

Integrating Architecting and Systems Engineering

**NDIA SE Conference
22 October 2008**



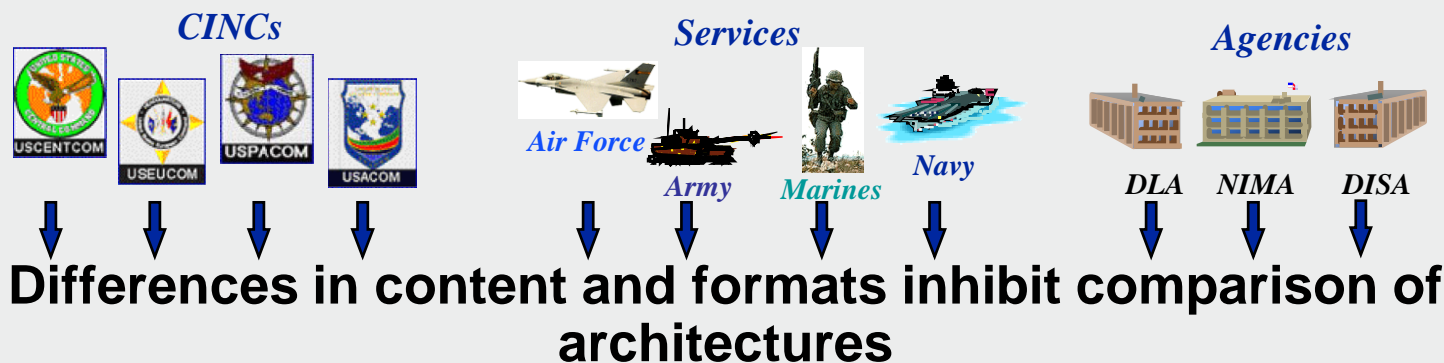
Intro/Topics





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

Organizations are developing major systems that need to interface and interact



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

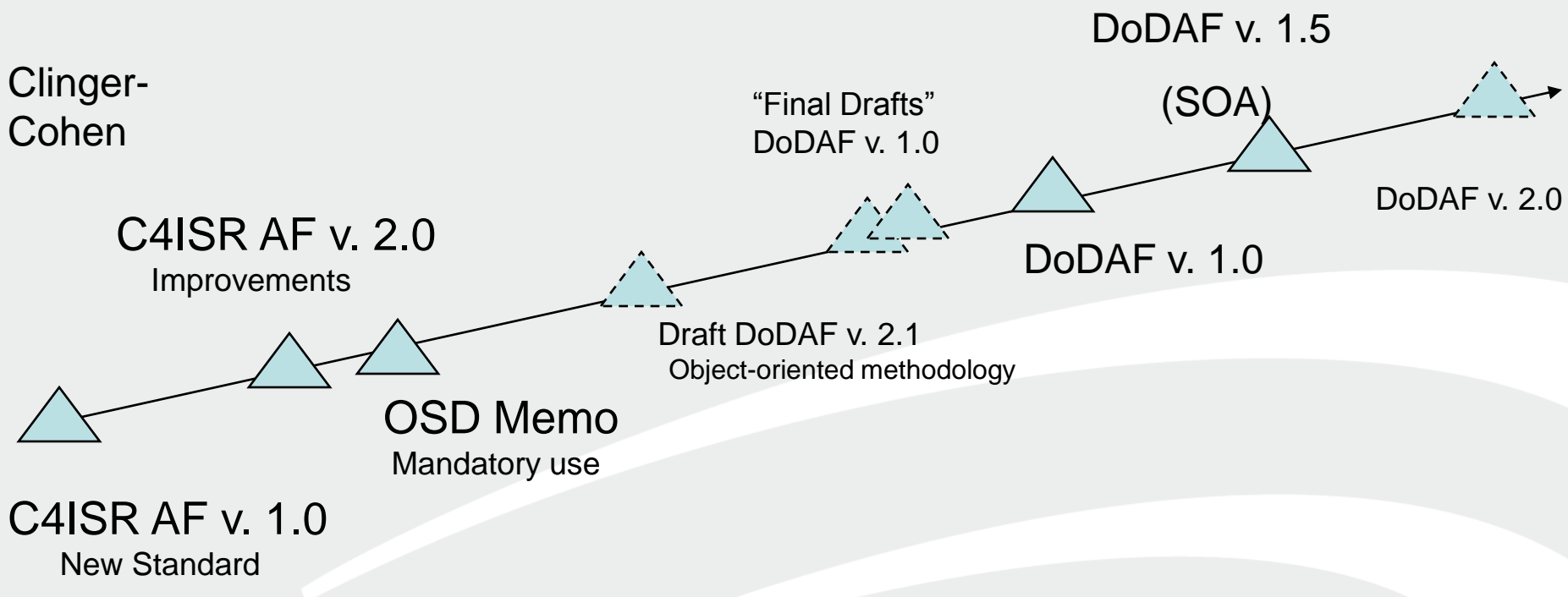
Reprinted from "C4ISR INCOSE Tutorial", A.H. Levis and L.W.Wagenhals, March 2001



Evolution DoDAF

1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009?

Clinger-Cohen



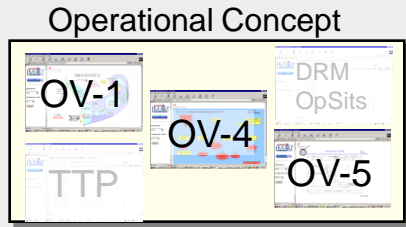


Motivations for DoDAF

- 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

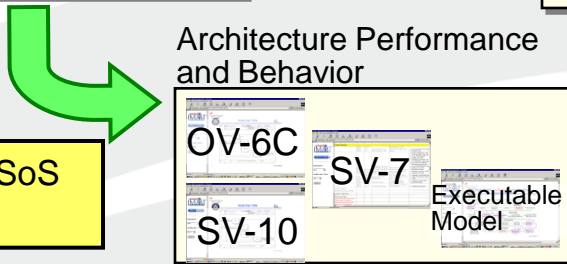
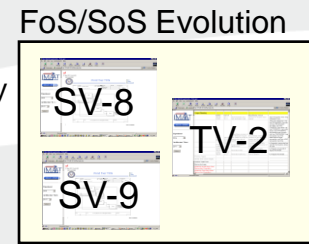
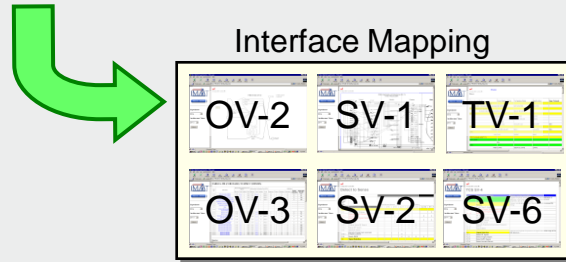
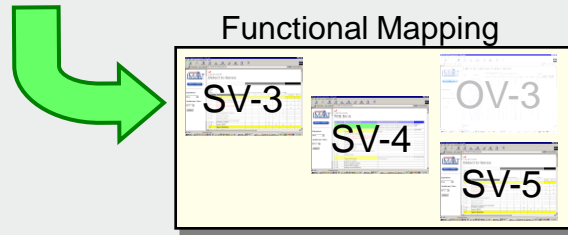


