Integrating Architecting and Systems Engineering

NDIA SE Conference

22 October 2008

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Intro/Topics

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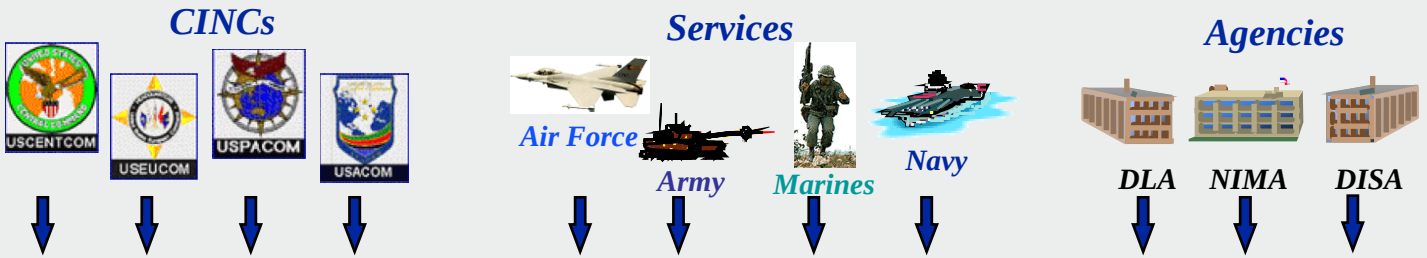
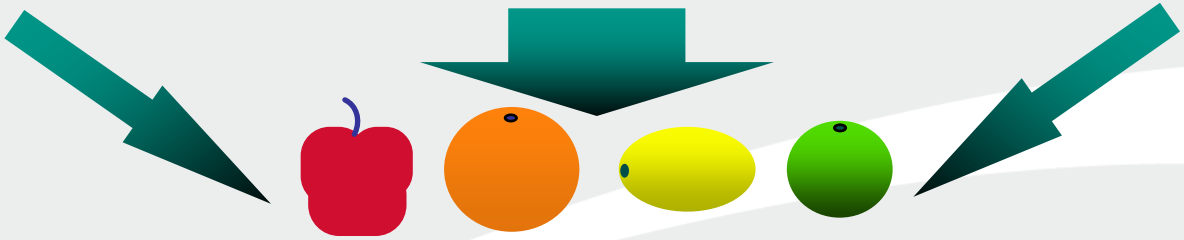
Background: What is the Problem?
Why is An Architecture Framework Needed?

Organizations are developing major systems that need to interface and interact



Differences in content and formats inhibit comparison of architectures



Disparate and unrelatable architecture products lead to non-integrated, non-interoperable, and non-cost effective capabilities in the field

Reprinted from "C4ISR INCOSE Tutorial", A.H. Levis and L.W.Wagenhals, March 2001

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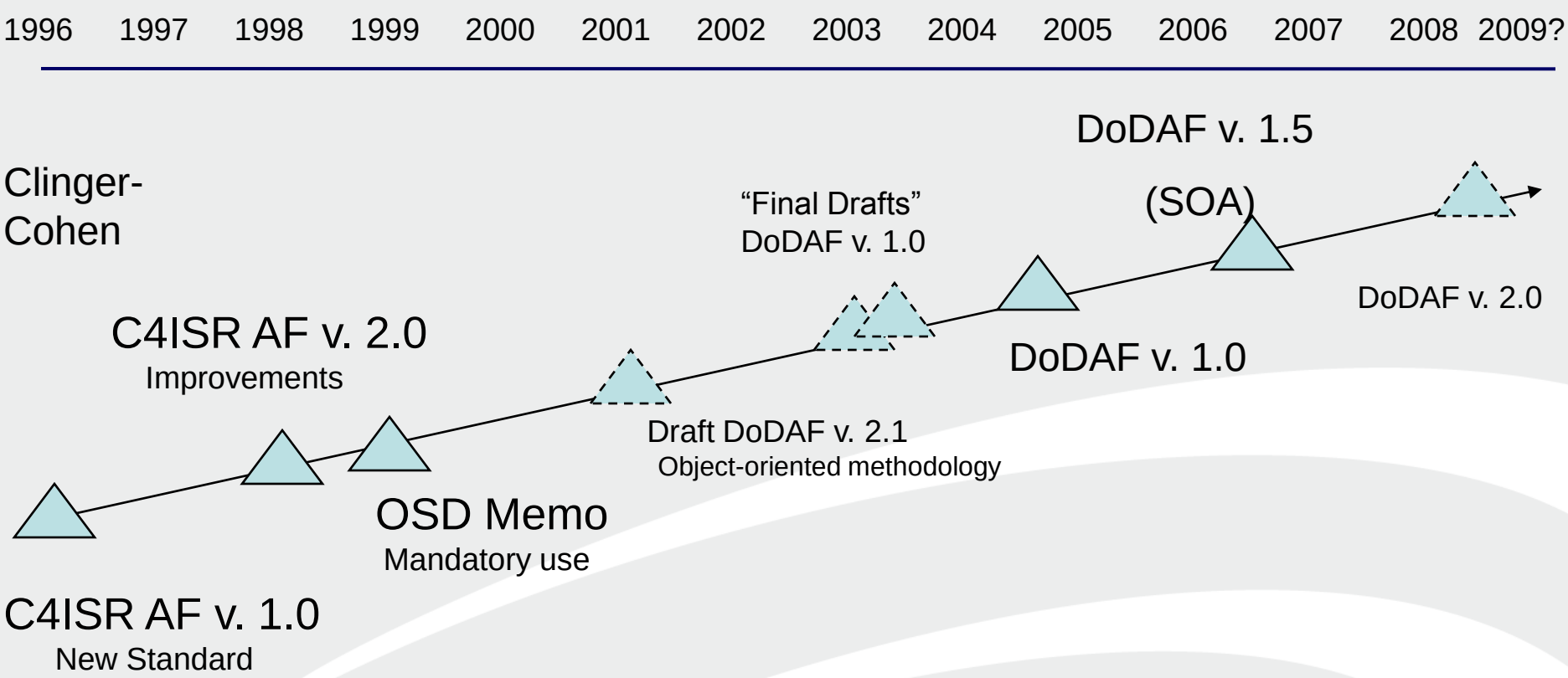
Evolution DoDAF



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Motivations for DoDAF

- Architectures required by law (Clinger-Cohen, etc.)
- Structured, repeatable *method* for investments and investment alternatives
- Influence and guide organizational change
- Create New Systems (*i.e.,* define System Requirements)
- Deploy (plan for) new technologies
  - Ex., Net-Centric Warfare

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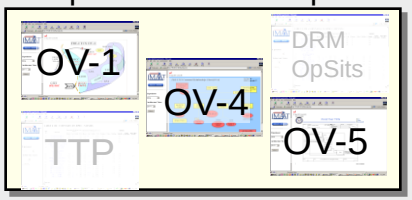
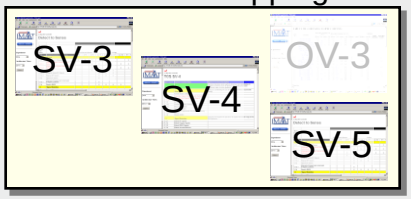
Typical DoDAF Taxonomy

Operational Concept



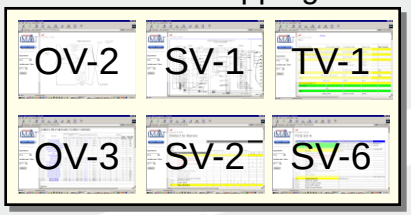
DRM: Design Reference Mission
OpSit: Operational Situation
TTP: Tactics, Techniques, Procedures
FoS: Family of Systems
SoS: System of Systems

Functional Mapping



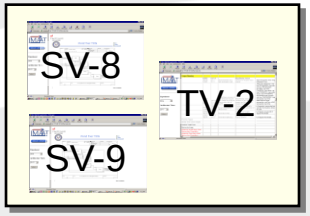
1st Order Analysis:
Functionality

Interface Mapping



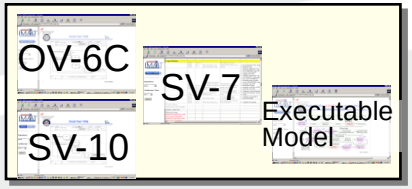
2nd Order Analysis:
Static Interoperability

FoS/SoS Evolution



Note: There are dependencies between the Architecture products that are not shown in the System Engineering flow. Many of the products are developed concurrently.

Architecture Performance and Behavior



3rd Order Analysis:
Dynamic Interoperability

OV-1	High-level Operational Concept Graphic
OV-2	Operational Node Connectivity Description
OV-3	Operational Information Exchange Matrix
OV-4	Command Relationships Chart
OV-5	Activity Model
OV-6C	Operational Event/Trace Description
SV-1	System Interface Description
SV-2	Systems Communication Description
SV-3	Systems Matrix
SV-4	System Functionality Description
SV-5	Operational Activity to System Function Traceability Matrix
SV-6	System Information Exchange Matrix
SV-7	System Performance Parameters Matrix
SV-8	System Evolution Description
SV-9	System Technology Forecast
SV-10	System Activity Sequence & Timing
TV-1	Technical Architecture Profile
TV-2	Standards Technology Forecast

Architectures Provide the Framework for FoS/SoS Systems Engineering & Acquisition

Ref: “Naval Collaborative Environment”, Dr. Harry Crisp, 2002

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Integrated Architectures – Defined

- Architecture data elements uniquely defined and consistently used
- Accomplished through the mapping of standardized terms, definitions, and relations
  - Objects used in more than one view are identical
  - Objects linked between views are linked within an underlying data base.
- *Common points of reference* linking different views of the architecture
- Examples

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View Creation Not Complete System Architecture

- No Requirements
- Need for integration with other SE related activities – (Test Planning)
- Representations of Traceability lacking

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Review of MBSE

- **Model-driven approach to capture and integrate:**
  - **Requirements Development**
  - **Logical Analysis**
  - **Design Solution**
  - **Implementation**
  - **Integration**
  - **Verification**
  - **Validation**
- **System Specification is the model, Model is the System Specification**

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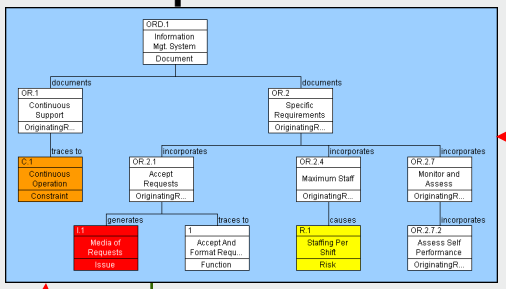
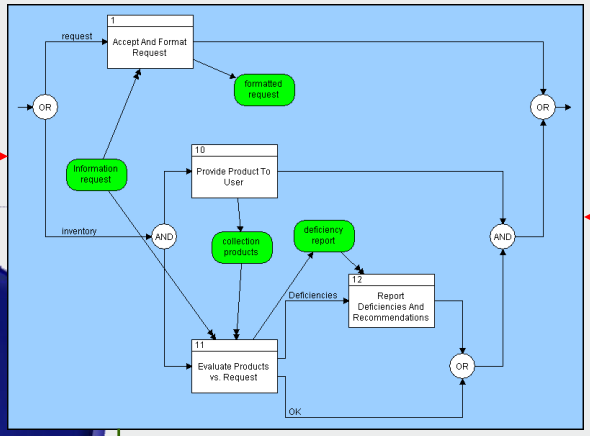
Example MBSE Taxonomy

Source Requirements Domain



Originating requirements trace to behavior

Behavior Domain

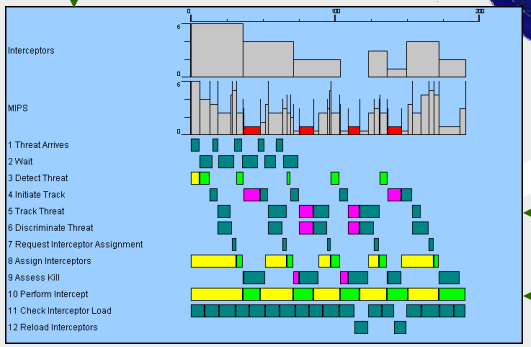


verified by

System Design Repository

Behavior is allocated to physical components

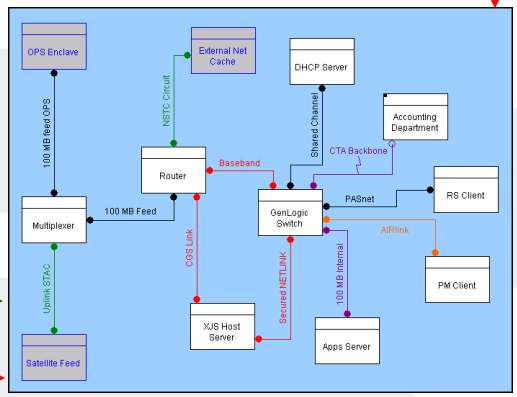
V&V Domain



verified by

verified by

Physical Architecture Domain



Originating requirements trace to physical components

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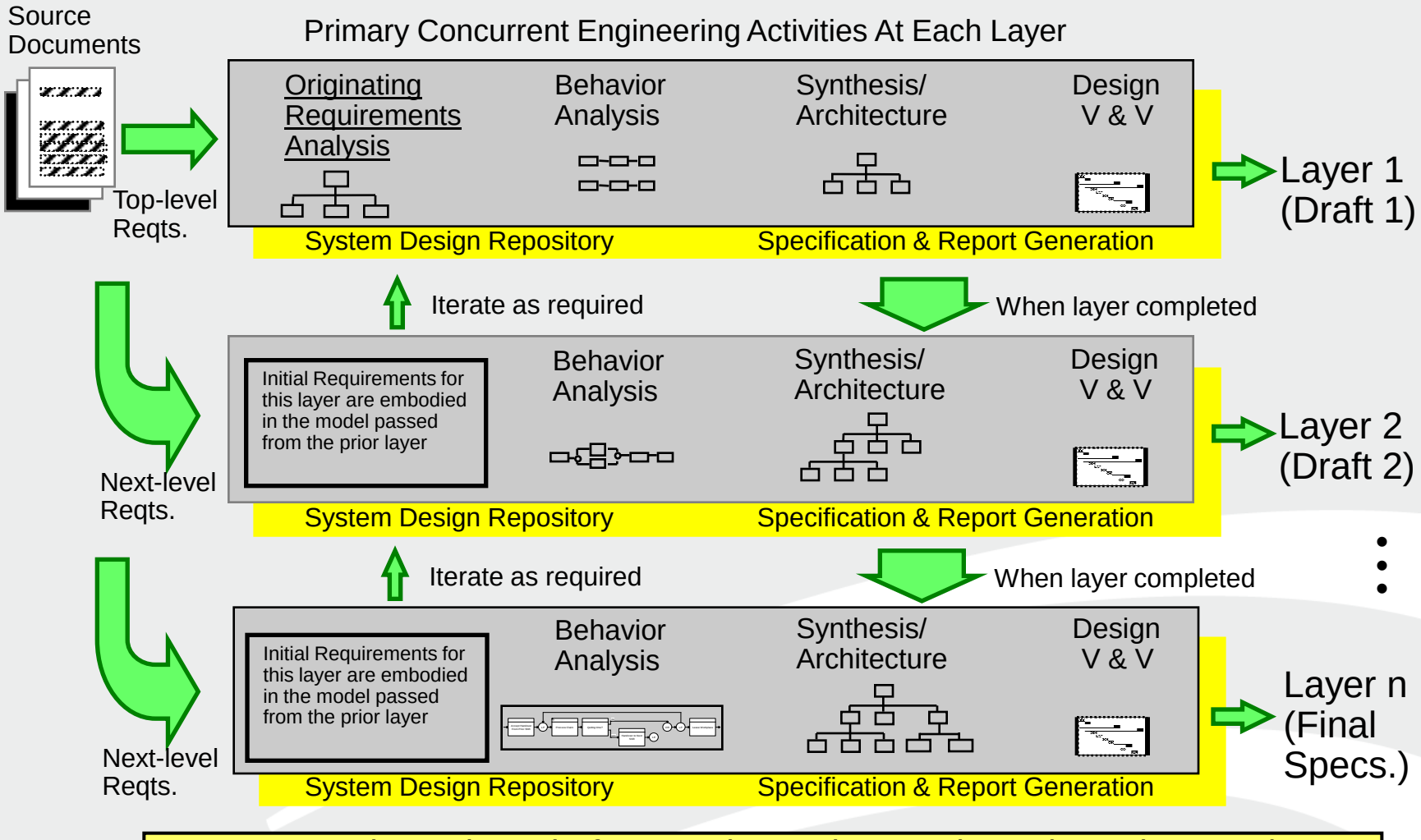
Example MBSE taxonomy (cont.)



