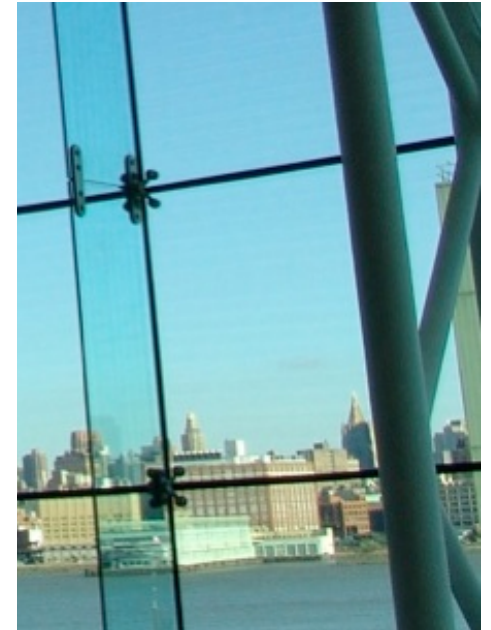




**STEVENS**  
INSTITUTE *of* TECHNOLOGY  
THE INNOVATION UNIVERSITY



# RT 24 - Architecture, Modeling & Simulation, and Software Design

Dennis Barnabe, Department of Defense  
Michael zur Muehlen & Anne Carrigy, Stevens Institute of Technology  
Drew Hamilton, Auburn University  
Russell Peak, Georgia Tech