Typical DoDAF Taxonomy



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

- 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



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

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

Ref: "Naval Collaborative Environment", Dr. Harry Crisp, 2002



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



View Creation Not Complete System Architecture

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

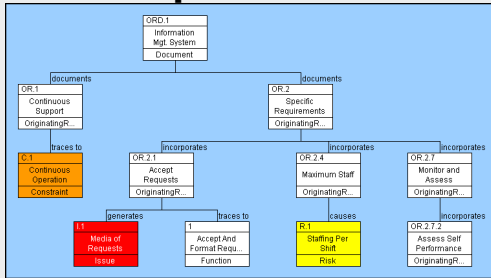


- **Model-driven approach to capture and integrate:**
 - Requirements Development
 - Logical Analysis
 - Design Solution
 - Implementation
 - Integration
 - Verification
 - Validation
- **System Specification is the model, Model is the System Specification**



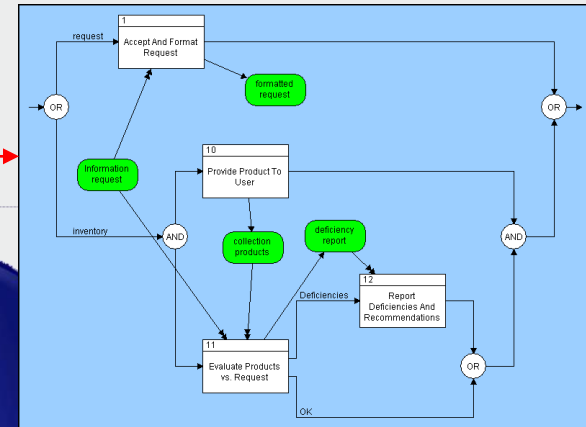
Example MBSE Taxonomy

Source Requirements Domain



Originating requirements trace to behavior

Behavior Domain

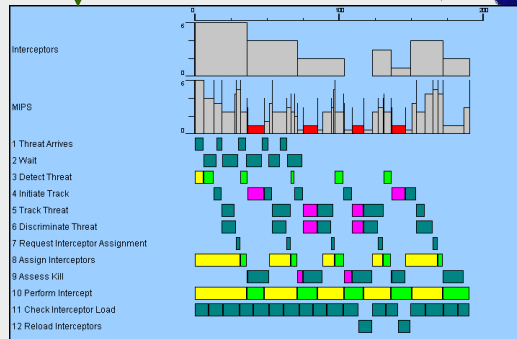


Behavior is allocated to physical components



verified by

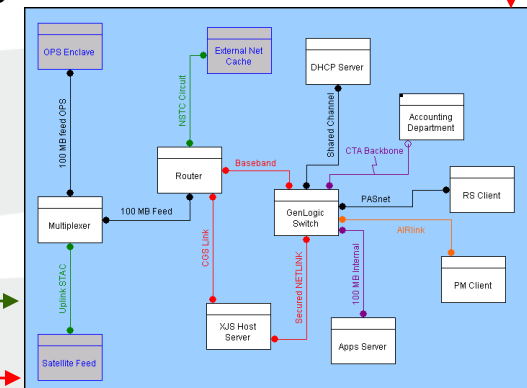
V&V Domain



verified by

verified by

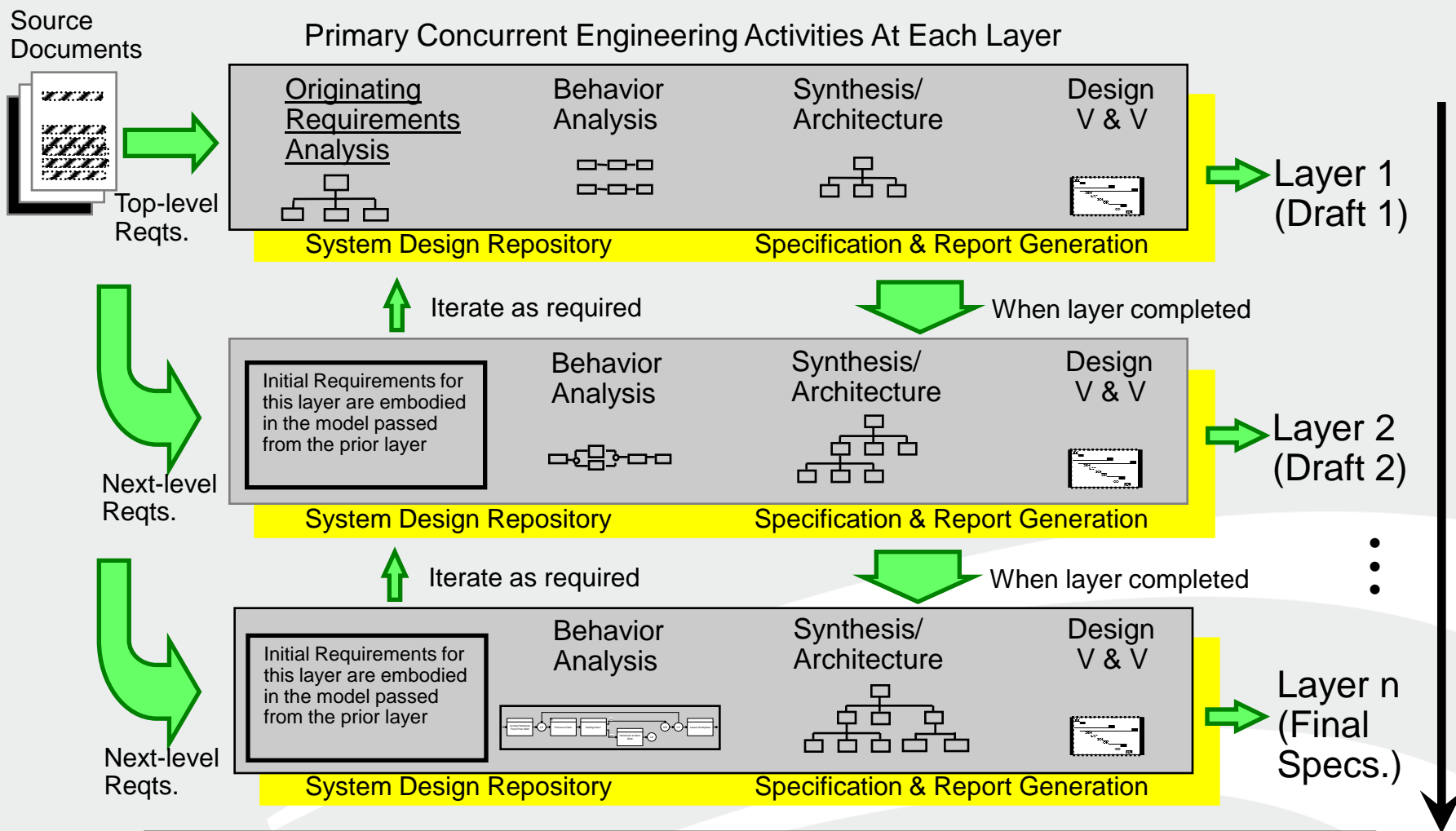
Physical Architecture Domain



Originating requirements trace to physical components



Example MBSE taxonomy (cont.)



