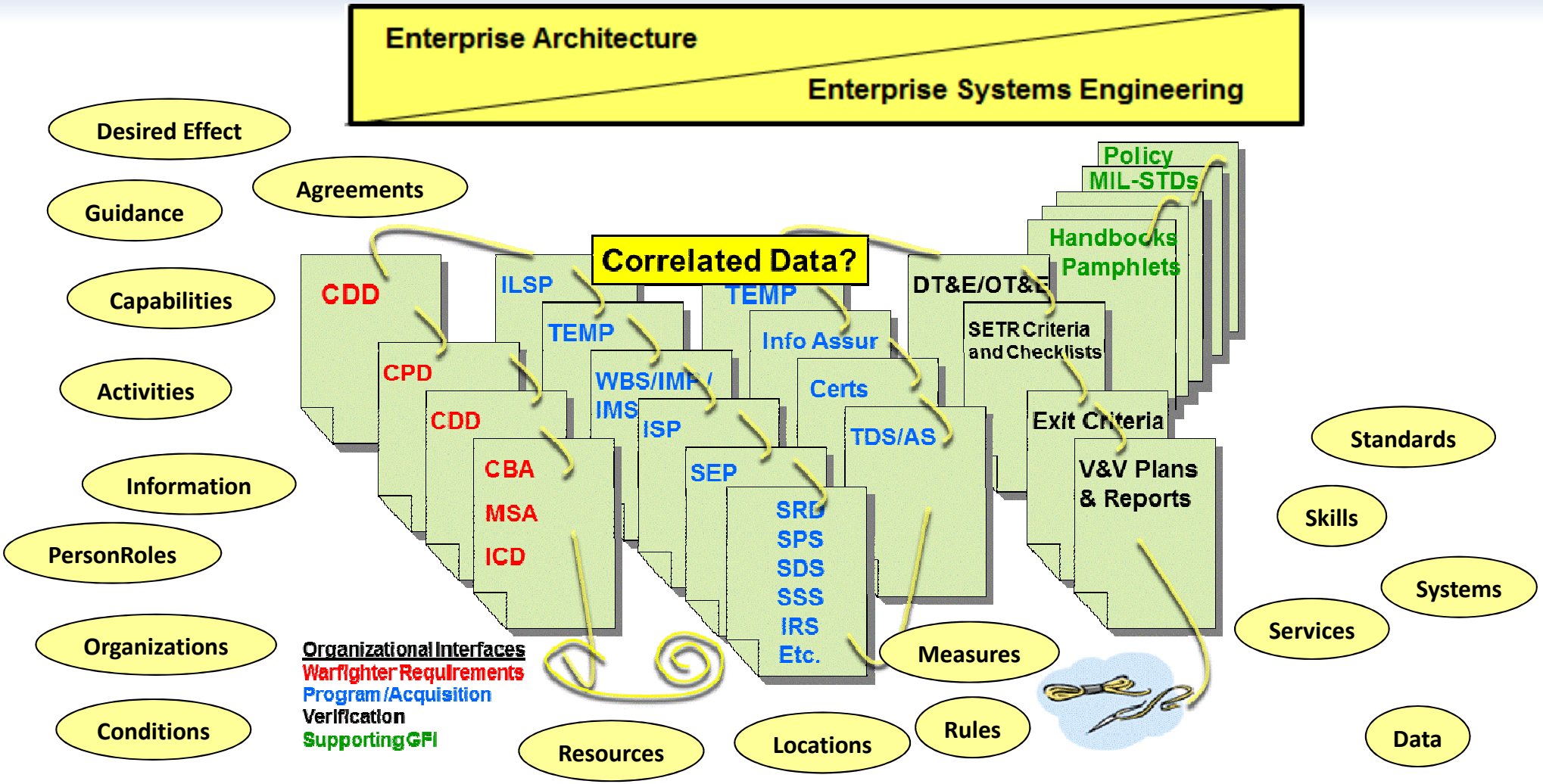

class DOTMLPF
Property
Condition
OverlapType
activityPerformableUnderCondition
Actions
Property
Capability
CoupleType
WholePartType
couple
wholePart
BeforeAfterType
OverlapType
ruleConstrainsActivity
IndividualType
Activity
activityPartOfCapability
BeforeAfterType
OverlapType
activityConsumesResource
BeforeAfterType
OverlapType
activityProducesResource
Principles
Guidance
Rule
Standard
OverlapType
activityPerformedByPerformer
IndividualType
Resource
OverlapType
resourceInLocationType
IndividualType
LocationType
Materiel
materielPartOfPerformer
Individual
Location
Property
Measure
numericValue: string
Military forces and elements
Performer
personRolePartOfPerformer
IndividualResource
GeoPoliticalExtent
IndividualTypeType
MeasureType
PerformerCapableOfResponsibility
Facility
Site
RealProperty
GeoPoliticalExtentType
RealPropertyType
GeoPoliticalExtentType
FacilityType
superSubtype
realPropertyTypeFacilityTypePartition
RuleType
MeasureTypeUnitsOfMeasure
units: string
OrganizationType
PersonRole
GeoPoliticalExtentType
SiteType
superSubtype
realPropertyTypeSiteTypePartition
propertyOfIndividual
measureOfIndividual
IndividualPerformerCapableOfResponsibility
Organization
IndividualPerformerCapableOfResponsibility
IndividualPersonRole
propertyOfType
skillOfPersonRole
Property
Skill
propertyOfType
measureOfType
measurableSkillOfPersonRole
MeasurableSkill

