

IMPROVING PROJECT MANAGEMENT USING FORMAL MODELS AND ARCHITECTURES

Theodore Kahn

theodore.e.kahn@nasa.gov

Ian Sturken

ian.sturken@nasa.gov

Project Management Challenge

February 9-10, 2011

Making Modeling Work

Problem Statement

2

Project information is stored in various documents, spreadsheets and systems with little consistency and/or formal structure



A lack of common understanding of a project's organizations, roles, objectives, behaviors and constraints .

Agenda

3

- ❑! Problem statement, objectives, agenda
- ❑! Theory of:
 - ❑! Enterprise and Business Architecture
 - ❑! Formal modeling
- ❑! Applying EA and Modeling to Project Management
- ❑! Case studies:
 - ❑! Ares development
 - ❑! Ames process modeling
 - ❑! MODEAR
 - ❑! Flight Readiness System
- ❑! **Making Modeling Work for You Today**
- ❑! Future Trends and Closing Remarks
- ❑! Q&A

Four Modeling Perspectives

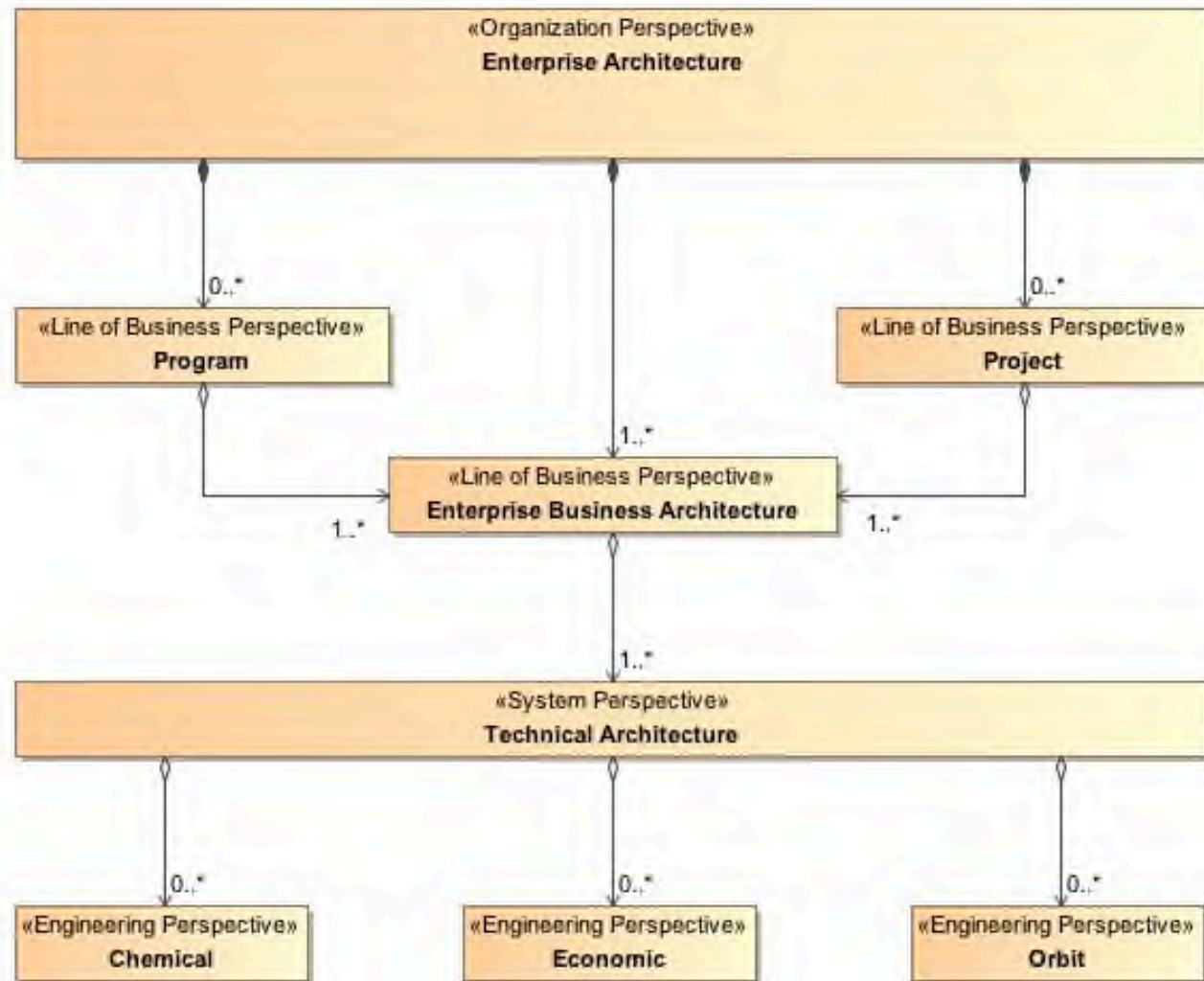
4

1

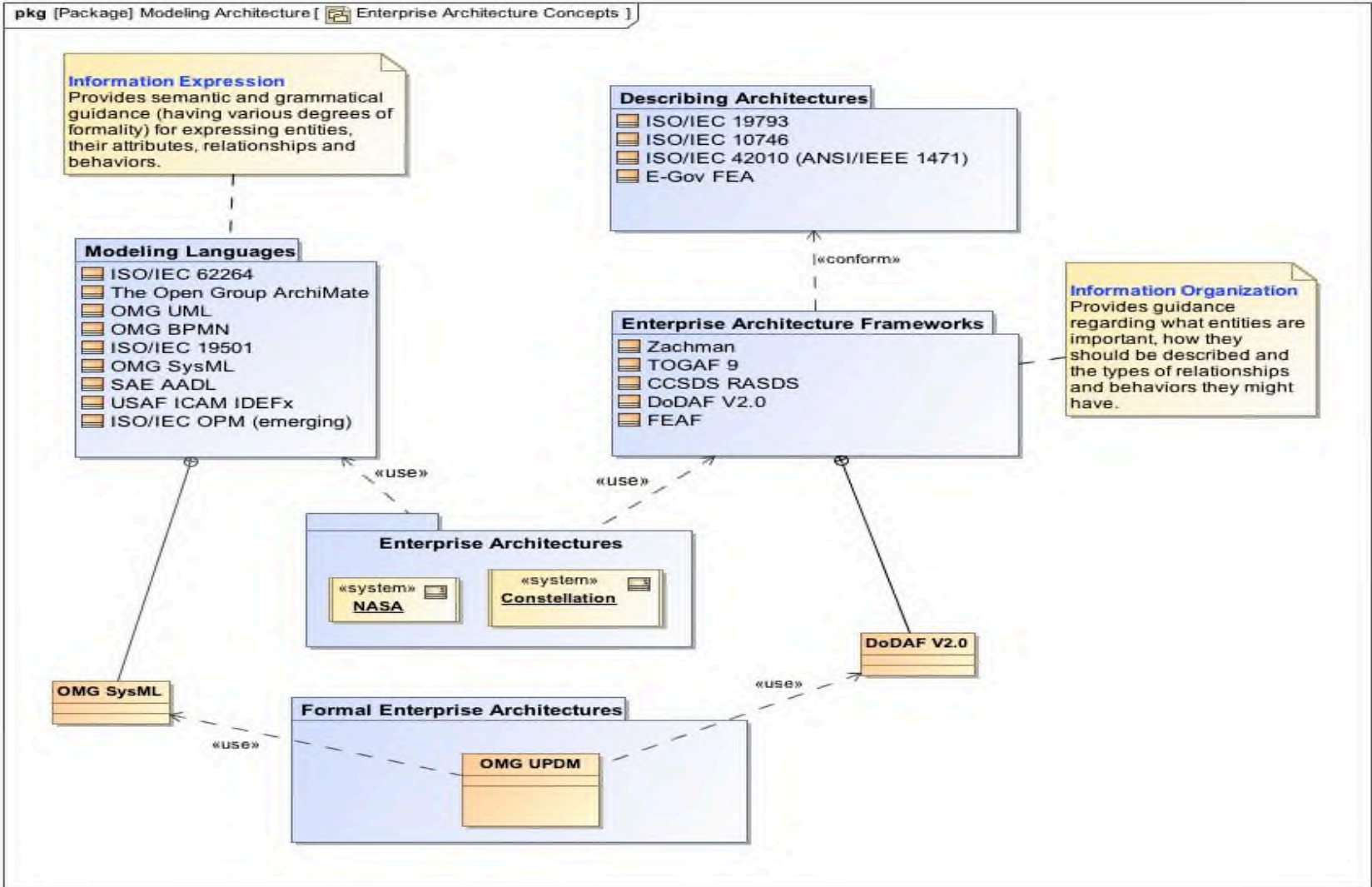
2

3

4



SE Standards, Languages, AFs



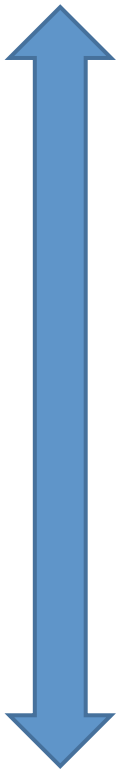
6

Enterprise Architecture

What is the Scope of an Enterprise Architecture?

7

Most
Restrictive



Most
Expansive

Several ideas are in common use:

- !An accounting of an organization's **IT artifacts** and their application to lines of business. (**Lists** of **IT** things.)
- !The relationships and behaviors of an organization's **IT artifacts** and their application to lines of business. (**Lists and Life-cycle** of **IT** things.)
- !An accounting of an organization's **meaningful artifacts** and their application to lines of business. (**Lists** of **"all"** things.)
- !The relationships and behaviors of an organization's **meaningful artifacts** and their application to lines of business. (**Lists and Life-cycle** of **"all"** things.)

FEA and DoDAF EA Definition

8

- A strategic information asset base,
- which **defines the mission**,
- the information necessary to perform the mission,
- the technologies necessary to perform the mission, and
- the transitional processes for implementing new technologies in response to changing mission needs.
- EA includes a baseline architecture, a target architecture, and a sequencing plan.

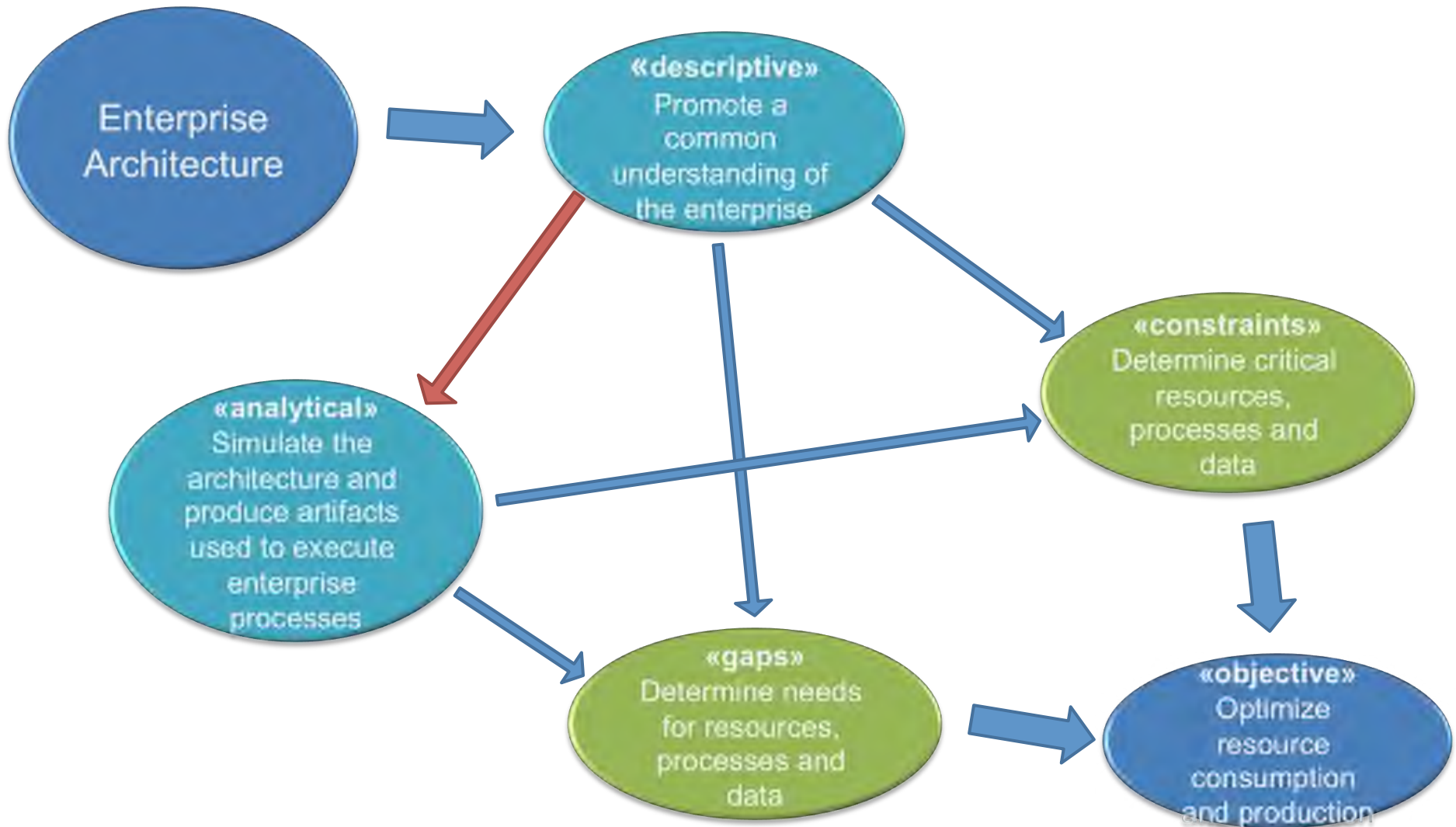
How did we use an Enterprise Architecture?