- Must complete a layer before moving to the next layer (completeness)
- Cannot iterate back more than one layer (convergence)

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MBSE and Integrated Architecture Common Traits

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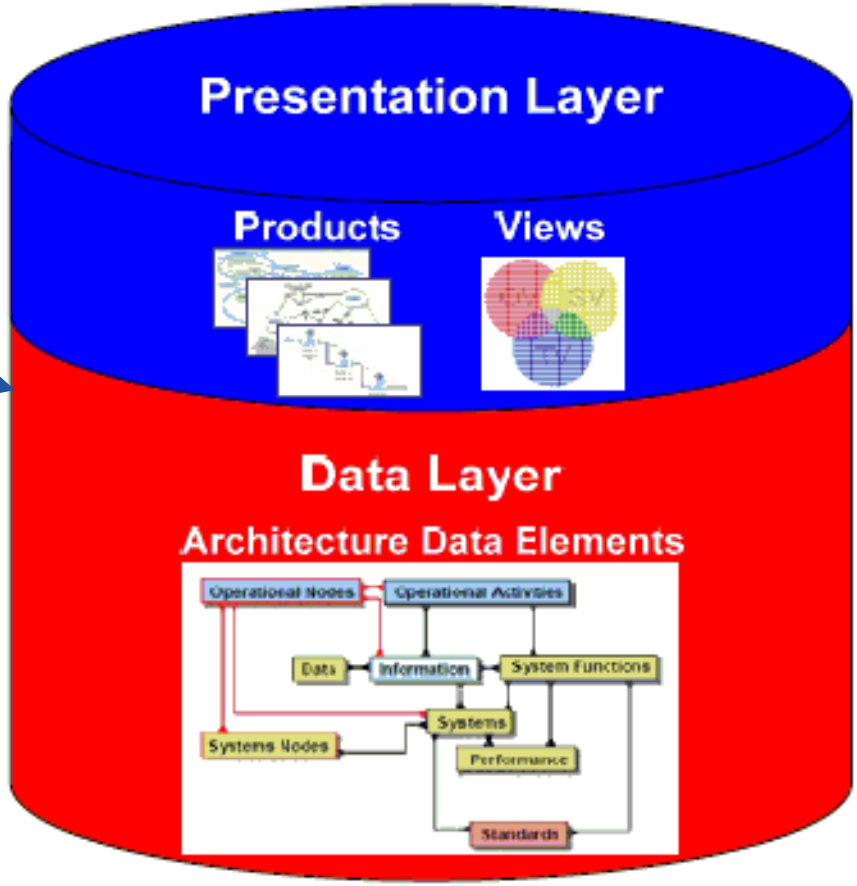
DoDAF Integrated Data Layer

Architecture Framework Structure

Synchronized



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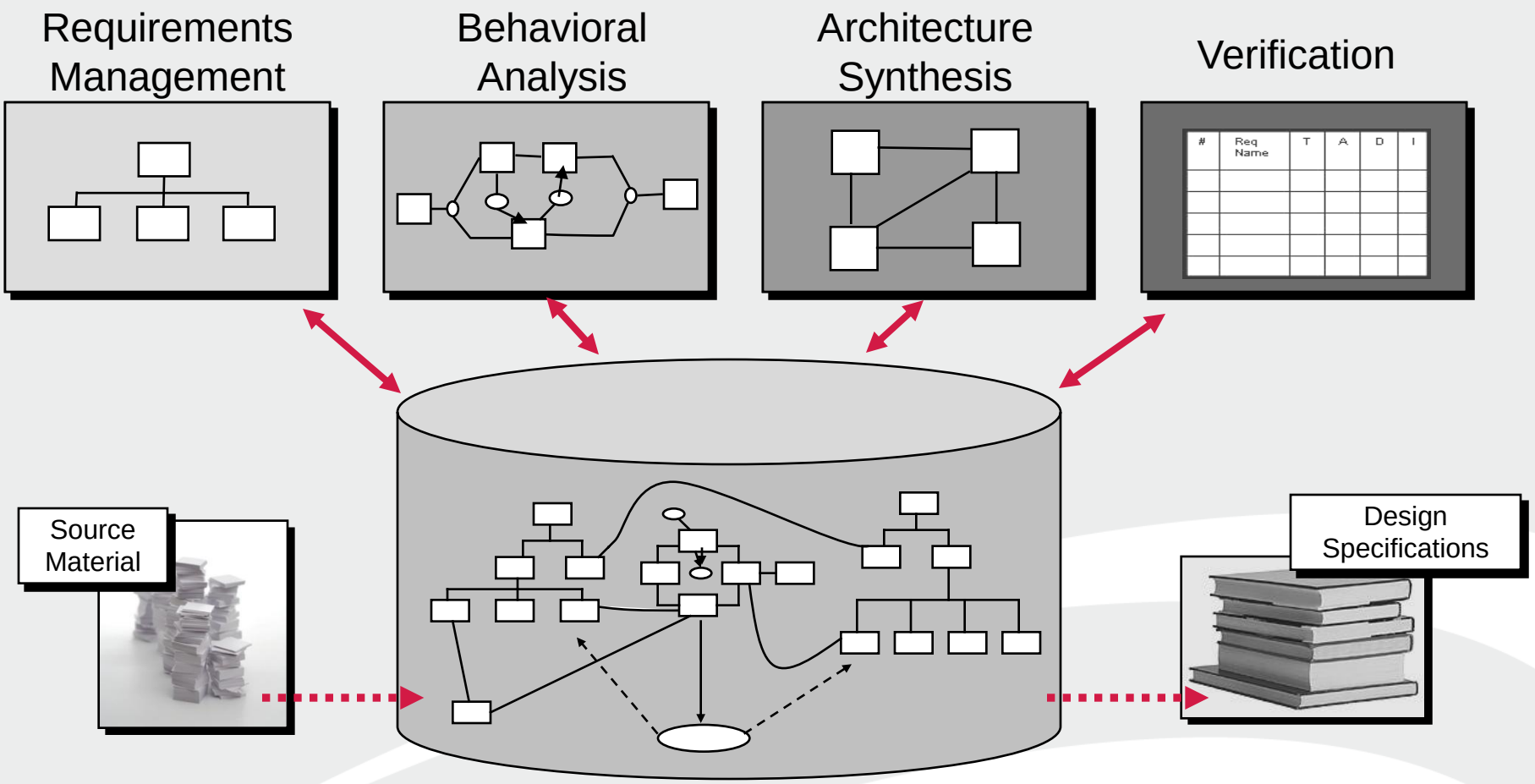
MBSE Integrated Data Layer



Integrated, Consistent Analysis: Complete Specifications, Project Documentation, Queries & Models

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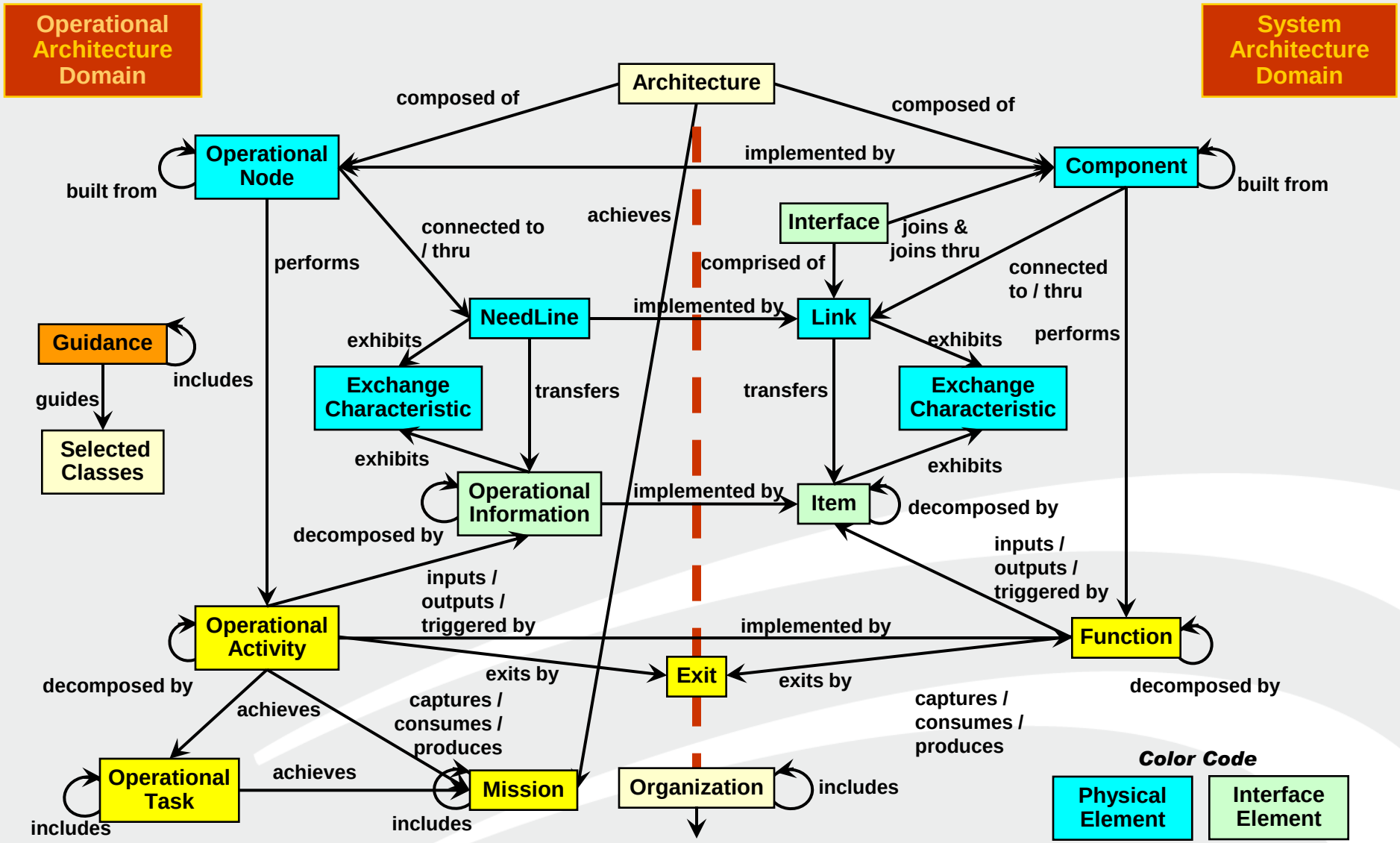
Integrated DoDAF Data Model



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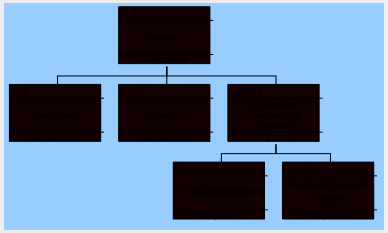
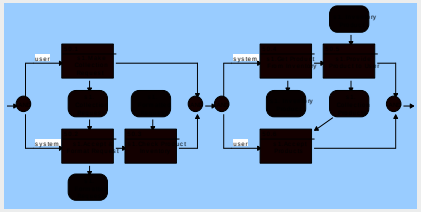
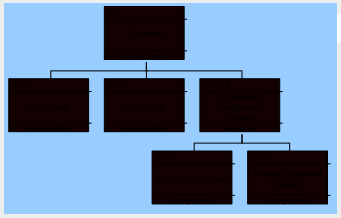
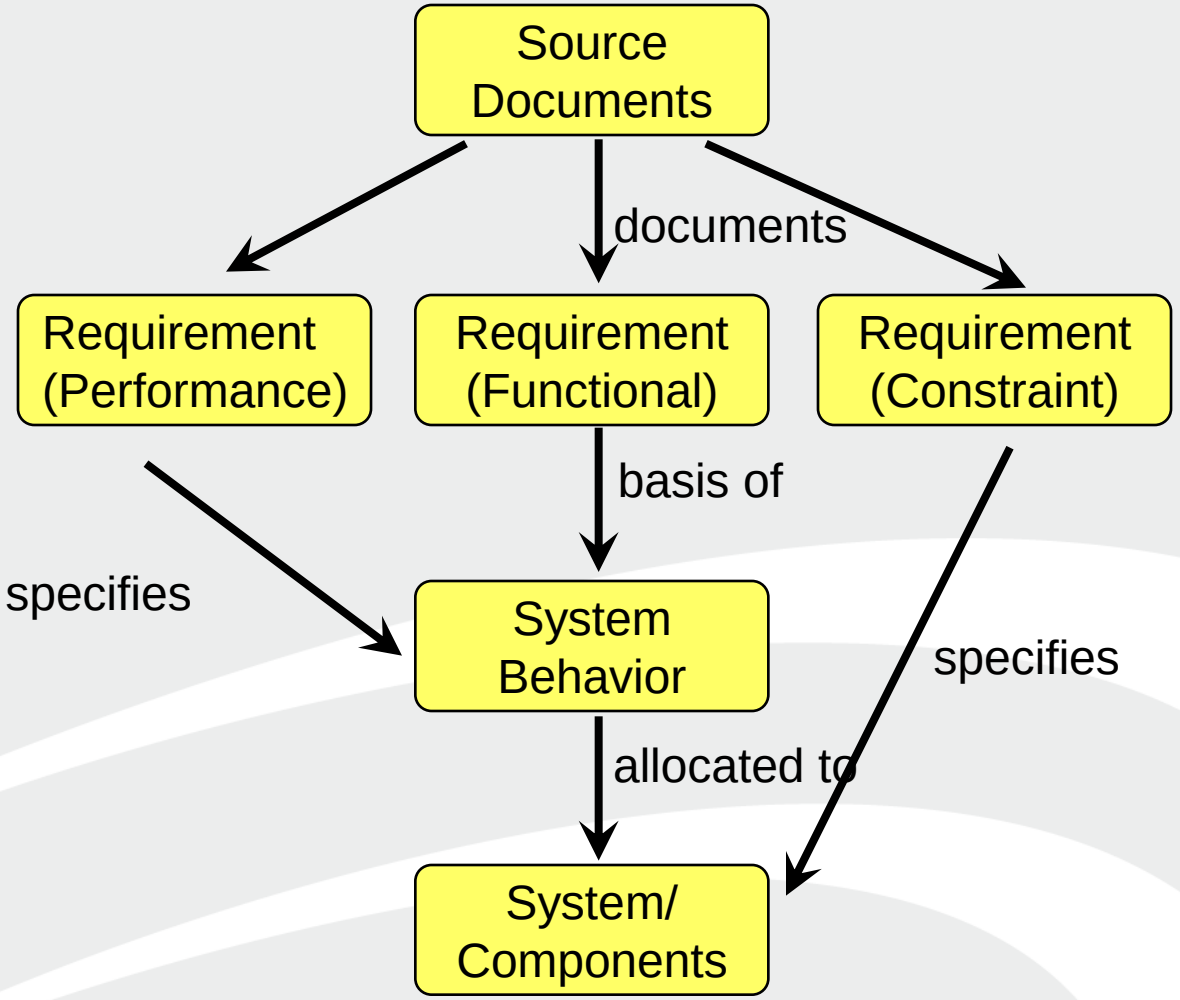
Systems Engineering Data Model (partial)









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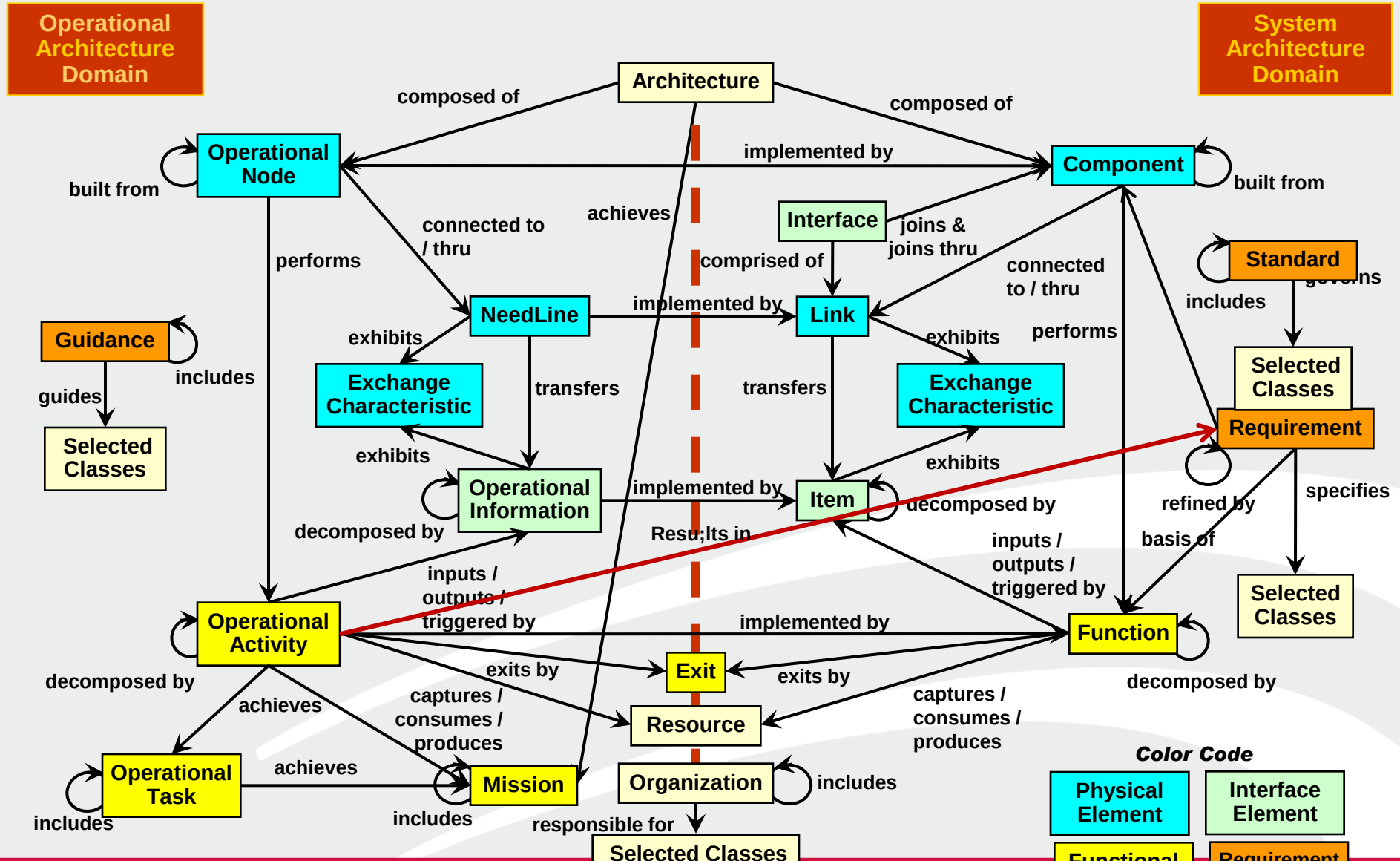
Integrated Data Model: Complete Traceability Between the Operational Architecture and System Engineering Domains