Schedule Views



DoDAF and Systems Engineering

Architecture and Systems Engineering: No sharp line between



Same types of concepts and relationships in both

DoDAF SV's were derived from SE documents

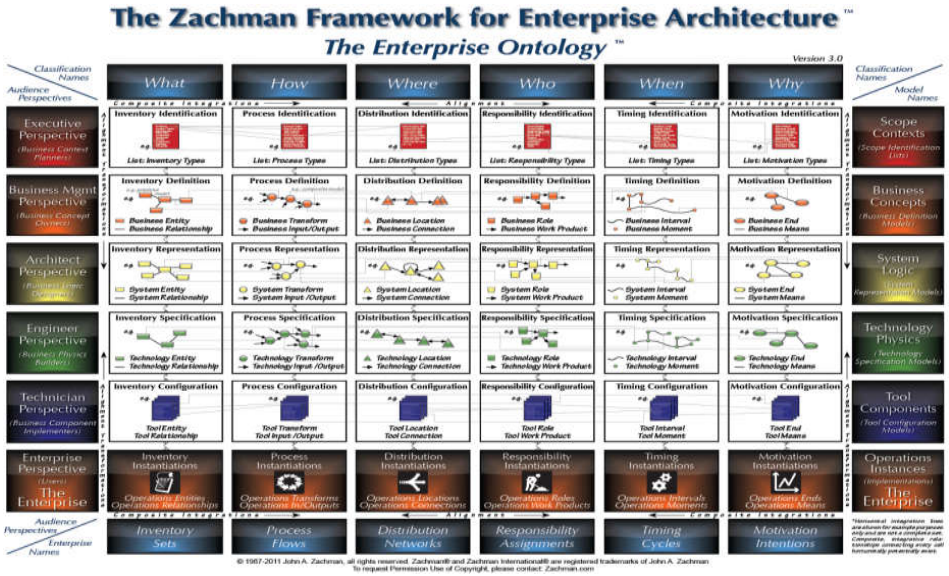
DoDAF Models

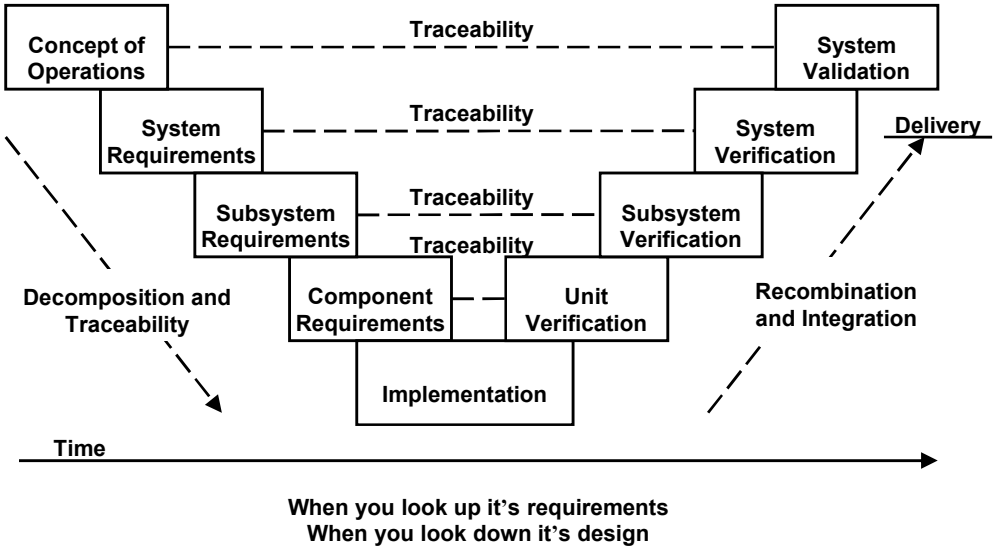
System Specification Requirement Type	OV-2	OV-3	OV-4	OV-5a	OV-5b	OV-6a	OV-6b	OV-6c	SV-1	SV-2	SV-3	SV-4	SV-5a	SV-5b	SV-6	SV-7	SV-8	SV-9	SV-10a	SV-10b	SV-10c
Operating Environment						X													X		
Operational Capabilities	X	X	X	?																	
System Performance Metrics																X					X
System Functional Requirements									X	X	X	X							X	X	X
System Interface Requirements									X	X	X	X			X						
Support (Non-Functional) Requirements						X										X	X	X			
Verification and Test					R	R	R	R					X	X							X
Traceability				R								R	X	X							

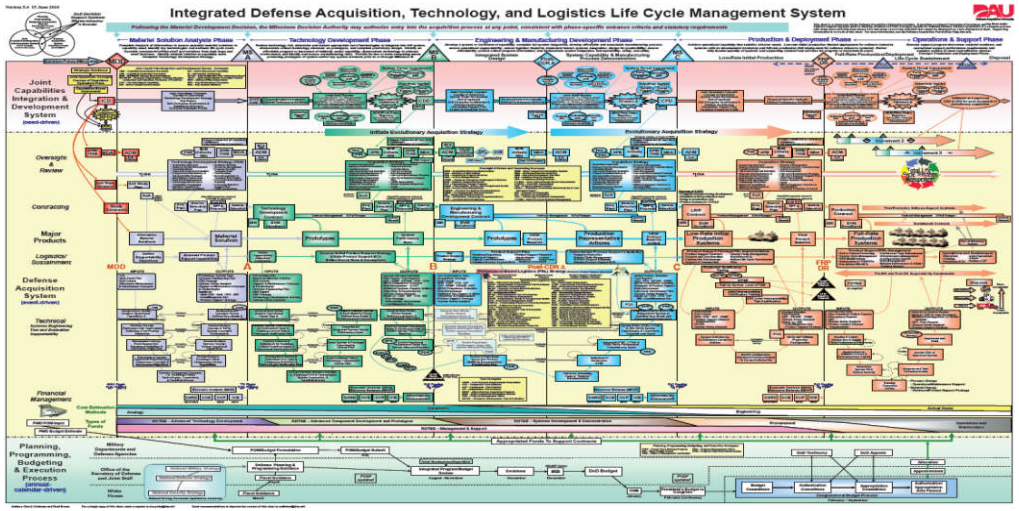
System Specification Requirement Type	SvcV-1	SvcV-2	SvcV-3a	SvcV-3b	SvcV-4	SvcV-5	SvcV-6	SvcV-7	SvcV-8	SvcV-9	SvcV-10a	SvcV-10b	SvcV-10c	StdV-1	StdV-2	CV-1	CV-2	CV-3	CV-4	CV-5	CV-6	CV-7	DIV-1	DIV-2	DIV-3
Operating Environment											X														
Operational Capabilities																X	X								
System Performance Metrics								X					X												
System Functional Requirements	X	X			X						X	X	X												
System Interface Requirements	X	X		X			X							X											
Support (Non-Functional) Requirements								X	X	X				X	X										
Verification and Test													X	X											
Traceability			X			X															X	X			