9

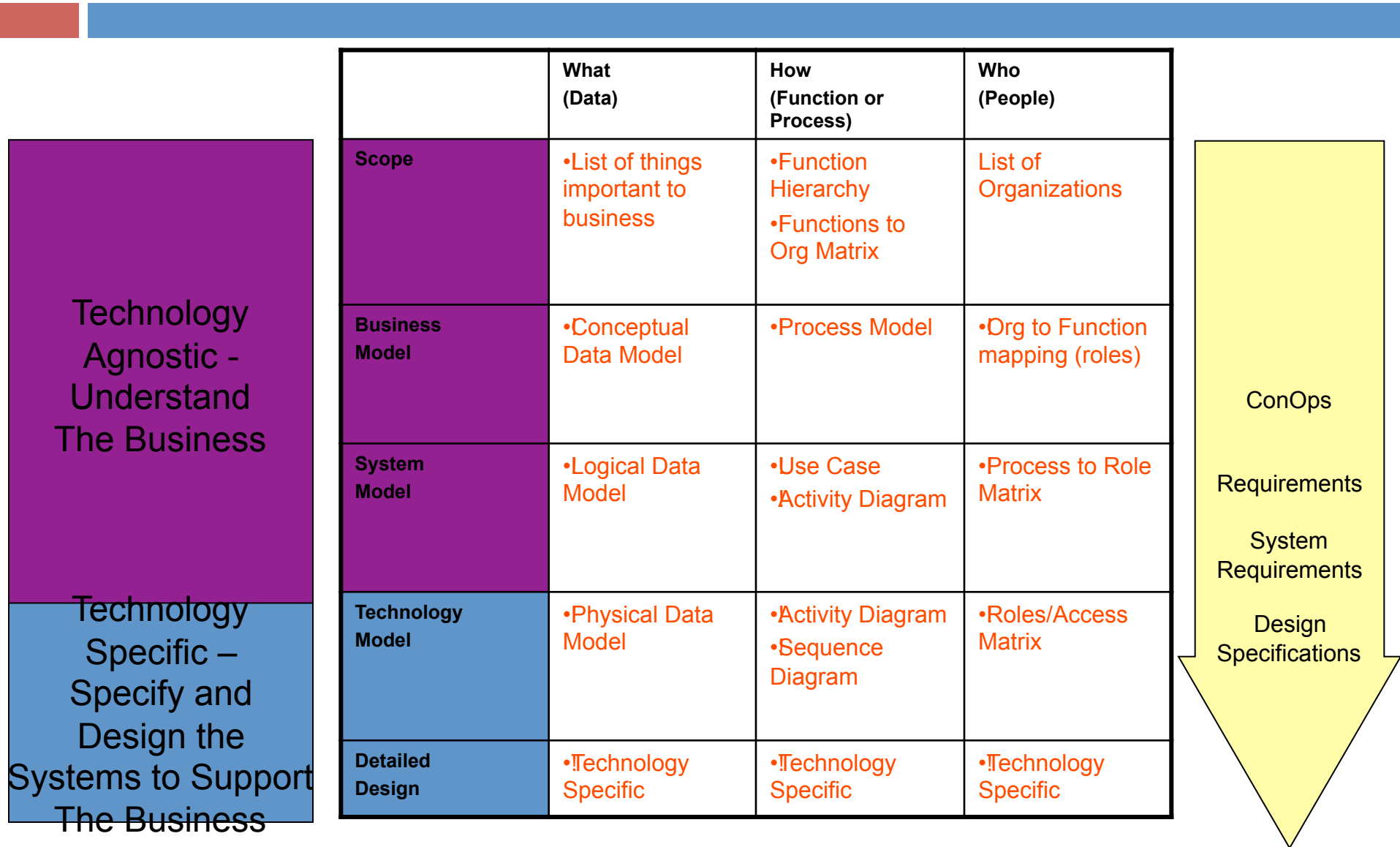
- ❑! To organize the information about our processes, products, people and systems
- ❑! To relate these entities to one another
- ❑! To provide different diagrams and reports of the information suitable to each of the stakeholders in the project
- ❑! To export information to other tools for analysis and simulations

Benefits of Enterprise Architecture

10

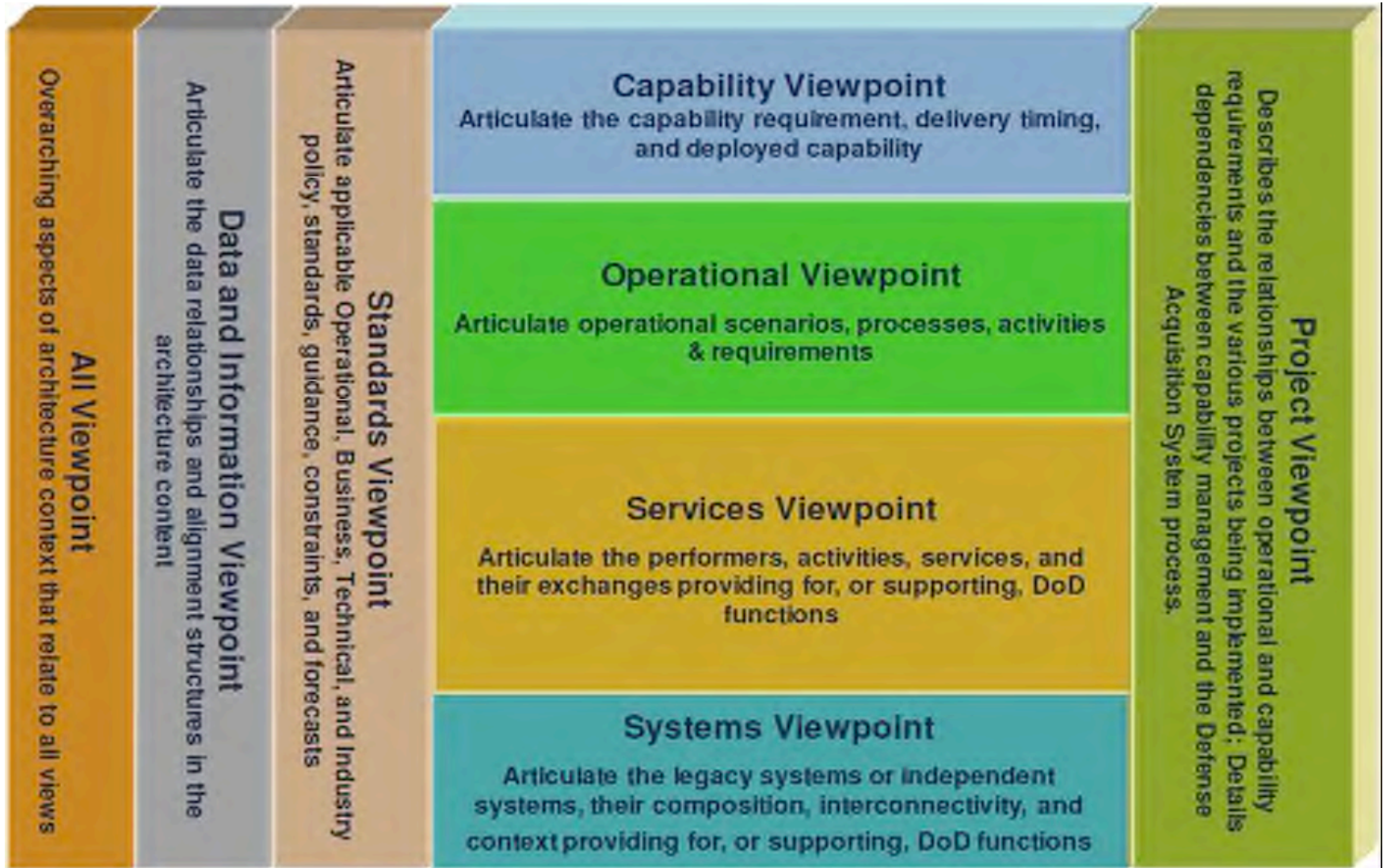


Zachman Framework



DoDAF 2.0 Framework

12



Which EAF do I Use?

13

▪ **Zachman**

- Easier to grasp and get started with. Can start with lists of “things” and start relating these to other parts of the business
- Hierarchical in nature, provides good mechanism for abstracting levels of detail from executive to engineer
- More IT centric

▪ **DoDAF**

- More prescriptive in nature – specific products to fill different purposes
- Separate different viewpoints – business processes from systems that support them
- Supported by many tools
- Has a modeling language specifically designed for it: UPDM
- General purpose

▪ **Create your own**

- If you don't use a standard framework – you will create your own mechanisms for organizing and relating information in your models!

Use Standard Architecture Framework, Model or Both?

14

- ❑! Architecture Frameworks:
 - ❑! Can range from simple (lists) to complex
 - ❑! Useful for providing an outline of what information to gather and how to organize that information
 - ❑! Can customize this outline to fit your needs
 - ❑! Can be used to compare different systems from different vendors
 - ❑! Can be used to study “as-is” states to “to-be” states
 - ❑! Can leverage modeling languages such as UML, SysML, and Archimate
- ❑! Modeling Standards
 - ❑! Can range from simple to complex
 - ❑! Quick to build a few diagrams
 - ❑! For larger projects will need to organize model
 - ❑! Formal language/annotations used
- ❑! Both
 - ❑! Provides guidance on what modeling artifacts you will need and how to organize them according to a standard framework

15

Modeling

Models, Formal Models and SysML

What is a Model?

16

An Abstraction of the Physical World Around Us

- !An electrical schematic of a radio
- !An economic model
- !A mathematical model
- !A model student
- !A non working model airplane
- !A written description of a pencil
- !A diagram
- !A spreadsheet
- !Music
- !Art
- !Natural languages

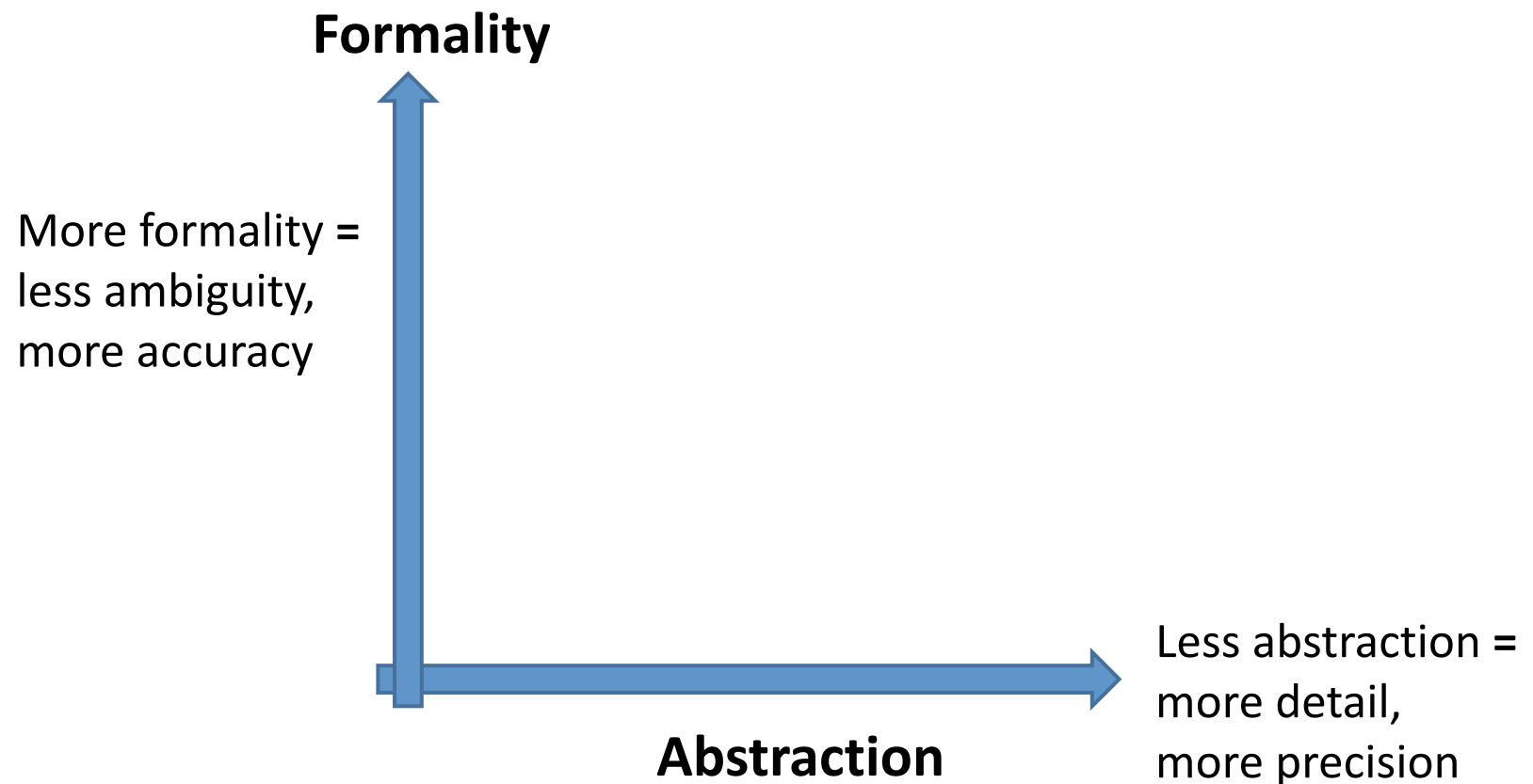
Sample of Modeling Languages

17

Language	Purpose
IDEF1x	Business
UML	Software
BPN	Software
AADL	Hardware, software, realtime (avionics, aerospace, automotive, and robotics).
Simulink	Simulation and analysis of multidomain dynamic systems
Archimate	Business
SysML	Systems of systems

Modeling Language Attributes

18



Abstraction Levels

19

La Joconde



Femme au Chapeau Orné



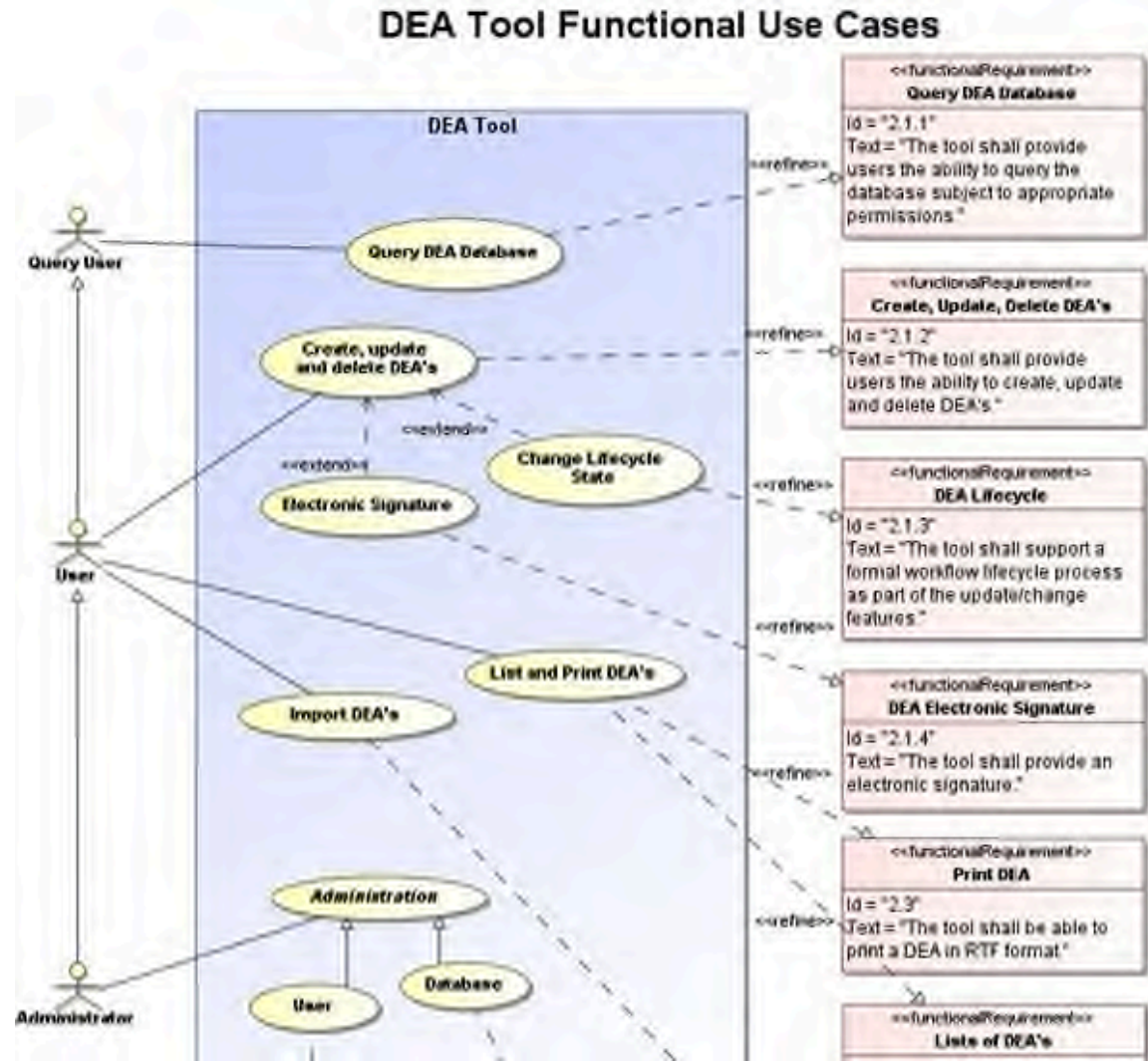
What is a Formal Model?