**STEVENS**  
INSTITUTE *of* TECHNOLOGY  
THE INNOVATION UNIVERSITY



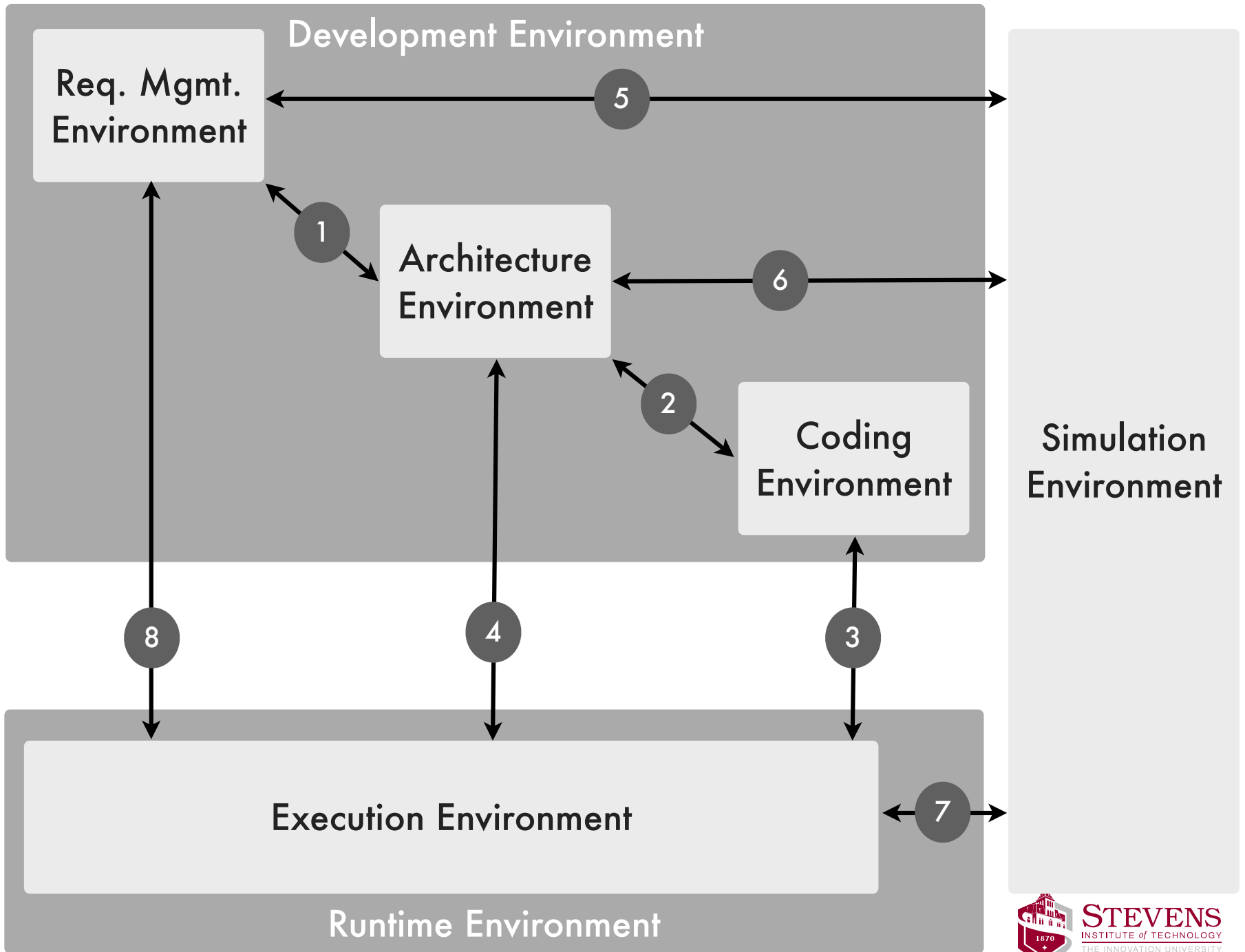
**AUBURN**  
UNIVERSITY

**Georgia  
Tech**



# Context

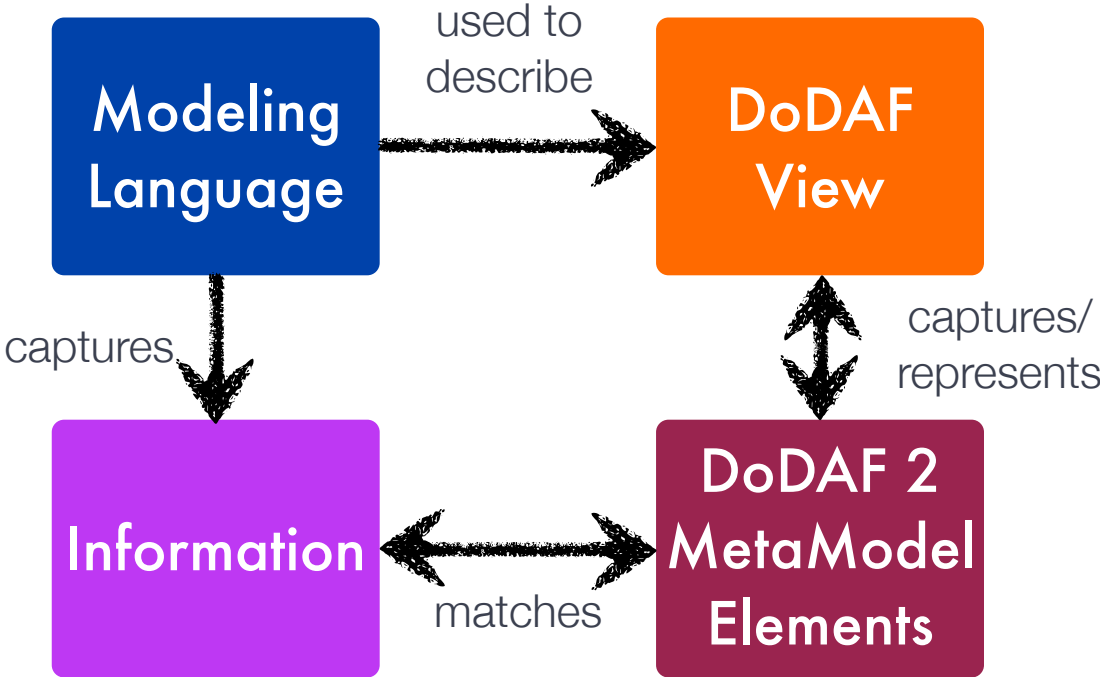
- ▶ The client is producing software-intensive, distributed systems in short development cycles (90 day increment spins)
- ▶ The DoD JCIDS process requires the documentation of systems in the form of certain DODAF products
- ▶ Occasionally this documentation is created after the fact and not as a basis for Modeling & Simulation or software development (notion: coding is faster than architecting)
- ▶ Effort spent on architecture development is essentially wasted, since architecture products are not used for value-added delivery, and architecture models and code evolve separate from each other



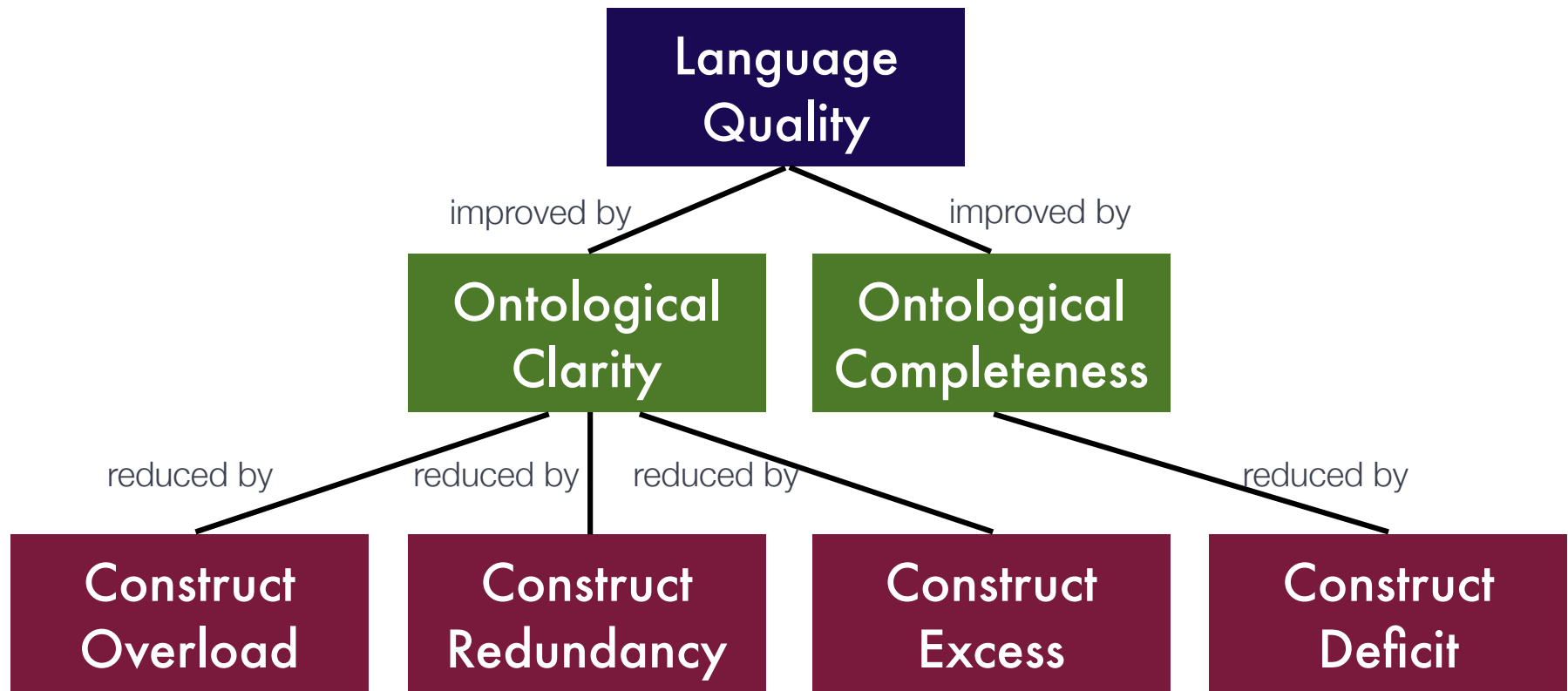
# Challenge

- ▶ Investigate the **integration** of Architecture models in the Modeling & Simulation and Software Design and Development Process
- ▶ Develop a **methodology** that:
  - ▶ Identifies those architecture products that are relevant for the design of software-intensive systems
  - ▶ Provides guidance as to the sequence in which these models should be created
  - ▶ Provides guidance as to the methods that should be used when creating these models
  - ▶ Provides guidance as to the use of the recommended methods
- ▶ Evaluate the methodology against tool capabilities available to the client
  - ▶ Particular focus on tool extensions (UPDM, SysML, SoaML, BPMN)
  - ▶ Leverage “best of breed” architecture methodologies
- ▶ Provide tooling to support the methodology