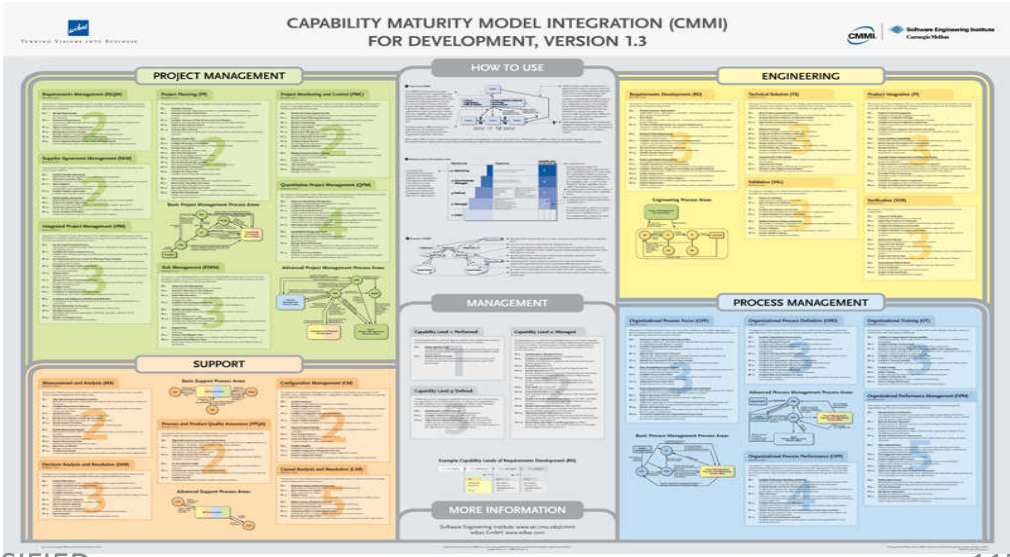
Key:
X – model created or updated
R – model is referenced (e.g., for traceability)

Some Life-Cycle Models









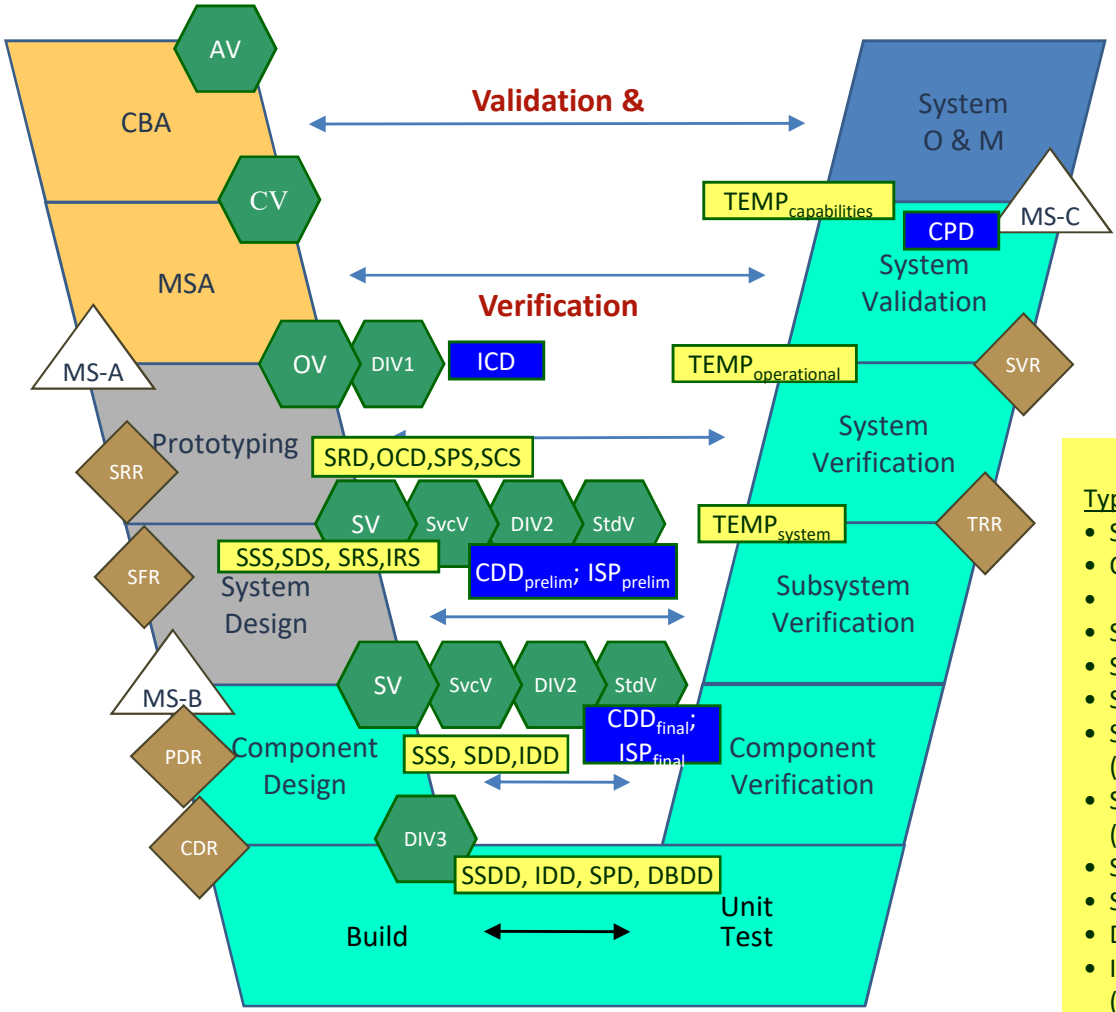
Architecture, SE documents, and the SE "V"