20

The degree to which the model adheres to:

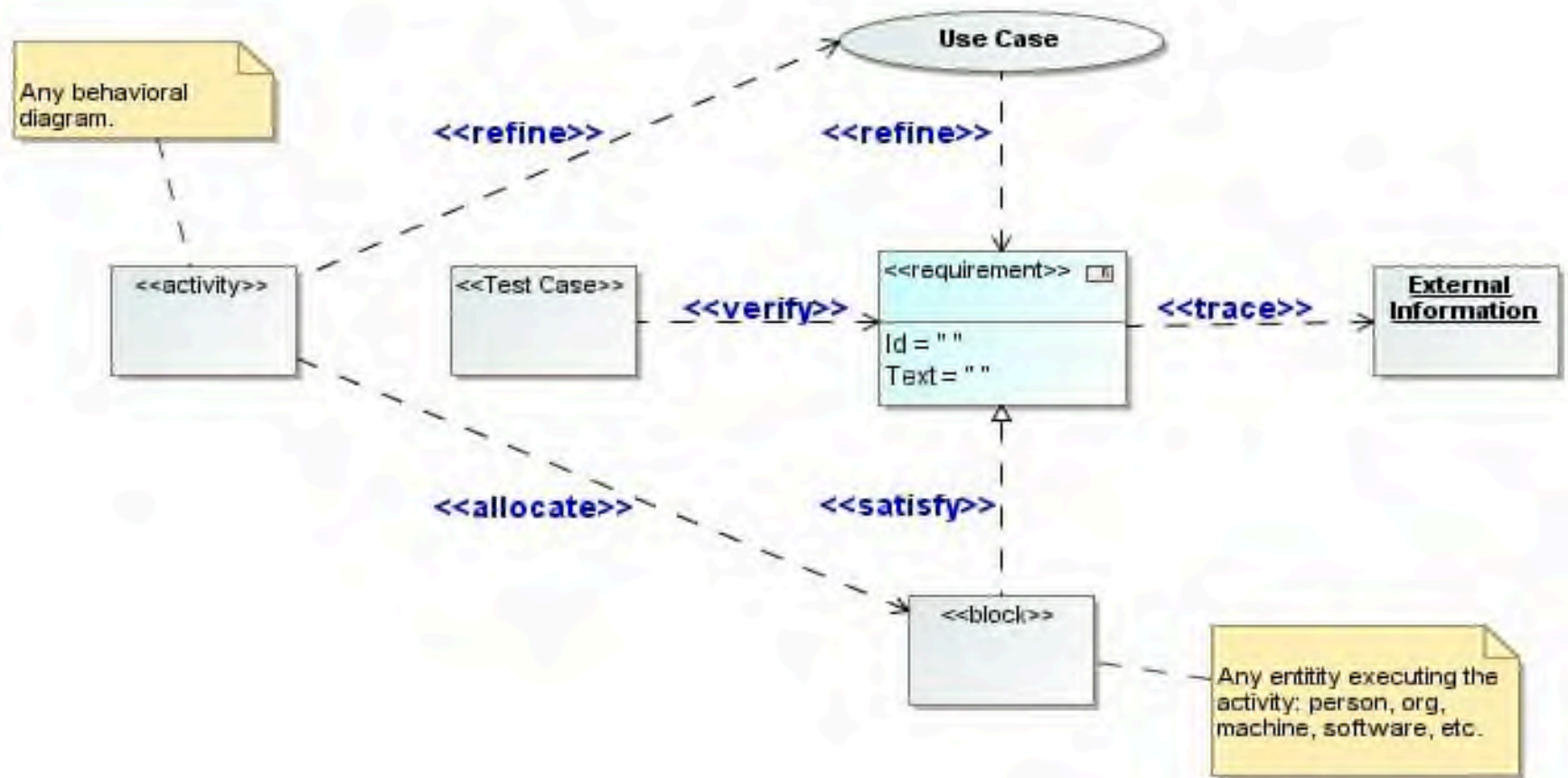
- !Well defined **semantics**: model components have precise interpretations.
- !Well defined **grammar**: model components can only be related using precise structural rules.

SysML Semantics

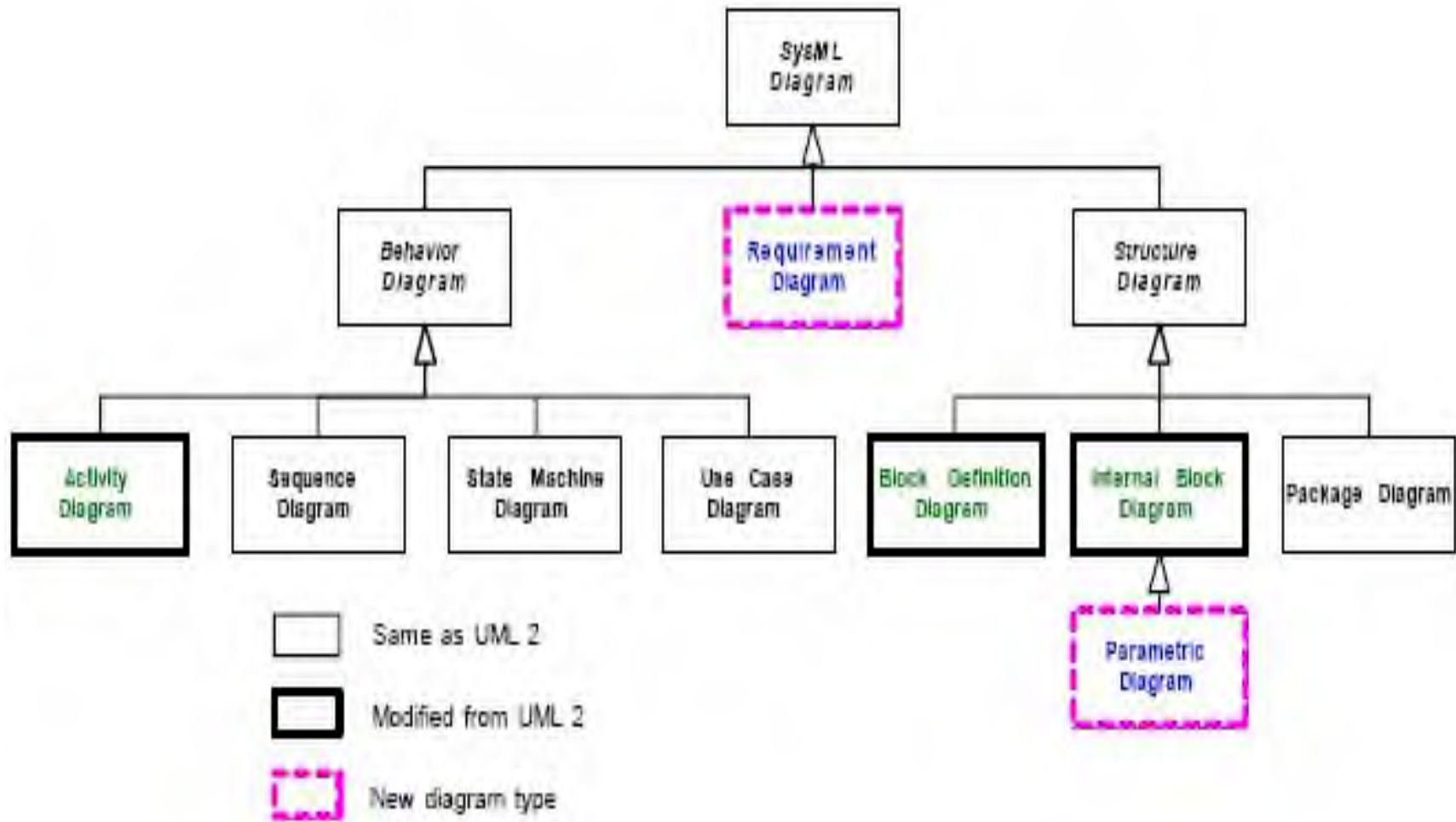


SysML Requirements Relationships

SysML Requirements Dependency Relationships



SysML Diagram Taxonomy



24

Applying EA & Modeling to PM

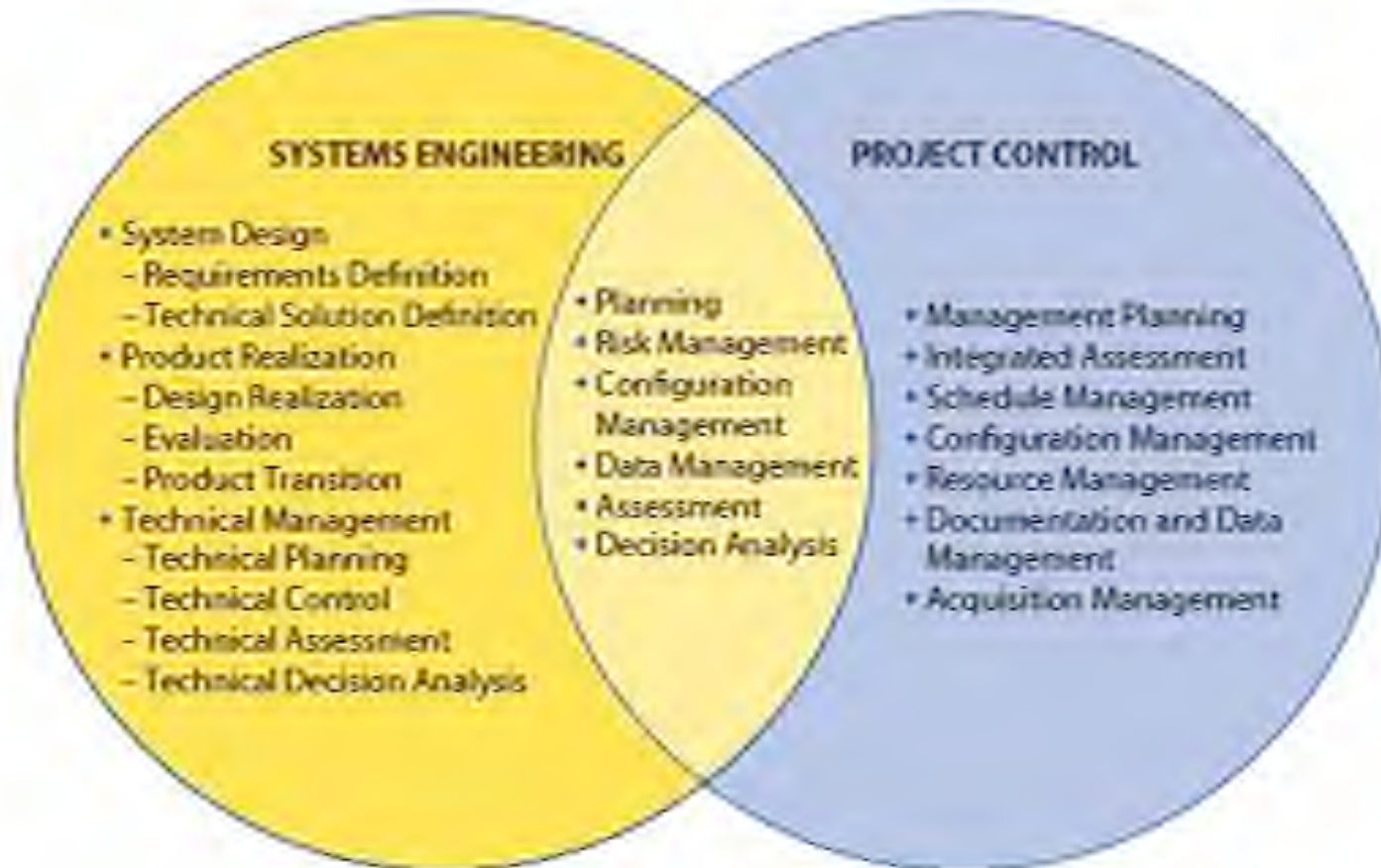
Modeling and PM

25

- ❑! Projects are now modeled using spreadsheets, diagrams and documents to represent different parts (components) of the project.
- ❑! A formal model does not change this. Instead, your project components must now be represented using formal grammar and semantics. And, if you are using a standardized framework, your project follows a well known architecture.

System Engineering and Project Management

26



From NASA System Engineering Handbook - NASA/SP-2007-6105

Review Entrance Criteria

(NASA Systems Engineering Handbook)

27

Milestone	Artifacts
System Concept Review	System Goals And Objectives
	Concept of Operations
System Requirements Review	System Requirements
	System Functionality Description
	Concept of Operations
Preliminary Design Review	Preliminary System Requirements
	Preliminary subsystem design Specs
	Operational Concept
	Interface Control Documents
	Requirements Traceability Matrix

These can all be described in one model!

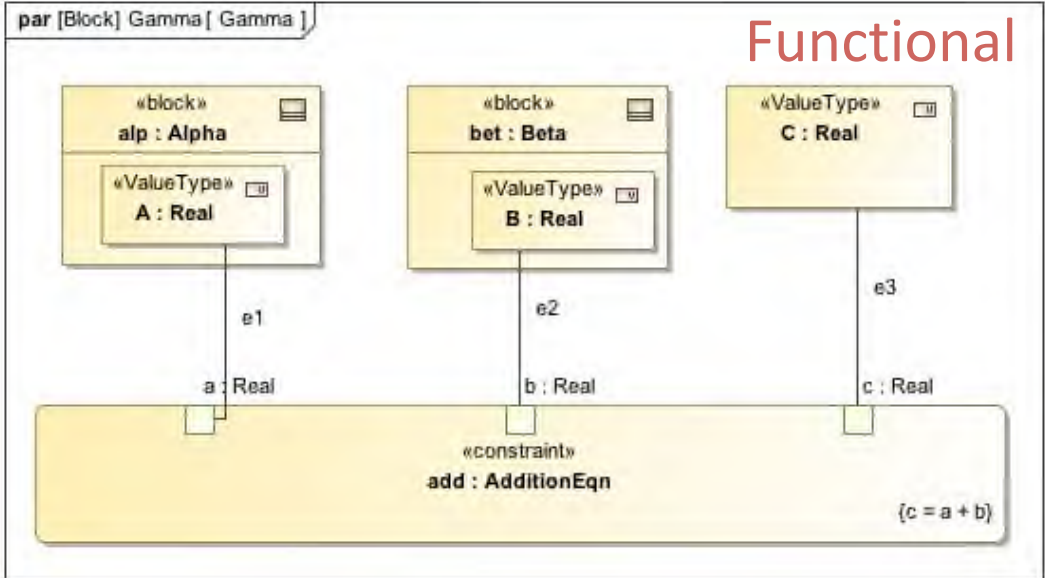
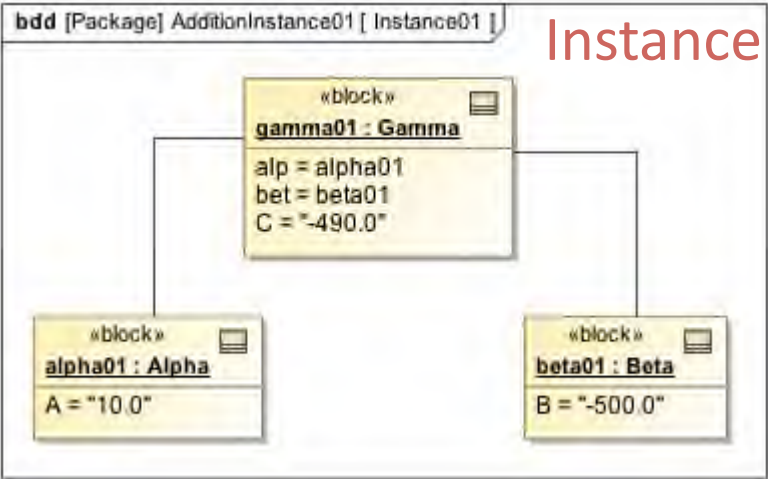
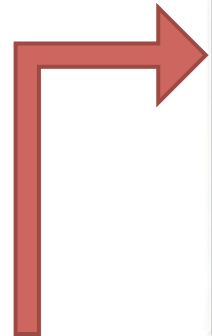
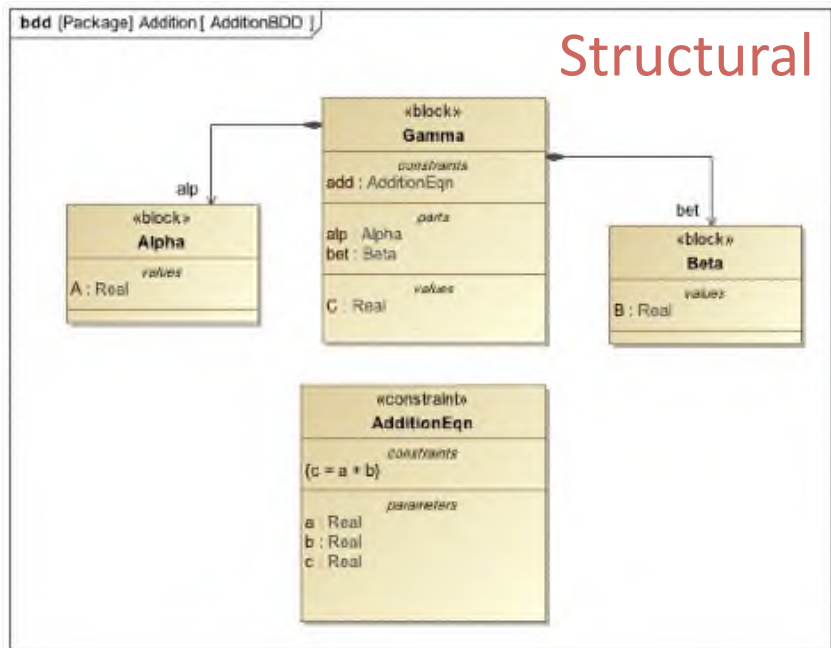
Building ConOps from Model

28

Conops Section	DoDAF product	SYSML Model
Scenarios	OV-5 Activity Diagram	Use Case Diagram, Activity Diagram
Conceptual Overview	OV-1 High Level Concept	Block Definition Diagram
Event sequence	OV-6c	Sequence Diagram
Connectivity Architecture	OV-2 Node Connectivity Diagram, OV-3 Information Exchanges, SV-1 System Interface, SV-2 System Communication	Block Definition Diagram
Glossary	AV-2 Integrated Dictionary	Block Definition Diagram

Technical Decision Analysis

(Trade Analyses)



Formal Modeling and Six Sigma

(Complementary Technologies.)