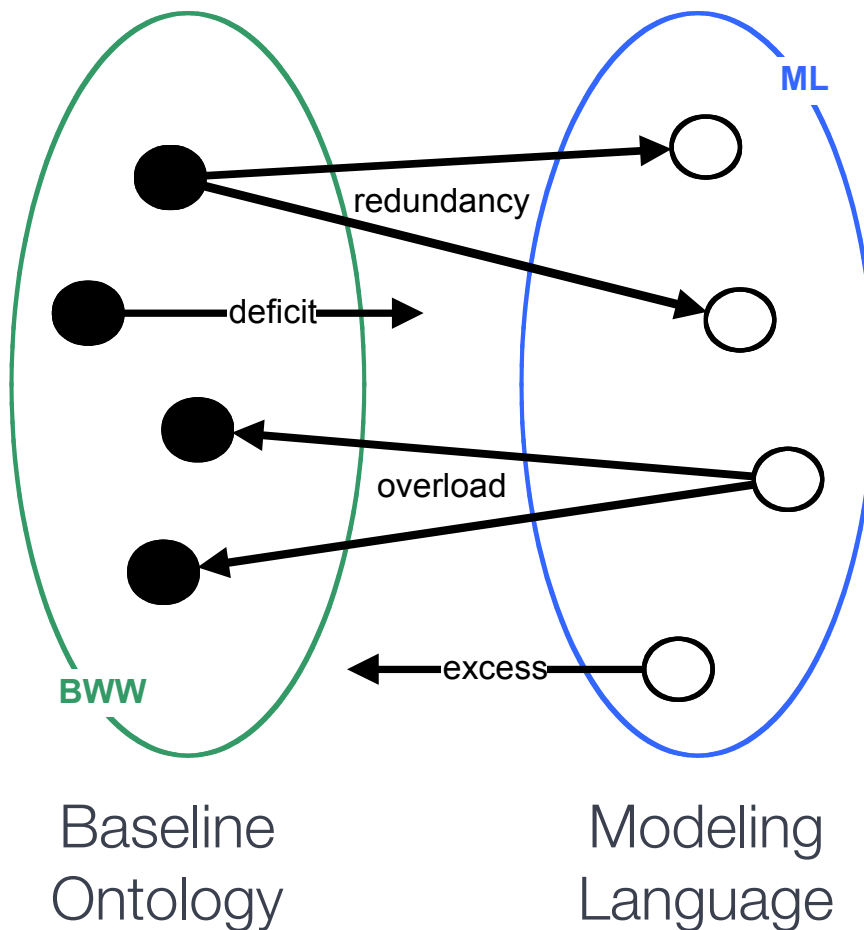
# DoDAF 2.0



# How Good is a Language?



# Benchmarking a Language



---

Key	
BWW	Set of constructs described in the <i>BWW</i> model
ML	Set of constructs comprising the <i>Modelling Language</i>
●	Construct described in the BWW model
○	Modelling language construct

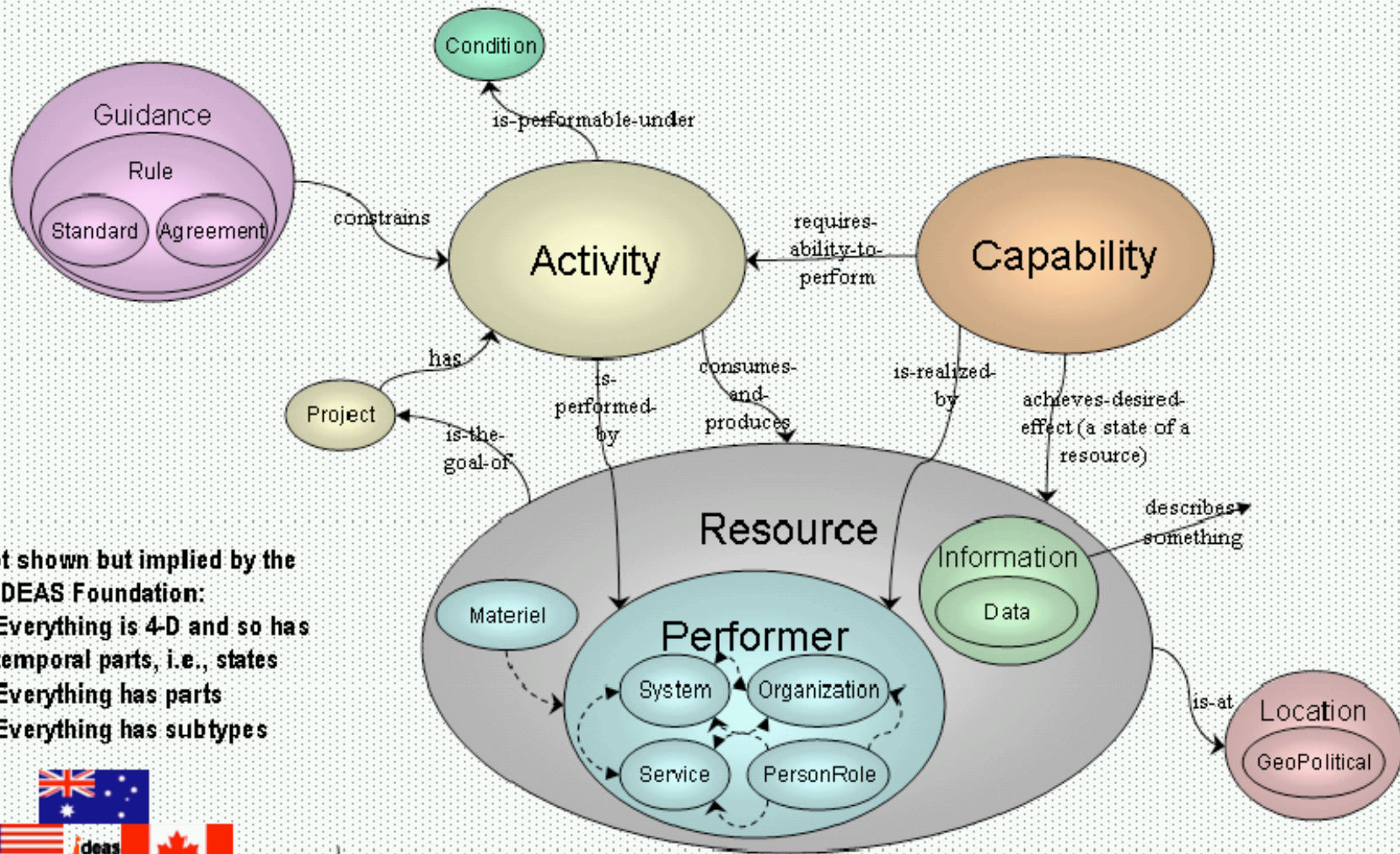
---

# Mapping Options

- ▶ Modeling Language (i.e. Diagram Type) to DoDAF View
  - ▶ Coarse-grained
  - ▶ Good for initial assessment
- ▶ Modeling Language Construct to DoDAF 2.0 MetaModel Entry
  - ▶ Fine-grained
  - ▶ May help in tailoring language