Acquisition Model Decisions & Milestones

- Capabilities Based Assessment (CBA)
- Material Solutions Analysis (MSA)
- Technology Development (TD)
- Engineering & Manufacturing Development (E&MD)

System Engineering Technical Reviews

- System Requirements Reviews (SRR)
- System Functional Reviews (SFR)
- Preliminary Design Reviews (PDR)
- Critical Design Reviews (CDR)
- Test Readiness Review (TRR)



Notional Systems Development "V"

DoDAF Viewpoints

- All (AV)
- Capabilities (CV)
- Operational (OV)
- Data / Information (DIV)
- Systems (SV)
- Services (SvcV)
- Standards (StdV)

JCIDS Documents

- Initial Capabilities Doc (ICD)
- Capabilities Design Doc (CDD)
- Capabilities Production Doc (CPD)
- Information Support Plan (ISP)

Typical Systems Engineering Work Products

- System Requirements Document (SRD)
- Operational Concept Description (OCD)
- System Capability Specifications (SCSs)
- Systems Performance Specification (SPS)
- System Design Specification (SDS)
- System/Subsystem Specification (SSS)
- System/Subsystem Design Description (SSDD)
- Software Requirements Specification (SRS)
- Software Design Description (SDD)
- Software Product Specification (SPS)
- Data Base Design Document (DBDD)
- Interface Requirements Specification (IRS)
- Interface Control Document (ICD) / Interface Design Document (IDD)
- Test and Evaluation Master Plan (TEMP)

Notional Systems Engineering Documents with embedded DoDAF artifacts

- System Specification (SSS, SDS, SDD, etc.)
  - Functional Description – SV-4
  - Performance Specification – SV-7
  - Interfaces – SV-1, high-level SV-2 and 6
  - Standards to Comply – StdVs mapped to SV's
  - Components – SV-1
- Interface Specification (IRS, ICD, etc.) – SV-2 and 6, possibly linked to DIV-2 and 3

DoDAF and Systems Engineering: Refinements Levels and Traceability

Reification and Traceability

- Reification
  - Definition – “Make (something abstract) more concrete or real.”
  - Sometimes called “refinement”, “more detailed”, …
  - Example: JIE ICD → EA → RAs → IDT SAs → Component solutions
- Traceability
  - Often applied in conjunction with a “spec tree”
  - Generally more rigorous than “alignment”
  - Tracing justifies subordinate artifacts and, conversely, indicates ordinate requirements are being satisfied
- Both accomplished in DoDAF via DM2 Pedigree model
  - But specific DoDAF views do not exist for most traceability requirements

How DoDAF Supports Reification

AN ARCHITECTURAL DESCRIPTION:

IDENTIFIES

Traceability (Pedigree)

Rules constrain (requirements)

DEFINES

Traceability (Pedigree)

Rules constrain (requirements)

REPRESENTS

Traceability (Pedigree)

Rules constrain (requirements)

SPECIFIES

Traceability (Pedigree)

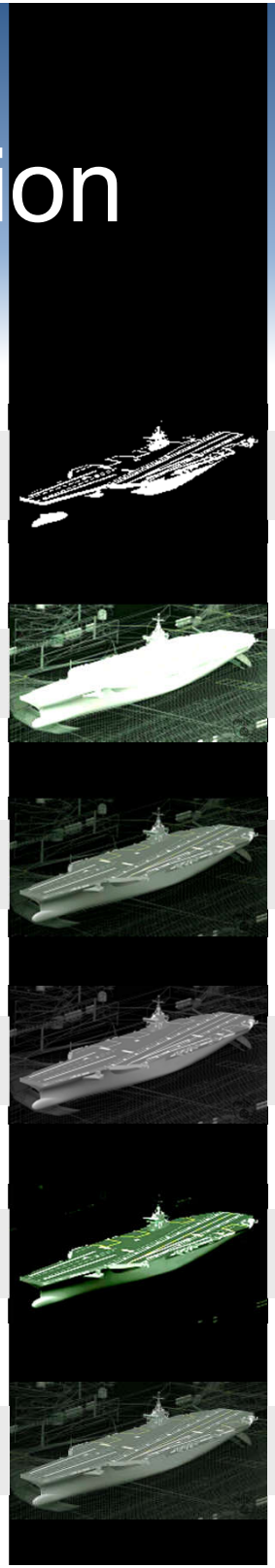
Rules constrain (requirements)