30

	Six Sigma	Formal Models	Both Together
Methodology	Yes	No	Yes
Formal Data Semantics & Grammar	No	Yes	Yes
Data Persistence	No	Yes	Yes

31

Case Studies


MOD Flight Production Process Re-engineering

32


- ❑ Goal: MOD needs to transform into an agile organization to be able to quickly meet needs and opportunities that arise in the next decade.
- ❑ Challenge: Currently, most information about how we conduct business is housed in different documents, spreadsheets, systems and other repositories. It is difficult to gain a comprehensive, integrated, common view of the way we conduct business and what the impact of changes are on our people, processes and systems.
- ❑ Approach: An enterprise architecture provides a framework that will allow us to organize information about our people, processes and systems in an organized, structured and integrated manner.
- ❑ Benefits: An organization that can quickly assess the impact of external events saving \$\$\$\$ and reducing risk.

MOD EA Repository

33



MODEAR



Op Nodes	Products	Info Exchanges	Functions	Op Activities	Processes	Exchanges	Tools	Edit	Export	History
----------	----------	----------------	-----------	---------------	------------------	-----------	-------	------	--------	---------

Browse Process Instances

Filter Number/OpNode/Title: [Clear filter](#)

Op Node	Number	Process Instance Title
DA6	2.4.2.1	Integrate Flight Software Development and Issues Resolution - Flight Design Post MRD Instance
DA6	2.4.2.2	Integrate Flight Software Development and Issues Resolution - Flight Design Uplink Instance
DA6	2.4.2.3	Integrate Flight Software Development and Issues Resolution - Flight Design DOLLU Instance
DA6	2.4.3.1	Provide Flight Software Change Coordination - Instance 1

Source Process Instances (and exchanged products)

[4.2.1.2_52_1 - Update Trajectory and I-Load Design Instance - Step 2](#)
--> [Flight Design Flight Software Discrepancy Report \(DM\)](#)

Selected Process Instance

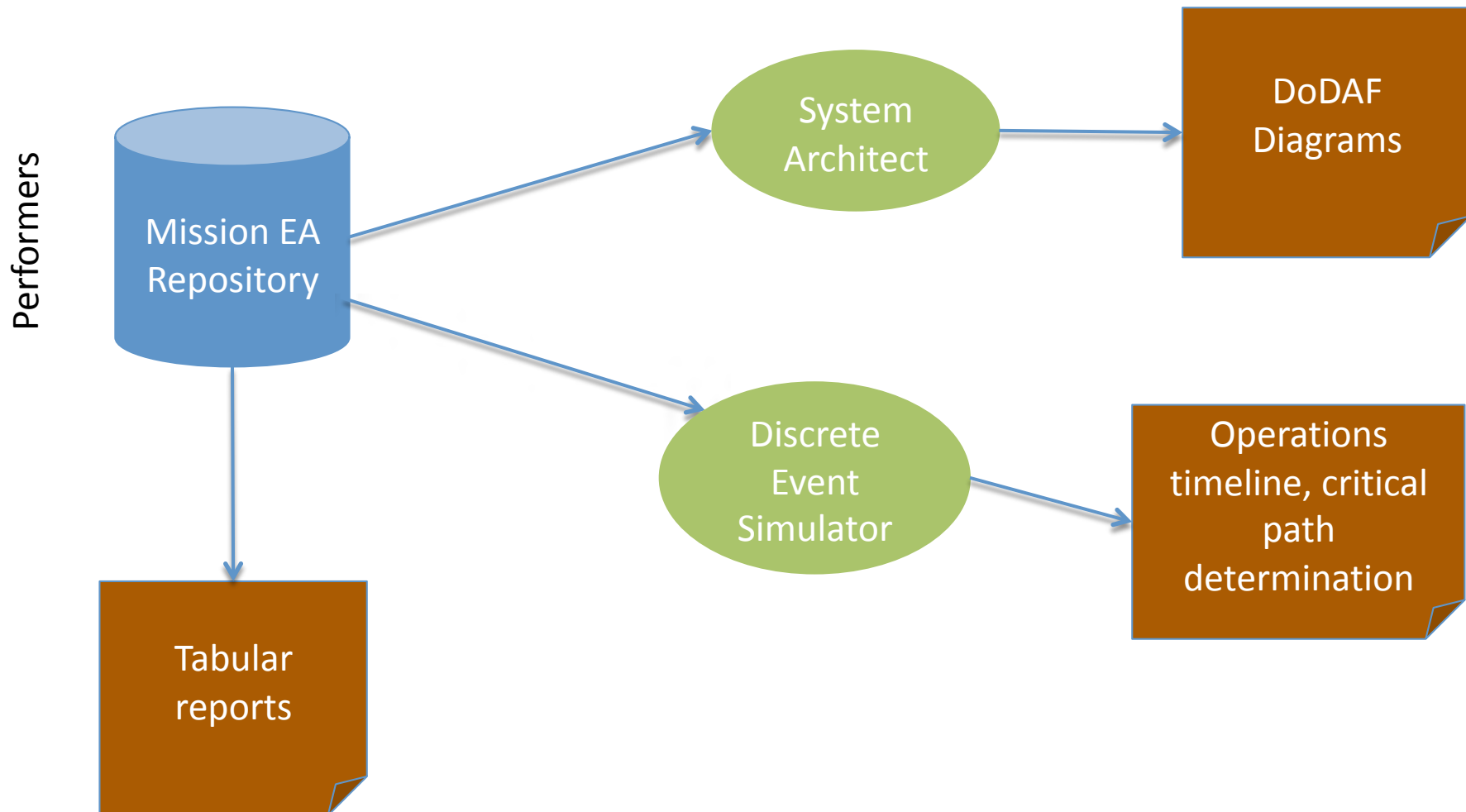
2.4.2.2 - Integrate Flight Software Development and Issues Resolution - Flight Design Uplink Instance
Function: 2.4.2 - [Integrate Flight Software Development and Issues Resolution](#)
Operational Node: DA6 - [Technical Integration and Production Control Office](#)
Description:

Recipient Process Instances (and exchanged products)

[4.2.1.3_51_1 - Generate Day-of-Launch I-Load Update Instance - Step 1](#)
--> [Flight Design Flight Software Discrepancy Resolution Report \(DM\)](#)

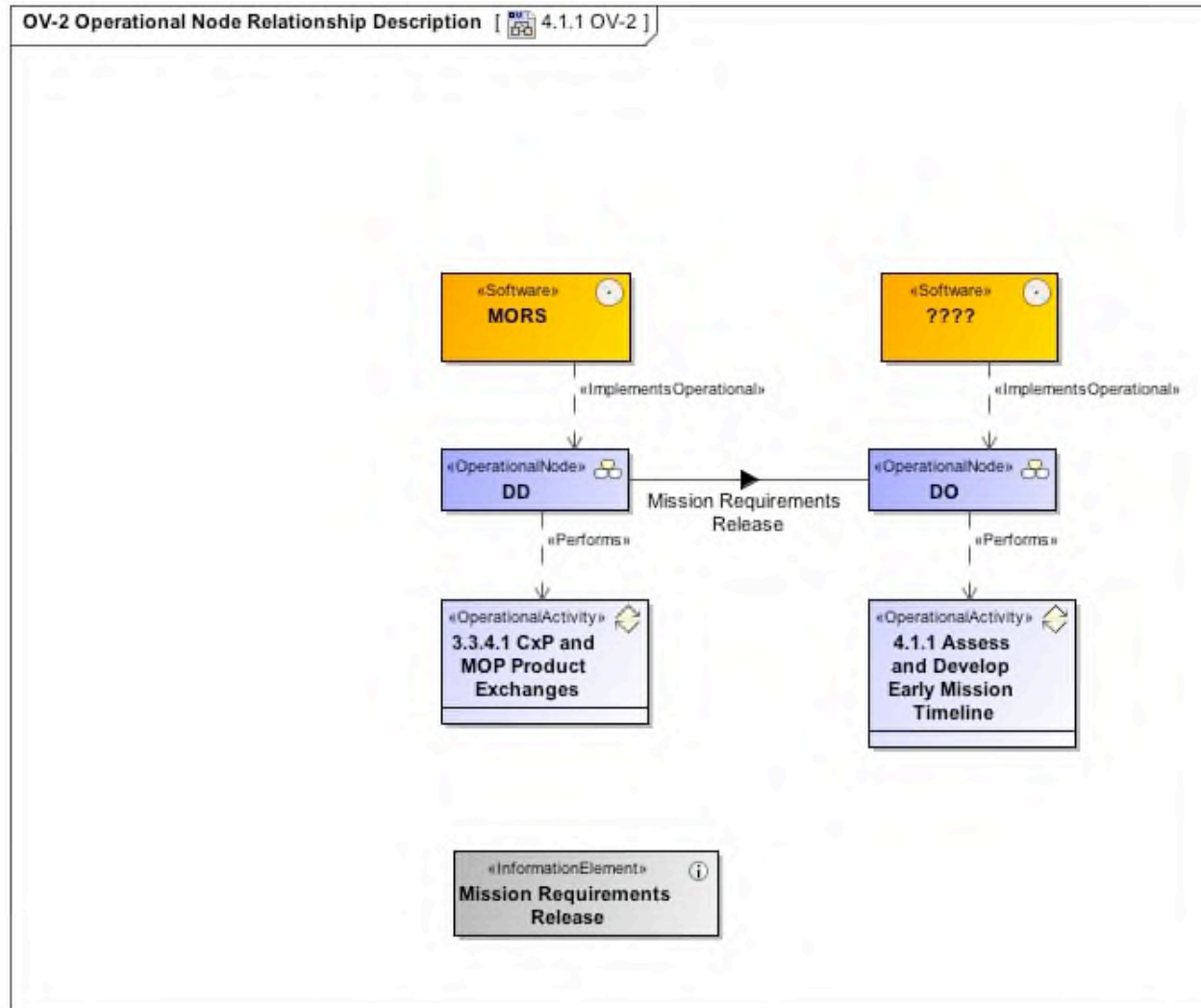
Use Architecture Information for Several Purposes

34



DoDAF Connectivity Diagram (OV-2)

35



Flight Readiness System

36

- ❑! Goal: Develop a new system to support certification of flight readiness for Cx
- ❑! Challenge: How do we specify the components of our system with varying levels of detail while maintaining consistency throughout
- ❑! Approach: Use DoDAF/UPDM to describe the 'as-is' process and systems for shuttle. Then design a new set of processes and supporting systems for Constellation as a 'to-be'.
- ❑! Benefits: Information is organized and represented consistently with various levels of detail appropriate to different stakeholders