# DM2 Concepts



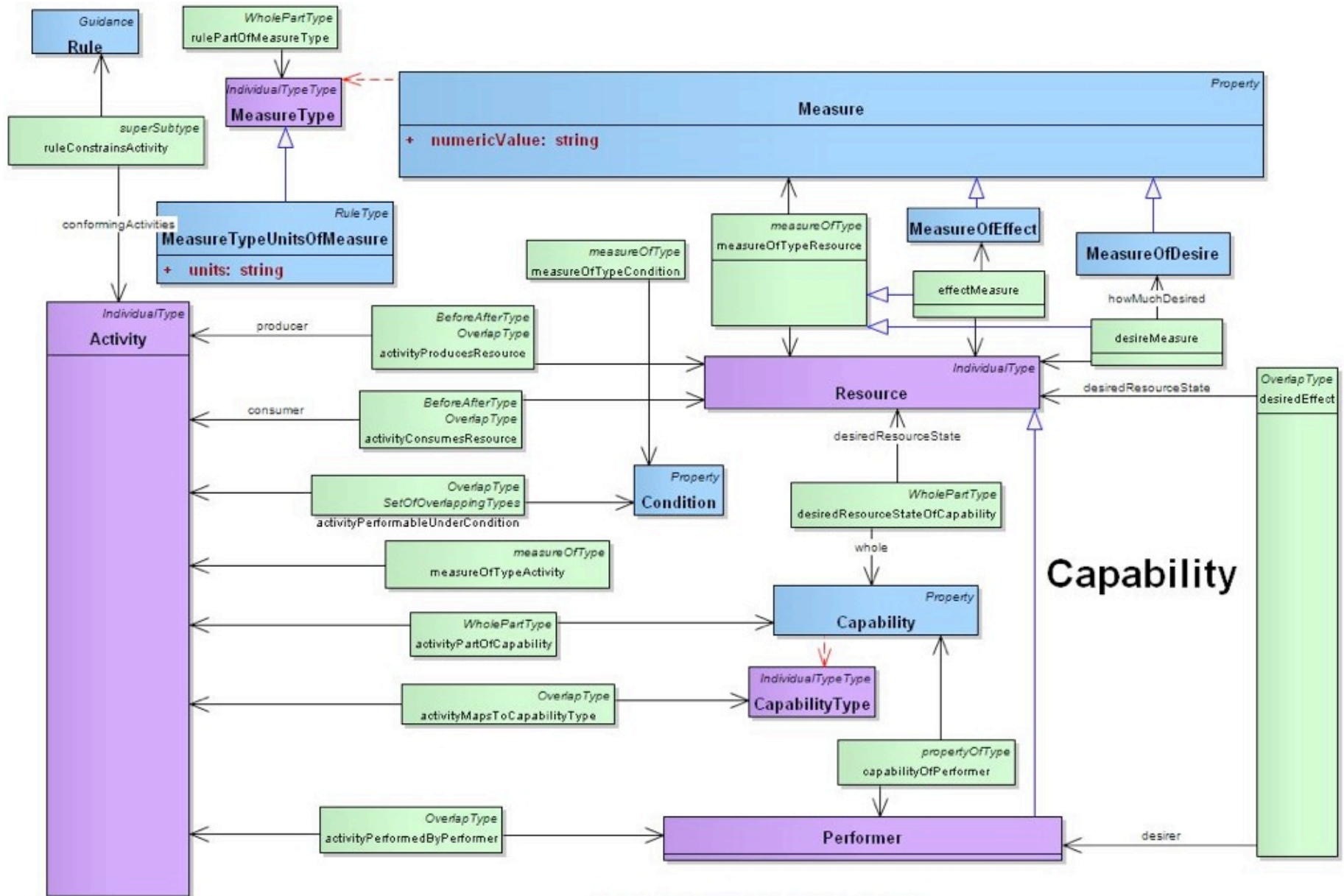
- Not shown but implied by the IDEAS Foundation:
- Everything is 4-D and so has temporal parts, i.e., states
  - Everything has parts
  - Everything has subtypes