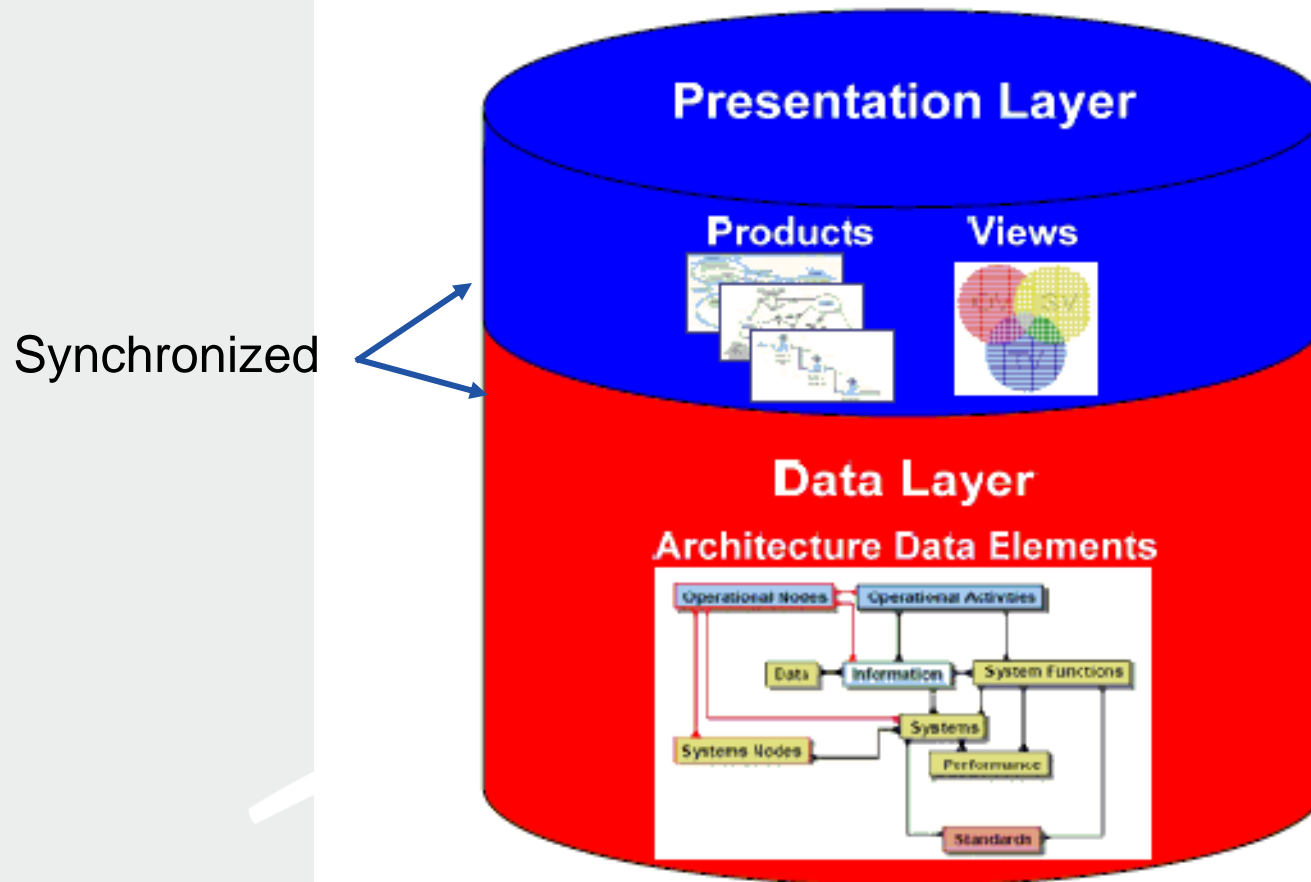
- Must complete a layer before moving to the next layer (completeness)
- Cannot iterate back more than one layer (convergence)