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DoDAF and MBSE System Model Overlap - Examples

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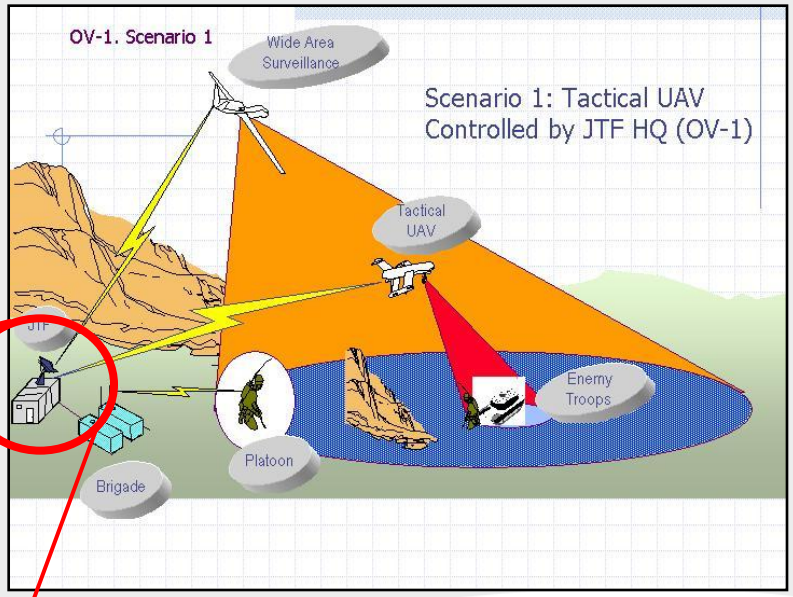
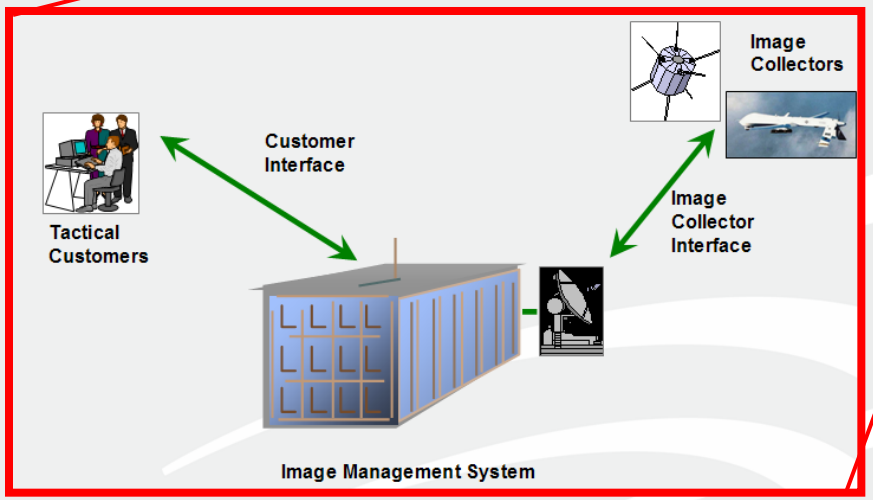
Sample Project
Tactical Imagery Gathering

***Description:** The Tactical Image Management Architecture is composed of both an operational element and an image management system which supports the architecture.*

The tactical scenario models an army platoon which is advancing over a hill and requires information about the tactical environment on the other side of hill. The platoon makes an image information request which is transferred back to joint task force. The joint task force has access to an image management system which checks to see if the information required is already available in its inventory. If the information is not in the inventory, a tactical UAV, in this case a Predator, is tasked to collect an image of the other side of the hill, send it back to the image management system, and then the requested tactical information is communicated to the platoon.





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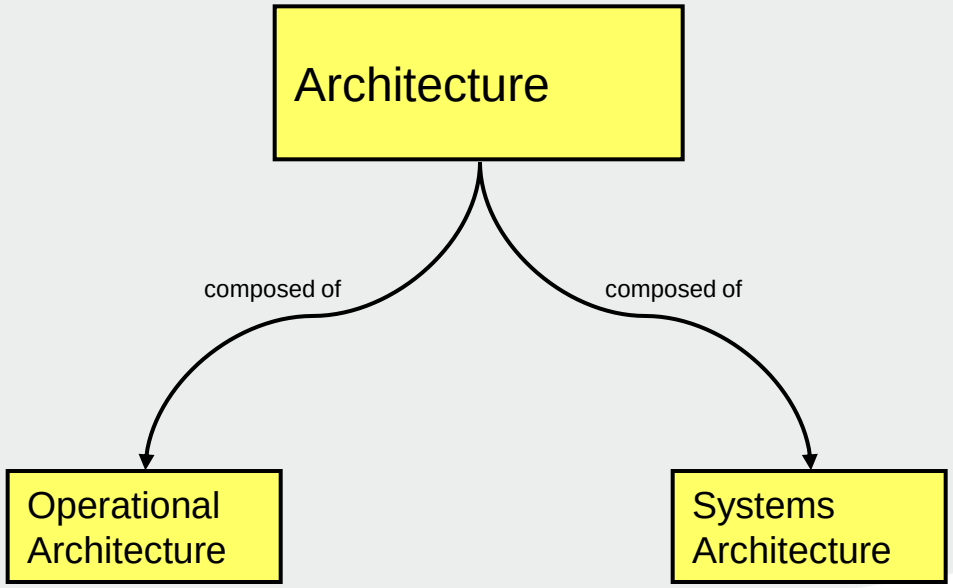
Architectures



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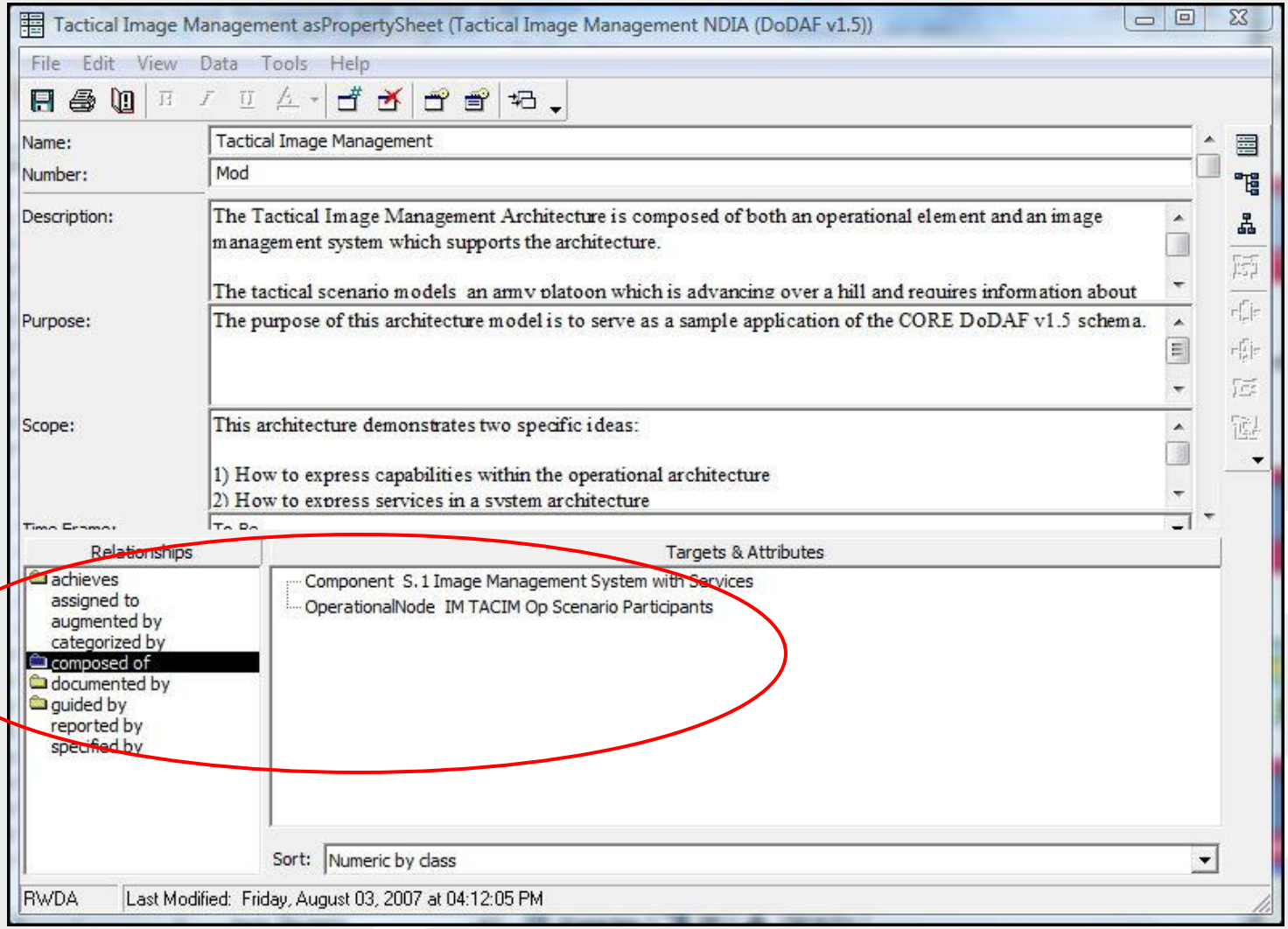
Modeled Relationships



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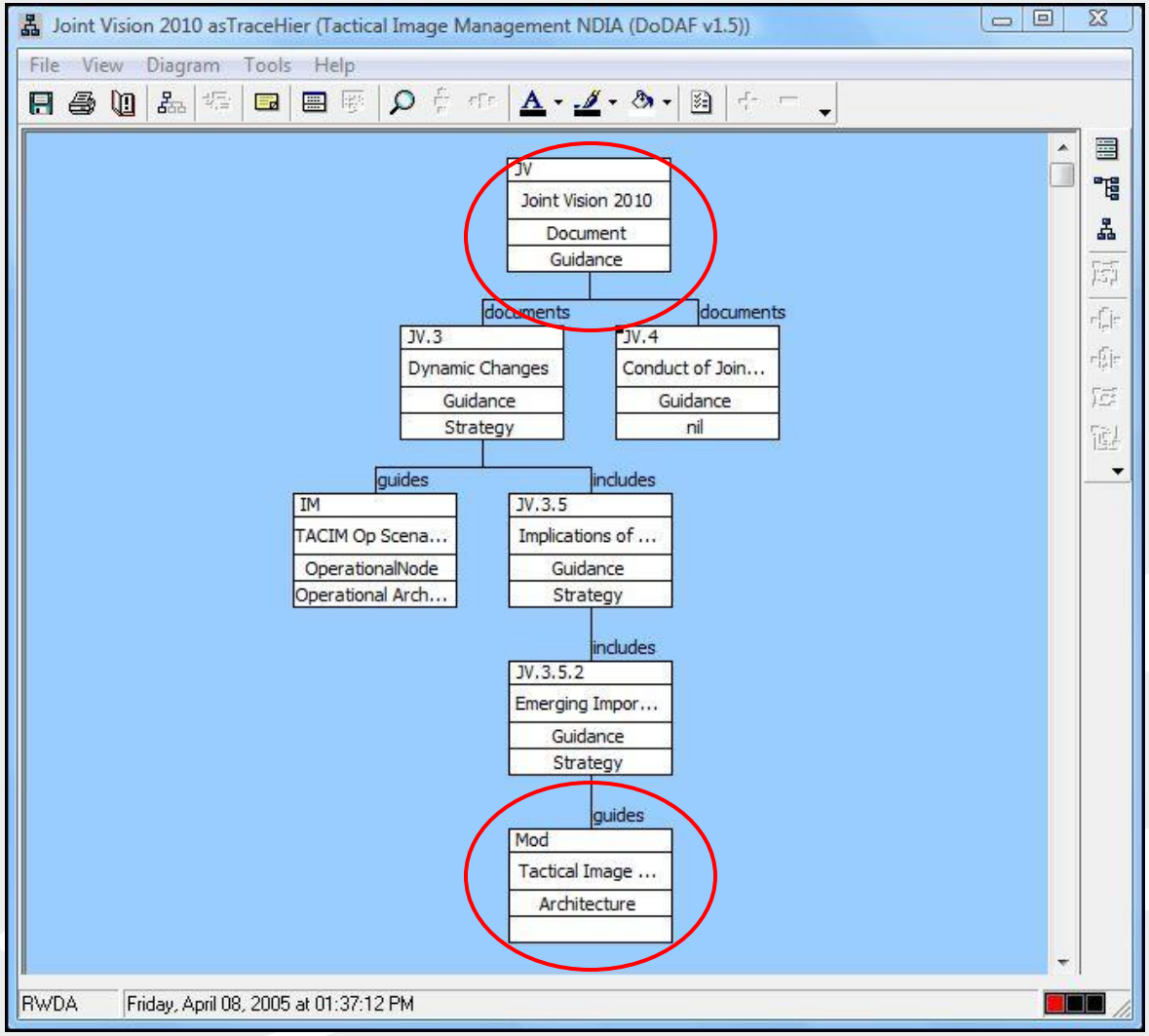
Architecture Traced to Guidance Documents



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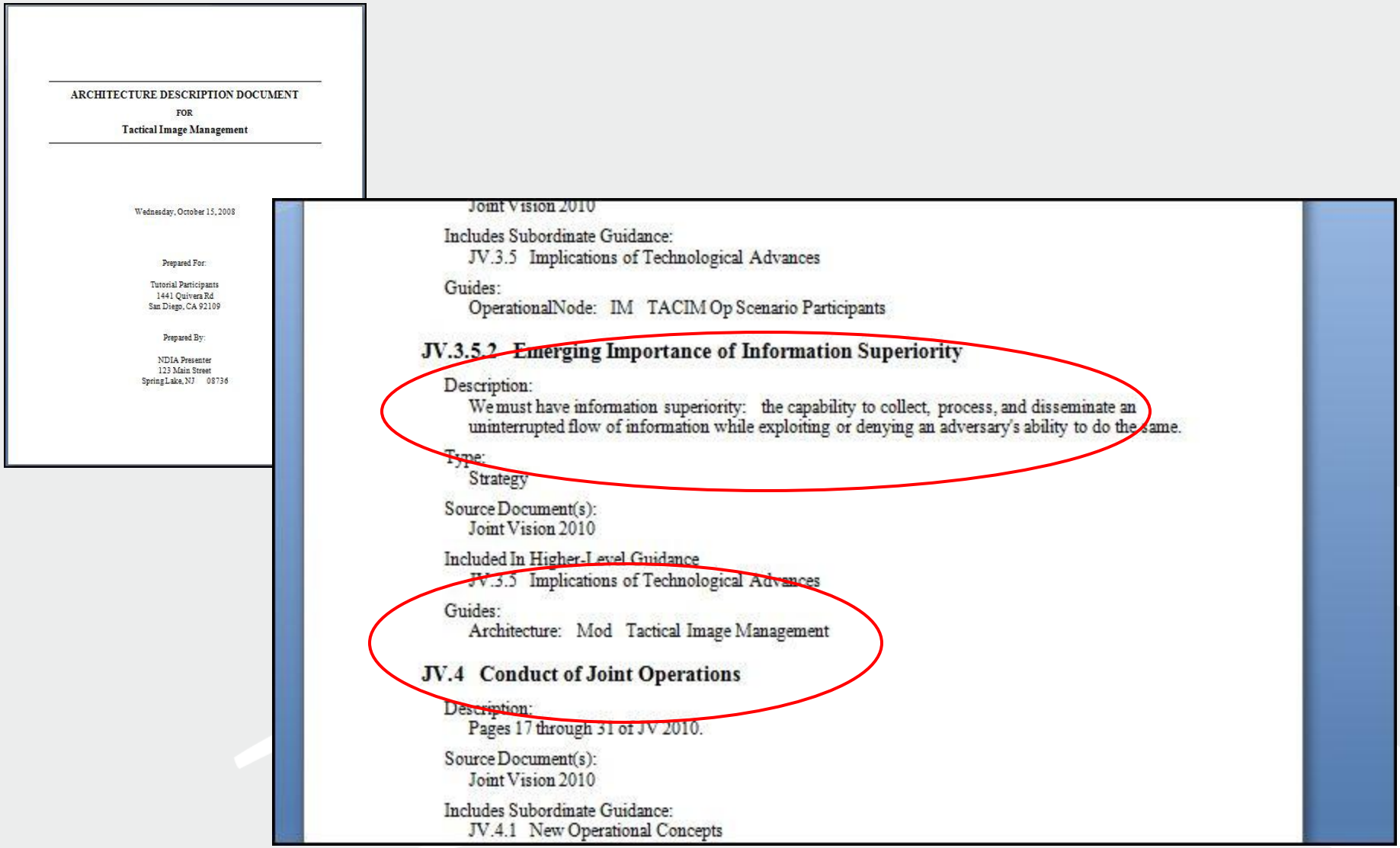
As seen in the produced AV-2



ARCHITECTURE DESCRIPTION DOCUMENT
FOR
Tactical Image Management

Wednesday, October 15, 2008

Prepared For:

Tutorial Participants
1441 Quivera Rd
San Diego, CA 92109

Prepared By:

NDIA Presenter
123 Main Street
Spring Lake, NJ 08736

Joint Vision 2010

Includes Subordinate Guidance:
JV.3.5 Implications of Technological Advances

Guides:
OperationalNode: IM TACIM Op Scenario Participants

JV.3.5.2 Emerging Importance of Information Superiority

Description:
We must have information superiority: the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same.