*is-part-of*

*anything can have Measures*

# Example: DoDAF 2.0 Capability



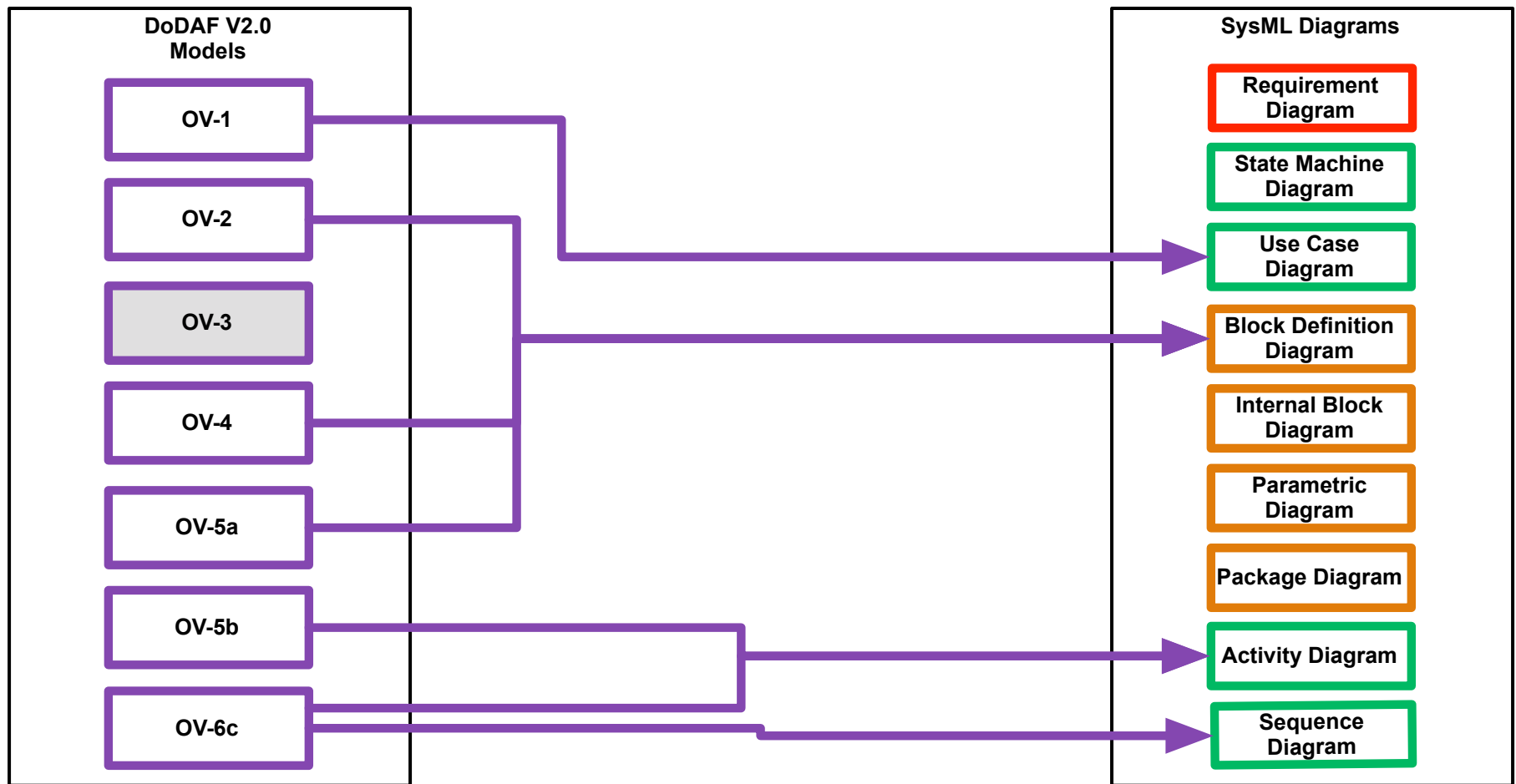
# Example: BPMN

BPMN  
MetaModel

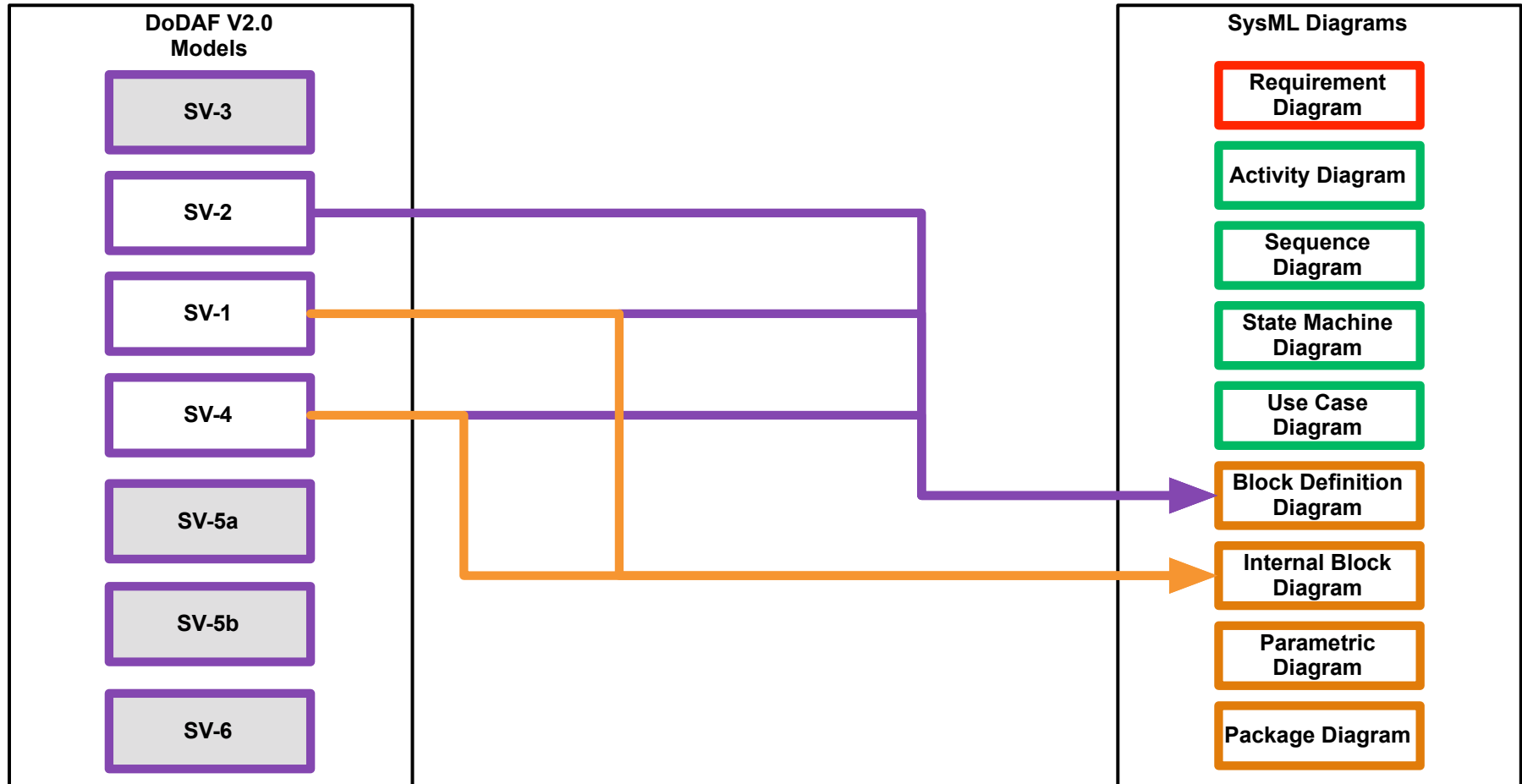
DoDAF 2.0  
MetaModel

	Accurate Mappings	Interpretative Mappings	Process	Business Process Diagram	Connecting Objects							Flow Objects					Activity	Task	Sub-Process (Collapsed)	Sub-Process (Expanded)	Ad-hoc Subprocess	Loop	Multiple Instance		
					Connecting Object	Normal Flow	Default Flow	Conditional Flow	Exception Flow	Message Flow	Association	Compensation Association	Flow Object	Sequence Flow Source	Sequence Flow Target	Message Flow Source								Message Flow Target	Association Source
<b>Accurate Mappings</b>	0	1	0	1	1	1	1	1	2	1	0	0	2	2	2	2	0	0	1	1	1	1	1	1	1
<b>Interpretative Mappings</b>	0	0	0	0	0	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Inherited Mapping</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Activity	1	0																	▲	▼	▼	▼	▼	▼	▼
ActivityChangesEffectObject	0	1								■															
ActivityConditionOverlap	0	0																							
ActivityPartOfCapability	0	0																							
ActivityPerformedByPerformer	0	0																							
ActivityPerformerOverlap	0	0																							
ActivityResourceOverlap	9	1				▲	▲	▲	▲	▲	■		▲	▲	▲	▲									
ActivityResourceOverlapOverlappingPartOfResource	0	0																							
Address	0	0																							
Agreement	0	0																							
ArchitectureOverviewAndPurpose	0	0																							
Capability	0	0																							
Condition	0	0																							
Constraint	0	0																							
ConsumingPartOfActivity	3	1																							
Data	1	1																							
DataAssociation	1	0																							
DataPartOfInformation	0	0																							
DescribedBy	0	0																							
DesiredEffect	0	0																							
DesiredEffectDirectsActivity	0	0																							
DomainInformation	0	0																							
EffectObject	2	1																							

# Mapping SysML to DoDAF 2.0



# Mapping SysML to DoDAF 2.0





# Understanding JCIDS

Document	Supportability Compliance	DOD Enterprise Architecture Products (IAW DODAF) (see Note 5)															Data/Service Exposure Sheets	IA Compliance	GTG Compliance		
		AV-1 /AV-2	OV-1	OV-2	OV-3	OV-4	OV-5	OV-6C	OV-7	SV-1	SV-2	SV-4	SV-5	SV-6	SV-11	TV-1				TV-2	
ICD			X																		
CDD	X	3	X	X	X	X	X	X			X	X	X	X		2	2	1	X	X	
CPD	X	3	X	X	X	X	X	X	1		X	X	X	X	1	2	2	1	X	X	
ISP	X	3	X	X	X	X	X	X	4		X	X	X	X	4	2	2	1	X	X	
TISP	X	3	X		X		X	X		X			X	X		2	2	1	X	X	
ISP Annex (Svcs/ Apps)	X	3	X				X				X	X	X	X		2	2	1	X	X	