MBSE and Integrated Architecture Common Traits



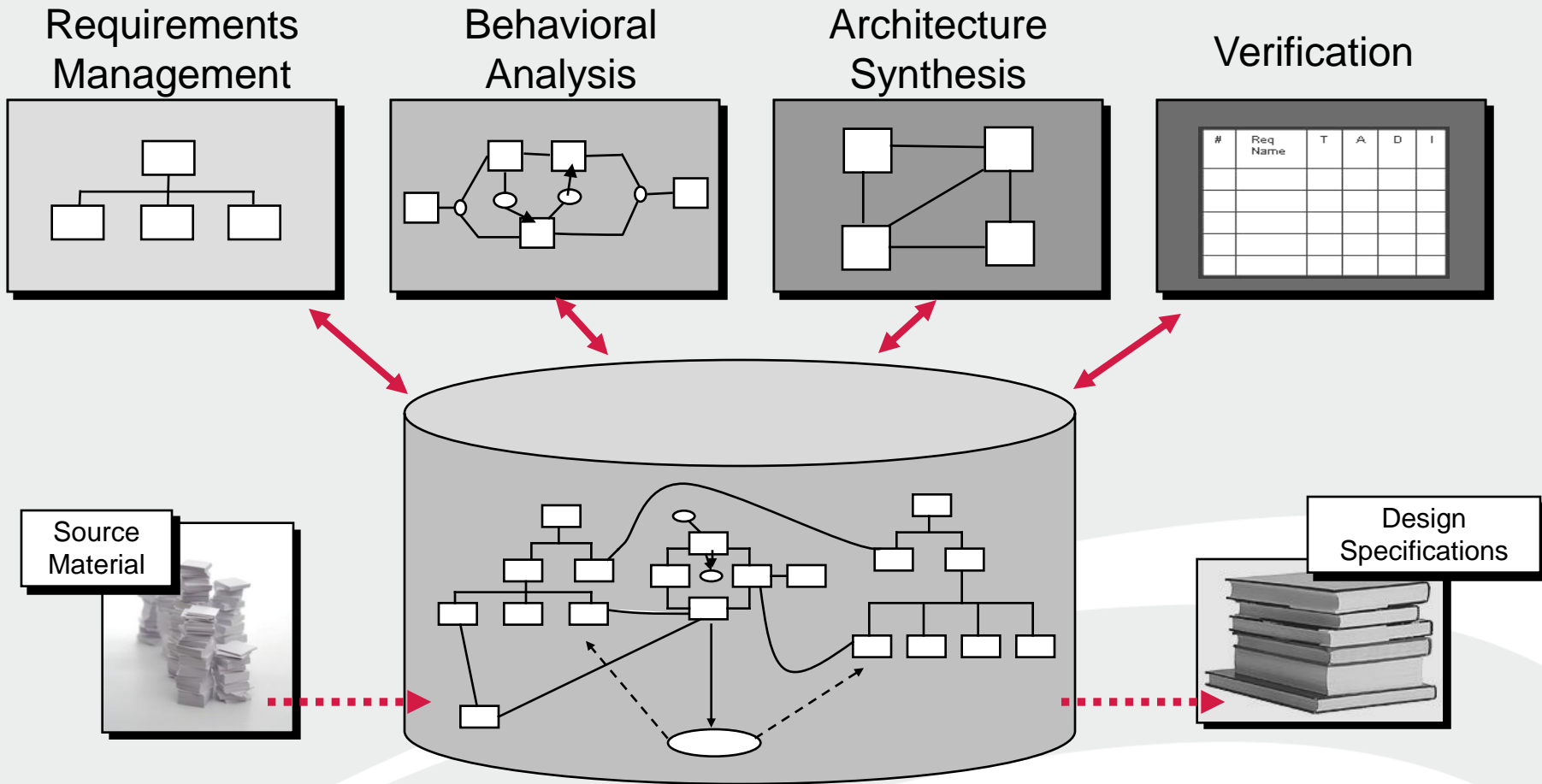
DoDAF Integrated Data Layer

Architecture Framework Structure





MBSE Integrated Data Layer



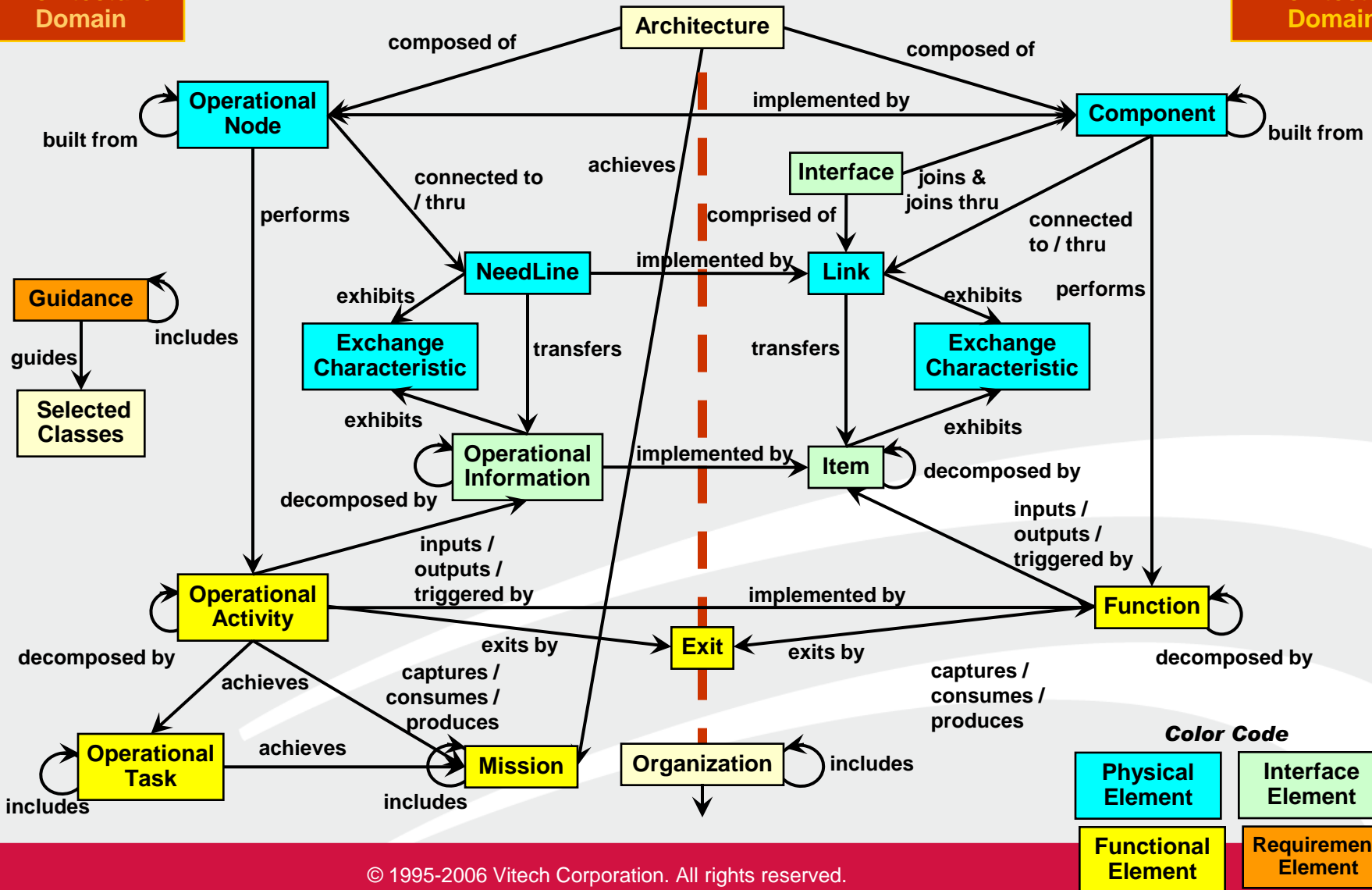
Integrated, Consistent Analysis: Complete Specifications, Project Documentation, Queries & Models



Integrated DoDAF Data Model

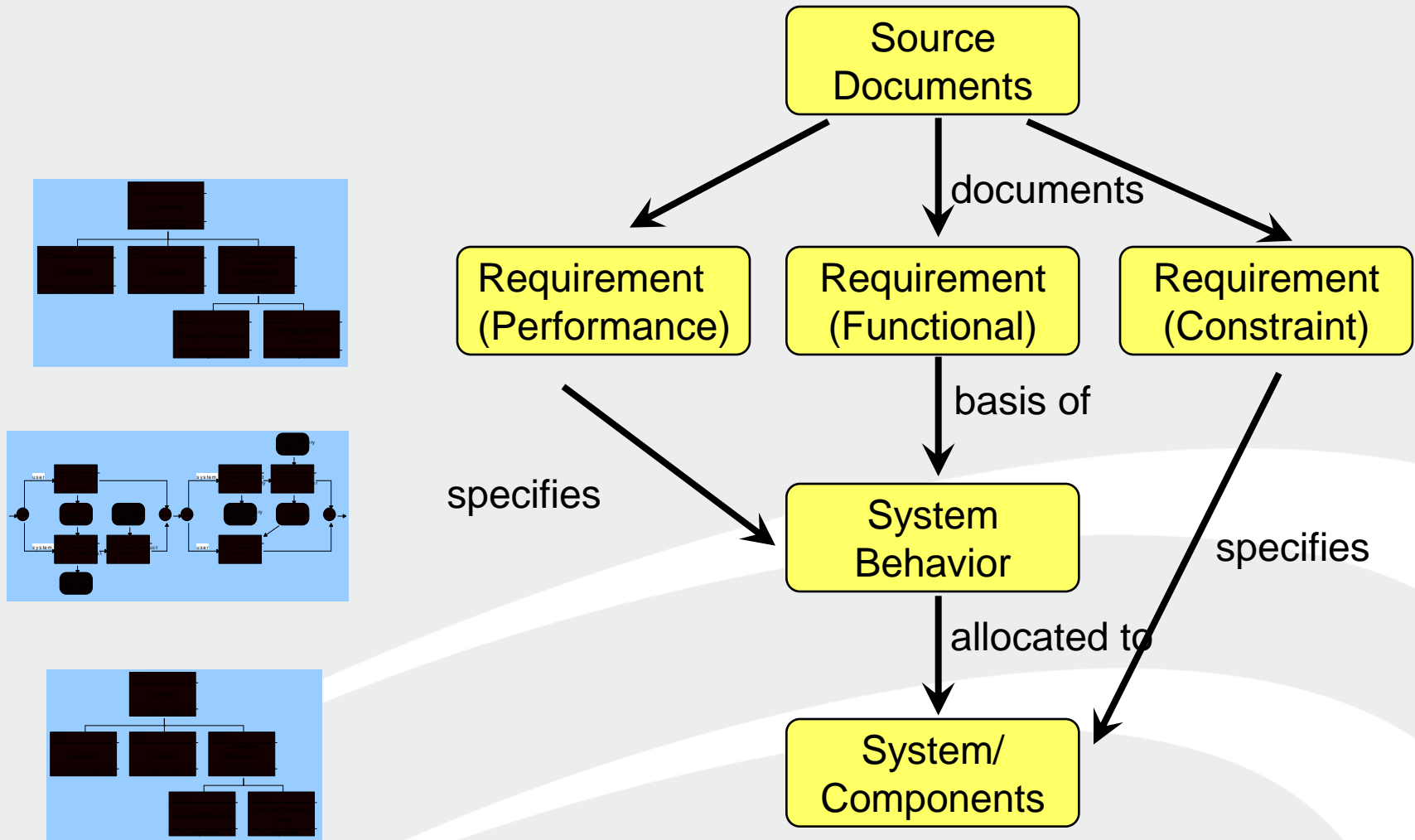
Operational
Architecture
Domain

System
Architecture
Domain





Systems Engineering Data Model (partial)