Type:
Strategy

Source Document(s):
Joint Vision 2010

Included In Higher-Level Guidance
JV.3.5 Implications of Technological Advances

Guides:
Architecture: Mod Tactical Image Management

JV.4 Conduct of Joint Operations

Description:
Pages 17 through 31 of JV 2010.

Source Document(s):
Joint Vision 2010

Includes Subordinate Guidance:
JV.4.1 New Operational Concepts

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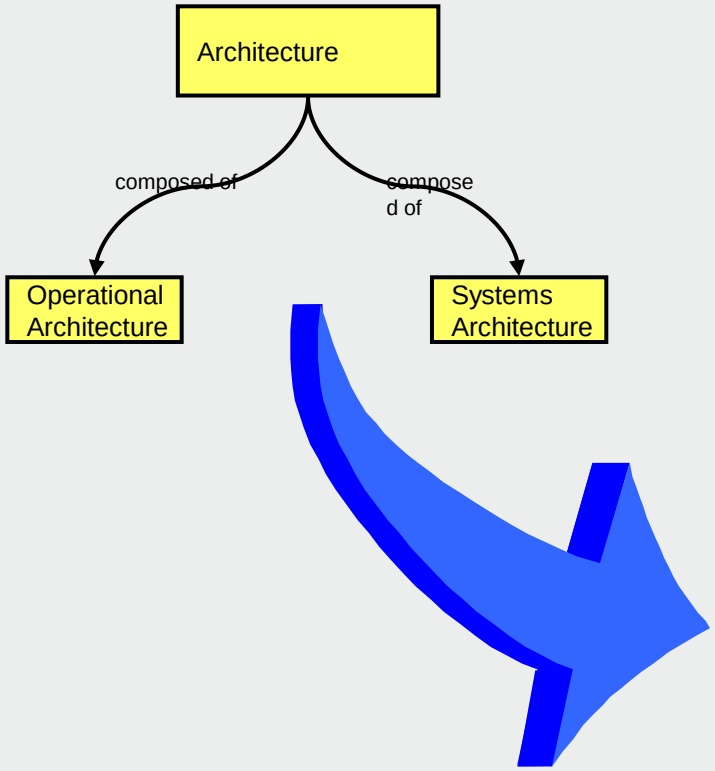
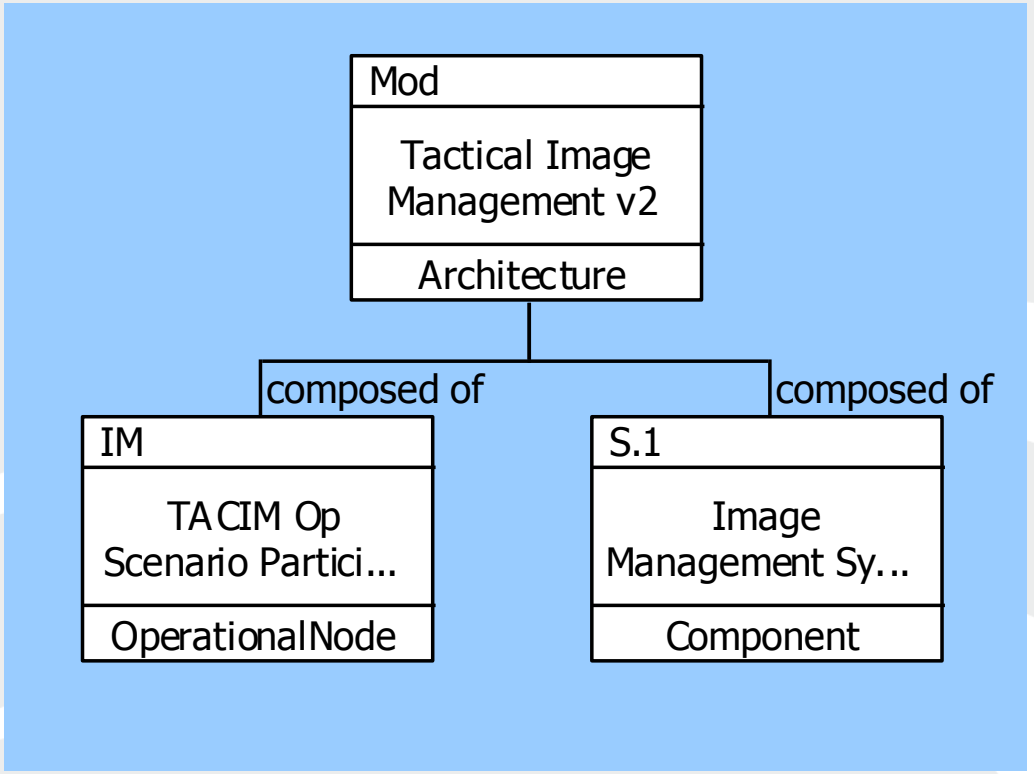
Architectures - Example





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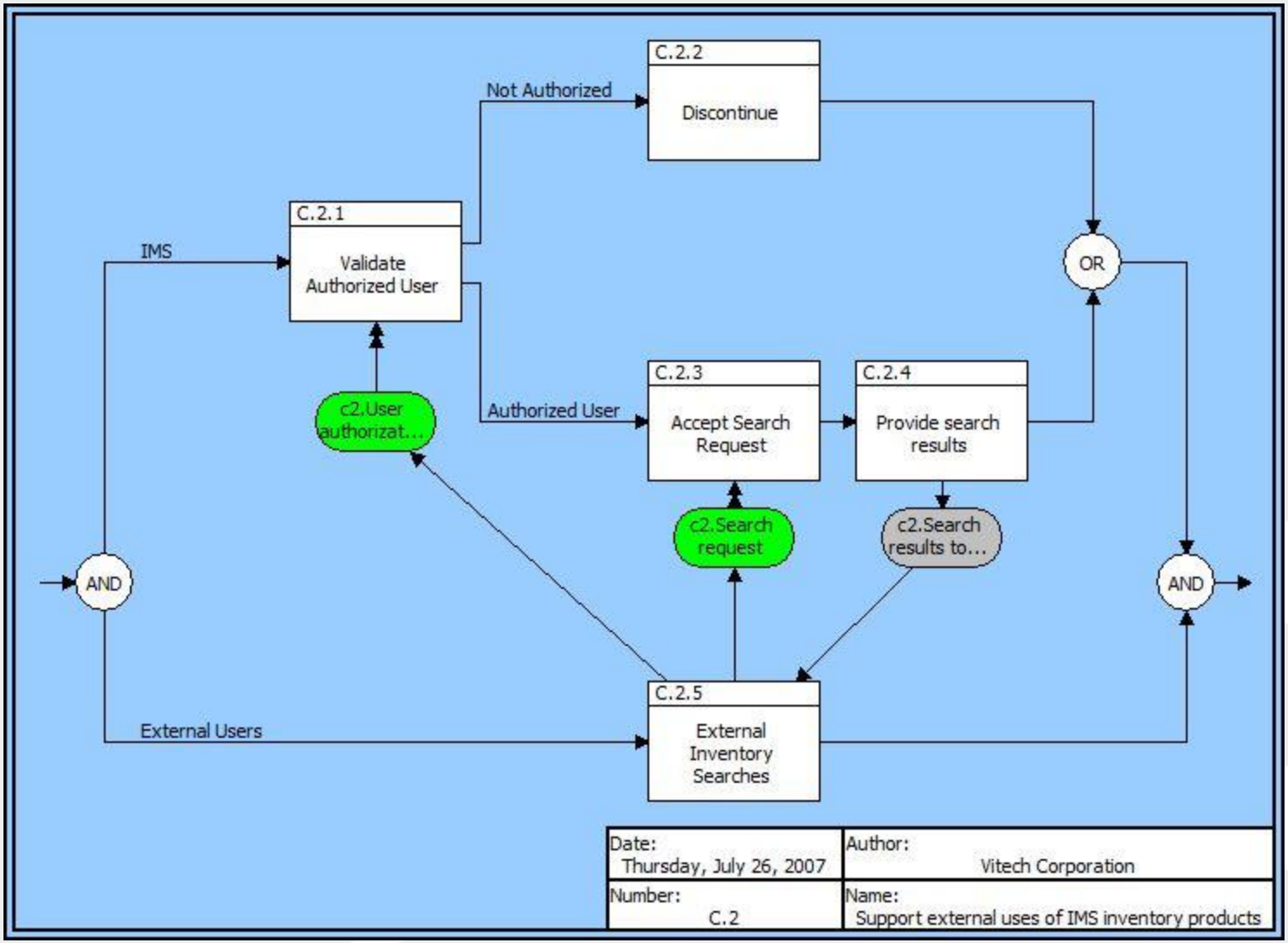
Capability – Support External Users



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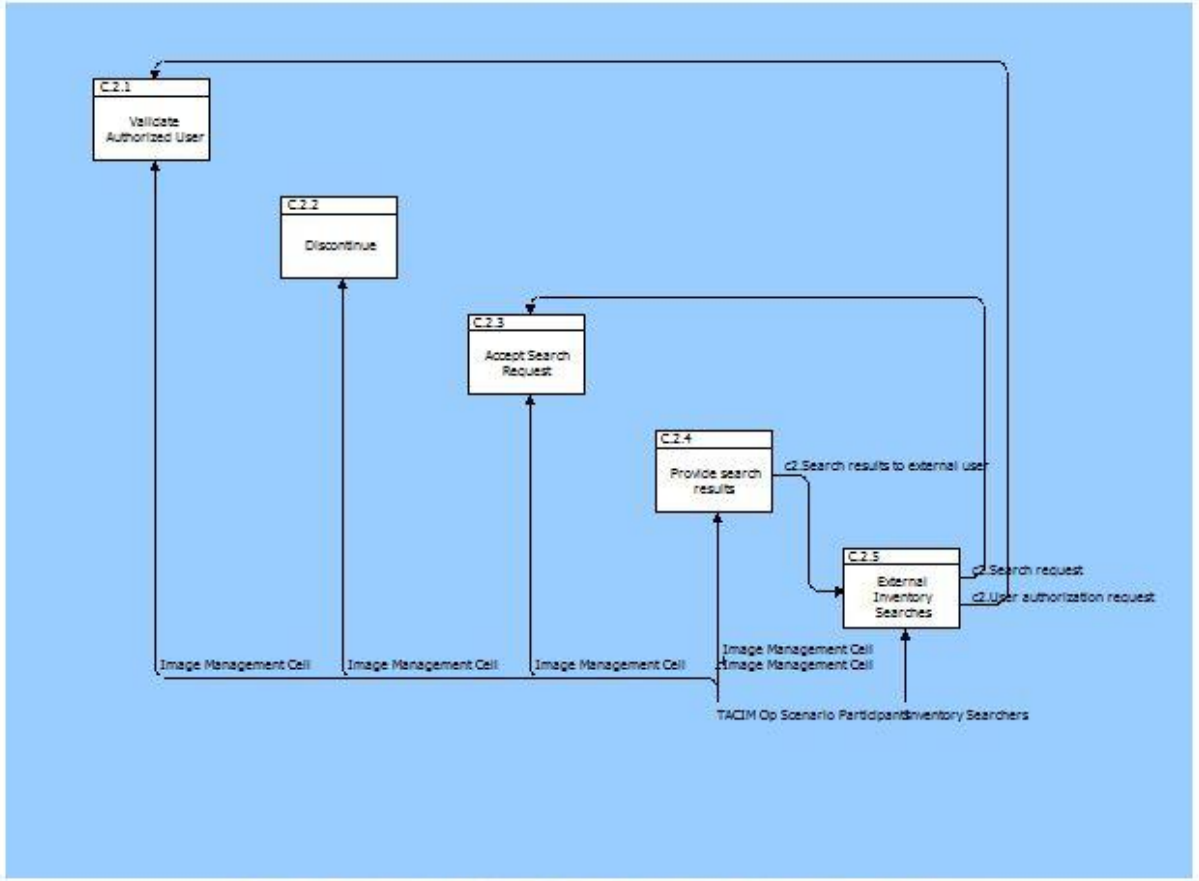
Support External Users as an OV-5

Support external uses of IMS inventory products
Operational Activity Model (OV-5)



C.2 Support external uses of IMS inventory products IDEF0 Diagram

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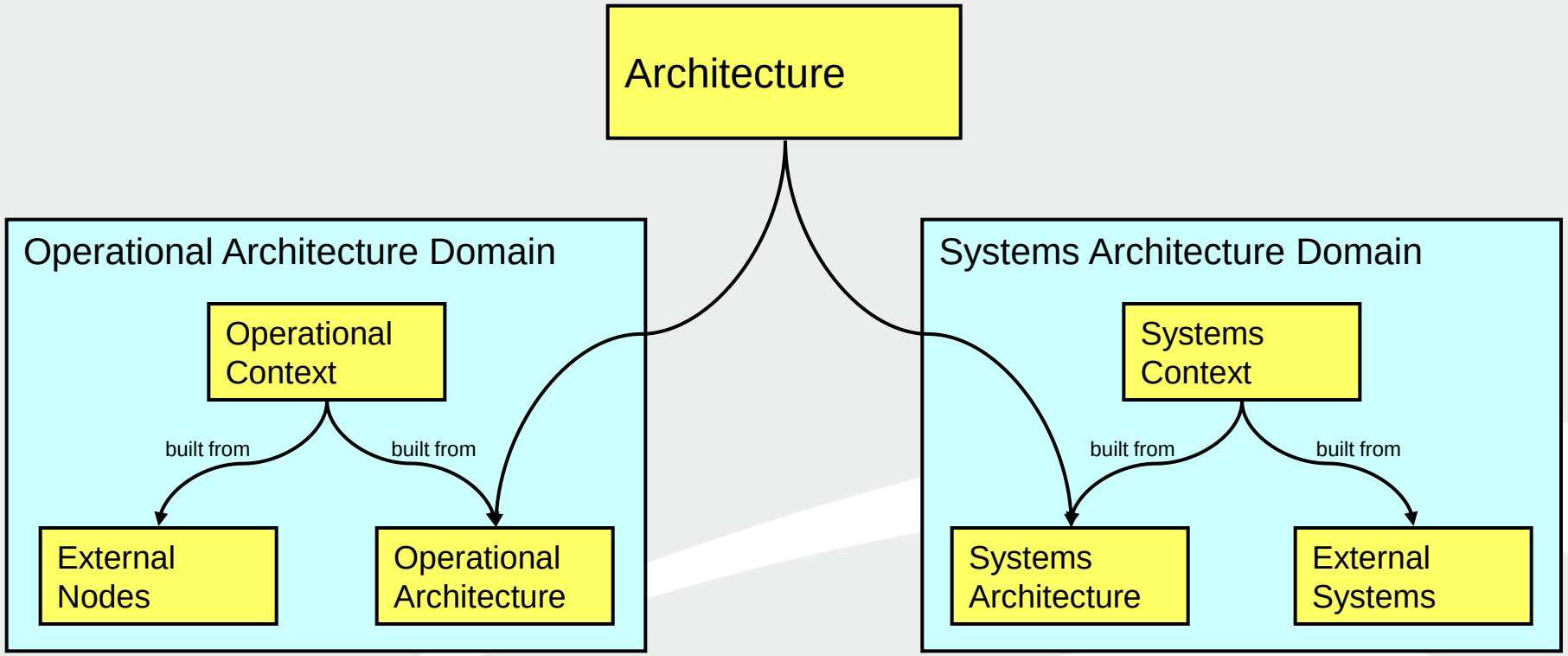
Architectures & Domains



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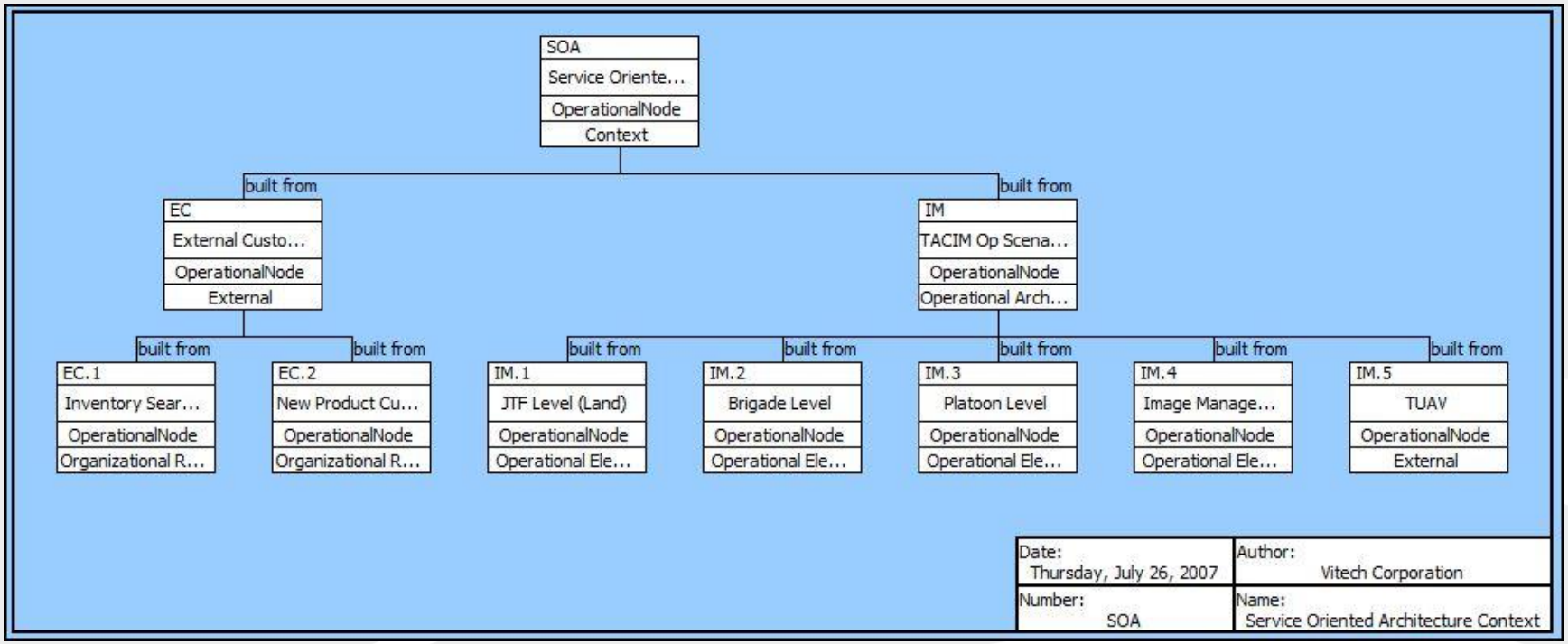
One View . . .