X		Required (PM needs to check with their Component for any additional architectural/regulatory requirements for CDDs, CPDs, ISPs/TISPs. (e.g., HQDA requires the SV-10c)																			
Note 1		Required only when IT and NSS collects, processes, or uses any shared data or when IT and NSS exposes, consumes or implements shared services,																			
Note 2		The TV-1 and TV-2 are built using the DISRonline and must be posted for compliance.																			
Note 3		The AV-1 must be uploaded onto DARS and must be registered in DARS for compliance																			
Note 4		Only required for Milestone C, if applicable (see Note 1)																			
Note 5		The naming of the architecture views is expected to change with the release of DODAF v2.0 (e.g., StdV, SvcV, StdV, DIV). The requirements of this matrix will not change.																			

Table E-1. NR-KPP Products Matrix

DoDAF 2.0 Product	Initial Capability Document (ICD)	Capability Development Document (CDD)	Capability Production Document (CPD)
OV-1 (Concept of Operations)	X	X	X
AV-1 (Project Overview)		X	X
AV-2 (Integrated Dictionary)		X	X
OV-2 (Operational Resource Flow Description)		X	X
OV-3 (Operational Resource Flow Matrix)		X	X
OV-4 (Organizational Relationship Chart)		X	X
OV-5a (Operational Activity Decomposition Tree)		X	X
OV-5b (Operational Activity Model)		X	X
OV-6c (Event-Trace Description)		X	X
SV-2 (Systems Resource Flow Description)		X	X
SV-4 (Systems Functionality Description)		X	X
SV-5a (Operational Activity to Systems Function Matrix)		X	X
SV-5b (Operational Activity to Systems Matrix)		X	X
SV-6 (Systems Resource Flow Matrix)		X	X
StdV-1 (Standards Profile)		X	X
StdV-2 (Standards Forecast)		X	X
DIV-2 (Conceptual Data Model)			X
DIV-3 (Conceptual Data Model)			X

DoDAF 2.0 Product	Initial Capability Document	Capability Development Document (CDD)	Capability Production Document (CPD)
OV-1 (Concept of Operations)		X	X
AV-1 (Project Overview)		X	X
AV-2 (Integrated Dictionary)		X	X
OV-2 (Operational Resource Flow Description)		X	X
OV-3 (Operational Resource Flow Matrix)		X	X
OV-4 (Organizational Relationship Chart)		X	X
OV-5a (Operational Activity Decomposition Tree)		X	X
OV-5b (Operational Activity Model)		X	X
OV-6c (Event-Trace Description)		X	X
SV-2 (Systems Resource Flow Description)		X	X
SV-4 (Systems Functionality Description)		X	X
SV-5a (Operational Activity to Systems Function Matrix)		X	X
SV-5b (Operational Activity to Systems Matrix)		X	X
SV-6 (Systems Resource Flow Matrix)		X	X
StdV-1 (Standards Profile)		X	X
StdV-2 (Standards Forecast)		X	X
DIV-2 (Conceptual Data Model)			X
DIV-3 (Conceptual Data Model)			X

**Need Org Structure**

OV-2 (Operational Resource Flow Description)  
 OV-3 (Operational Resource Flow Matrix)  
 OV-4 (Organizational Relationship Chart)