CONFIGURES

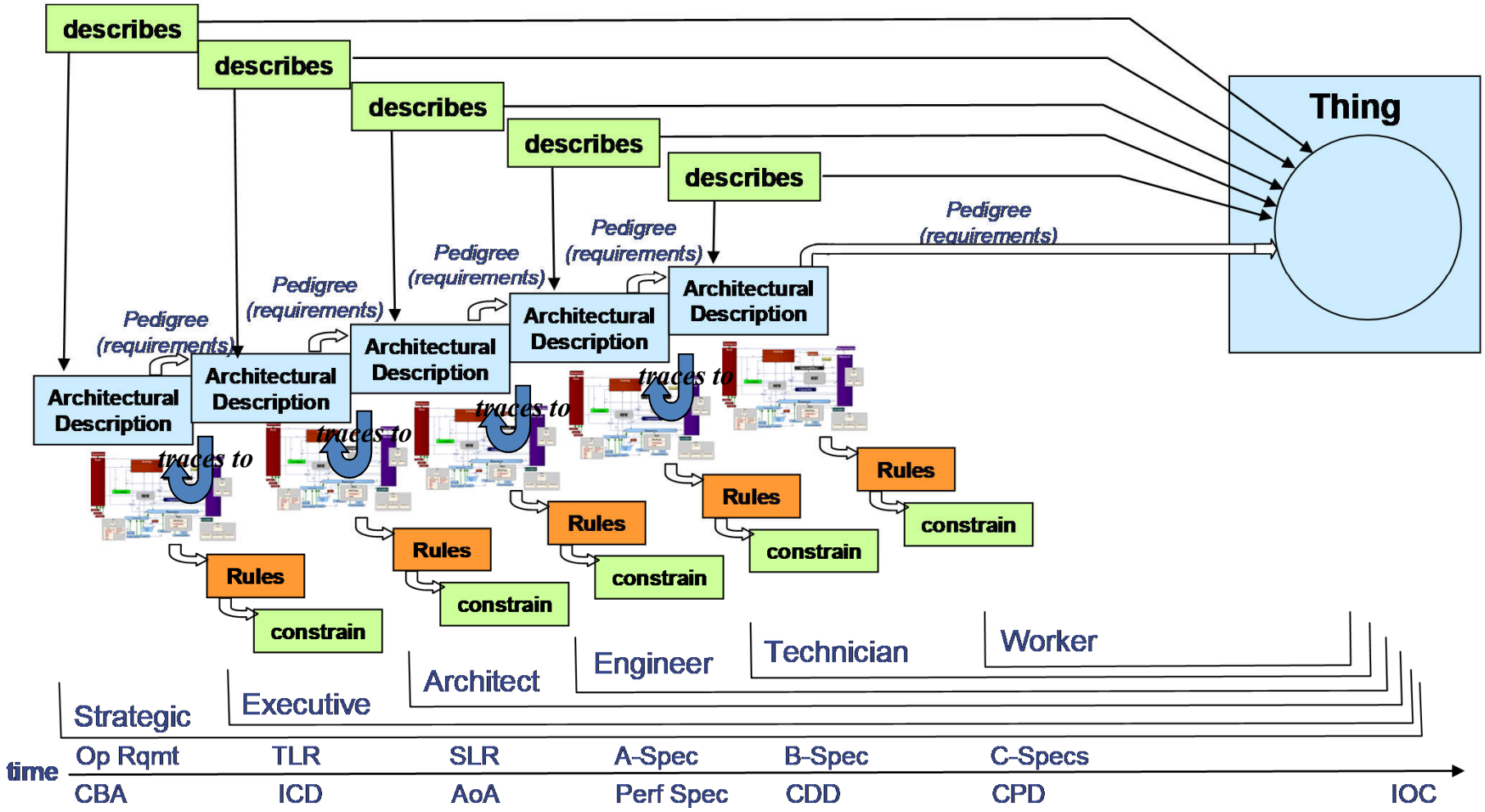
Traceability (Pedigree)

Rules constrain (requirements)

INSTANTIATED



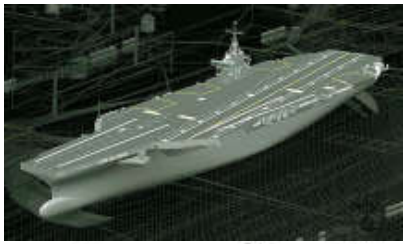
Reification and Traceability



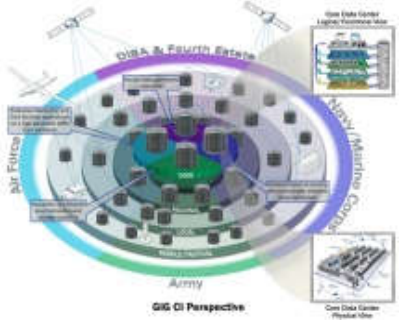
Reification Pattern Applies To:

- Capabilities
- Acquisitions
- Consolidations
- Migrations
- Life-Cycle Sustainment

JIE



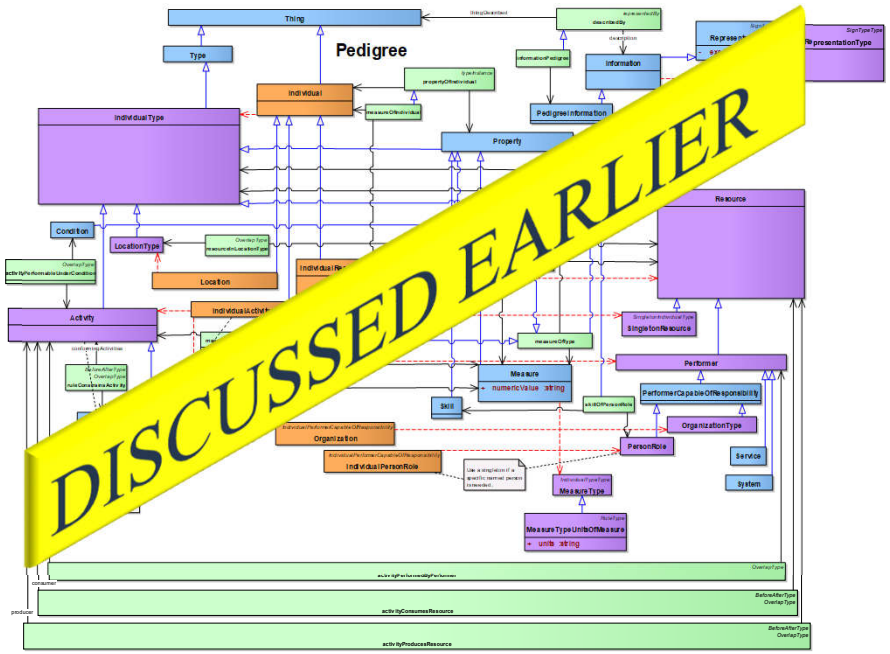
CVN-79



Data Center Consolidation

DoD Enterprise Cloud Environment

Reification and traceability are recorded via Pedigree (Provenance)