Hierarchy of Operational Nodes



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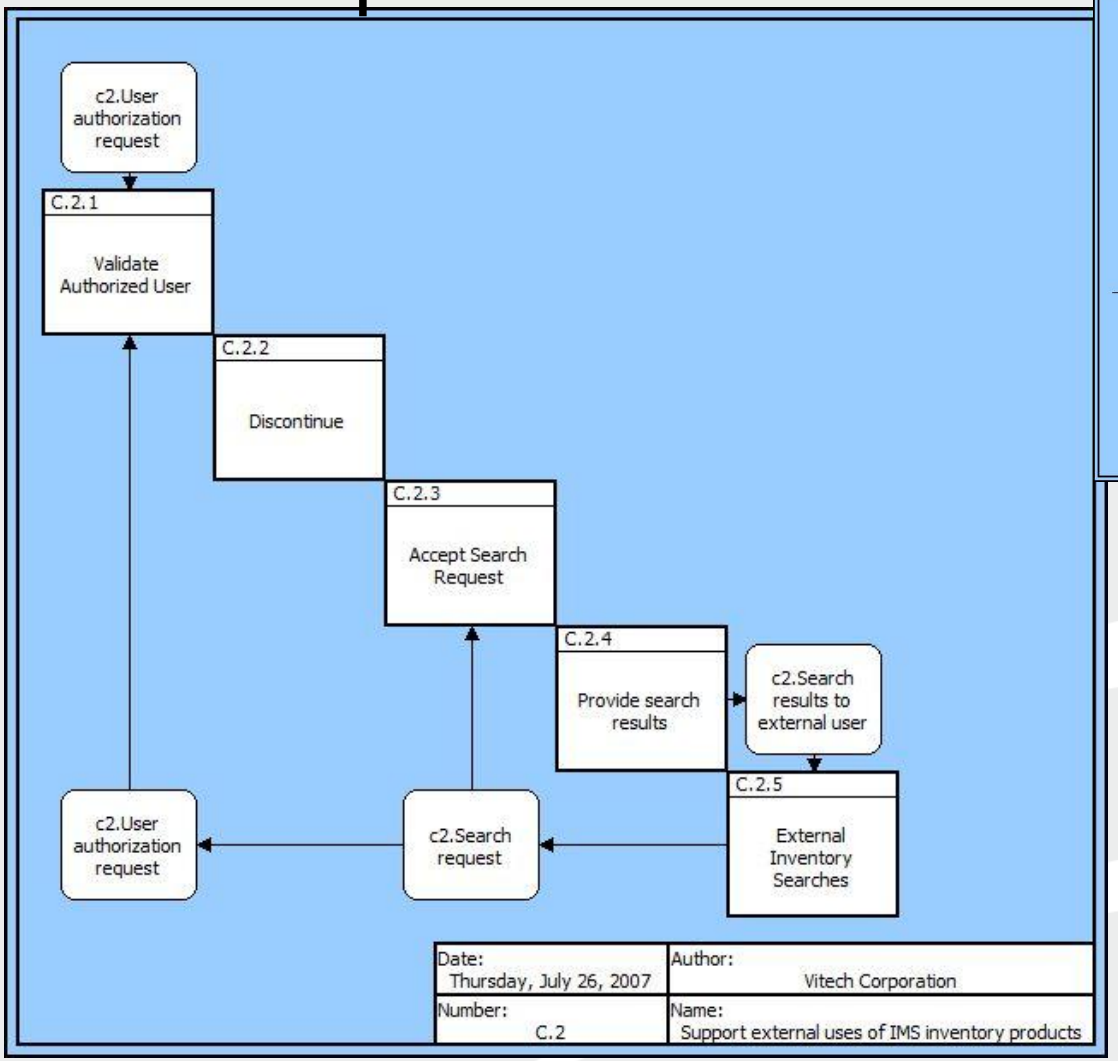
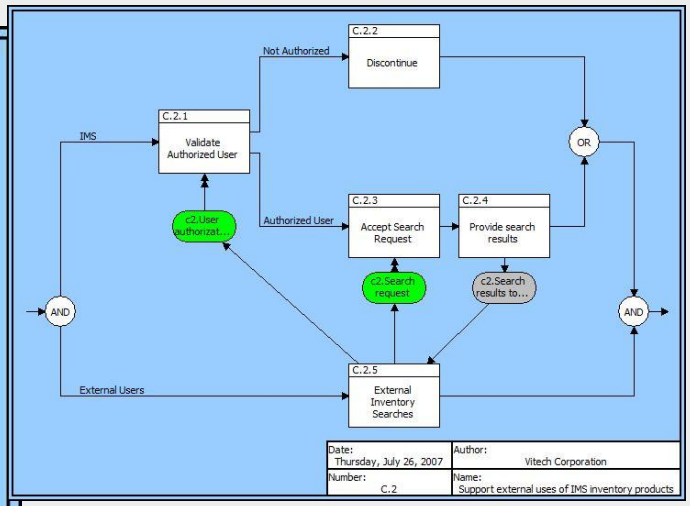
. . . Relates to the Next . . .

I/O of Operational Activities





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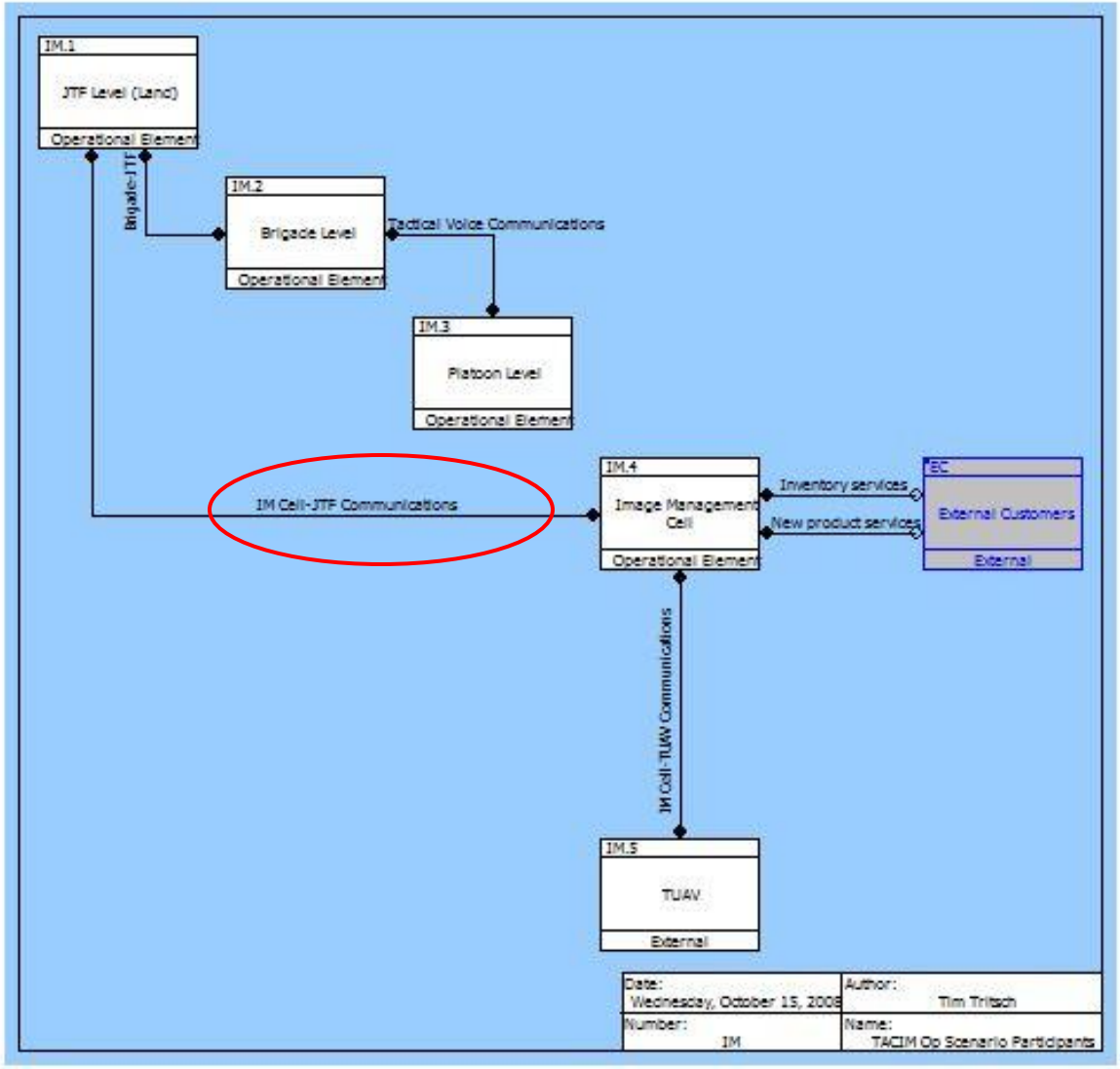
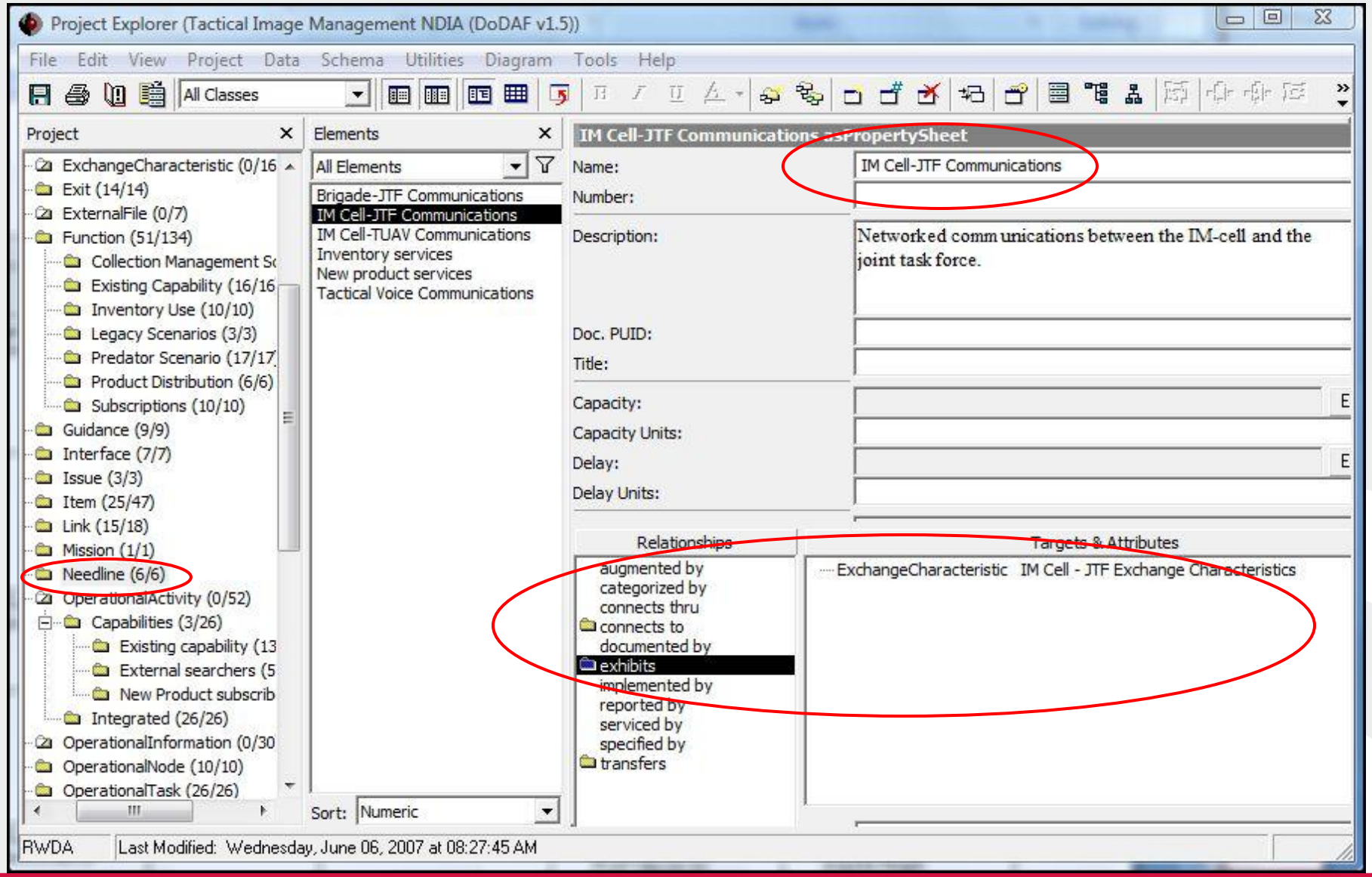
. . . Relates to the Next . . .

TACIM Op Scenario Participants
Operational Node Connectivity (OV-2)



. . . And From Our Integrated Architecture . . .