As-Is and To-Be Templates

37

As-Is

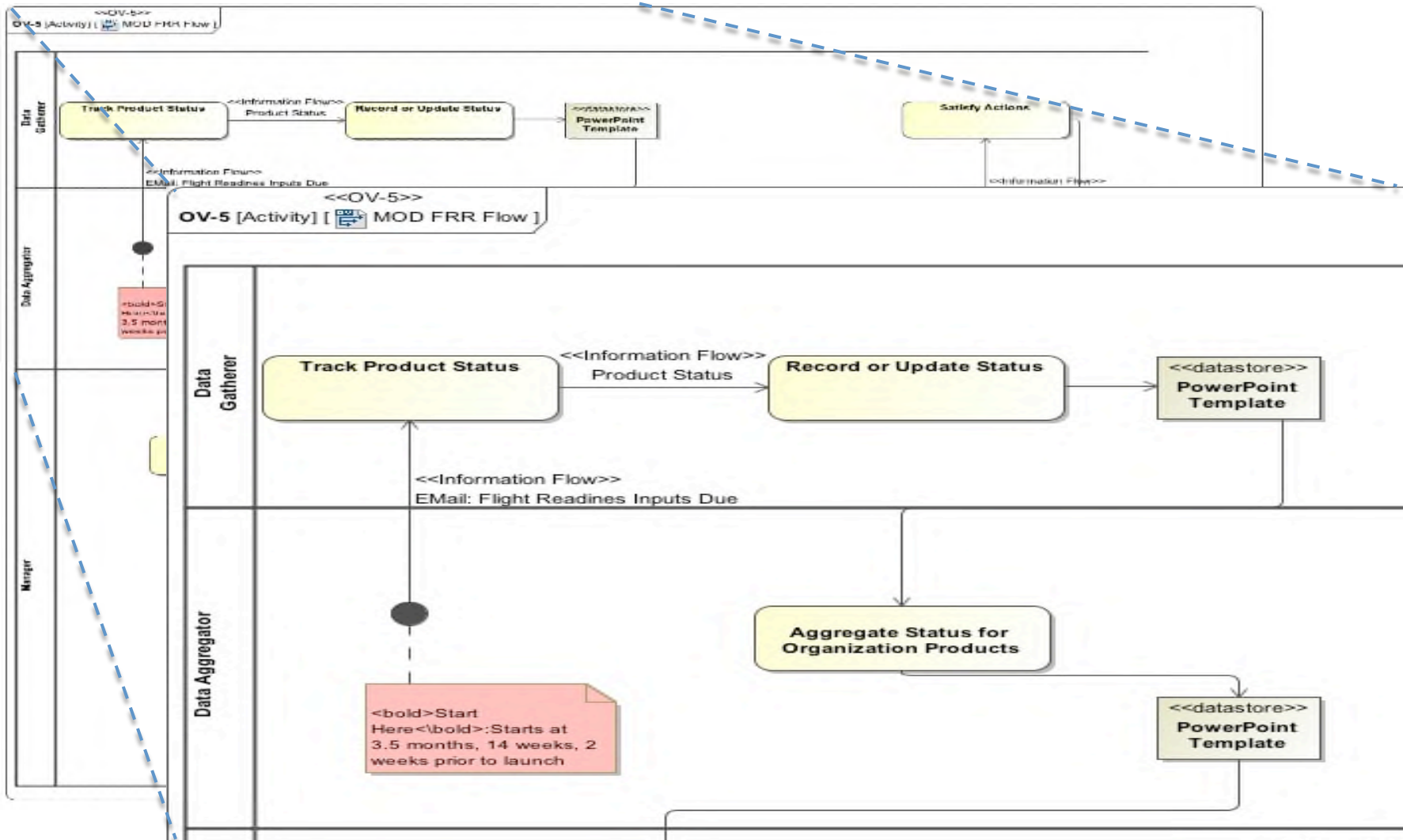


To-Be



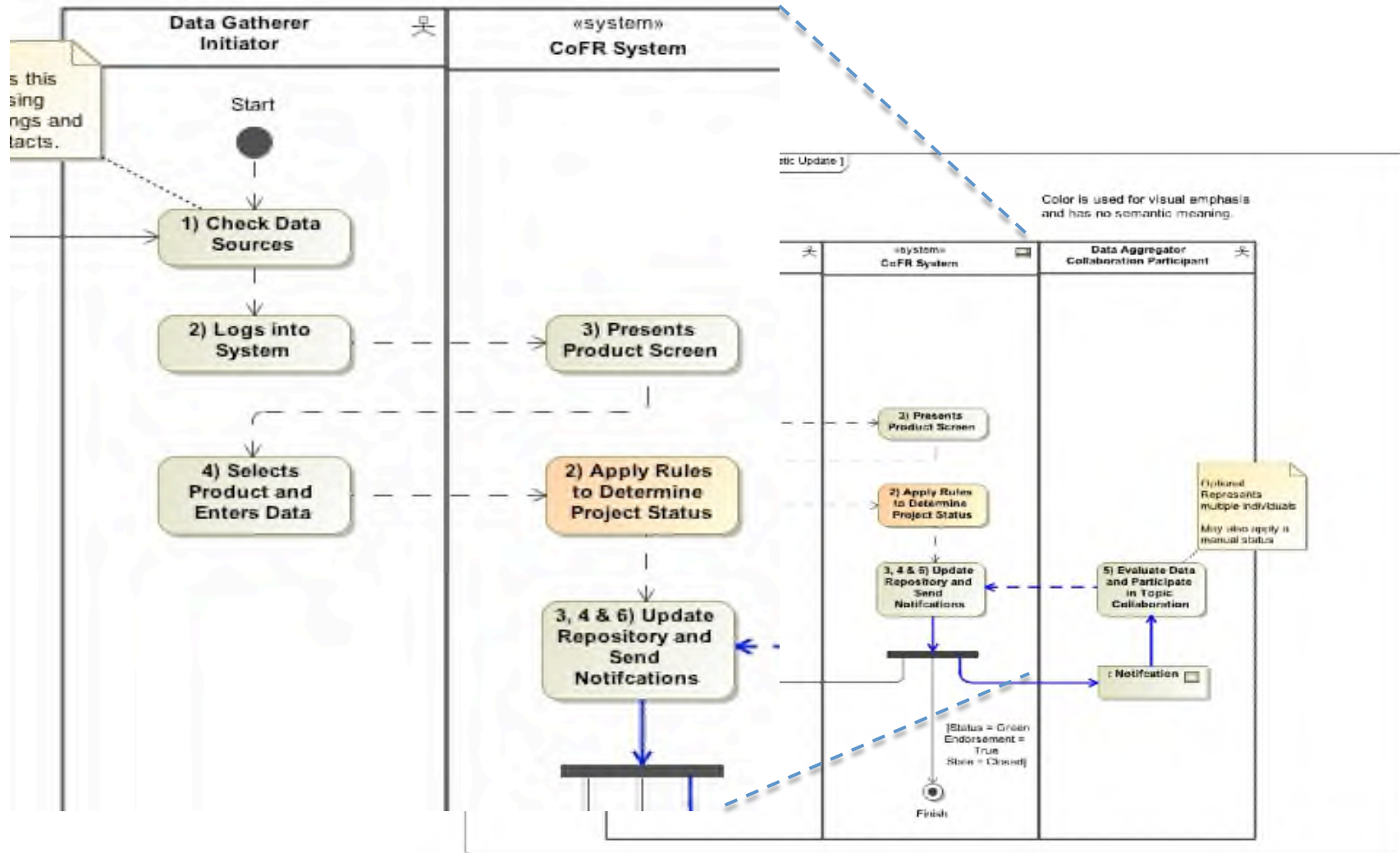
Flight Readiness "As-Is" OV-5

38

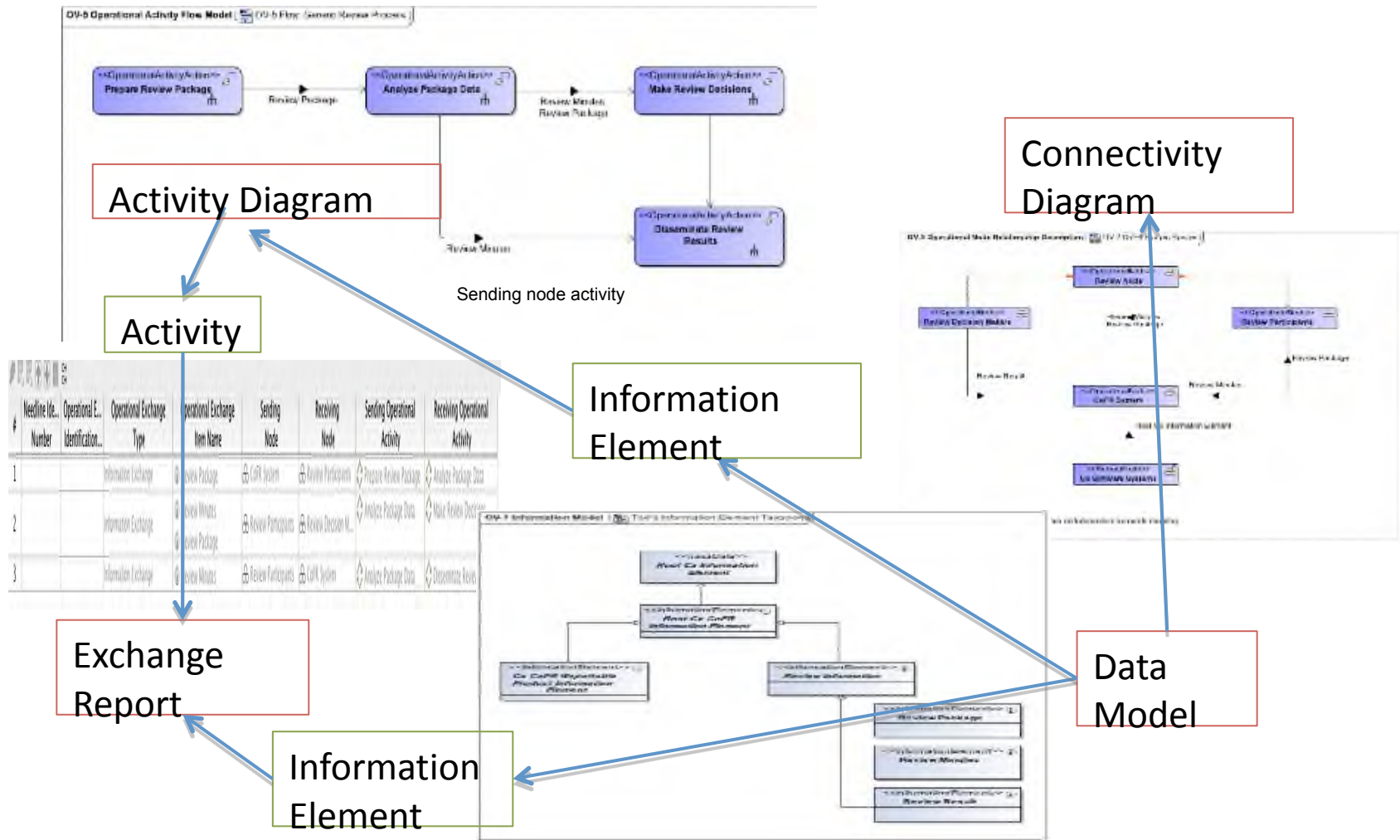


Flight Readiness "To-Be" OV-5

39



Flight Readiness System Model



Modeling Ares Development

41

Problem Definition:

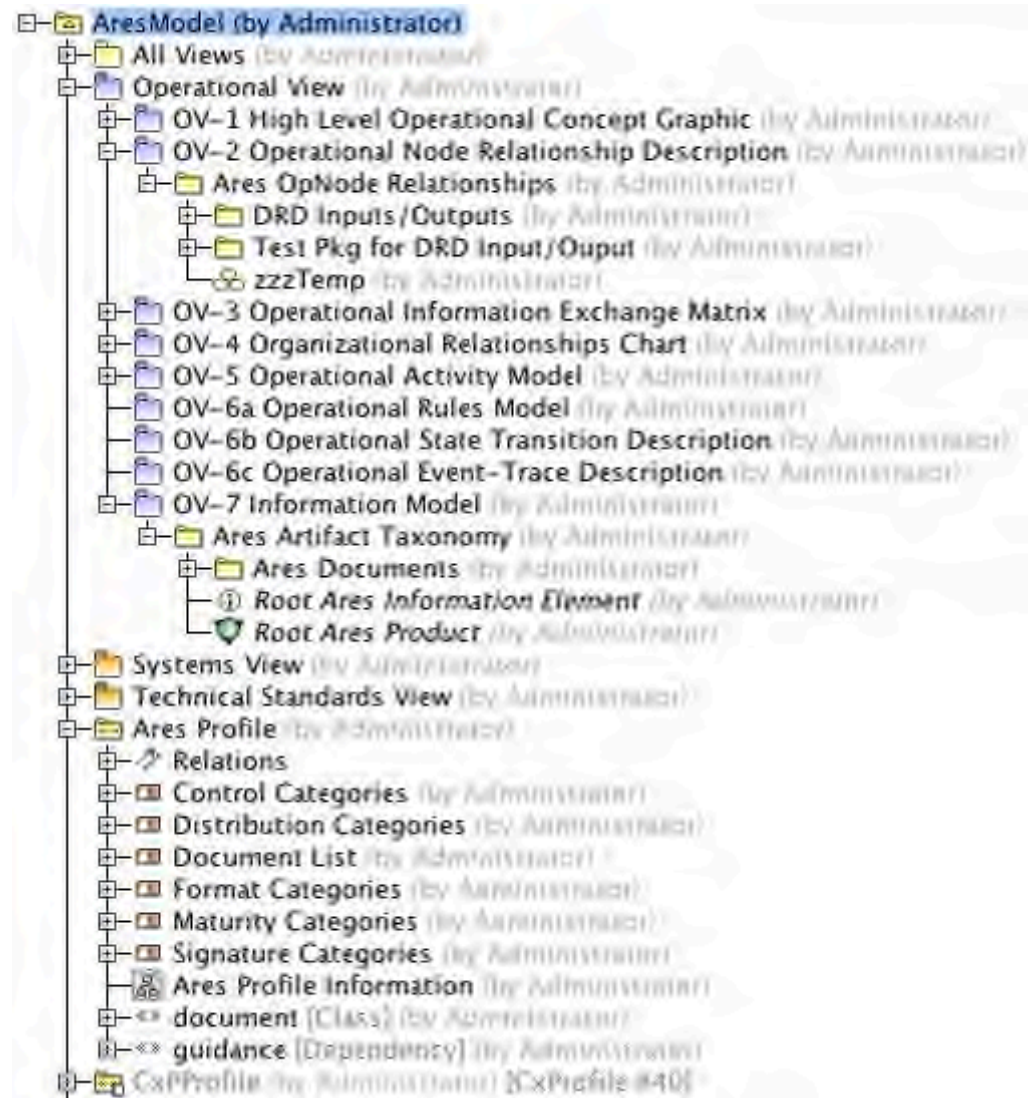
- 1.! Large amount of data...
- 2.! maintained in three separate artifacts: document, spreadsheet and diagram...
- 3.! to meet different stakeholder needs.

Lead to the following concerns:

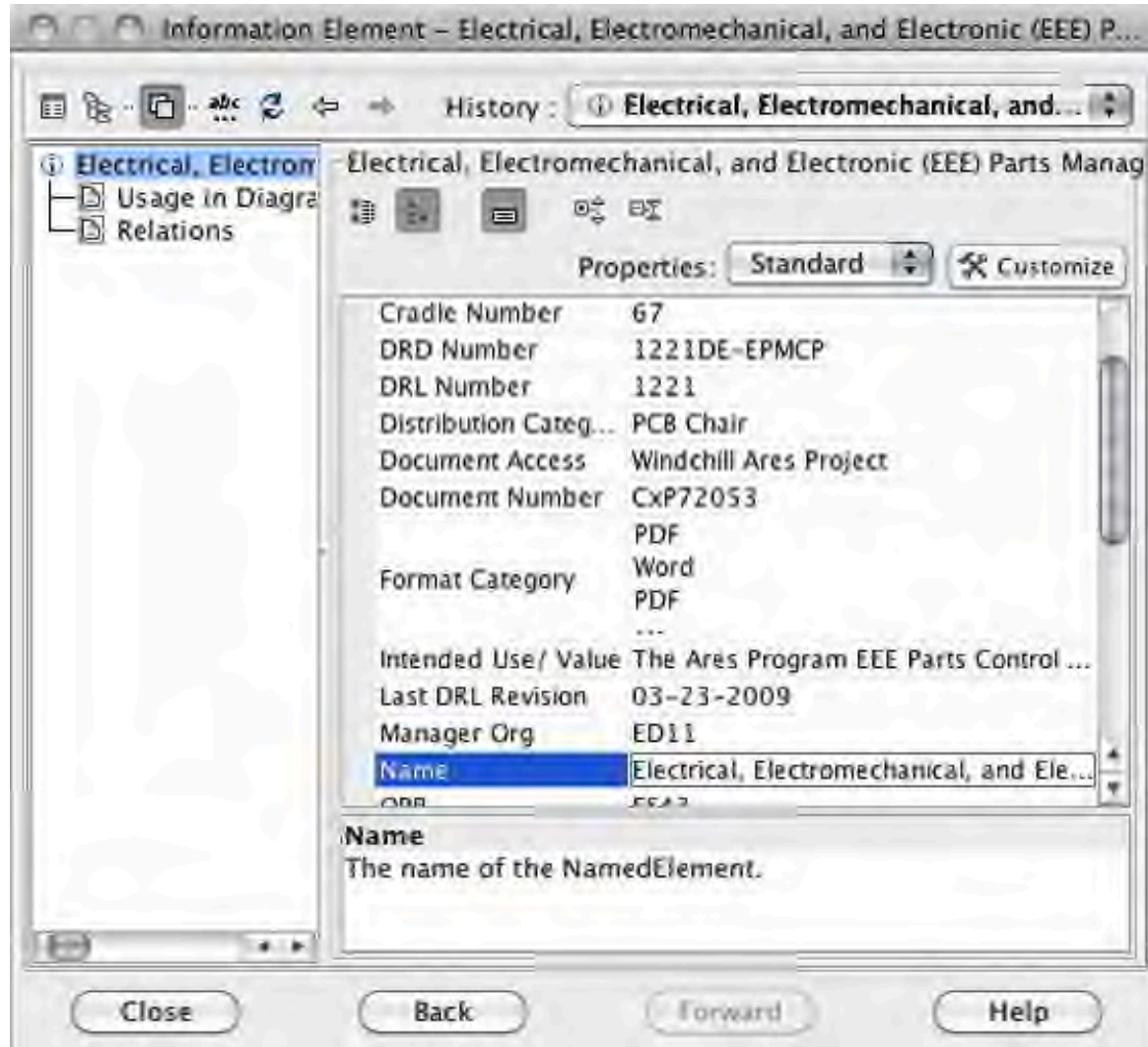
- 1.! Time consuming and error prone to modify data as Ares program changes.
- 2.! Not easy to meet new stakeholder needs.