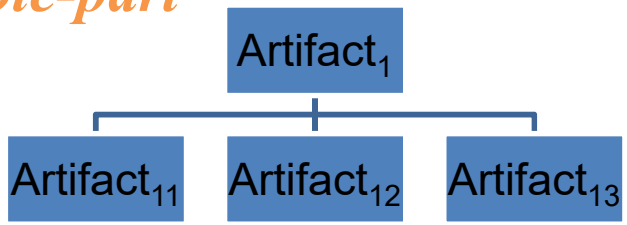


- workflow model, e.g., open provenance model (provenance = linked together pedigrees)
- = activity model (OV-5 + 6c)
- “link while you think”

Two ways to reify in DoDAF

- By extension (specialization) or decomposition

DM2 super-subtype or whole-part



- By mapping or allocation

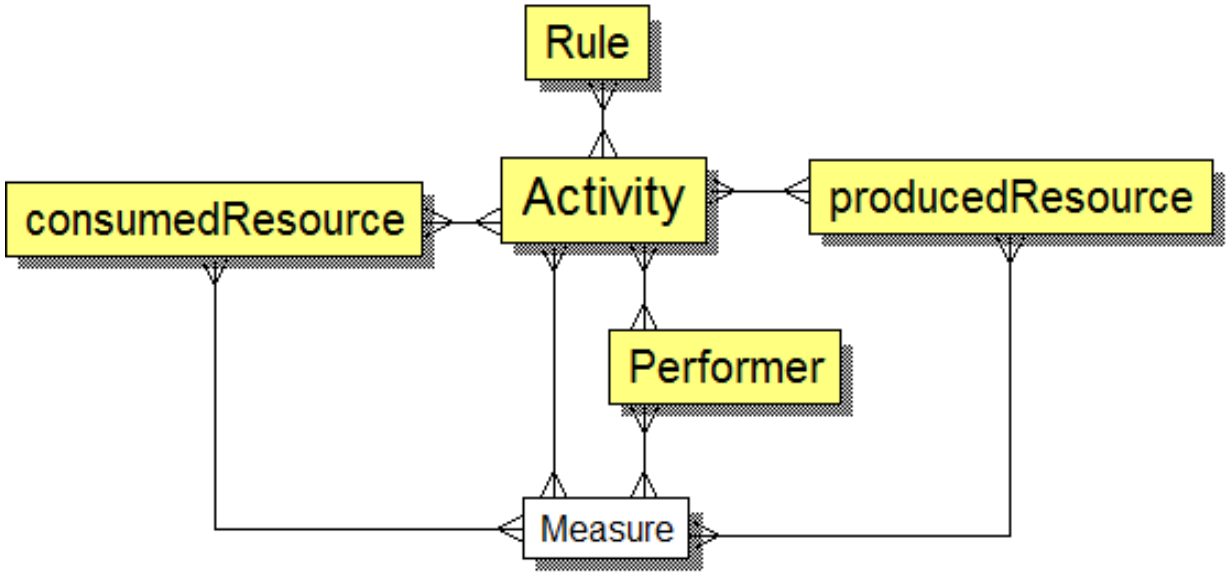
	Artifact A	Artifact B	Artifact C	Artifact D
Artifact 1	x		x	
Artifact 2		x		x
Artifact 3			x	
Artifact 4	x	x		

DM2 overlap

Reification in DoDAF formally is superSubtype, wholePart, or overlap

Reification of Activities

- DoDAF definition of Activity –
  - "Work, not specific to a single organization, weapon system or individual that transforms inputs (Resources) into outputs (Resources) or changes their state."
- ⇒ Activities are structures
- ⇒ to reify them means to reify the structure



For example, in an OV-5a, "Activity-1.1 reifies Activity-1", means it reifies Activity-1's structure:

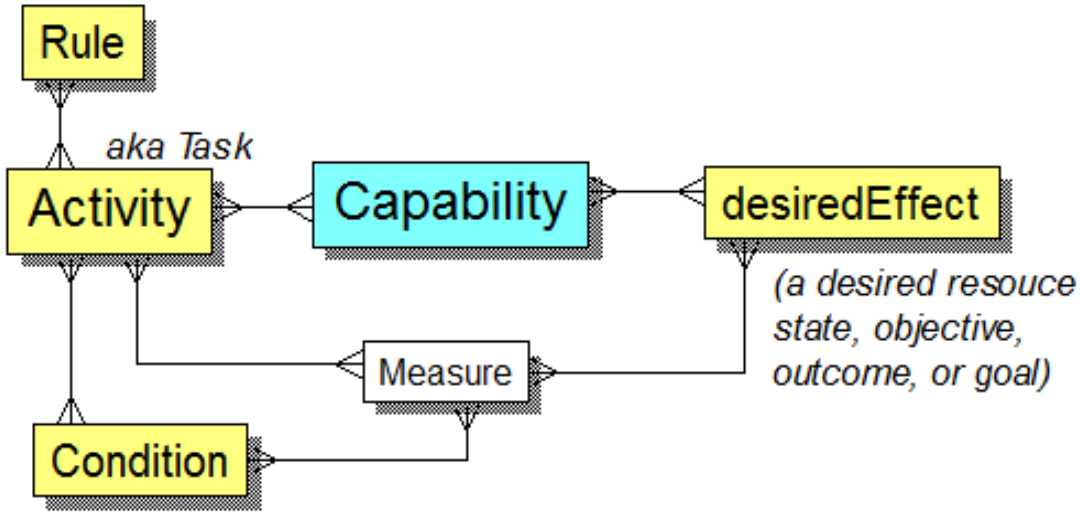
- Activity-1
- consumedResources-A1.i
- producedResources-A1.j
- Rules-A1.k
- Performers-A1.l
- Measures-A1.m