DoDAF 2.0 Product	Initial Capability Document	Capability Development Document (CDD)	Capability Production Document (CPD)
OV-1 (Concept of Operations)		X	X
AV-1 (Project Overview)		X	X
AV-2 (Integrated Dictionary)		X	X
OV-2 (Operational Resource Flow Description)		X	X
OV-3 (Operational Resource Flow Matrix)		X	X
OV-4 (Organizational Relationship Chart)		X	X
OV-5a (Operational Activity Decomposition Tree)		X	X
OV-5b (Operational Activity Model)		X	X
OV-6c (Event-Trace Description)		X	X
SV-2 (Systems Resource Flow Description)			X
SV-4 (Systems Functionality Description)		X	X
SV-5a (Operational Activity to Systems Function Matrix)		X	X
SV-5b (Operational Activity to Systems Matrix)		X	X
SV-6 (Systems Resource Flow Matrix)		X	X
StdV-1 (Standards Profile)		X	X
StdV-2 (Standards Forecast)		X	X
DIV-2 (Conceptual Data Model)			X
DIV-3 (Conceptual Data Model)			X

**Need Org Structure**

**All based on Activities**

DoDAF 2.0 Product	Initial Capability Document	Capability Development Document (CDD)	Capability Production Document (CPD)
OV-1 (Concept of Operations)		X	X
AV-1 (Project Overview)		X	X
AV-2 (Integrated Dictionary)		X	X
OV-2 (Operational Resource Flow Description)		X	X
OV-3 (Operational Resource Flow Matrix)		X	X
OV-4 (Organizational Relationship Chart)		X	X
OV-5a (Operational Activity Decomposition Tree)		X	X
OV-5b (Operational Activity Model)		X	X
OV-6c (Event-Trace Description)		X	X
SV-2 (Systems Resource Flow Description)		X	X
SV-4 (Systems Functionality Description)		X	X
SV-5a (Operational Activity to Systems Function Matrix)		X	X
SV-5b (Operational Activity to Systems Matrix)		X	X
SV-6 (Systems Resource Flow Matrix)		X	X
StdV-1 (Standards Profile)		X	X
StdV-2 (Standards Forecast)		X	X
DIV-2 (Conceptual Data Model)		X	X
DIV-3 (Conceptual Data Model)		X	X

**Need Org Structure**

OV-2 (Operational Resource Flow Description)  
 OV-3 (Operational Resource Flow Matrix)  
 OV-4 (Organizational Relationship Chart)  
 OV-5a (Operational Activity Decomposition Tree)  
 OV-5b (Operational Activity Model)  
 OV-6c (Event-Trace Description)

**All based on Activities**

SV-2 (Systems Resource Flow Description)  
 SV-4 (Systems Functionality Description)  
 SV-5a (Operational Activity to Systems Function Matrix)  
 SV-5b (Operational Activity to Systems Matrix)  
 SV-6 (Systems Resource Flow Matrix)

**All derived from OV2 - OV4**

DoDAF 2.0 Product	Initial Capability Document	Capability Development Document (CDD)	Capability Production Document (CPD)
OV-1 (Concept of Operations)		X	X
AV-1 (Project Overview)		X	X
AV-2 (Integrated Dictionary)		X	X
OV-2 (Operational Resource Flow Description)		X	X
OV-3 (Operational Resource Flow Matrix)		X	X
OV-4 (Organizational Relationship Chart)		X	X
OV-5a (Operational Activity Decomposition Tree)		X	X
OV-5b (Operational Activity Model)		X	X
OV-6c (Event-Trace Description)		X	X
SV-2 (Systems Resource Flow Description)		X	X
SV-4 (Systems Functionality Description)		X	X
SV-5a (Operational Activity to Systems Function Matrix)		X	X
SV-5b (Operational Activity to Systems Matrix)		X	X
SV-6 (Systems Resource Flow Matrix)		X	X
StdV-1 (Standards Profile)		X	X
StdV-2 (Standards Forecast)		X	X
DIV-2 (Conceptual Data Model)		X	X
DIV-3 (Conceptual Data Model)		X	X

**Need Org Structure**

**All based on Activities**

**All derived from OV2 - OV4**

**Useful, but not required**



# Modeling & Simulation

## Basic Process

- |           |          |
|-----------|----------|
|           |          |
| Create    | Dispose  |
|           |          |
| Process   | Decide   |
|           |          |
| Batch     | Separate |
|           |          |
| Assign    | Record   |
|           |          |
| Attribute | Entity   |
|           |          |
| Queue     | Resource |
|           |          |
| Variable  | Schedule |
|           |          |
| Set       |          |

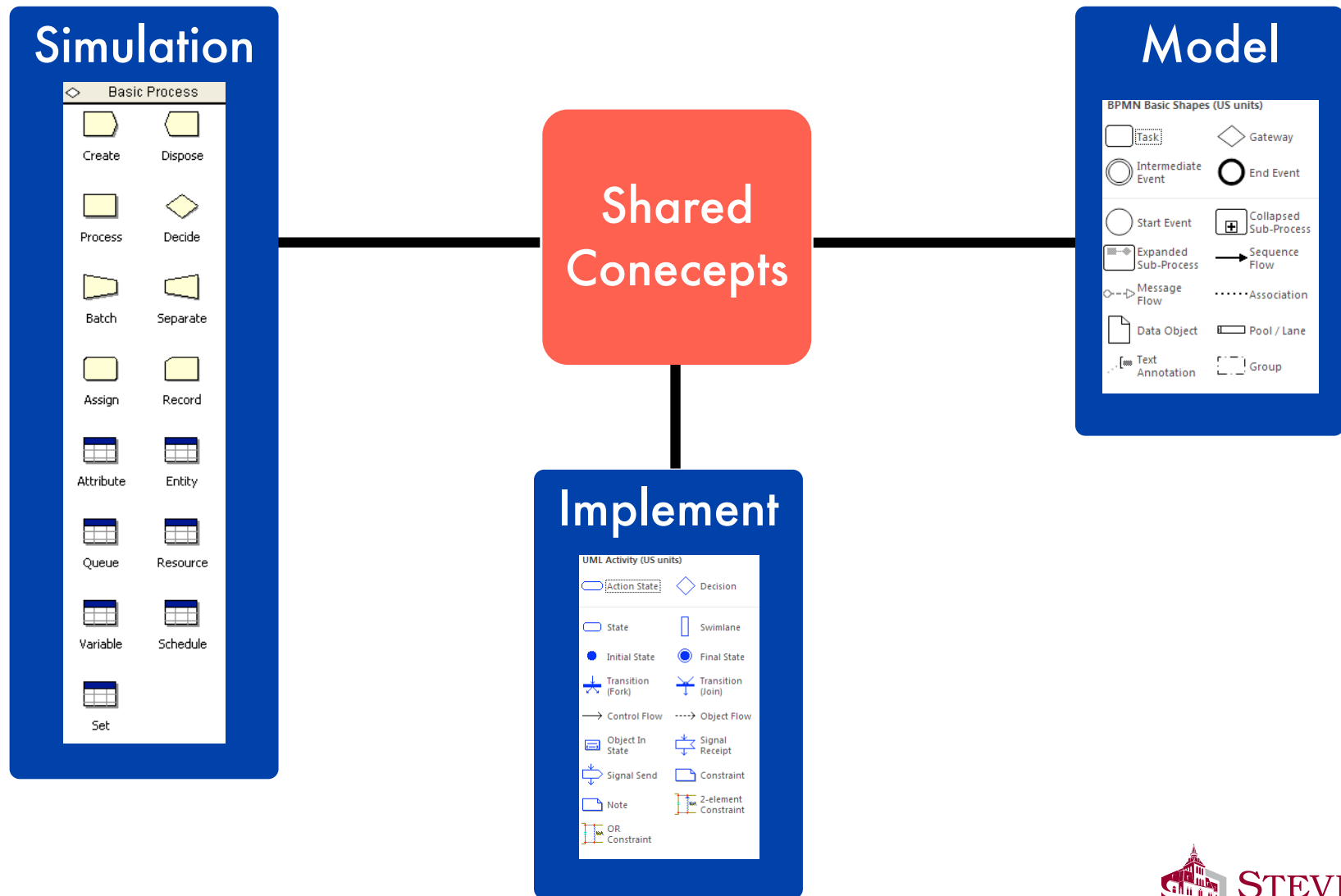
## UML Activity (US units)