Ares Model Architecture

(UPDM)

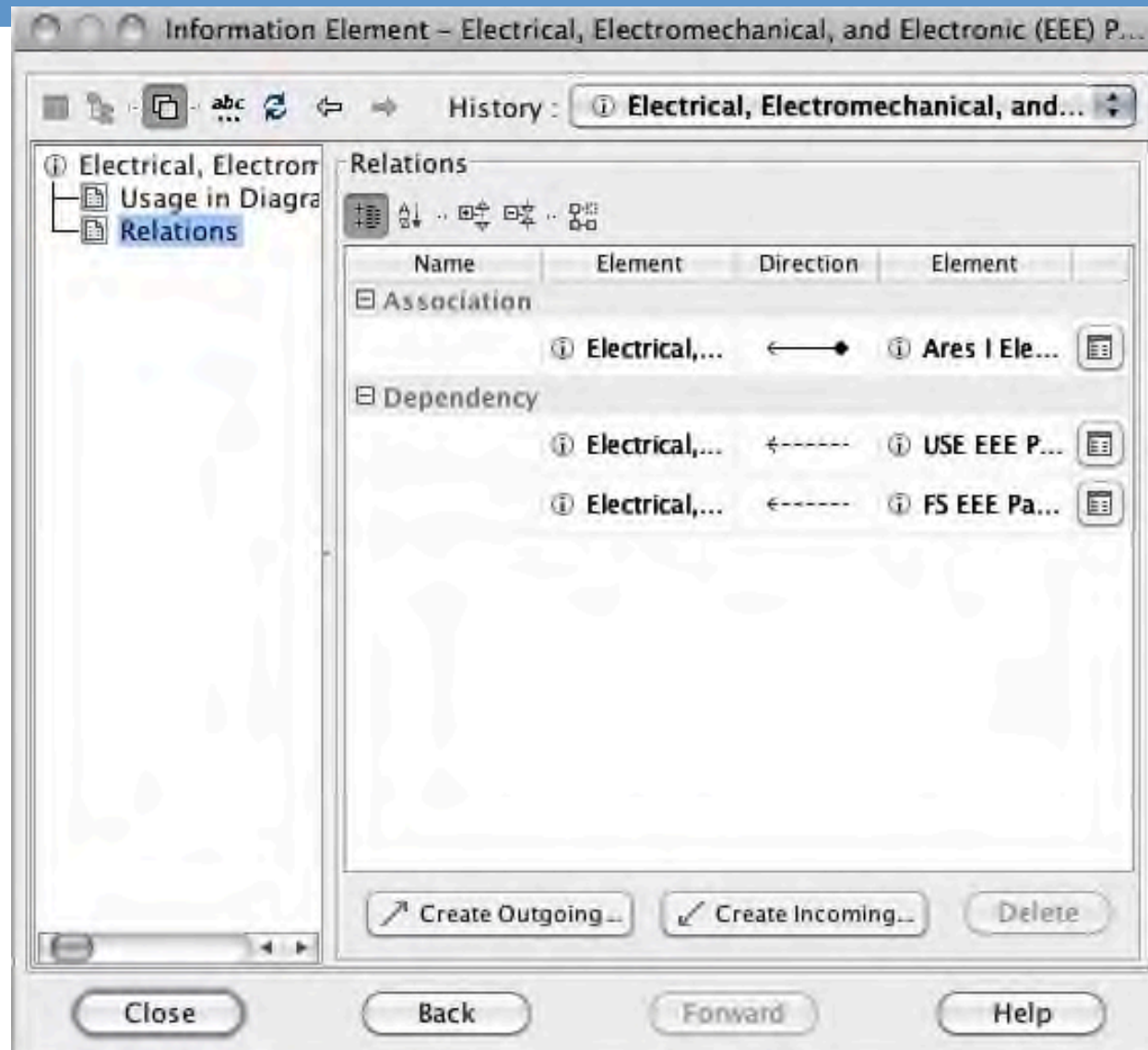


Ares Document Attributes



Ares Document Relations

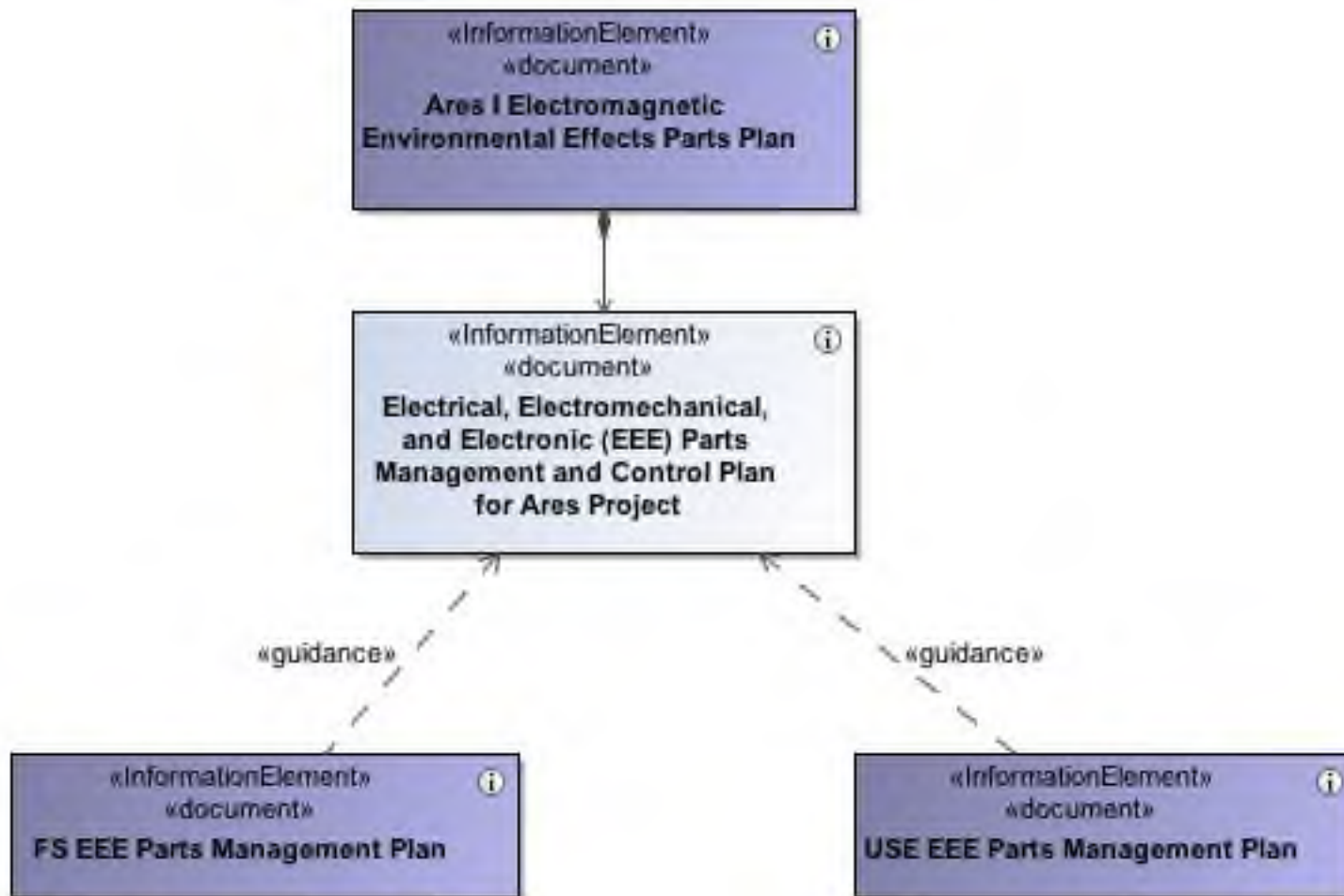
44



UPDM OV7 Diagram

(Structure)

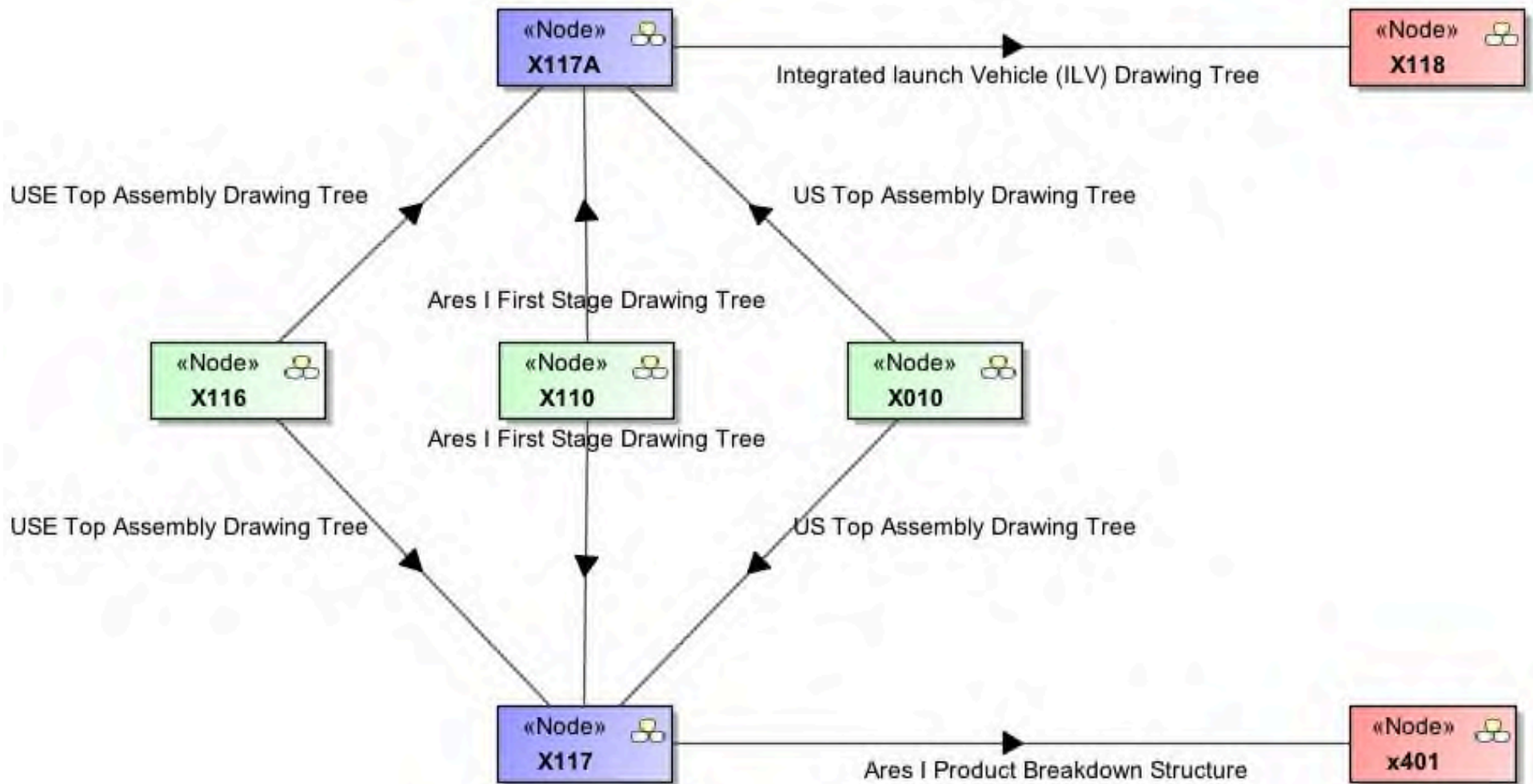
45



UPDM OV2 Diagram

(Behavior)