Where "reify" means:

- superSubtype,
- wholePart, or
- overlap

Reification of Capabilities

- DoDAF definition of Capability
  - "The ability to achieve a Desired Effect under specified [performance] standards and conditions through combinations of ways and means [rules, activities, and resources] to perform a set of activities."
- ⇒ Capabilities are structures
- ⇒ to reify them means to reify the structure



For example, in a CV-2, "Capability-1.1 reifies Capability-1" means it reifies the Capability-1 structure:

Capability-1
- desiredEffects-C1.i
- Tasks-C1.j
- Rules-C1.k
- Conditions-C1.l
- Measures-C1.m

Where "reify" means:
- superSubtype,
- wholePart, or
- overlap

Example: Capabilities Reification Traceability Criteria

- superSubtype reification: Capability11 reifies Capabilitiy1 iff:

$\forall \text{desiredEffect}^{i}_{11} \underset{WPT}{\subset} \text{Capability}_{11},$

$\exists \text{desiredEffect}^{j}_{1} \underset{WPT}{\subset} \text{Capability}_{1}$ ∋

$\text{desiredEffect}^{i}_{11} \underset{WPT}{\subset} \text{desiredEffect}^{j}_{1} \wedge$

$\text{measureOfDesiredEffect}^{i}_{11} \subset \text{measureOfDesiredEffect}^{j}_{1}$

$\forall \text{Task}^{i}_{11} \underset{WPT}{\subset} \text{Capability}_{11},$

$\exists \text{Task}^{j}_{1} \underset{WPT}{\subset} \text{Capability}_{1}$ ∋

$\text{Task}^{i}_{11} \underset{WPT}{\subset} \text{Task}^{j}_{1} \wedge$

$\forall \text{Condition}^{ix}_{11} \underset{WPT}{\subset} \text{Task}^{i}_{11},$

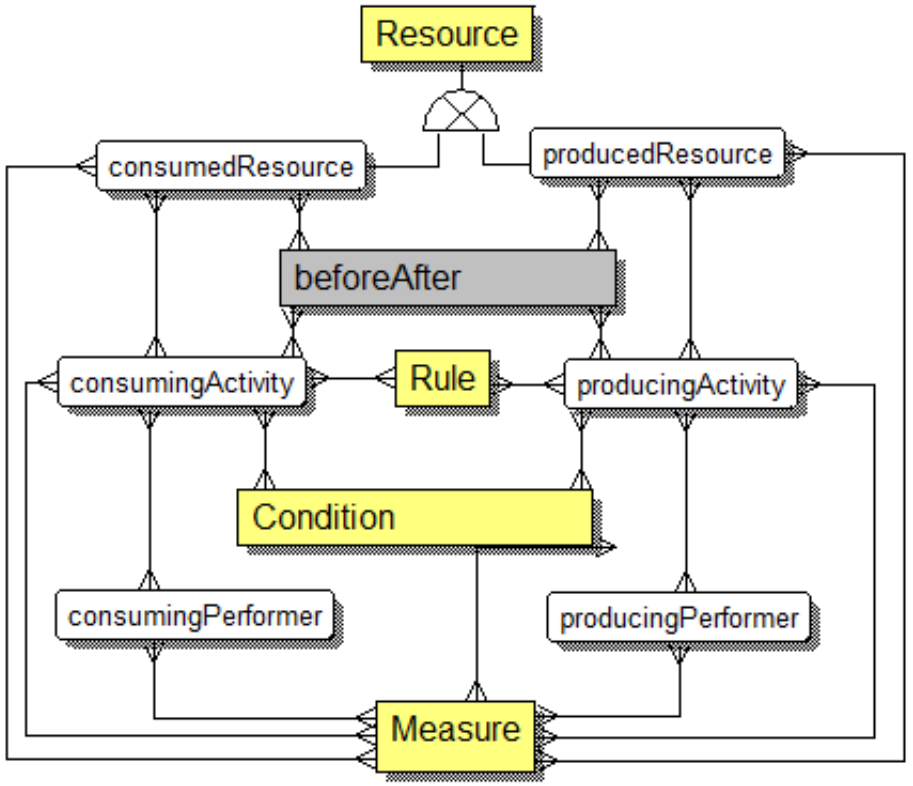
$\exists \text{Condition}^{jy}_{1} \underset{WPT}{\subset} \text{Task}^{j}_{1}$ ∋

$\text{Condition}^{ix}_{11} \underset{WPT}{\subset} \text{Condition}^{jy}_{1}$

- wholePart reificaiton:
  - Proper wholePart:
  - Improper wholePart:
- typeInstance:
- overlap:

Reification of Resource Flow

- DoDAF definition of Resource Flow
  - "The behavioral and structural representation of the interactions between activities (which are performed by performers) that is both temporal and results in the flow or exchange of things such as information, data, materiel, and performers..."
- ⇒ in an SV-1, each element of a reified resource flow must be a reification of elements from ordinate resource flows
- Note: more complex reifying across allocation levels (e.g., OV→SV) because of typical many-many allocations
  - Some flows get rolled-up
  - New ones get created