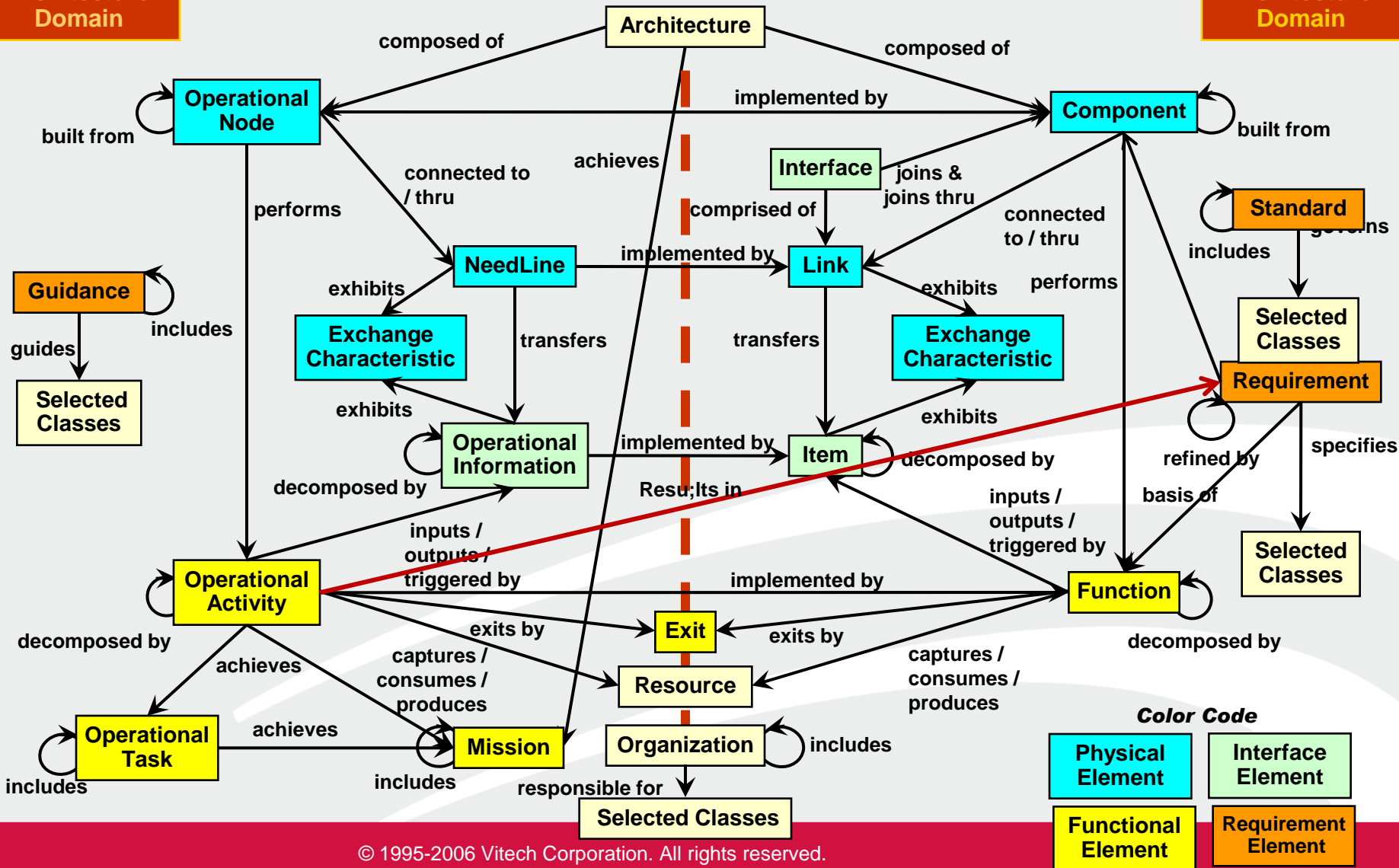




Integrated Data Model: Complete Traceability Between the Operational Architecture and System Engineering Domains

Operational Architecture Domain

System Architecture Domain

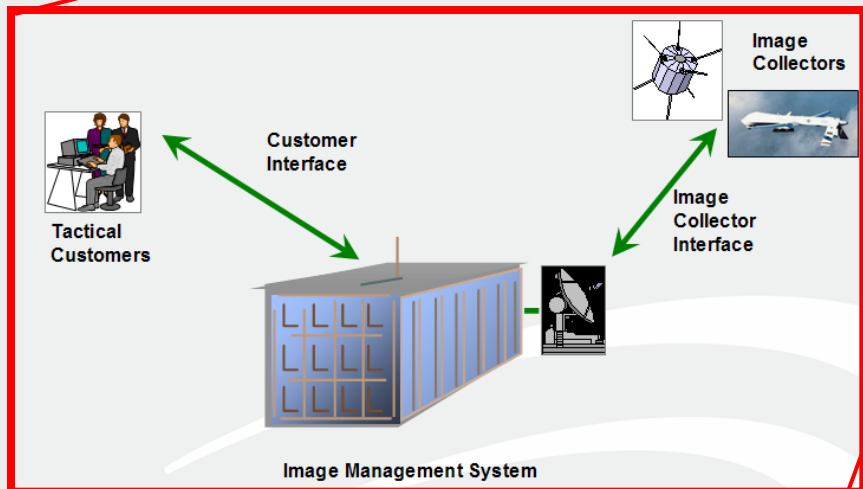
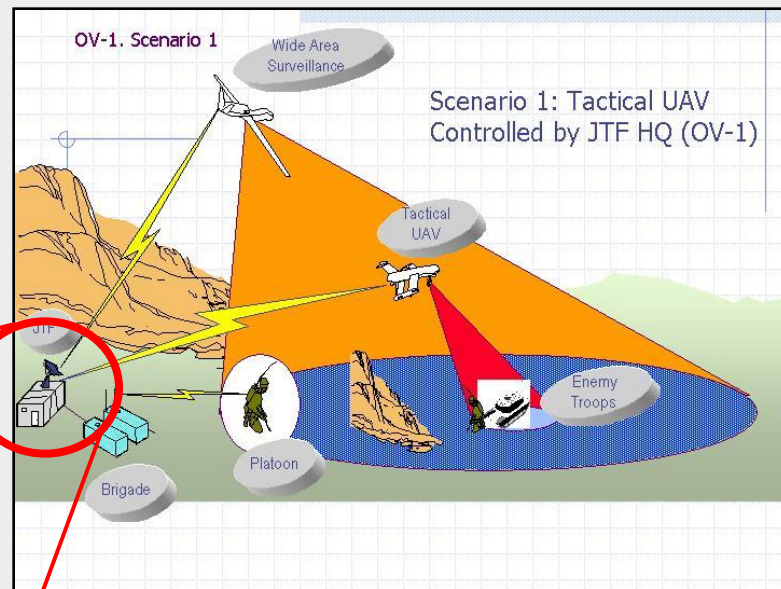