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. . . The Resulting OV-3

Tactical Image Management
Operational Information Exchange Matrix (OV-3)

PART I				
Needline	**Information Exchange**	**Operational Information Element**	**Information Source**	**Information Destination**
Brigade-JTF Communications	Brigade - JTF Exchange Characteristic	c1.Collected Information Description: Package of imaging information and augmenting material returned to the customer. Accuracy: Medium	JTF Level (Land) *Transmit Collected Information(As-Is)*	Brigade Level *Translate Information into Verbal Commands(As-Is)*
		c1.Formatted RFI Description: Formatted Request for Information requesting intelligence on a target at a specified location. Accuracy: High	Brigade Level *Request Latest Information for Location(As-Is)*	JTF Level (Land) *Receive Formatted RFI(As-Is)*
IM Cell-JTF Communications	IM Cell - JTF Exchange Characteristics	c1.Tactical Image Products Description: Processed imaging products. Accuracy: Medium	Image Management Cell *Provide Current Target Imaging Product(As-Is)*	JTF Level (Land) *Process Tactical Operational Information(As-Is)*
		c1.Tactical Tasking Imaging Request Description: Tasking request to acquire imaging intelligence for tactical commanders. Accuracy: High	JTF Level (Land) *Receive Formatted RFI(As-Is)*	Image Management Cell *Accept Tasking for Tactical Operations(As-Is)*
IM Cell-TUAV Communications		c1.Target Imaging	TUAV *TUAV Ops(As-Is)*	Image Management Cell *Acquire Target Imaging(As-Is)* Image Management Cell *Subscriber(s) for this*

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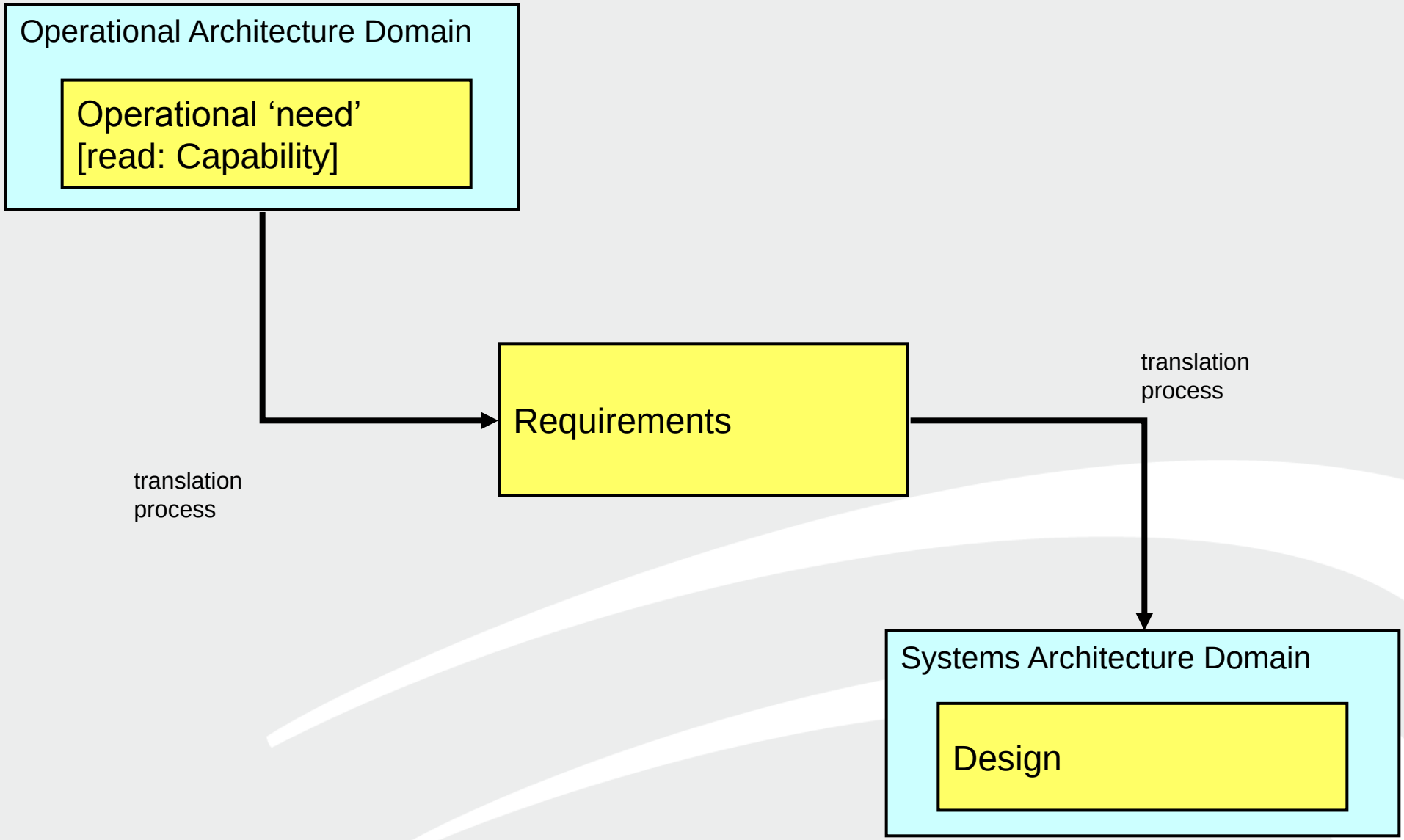
Architectures & Requirements



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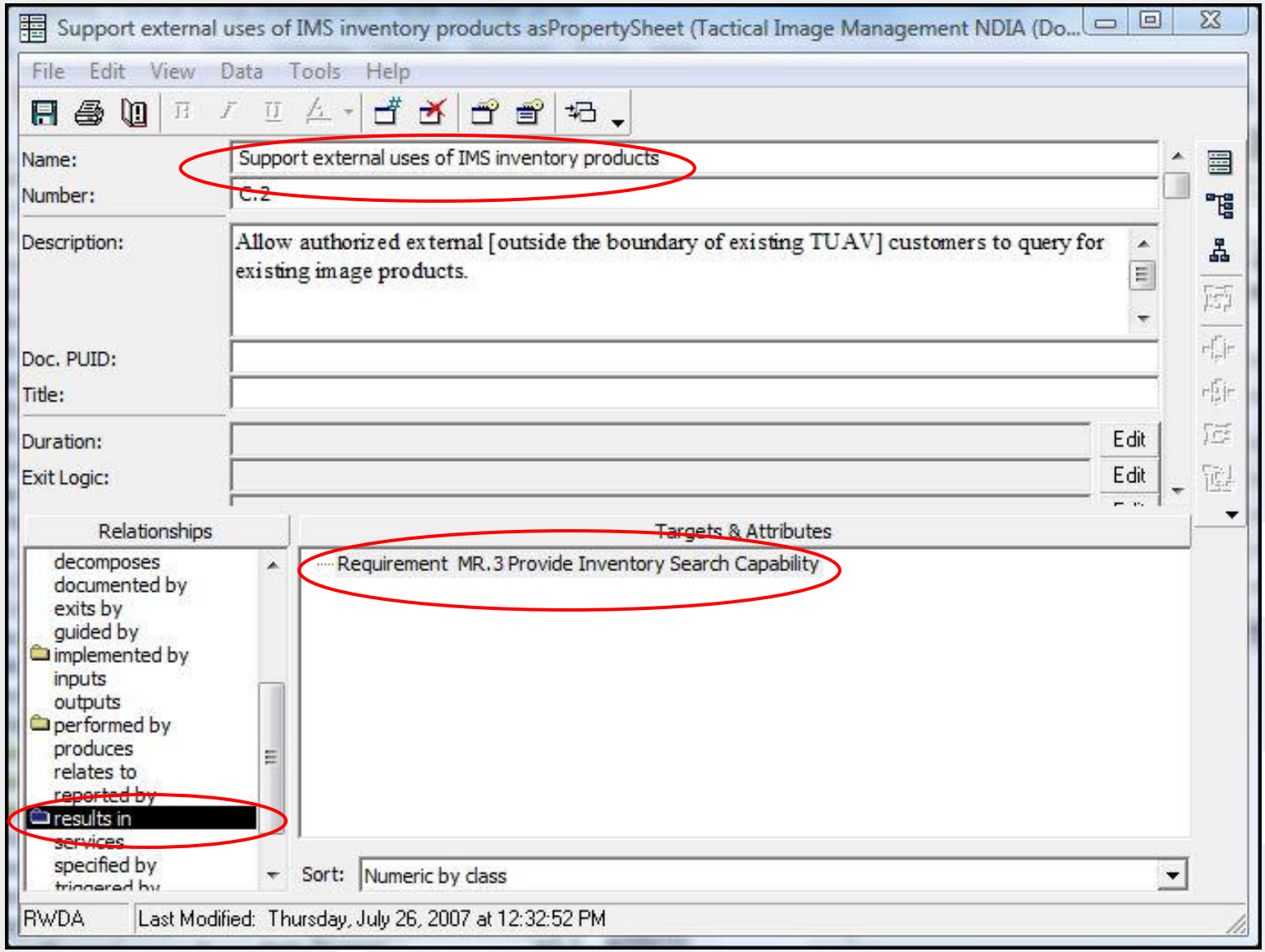
Capability to Requirement Traceability



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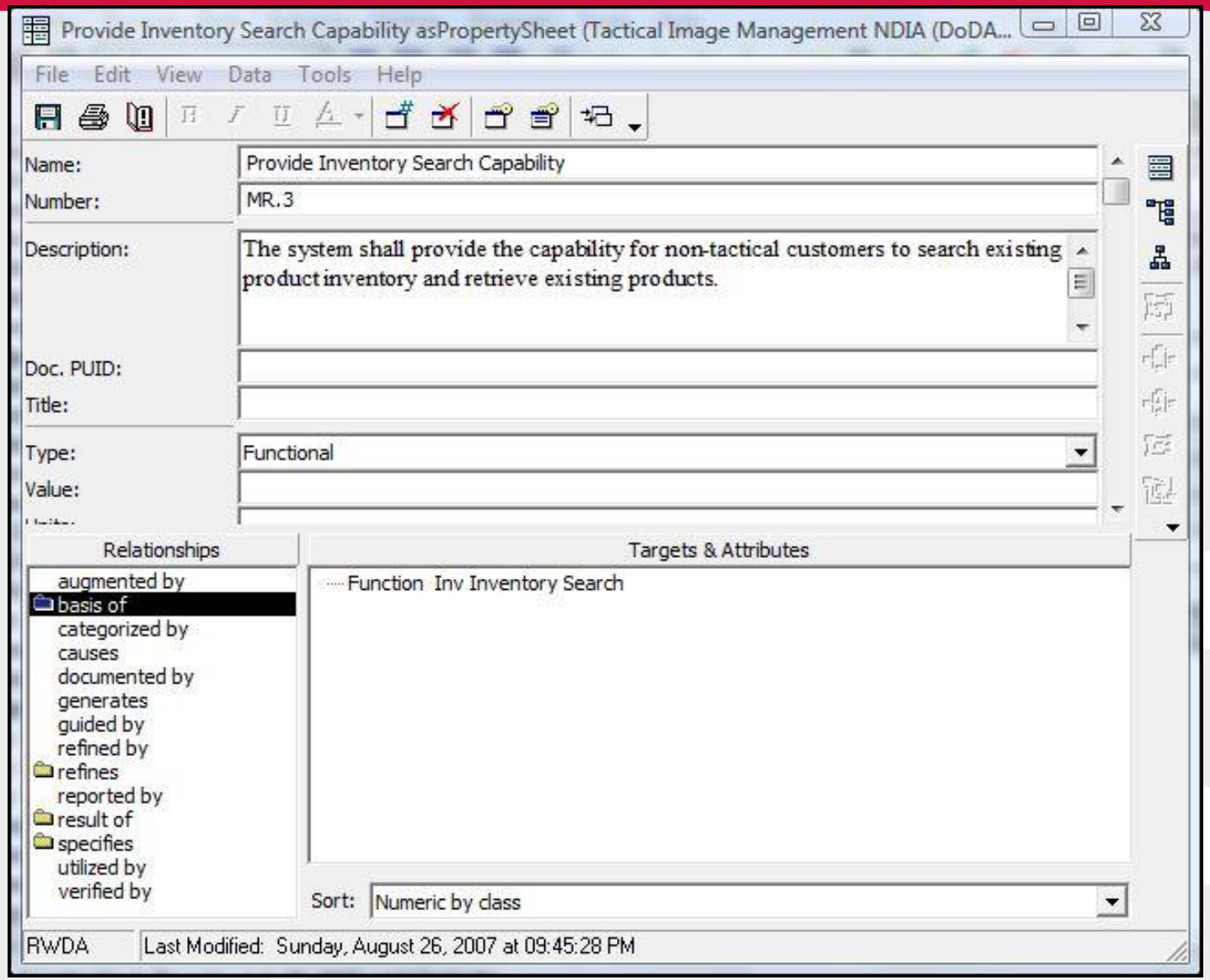
Requirement to Function Traceability



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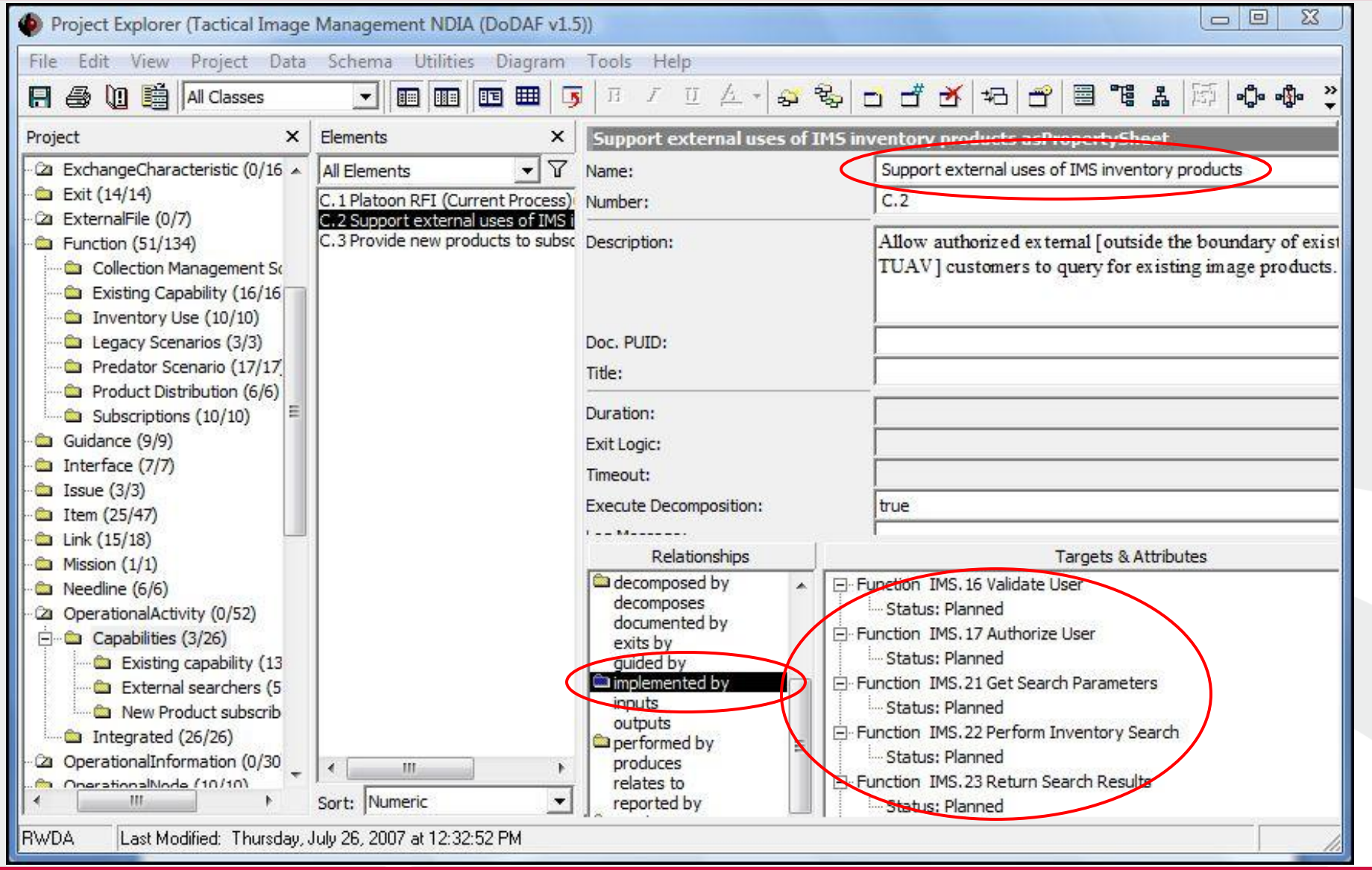
Op Activities *implemented by* System Functions



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SV-5a Operational Activity to Systems Function Traceability Matrix

Support external uses of IMS inventory products to
Operational Activity to Systems Function Traceability Matrix (SV-5)

Function	Operational Activity				
	Accept Search Request	Discontinue	External Inventory Searches	Provide search results	Validate Authorized User
Accept and Format Request					
Authorize User					X
Check Product Inventory					
Check Subscriber Requests					
Determine Sensor Mix					
Distribute New Product					
Existing Subscriptions?					
Fly to Surveillance Position					
Get Product From Inventory					
Get Search Parameters	X				
Get Subscription Parameters					
New Product Received					
Not Authorized		X			X
Perform Inventory Search	X				
Perform Predator Surveillance					
Prioritize Request					

— 1 —

Wednesday, October 15, 2008

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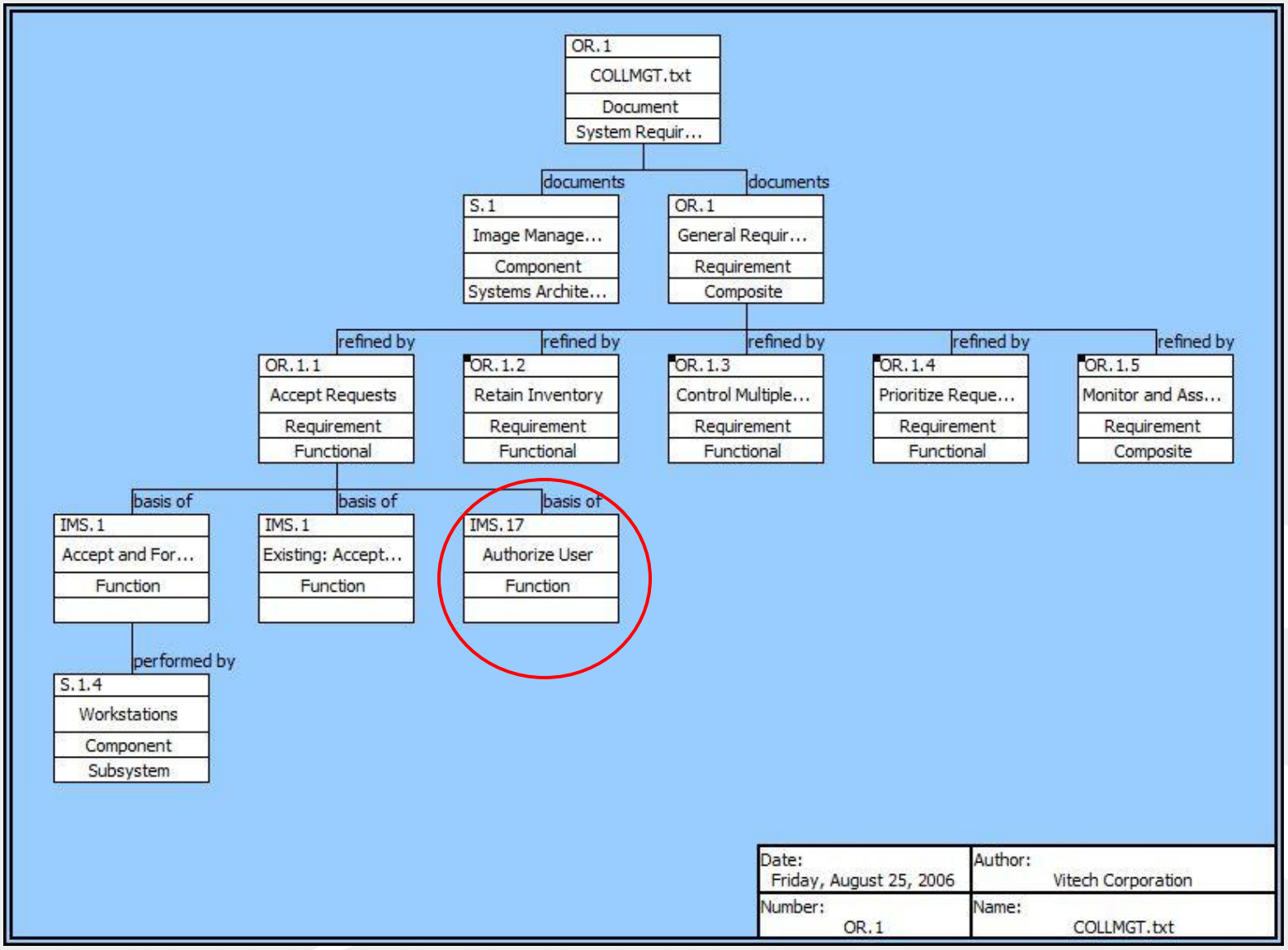
SE Traceability