- |                   |                      |
|-------------------|----------------------|
|                   |                      |
| Action State      | Decision             |
|                   |                      |
| State             | Swimlane             |
|                   |                      |
| Initial State     | Final State          |
|                   |                      |
| Transition (Fork) | Transition (Join)    |
|                   |                      |
| Control Flow      | Object Flow          |
|                   |                      |
| Object In State   | Signal Receipt       |
|                   |                      |
| Signal Send       | Constraint           |
|                   |                      |
| Note              | 2-element Constraint |
|                   |                      |
| OR Constraint     |                      |

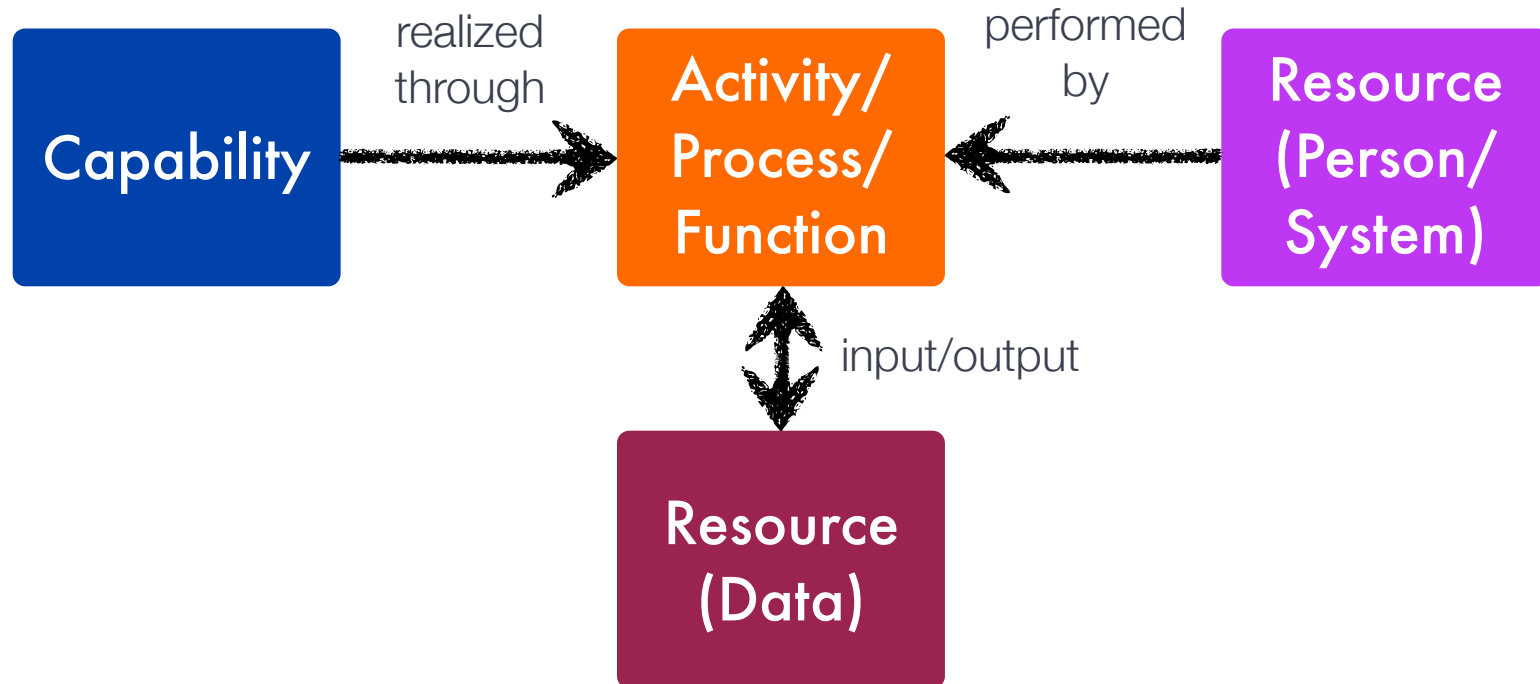
## BPMN Basic Shapes (US units)

- |                      |                       |
|----------------------|-----------------------|
|                      |                       |
| Task                 | Gateway               |
|                      |                       |
| Intermediate Event   | End Event             |
|                      |                       |
| Start Event          | Collapsed Sub-Process |
|                      |                       |
| Expanded Sub-Process | Sequence Flow         |
|                      |                       |
| Message Flow         | Association           |
|                      |                       |
| Data Object          | Pool / Lane           |
|                      |                       |
| Text Annotation      | Group                 |

# Modeling & Simulation



# Core Description



# Big Picture