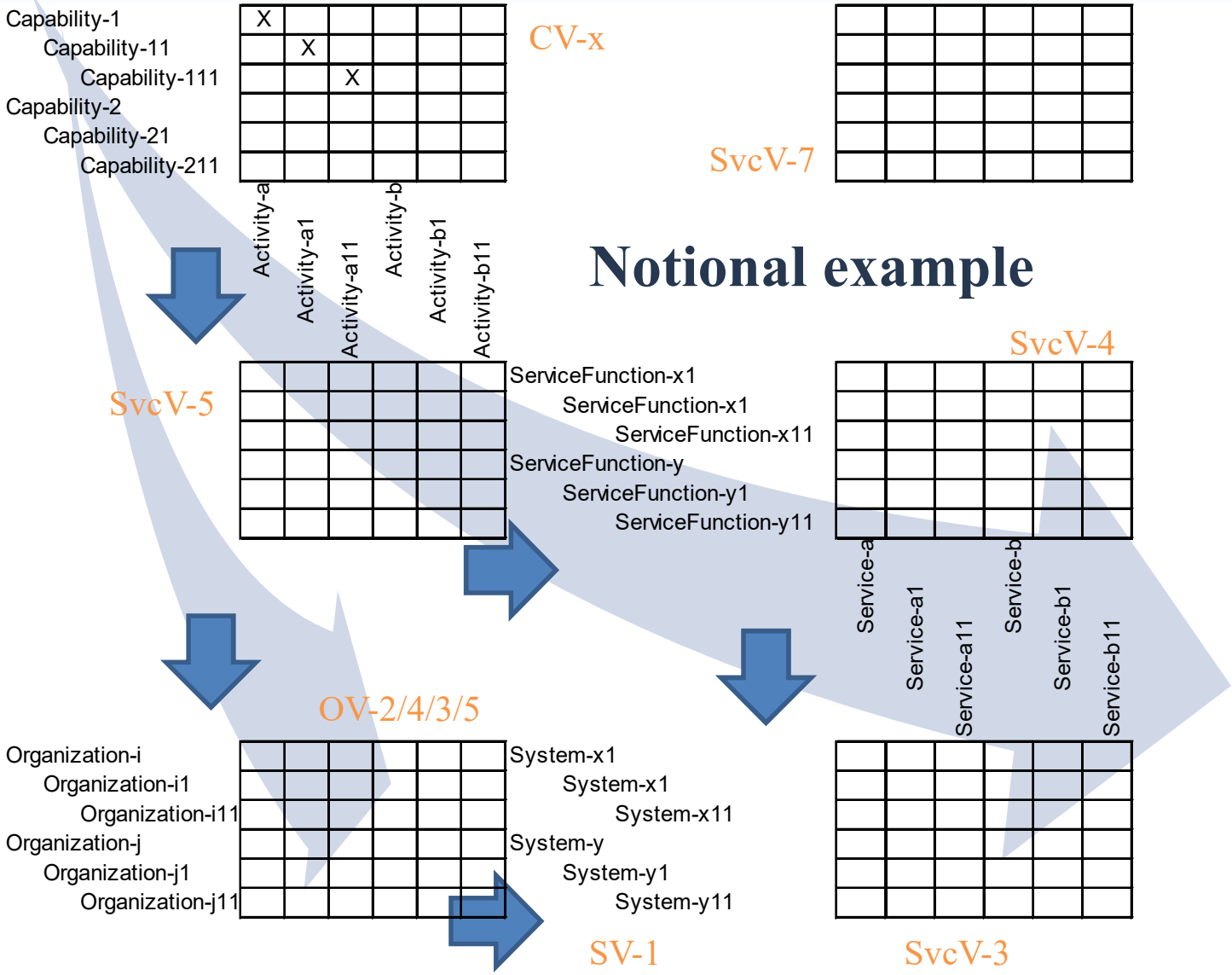
The Reification can be in the form of different types of artifacts

e.g., CV-x Data	*e.g., SV/SvcV-7 Data* Performer measure a	Performer measure a	Performer measure a
Capability desiredEffect measure 1	x		x
Capability desiredEffect measure 11	x		x
Capability desiredEffect measure 111	X		X
Capability desiredEffect measure 2		x	x
Capability desiredEffect measure 21		x	x
Capability desiredEffect measure 211		X	X

The mapping is at the leaf level but some mapping to the "parents" is implied

Analogous to the traditional MOE to MOP relationship

The Reification (and hence traceability) span from requirements to implementation



Views Don't Support as much Traceability as the Meta-Model

- DoDAF-defined traceability views: only CV-7, SV/SvcV-5
- In DM2, there are many more, e.g.,
  - CV-2 MOEs to SV/SvcV-7 MOPs
  - OV Organizational Performers to SvcV Service Performers and SV System Performers
  - OV-6a Rules to SV/SvcV-10a and StdV Rules (Standards are types of Rules)
  - Information (DIV-1/2) to Data (DIV-3)
  - OV Resource Flows to SV/SvcV functional Resource Flows to SV/SvcV Resource Flows
  - OV sequences and state transitions to SV/SvcV sequences and state transitions
  - SV/SvcV functional performance and resource and temporal flows and state transitions to SV/SvcV counterparts

Summary

- DoDAF 2 is responsive to DoD's 6 core processes
- DoDAF terminology and relationships are the Meta Model (DM2)
  - conceptually simple yet highly expressive due to leveraging of IDEAS
  - was designed to allow modeling beyond the legacy views
- DoDAF's model for reification supports many life-cycle models, including SE "V"
- DoDAF artifacts, SE documents, and DM2 data should be complimentary

Questions?