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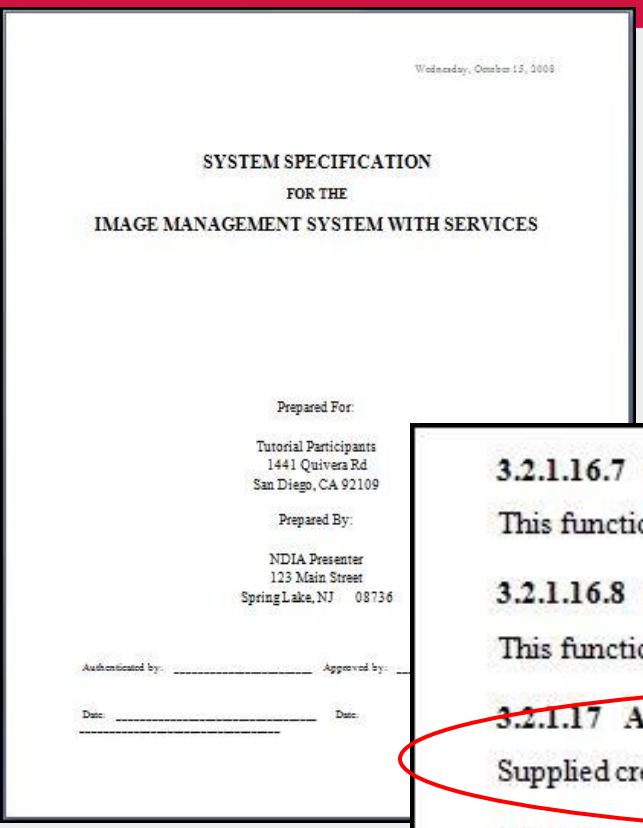
Function Appears in the SSS



Wednesday, October 15, 2008

SYSTEM SPECIFICATION

FOR THE

IMAGE MANAGEMENT SYSTEM WITH SERVICES

Prepared For:

Tutorial Participants
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Prepared By:

NDIA Presenter
123 Main Street
Spring Lake, NJ 08736

Authenticated by: _____ Approved by: _____

Date: _____ Date: _____

3.2.1.16.7 Send User Access Rights

This function responds with the user's access rights.

3.2.1.16.8 Send Unknown User

This function notifies the interfacing service that the user is unknown.

3.2.1.17 Authorize User

Supplied credentials indicate the user is authorized access, so acknowledge the access.

3.2.1.18 Get Subscription Parameters

This function receives user inputs for a subscription to new products.

— 6 —

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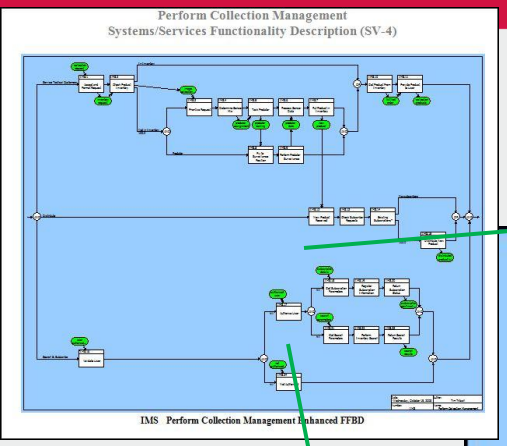
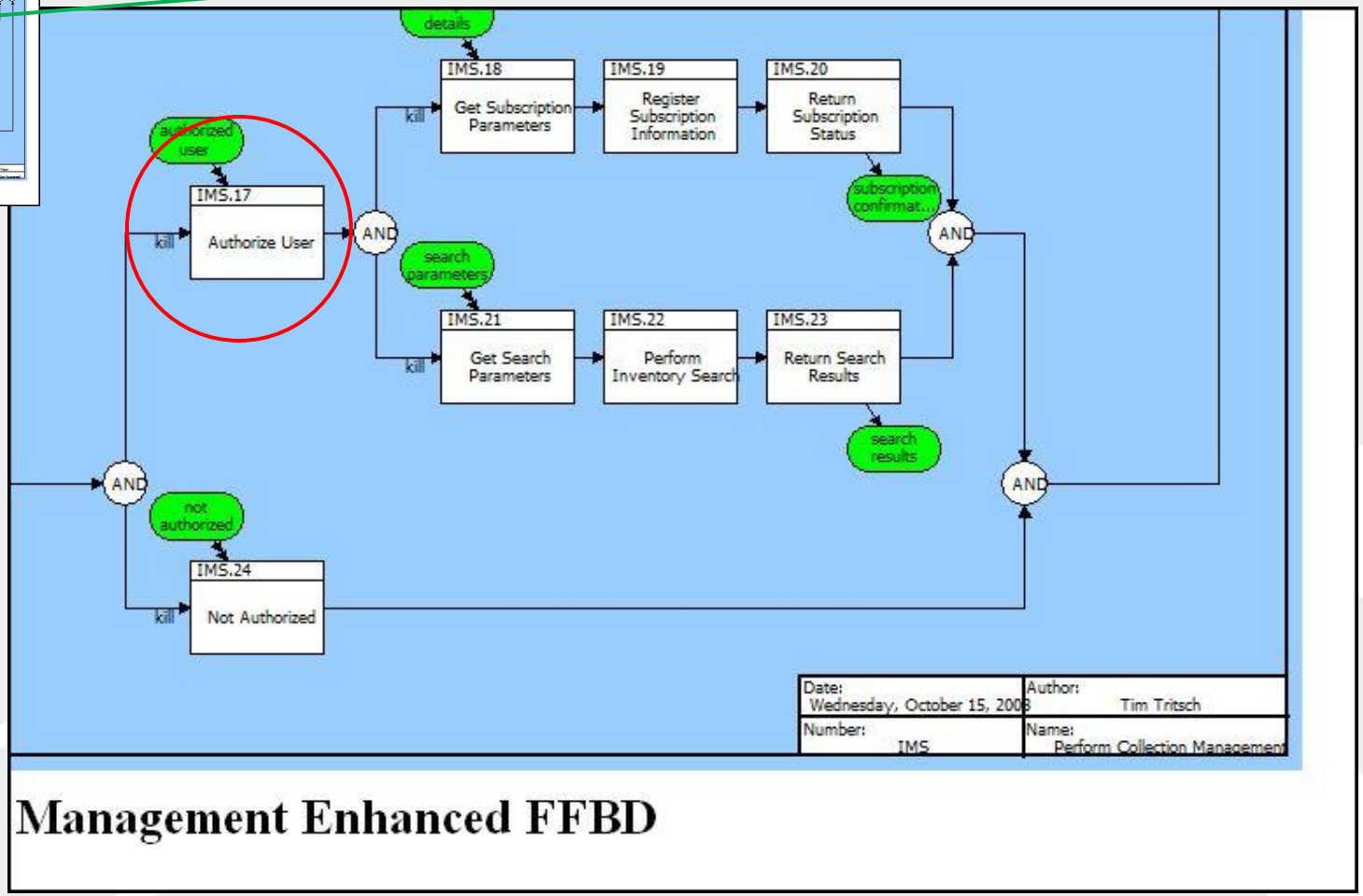
Function As Part Of SV-4





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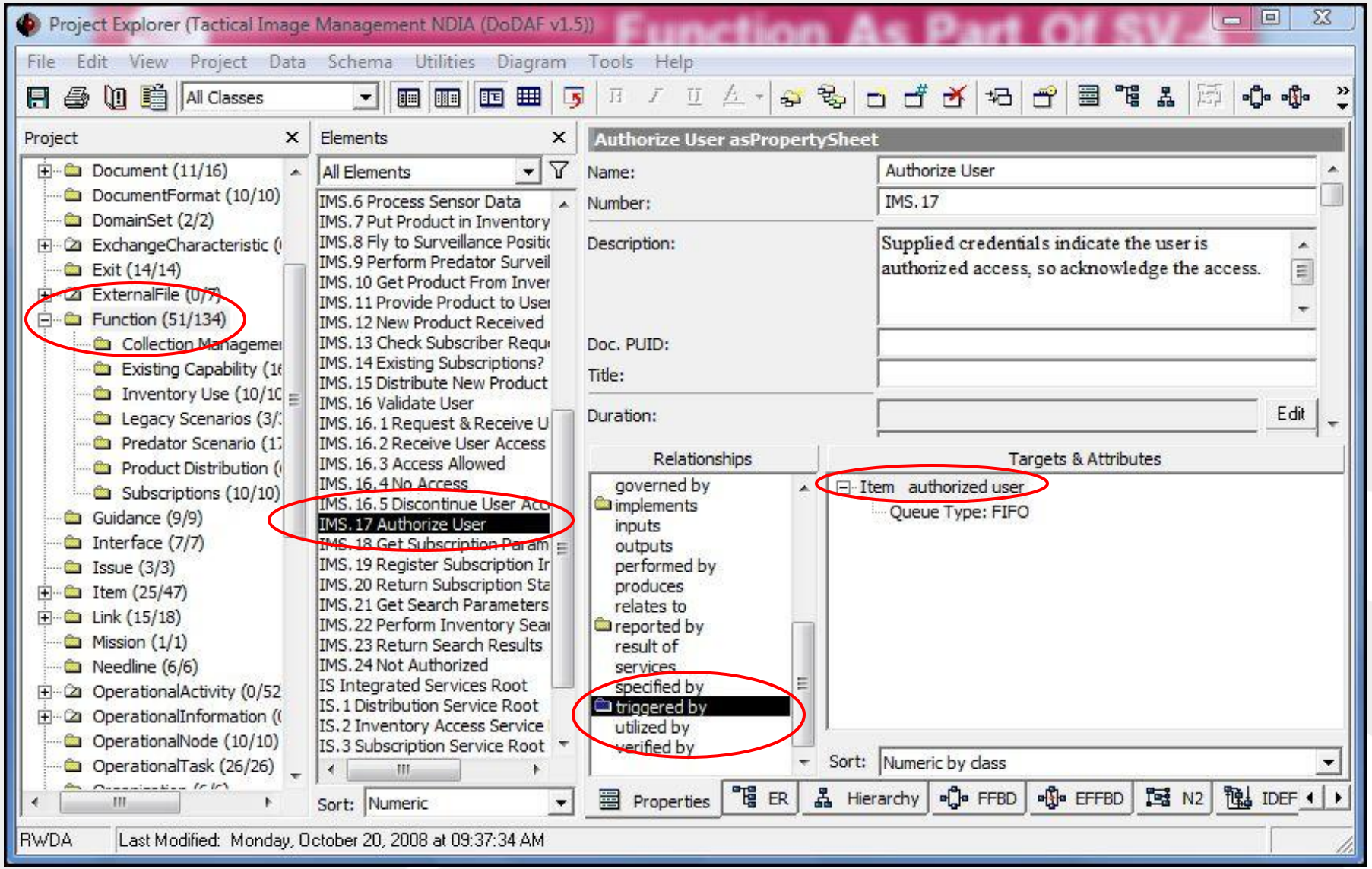
Inside the Data Model . . .



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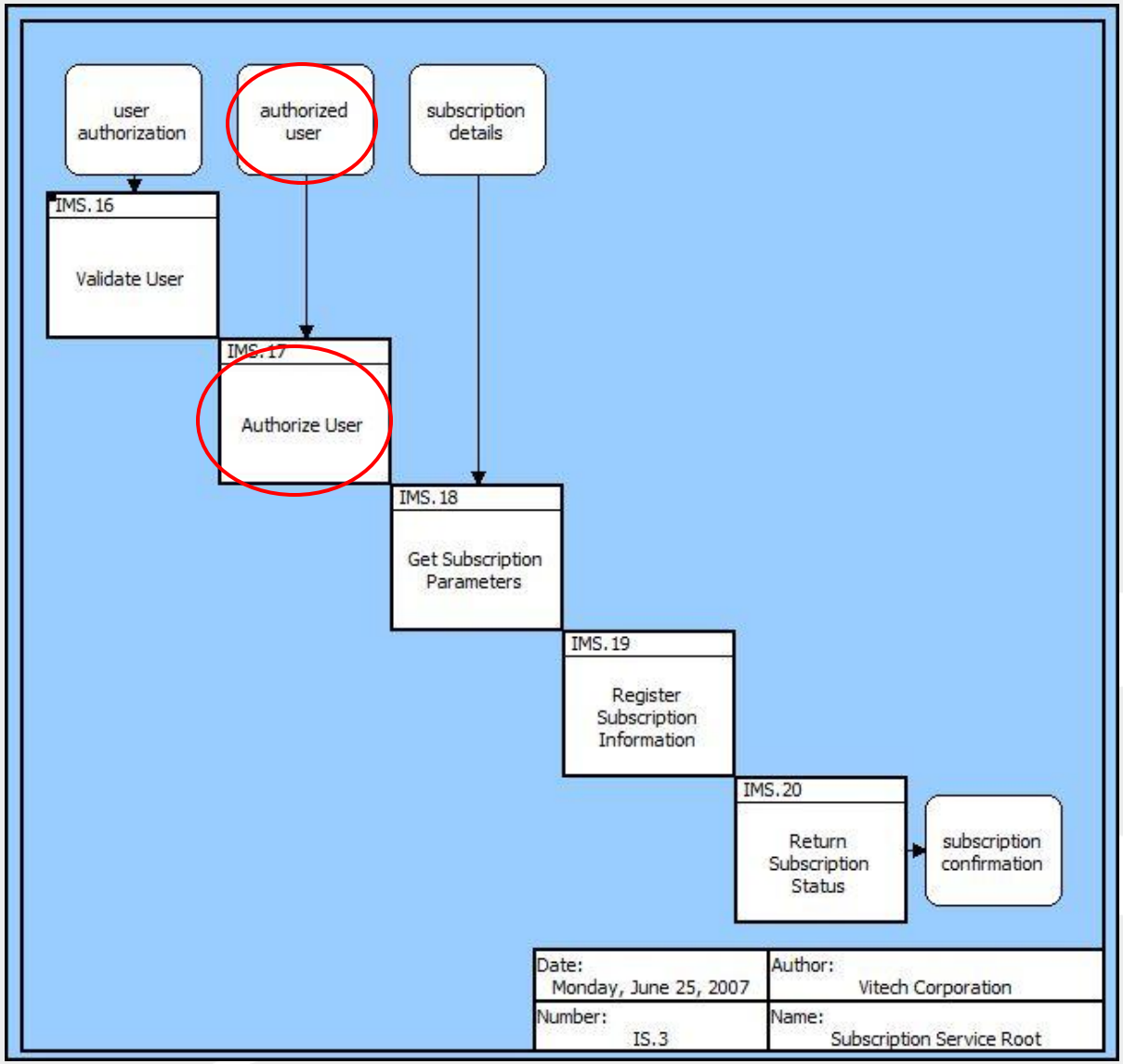
N2 Diagram Provides a Snapshot of System I/O