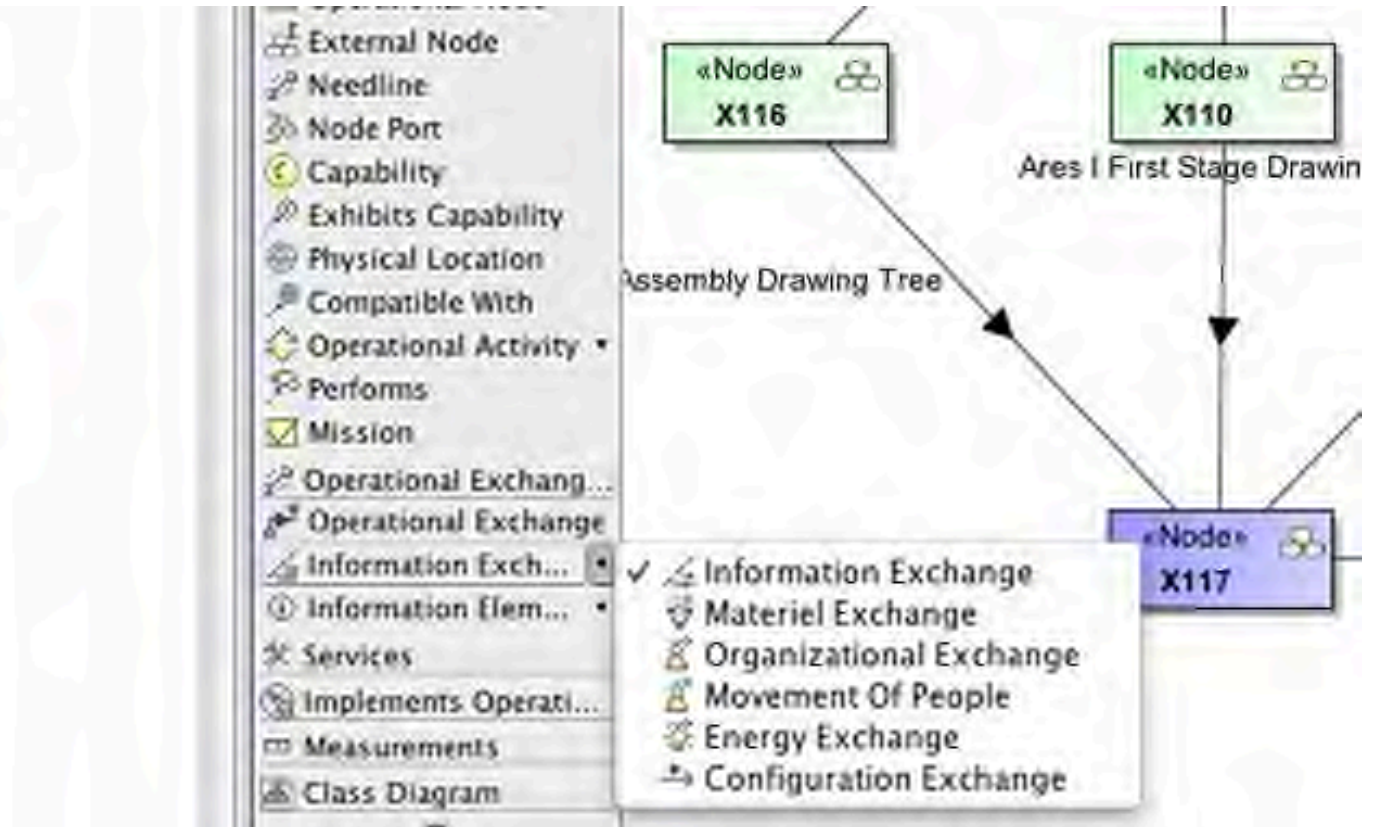
46



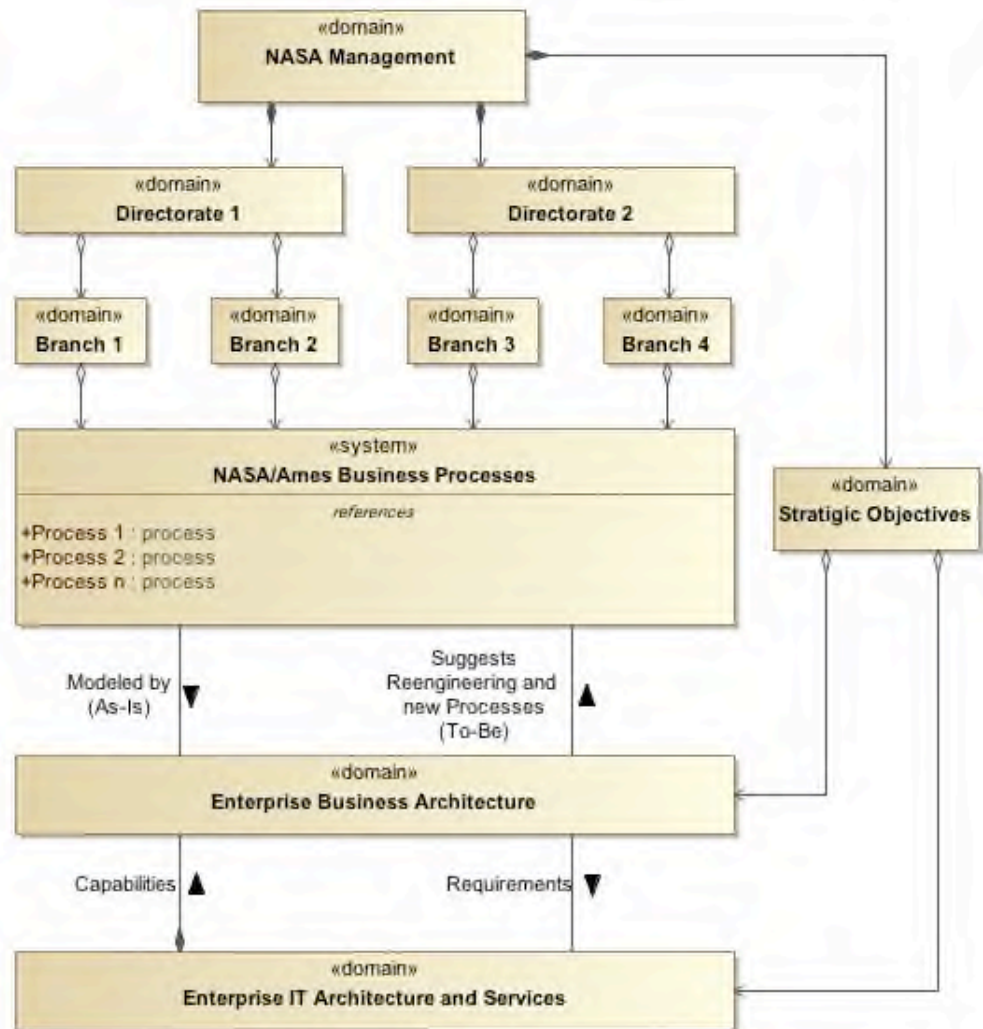
UPDM Exchange Types

47

- Needline[X109 - X111]
- Needline[X109 - X146]
- Needline[X110 - X117]
- Needline[X110 - X117A]
- Needline[X111 - X112]
- Needline[X111 - X127]
- Needline[X113 - X102]
- Needline[X113 - X129]
- Needline[X113 - X151]
- Needline[X116 - X117]
- **Needline[X116 - X117A]**
- Needline[X117A - X118]
- Needline[X117 - x401]
- Needline[X119 - X005]
- Needline[X119 - X032]
- Needline[X119 - X161]
- Needline[X120 - X005]
- Needline[X120 - X032]
- Needline[X120 - X161]
- Needline[X121 - X005]
- Needline[X121 - X032]
- Needline[X121 - X161]
- Needline[X122 - X125]
- Needline[X122 - X125]



Ames and EBA

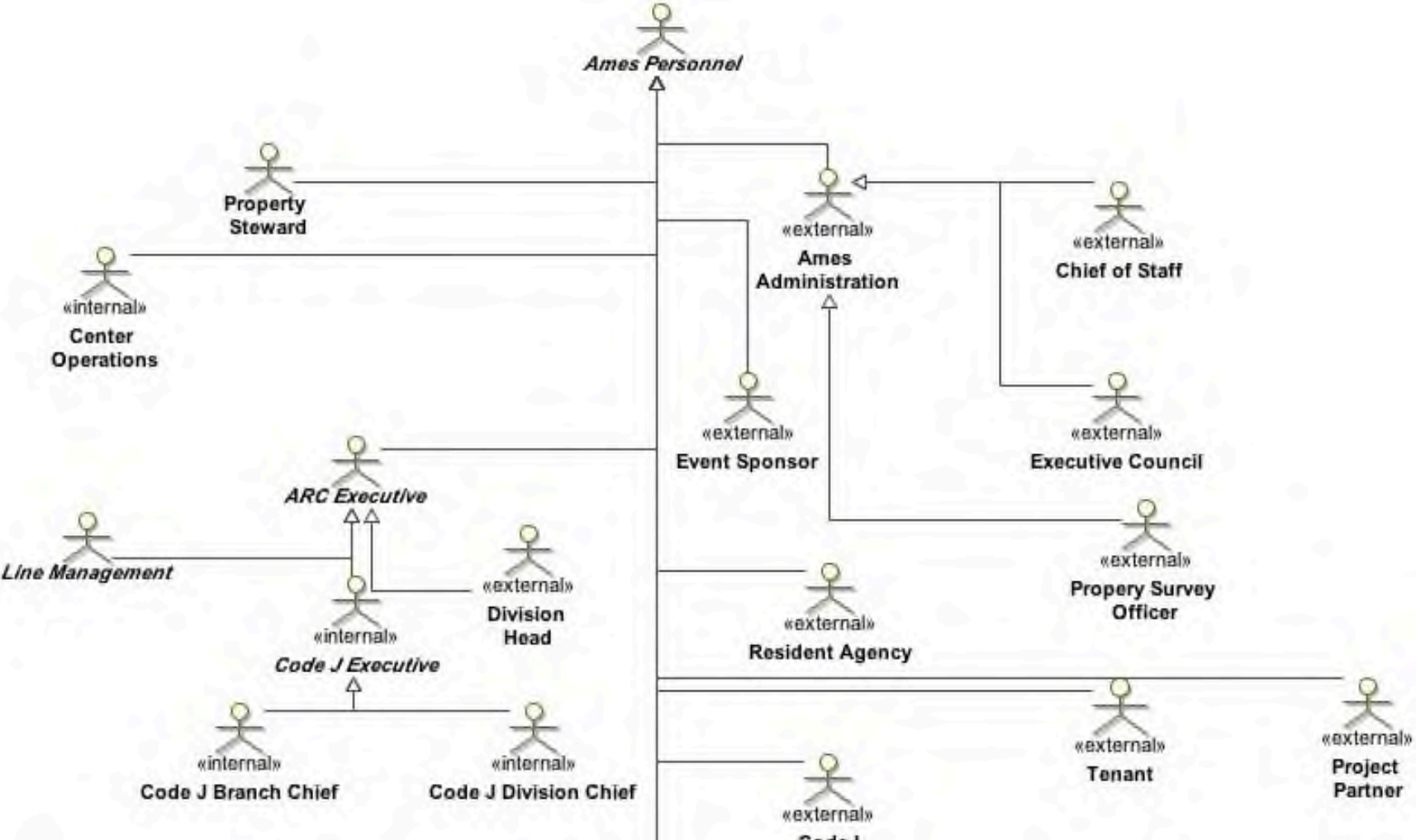


EBA Architecture

49

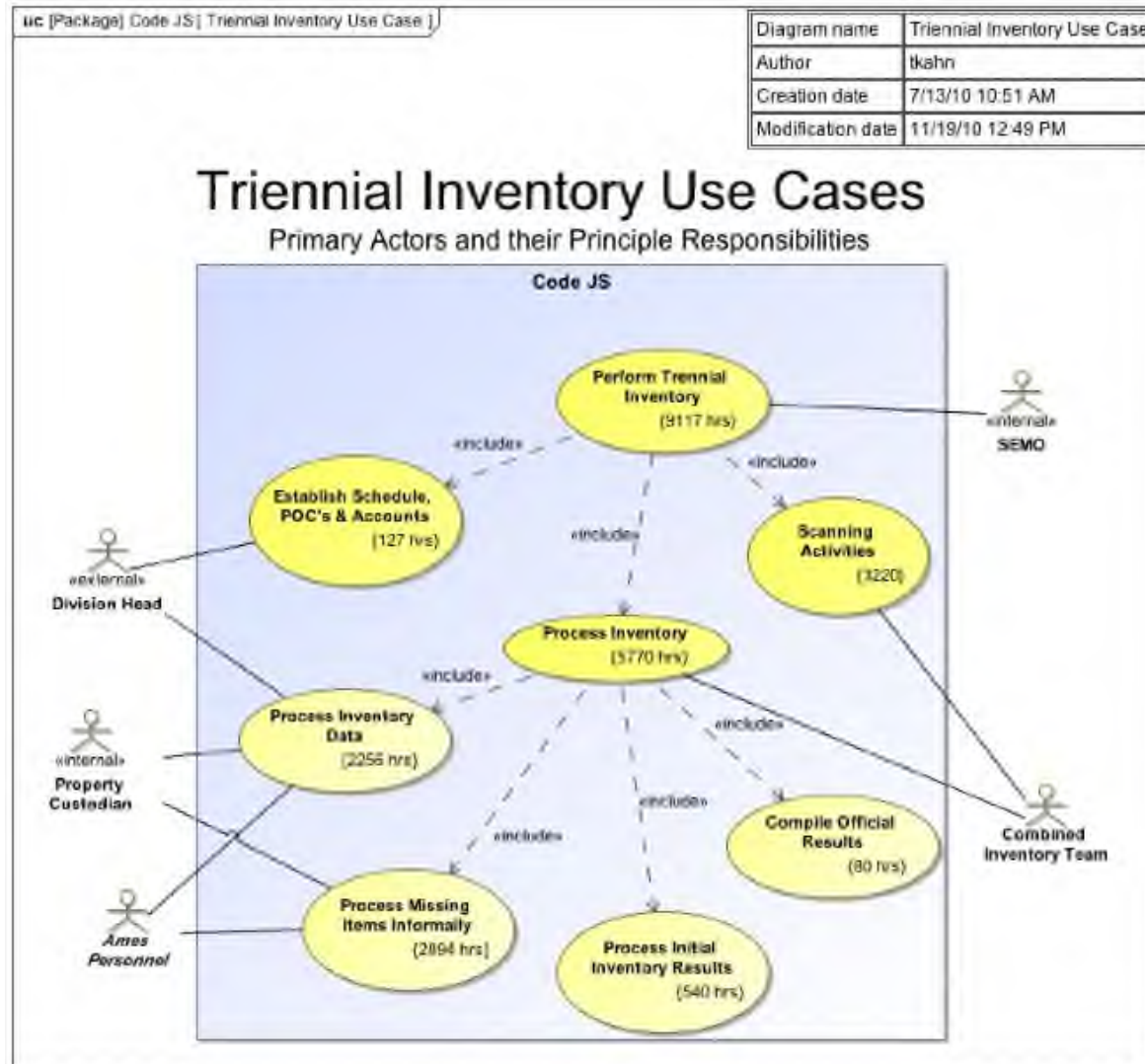


Stakeholder Taxonomy

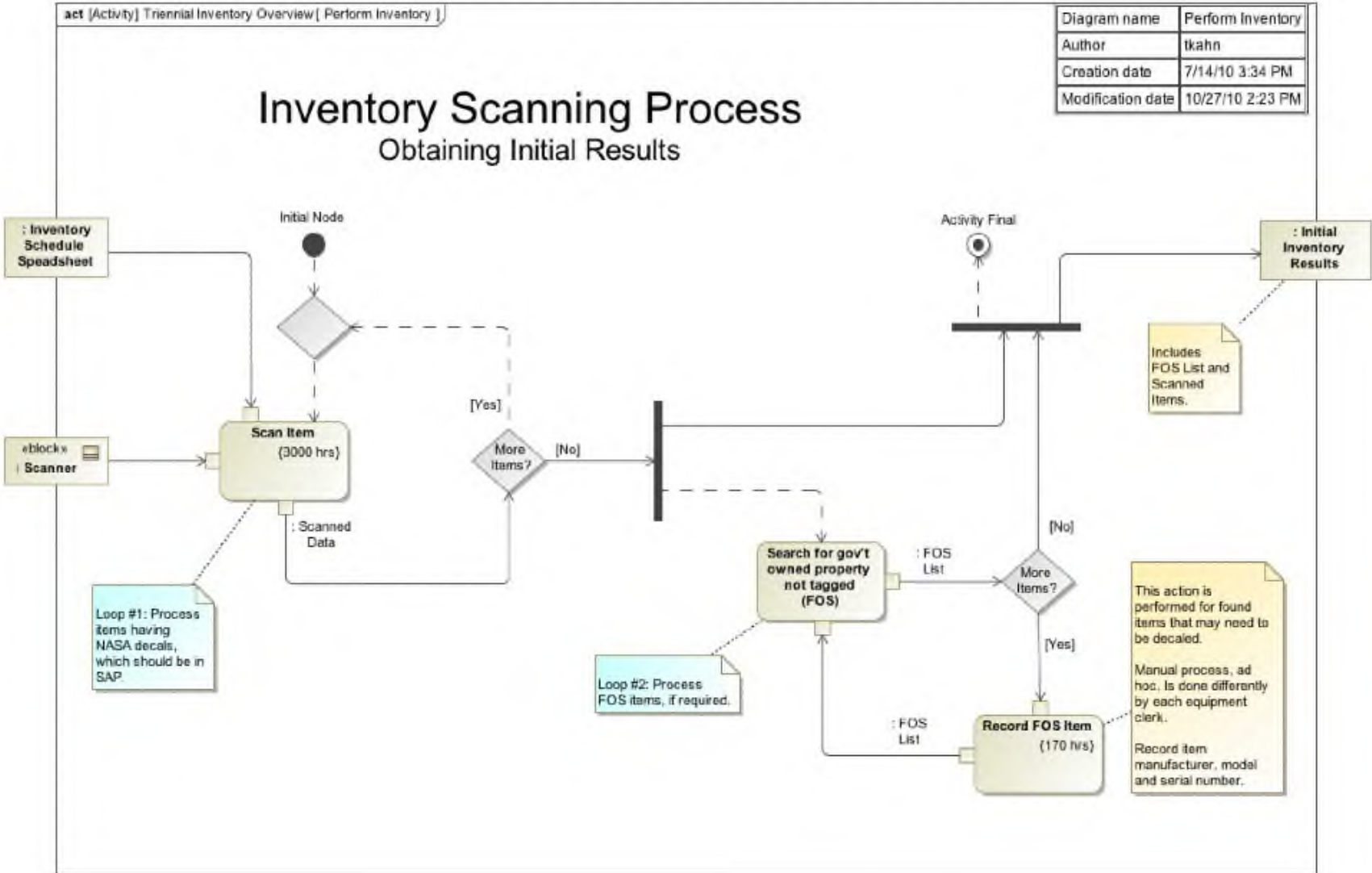


Use Cases

51



SysML Activity Diagram



Constraints

53

Record FOS Item=170 hrs (by Administrator)
Perform Inventory=3170 hrs (by Administrator)
Scan Items=3000 hrs (by Administrator)
3000 hrs
Establish Schedule=10 hrs (by Administrator)
Obtain Schedule Agreement=117 hrs (by Administrator)
Prepare Scanner=50 hrs (by Administrator)
Requirements (by Administrator)
Stakeholders (by Administrator)
Use Cases (by Administrator)