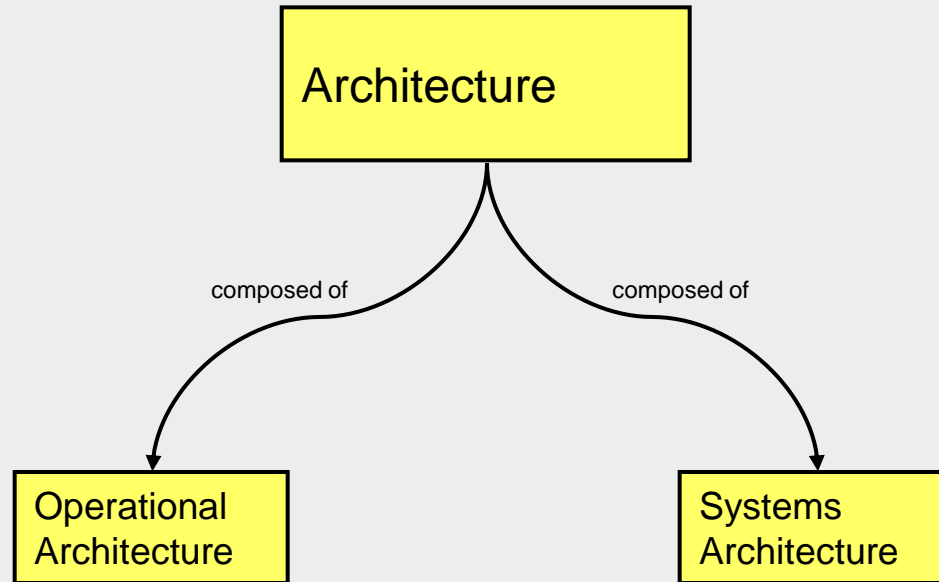
DoDAF and MBSE System Model Overlap - Examples



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.







Modeled Relationships

Tactical Image Management asPropertySheet (Tactical Image Management NDIA (DoDAF v1.5))

File Edit View Data Tools Help

Name: Tactical Image Management
Number: Mod

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

Purpose: The tactical scenario models an amv platoon which is advancing over a hill and requires information about
The purpose of this architecture model is to serve as a sample application of the CORE DoDAF v1.5 schema.

Scope: This architecture demonstrates two specific ideas:
1) How to express capabilities within the operational architecture
2) How to express services in a system architecture

Time Frame: To Be

Relationships

- achieves
- assigned to
- augmented by
- categorized by
- composed of**
- documented by
- guided by
- reported by
- specified by

Targets & Attributes

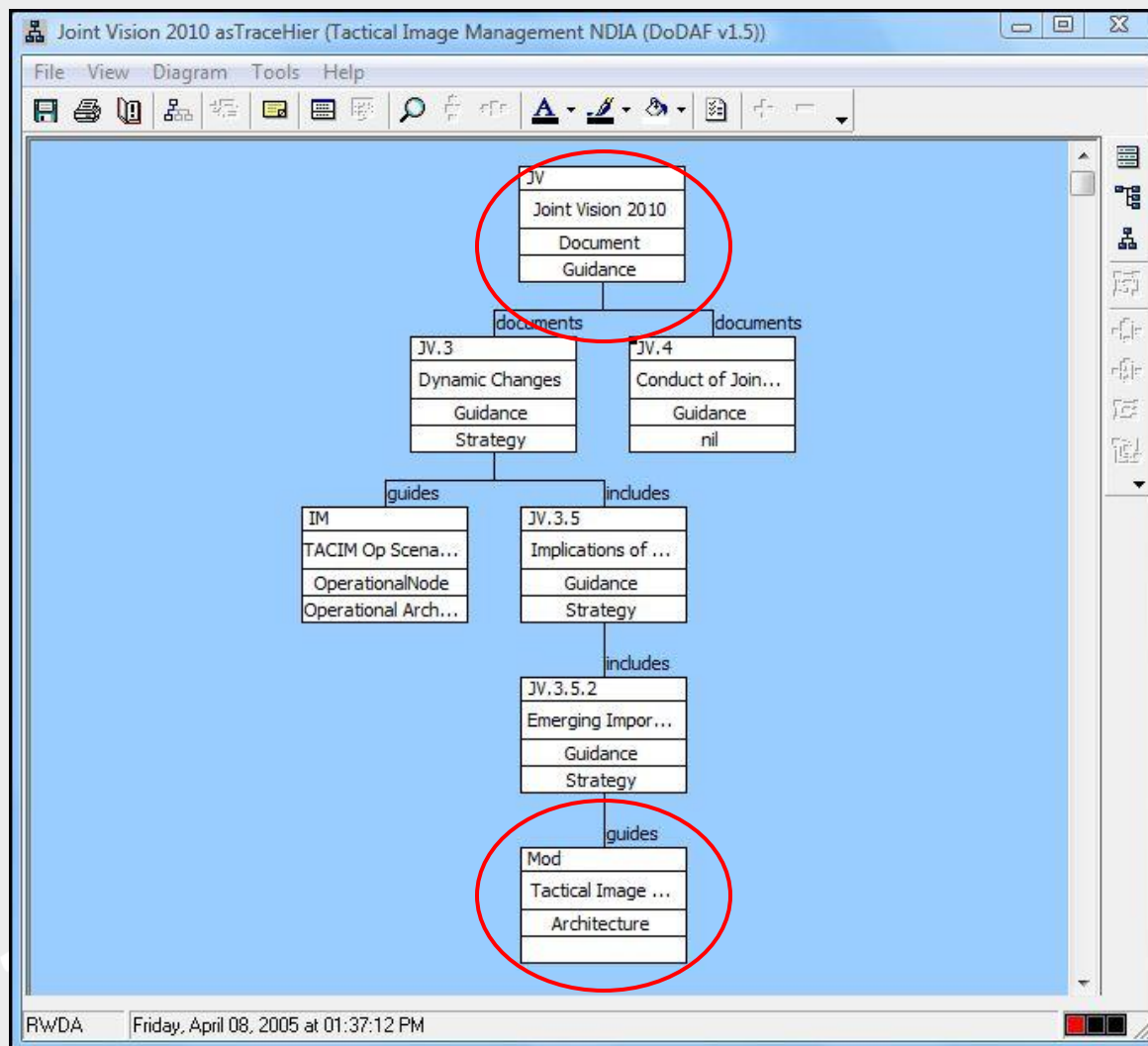
- Component S.1 Image Management System with Services
- OperationalNode IM TACIM Op Scenario Participants

Sort: Numeric by class

RWDA Last Modified: Friday, August 03, 2007 at 04:12:05 PM



Architecture Traced to Guidance Documents





As seen in the produced AV-2

ARCHITECTURE DESCRIPTION DOCUMENT
FOR
Tactical Image Management

Wednesday, October 15, 2008

Prepared For:

Tutorial Participants
1441 Quivern Rd
San Diego, CA 92109

Prepared By:

NDIA Presenter
125 Main Street
Spring Lake, NJ 08136

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):