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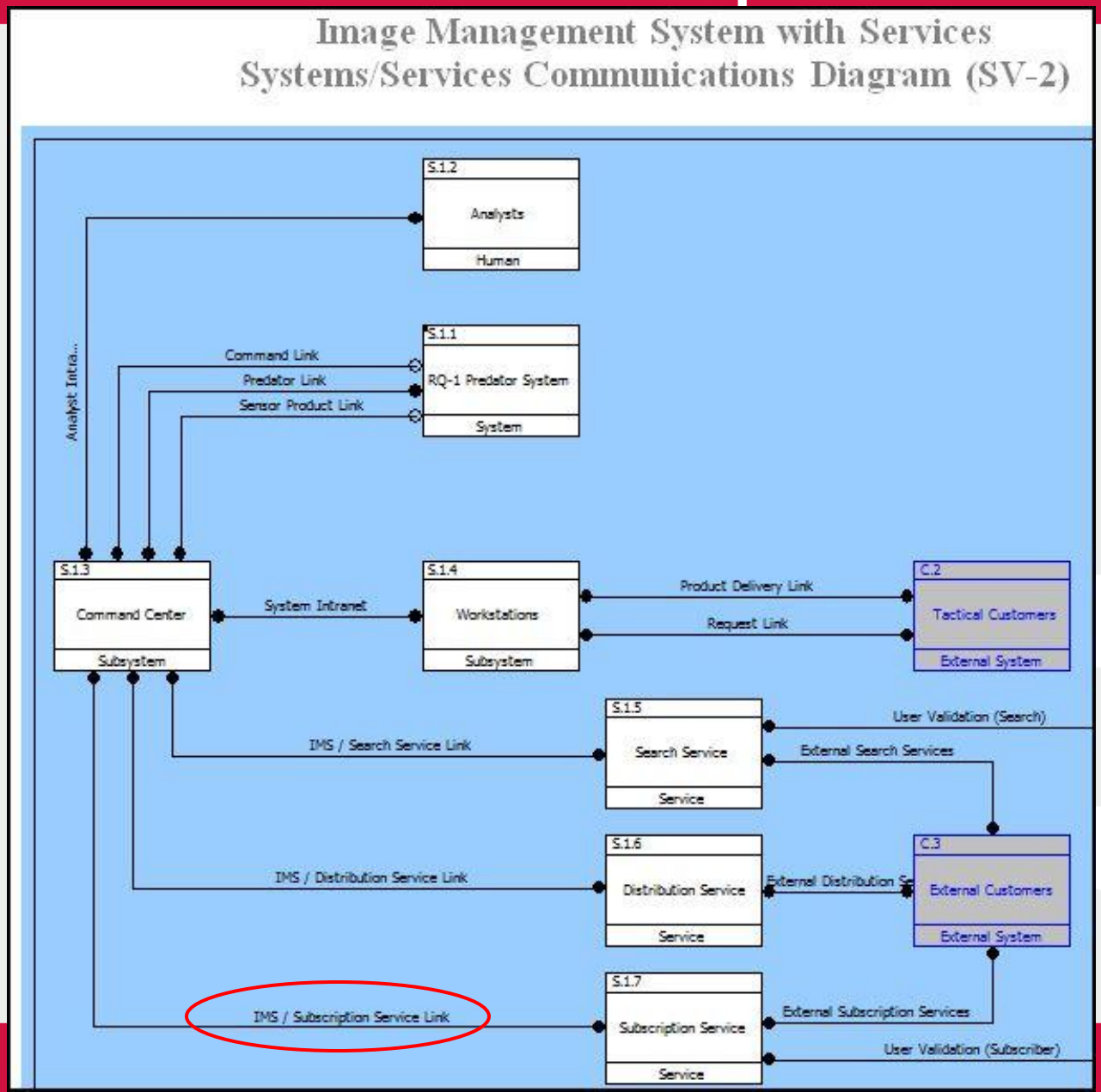
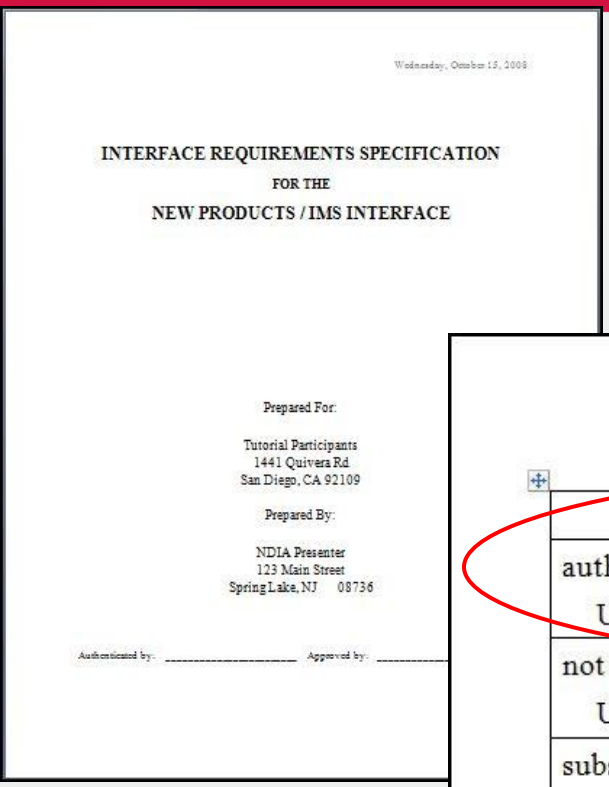
Functional Allocation to System Components Reveals Required Connectivity



System Interoperability Also Used In Interface Requirement Specifications



Wednesday, October 15, 2008

INTERFACE REQUIREMENTS SPECIFICATION

FOR THE

NEW PRODUCTS / IMS INTERFACE

Prepared For:

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Table 3 IMS / Subscription Service Link Item Definitions

Name and Description	Source / Destination	Characteristics
authorized user User authorized status.	Source: Subscription Service Destination: Command Center	Accuracy: High
not authorized User is not authorized.	Source: Subscription Service Destination: Command Center	
subscription confirmation Subscription details returned for verification.	Source: Subscription Service Destination: Command Center	
subscription details Subscription request details provided.	Source: Destination:	
user authorization User authorization status.	Source: Destination:	

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SV-3 Systems-Systems Matrix

Image Management System
Systems-Systems Matrix (SV-3)

	Analysts	Command Center	Ground Control Station (GCS)	Predator Crew	Predator Vehicle	Work Stations	Tactical Customers
Analysts		X					
Command Center	X		X			X	
Ground Control Station (GCS)		X		X	X		
Predator Crew			X				
Predator Vehicle			X				
Work Stations		X					X
Tactical Customers						X	

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Test Planning In

3.2.1 Accept Request Test

a) SCHEDULE:

Estimated Duration	Start Date	End Date

b) TEST CONFIGURATION:

The Accept Request configuration consists of one or more tactical customers conne
and entering new product requests.

Test Equipment	Description
System Context	A reference component used to incorporate and a system under one physical representa

c) TEST TEAM:

d) TEST PROCEDURES:

1. TP.Accept Request Test steps are documented here:

1. View active job log

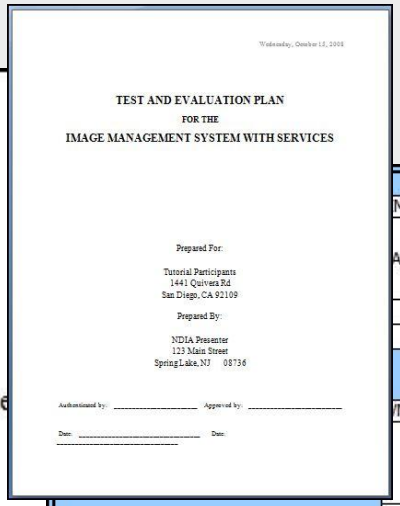
   a. Document existing IMS jobs in progress

2. Enter new product request

3. Ensure product request is entered into IMS

   3.1 View active job log

   3.2 Document new IMS job has been entered into active list



Wednesday, October 15, 2008

TEST AND EVALUATION PLAN
FOR THE
IMAGE MANAGEMENT SYSTEM WITH SERVICES

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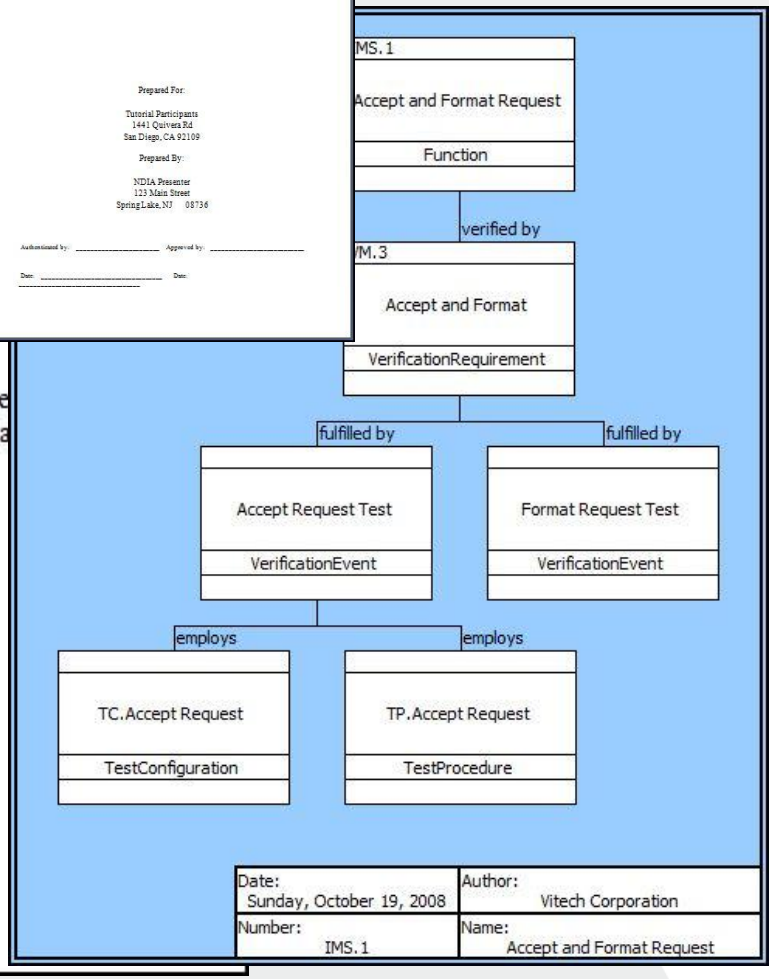

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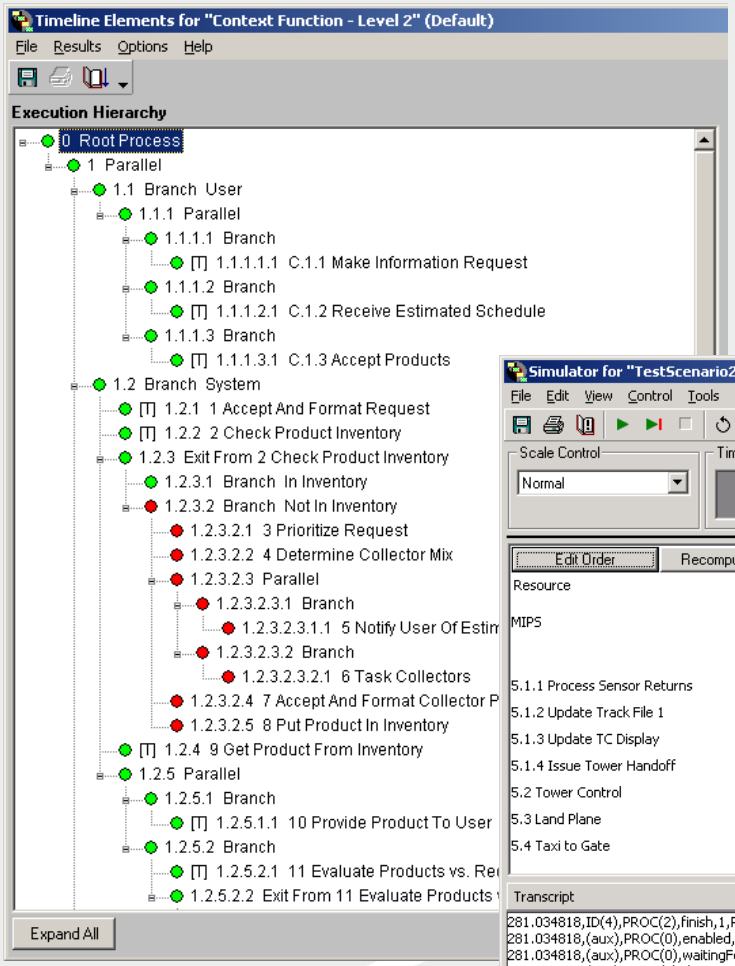
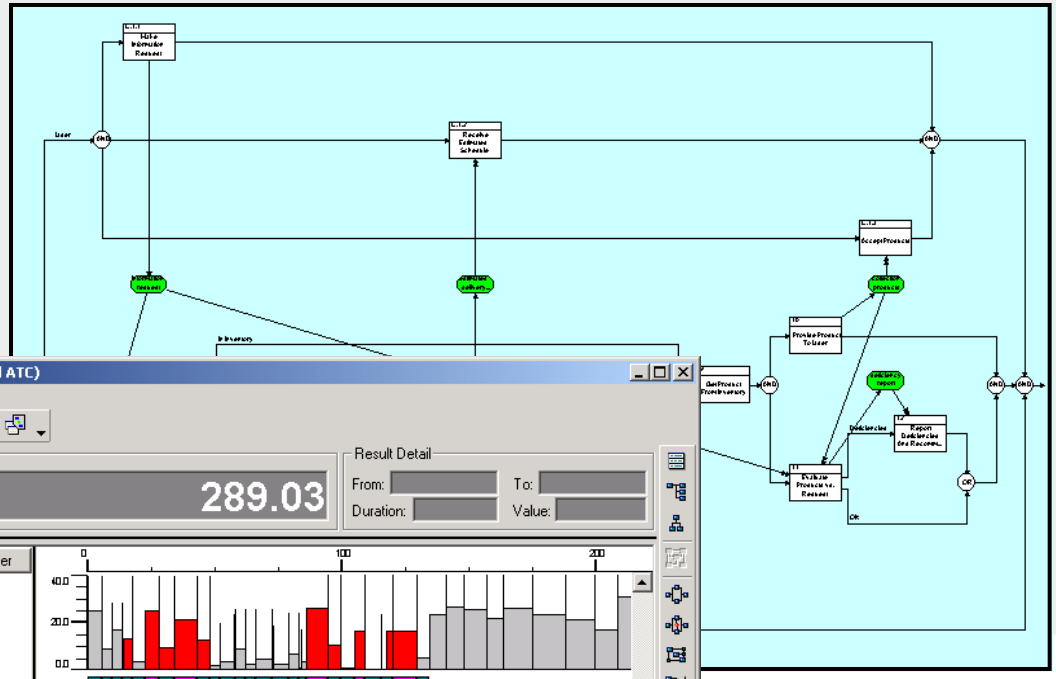
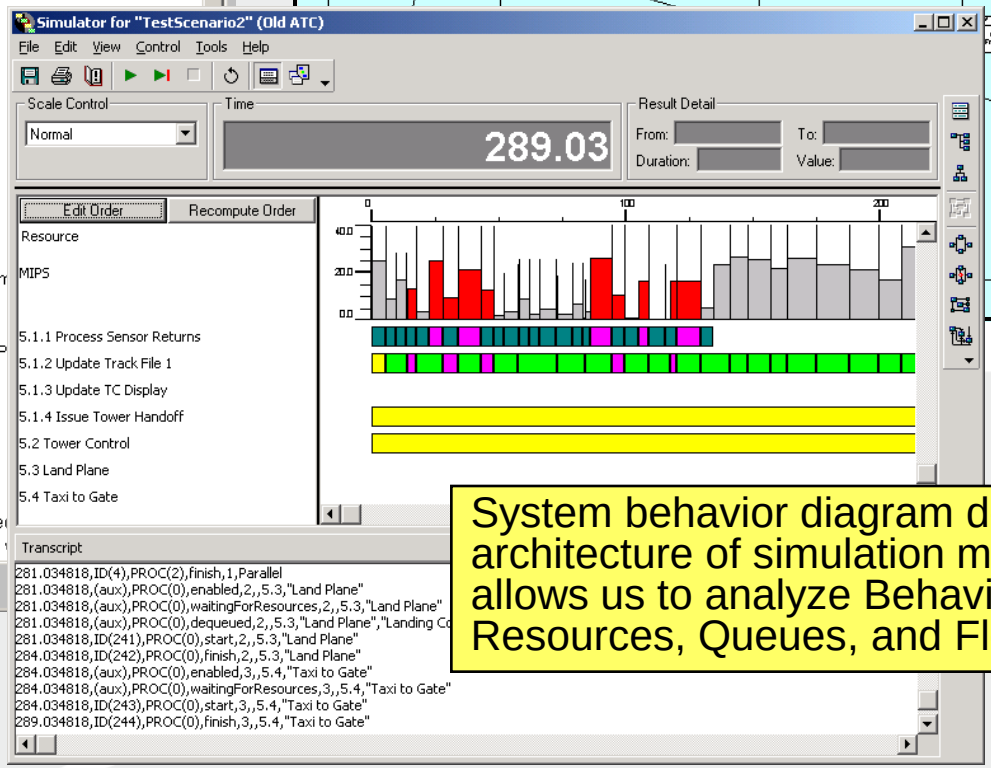
Architecture Executeability: Operational and System Level







System behavior diagram defines architecture of simulation model which allows us to analyze Behavior, Timelines, Resources, Queues, and Flows

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Integrated Model Benefits

- Synchronization between DoDAF views and systems Engineering products
- Traceability of Operational Doctrine to System-level Functional Requirements
  - Can be establish through Operational Scenarios
  - Supports Operational Testing

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Discussion

- Implications for CADM (?)
- DoDAF Views lend themselves to analysis, not system development
- Migration from C4ISR to DoDAF
  - Typical modeling techniques limited to computer stuff
  - Much discovery work goes straight to software
  - Traced from TOGAF?

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Things to Mention

- TOGAF – The Open Group Architecture Framework
  - TOGAF ADM – Architecture Development Method, limited to amorphous, distributed computer gunk
- SE principles applicable to all levels of analysis
- Why is the DoD “Chief Information Officer” dictating methods and tools by which we develop systems?
- “Interoperability” issues not limited to “purple”
  - Including “disadvantaged” or “tactical edge” users (the real war fighters)

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The End

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