Zoom | Documentation | Properties |
Documentation

Documentation of Constraint Scan Items

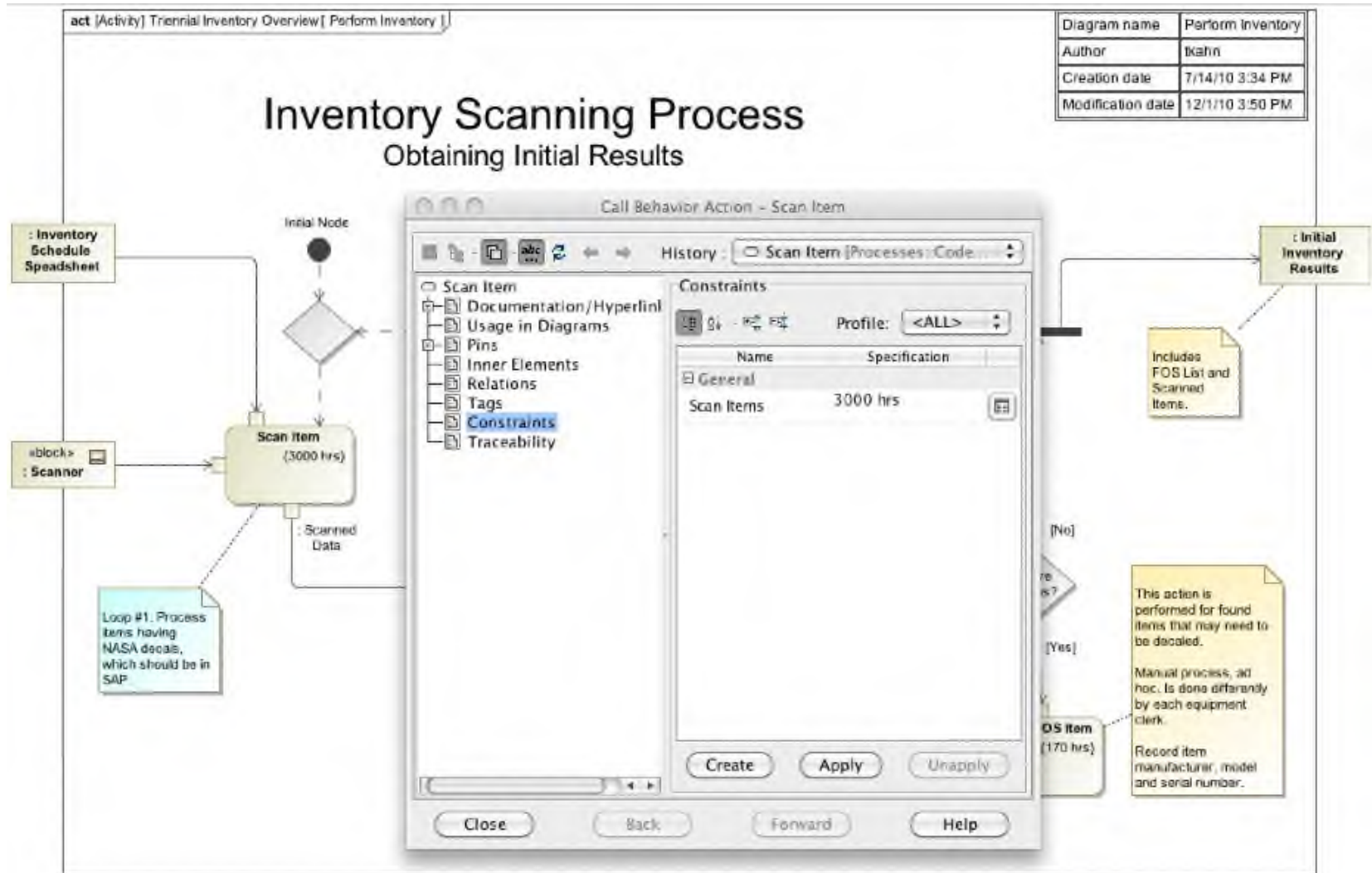
HTML

$(2 \text{ wks} * (.5 \text{ person}) * 27 \text{ inventories} * 2 \text{ people}) * 1.5 \text{ overhead} = 300\text{hrs}$

Basically, this says that 2 people are working half time for 2 weeks which = 2 person-weeks = 80 hrs.

1.5 (50%) overhead represents starting/stopping inefficiencies as well as working with property custodians having little experience.

Applying Constraints



55

Making Modeling Work for You Today

Practical Information for achieving quick ROI

Modeling is an Engineering Task

56

- ❑! Approach it systematically
- ❑! Know what resources you will need
- ❑! Define milestones, a roadmap
- ❑! Be pragmatic

What Makes a Good Formal Model?

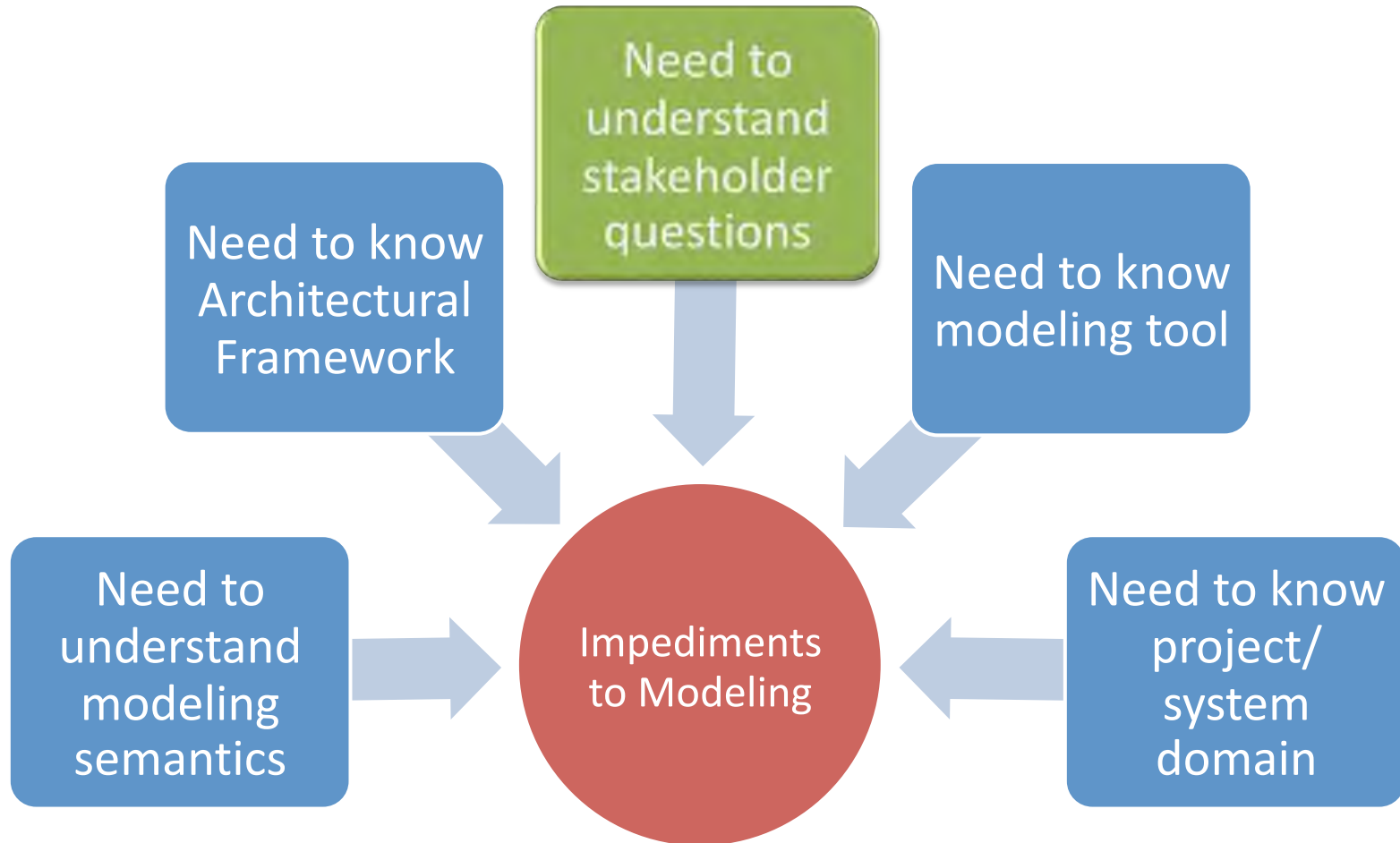
57

- ❑! Model those aspects of the project required to answer stakeholder questions, and no more.
- ❑! Model the degree of precision required to answer stakeholder questions, and no more.
- ❑! Models must always be accurate.

Five Knowledge Domains

(Why modeling is hard)

58



Four Modeling Steps

(Do only one at a time.)

59

Questions & Project knowledge

translate to

Architectural Framework Knowledge

apply to

Modeling Language knowledge

apply

Tool knowledge

Modeling Tools Encompass Two Areas

(Do only one at a time.)

60

- ❑! Database program
- ❑! Drawing program

Think Small, Think Focused

(Get ROI in Weeks!)

61

- ❑! What questions should your model answer?
- ❑! Select a modeling language.
- ❑! Determine the architecture.
- ❑! Select a tool.

You're in Front of your Computer

(Now what do you do?)

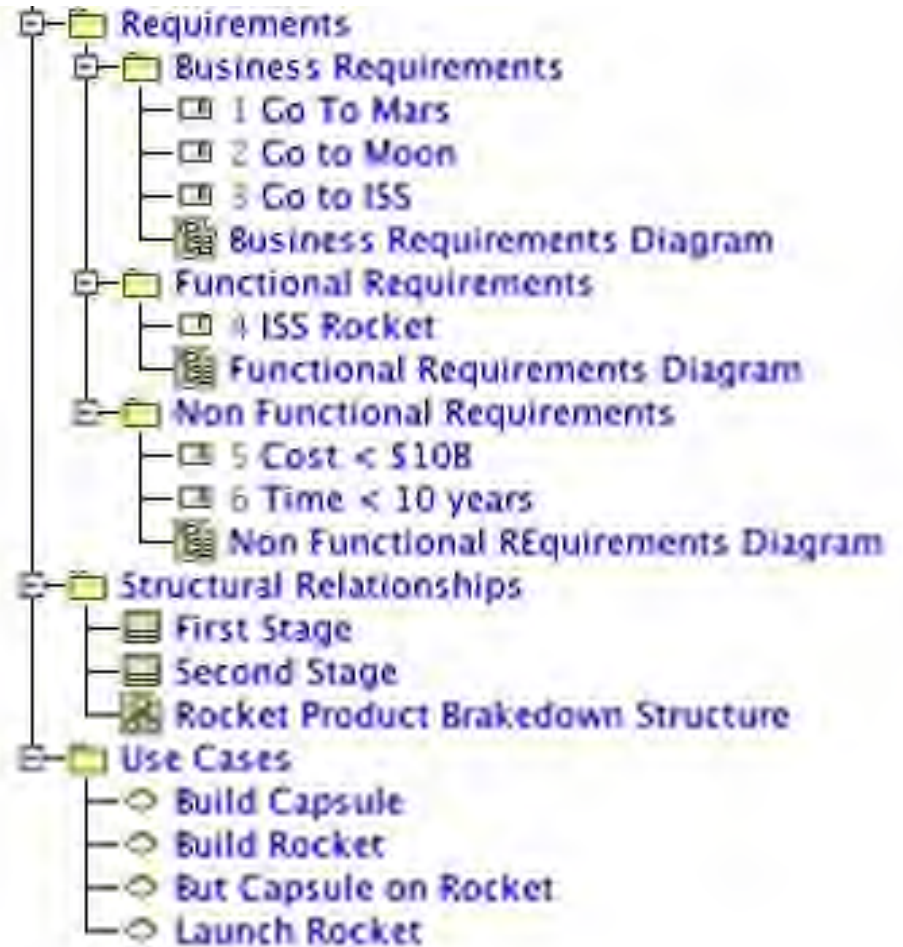
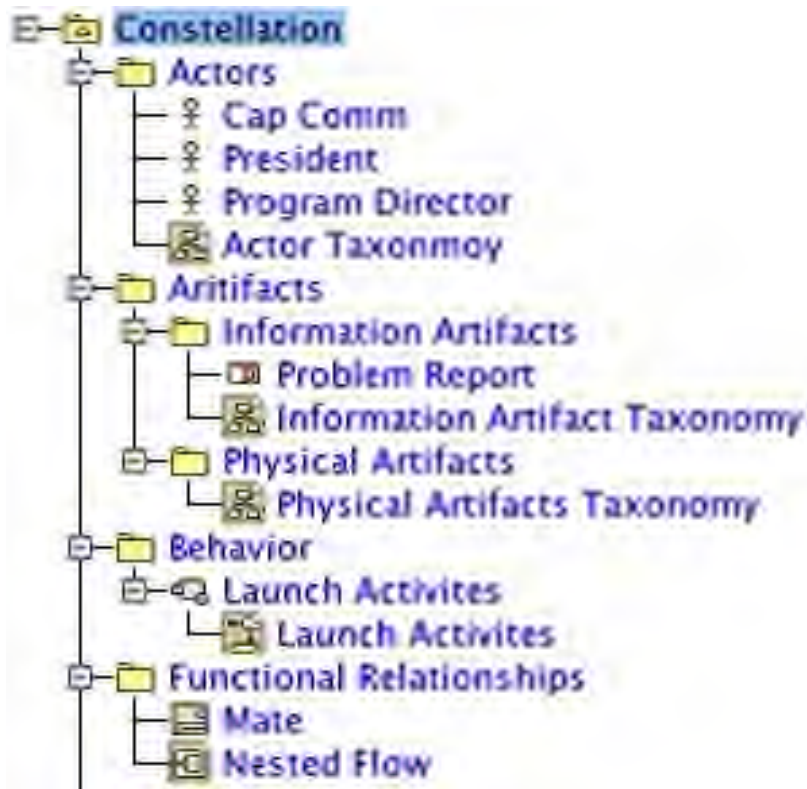
62

- ❑! Your tool is running
- ❑! You created a new SysML project
- ❑! And...
- ❑! You create packages to organize your project



A “Template” SysML Model

63



Extending SysML

64

- ❑! Use English to document each entity.
- ❑! Use diagram notes to highlight explain diagram elements.
- ❑! Use SysML Profiles to extend SysML semantics to meet your own domain specific needs.

Modeling Tips

65

- ❑! What if you don't know something?
 - ❑! Make your best guess, its easy to change.
- ❑! What should go on a diagram?
 - ❑! It should tell a story, answer a question, address a specific stakeholder need.
- ❑! Look to see how a set of diagrams might meet a stakeholder's need in some specific area.
- ❑! Model only those elements for which you know there is a value.

Culture Issues

(Modeling is about sharing information.)

66

- ❑! Some people do not necessarily want to share their information
 - ❑! Job security
 - ❑! They don't know the information, and perhaps reluctant to say so.
 - ❑! Its time-consuming to get the information, what's in it for them?
- ❑! Some people like to work independently

Modeling Summary

67

- ❑! Think small, know what questions your model should answer.
- ❑! Keep the architecture simple.
- ❑! Learn your modeling language semantics.
- ❑! Pro actively manage the modeling task:
 - ❑! Engineering effort
 - ❑! Cultural issues

68

Future Trends and Closing Remarks

Future Trends

69

- ❑! Fully defined semantics
- ❑! Prescriptive methodologies
- ❑! Improved tooling
- ❑! Analytical integration
- ❑! EA Frameworks are adding behavior and project management representations

Backup

70



DODAF 2.0

71

Capability Viewpoint

Vision
Taxonomy
Phasing
Dependencies
Organizational Mapping
Activities Mapping
Services Mapping

Project Viewpoint

Portfolio
Timelines
Capabilities Mapping

Project Management Information:
Gantt Chart, Event Chain Diagram, ISO 10006, Six Sigma

72

5

...producing **strategic**
PM artifacts...

...leading to better estimates for
schedule, scope and resources..



4

...and also used for aligning project
schedule, scope and resources...

...maintaining a consistent, feasible
project and a refined model...

Formal Model Formal semantic relationships + consistent representations
 improved common understandings & decisions.

3

...used for creating
SysML model...

...providing consistent **operational**
information used by all stakeholders...

2

...which encompasses
project data...

Text Docs

Spreadsheets

Diagrams

1

Represented by...

Projects are defined and change mostly due to external events: Continuously.