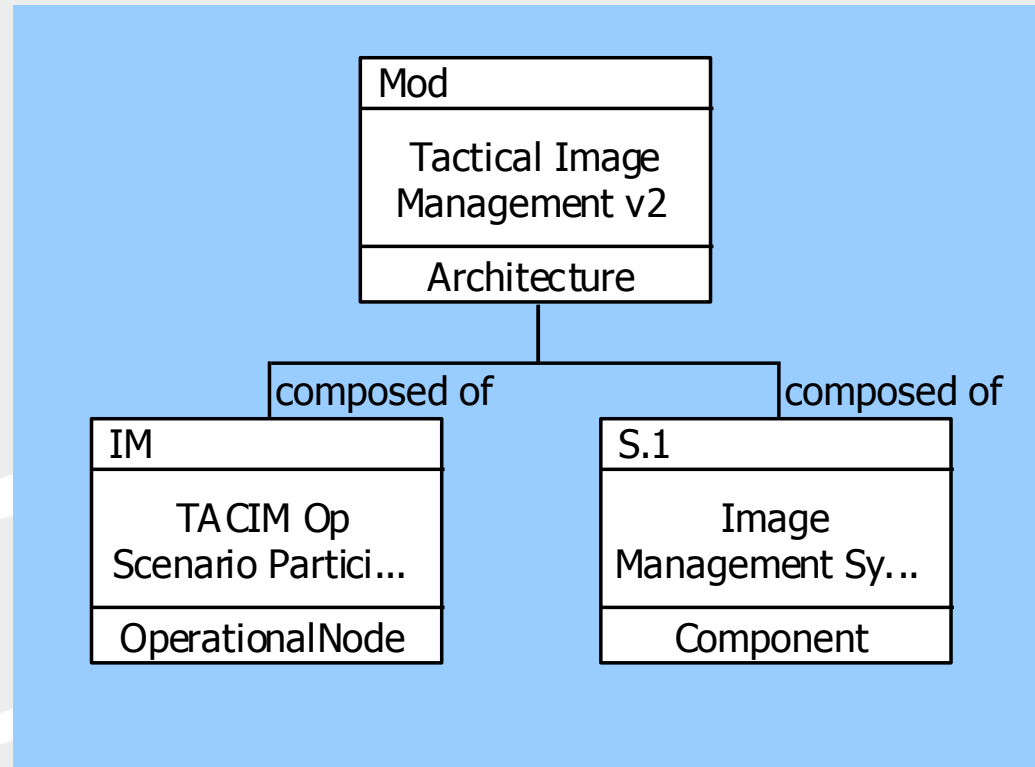
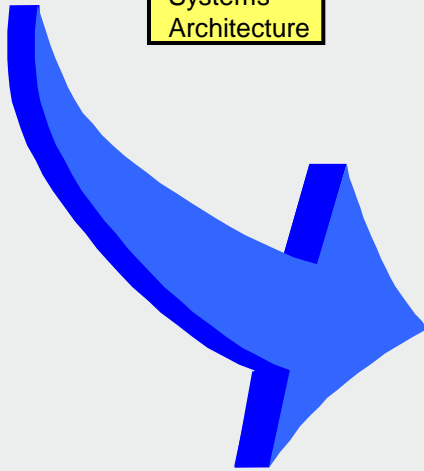
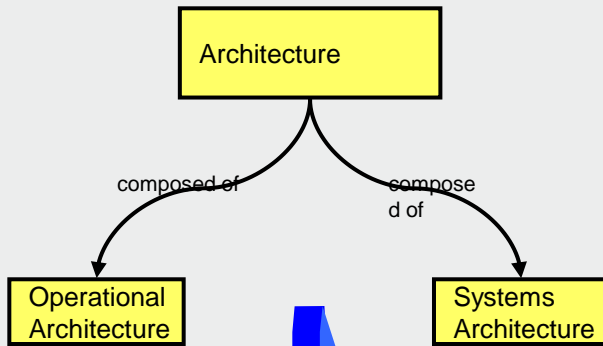
Joint Vision 2010

Includes Subordinate Guidance:

JV.4.1 New Operational Concepts

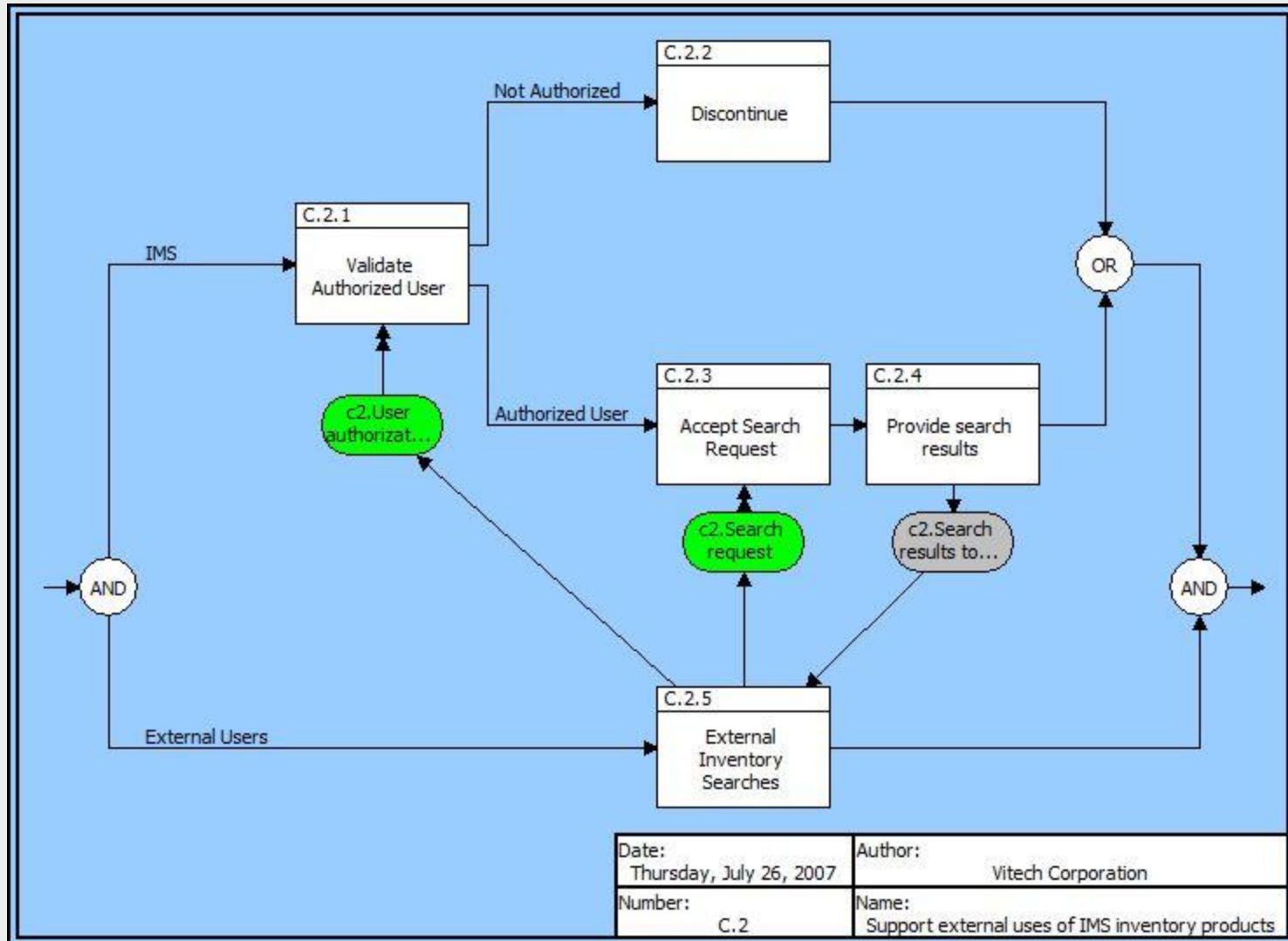


Architectures - Example





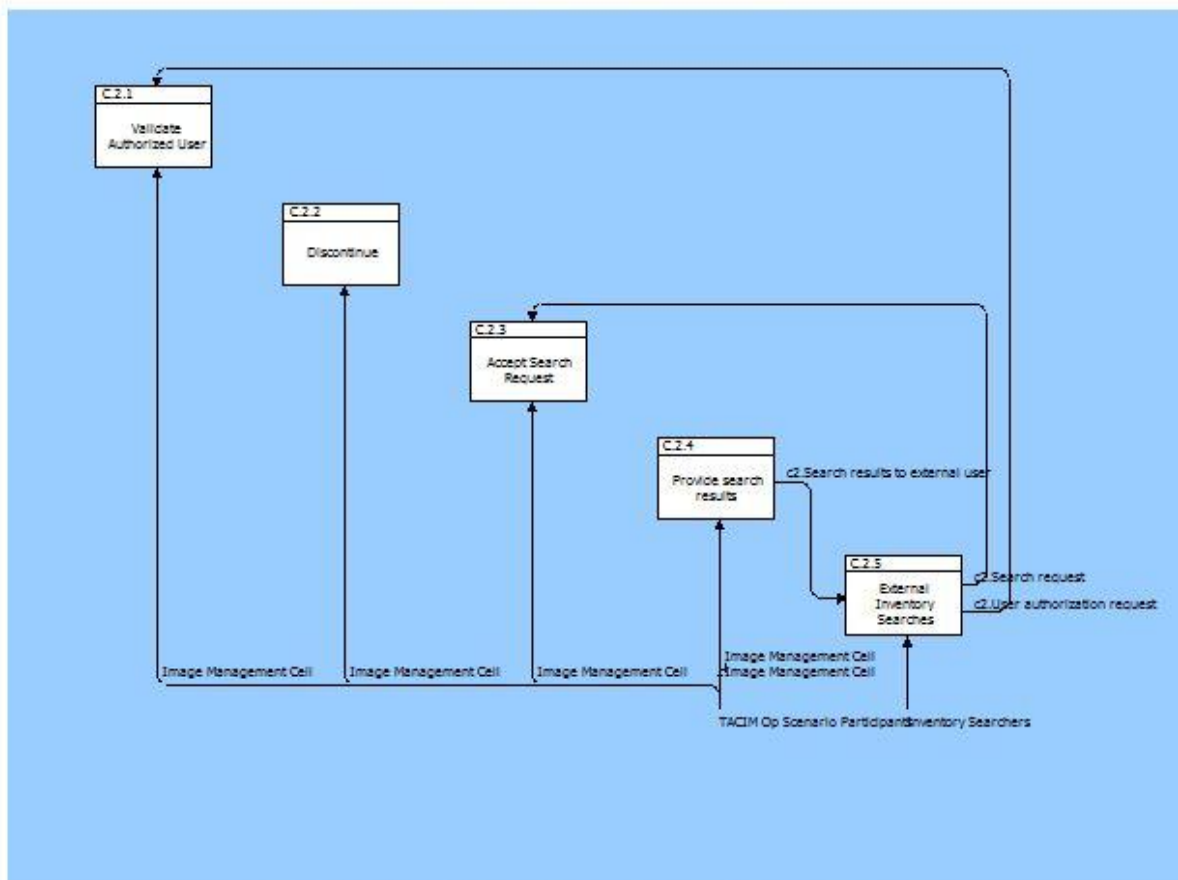
Capability – Support External Users





Support External Users as an OV-5

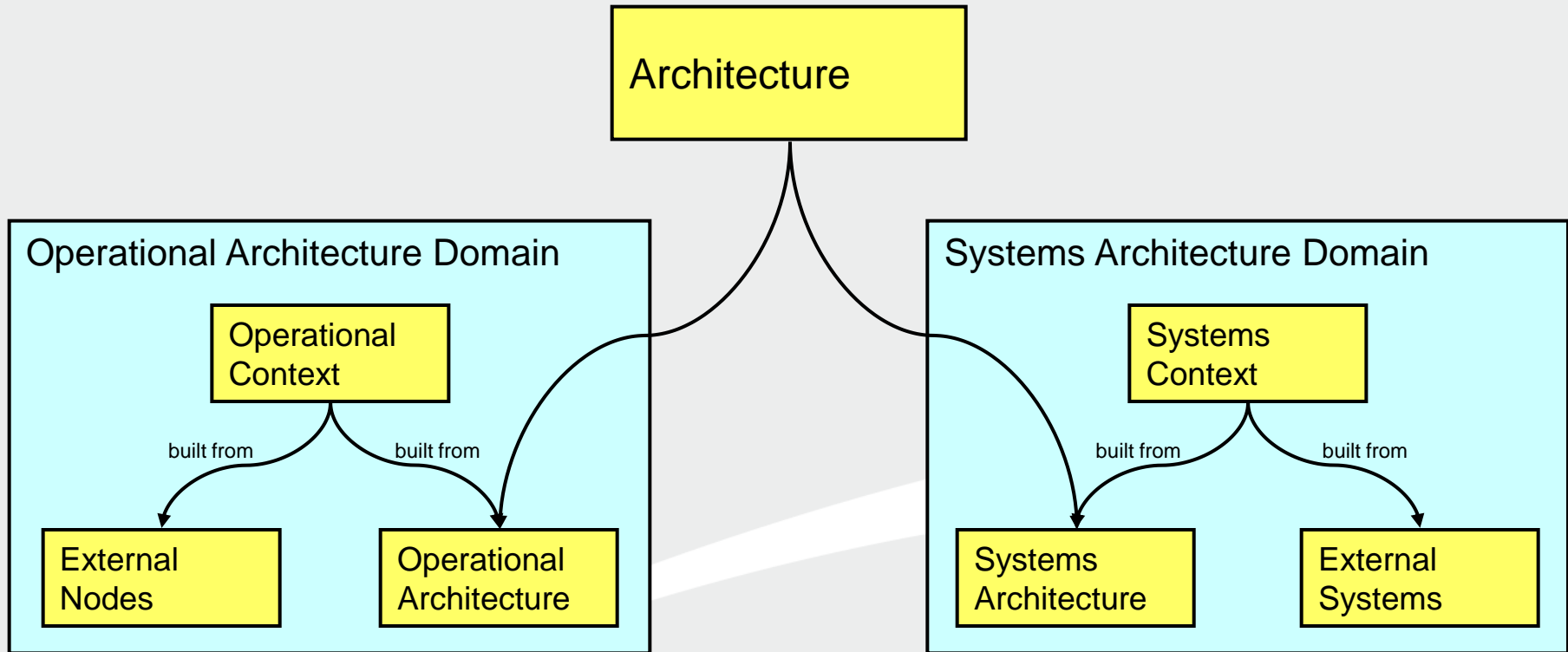
Support external uses of IMS inventory products Operational Activity Model (OV-5)



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

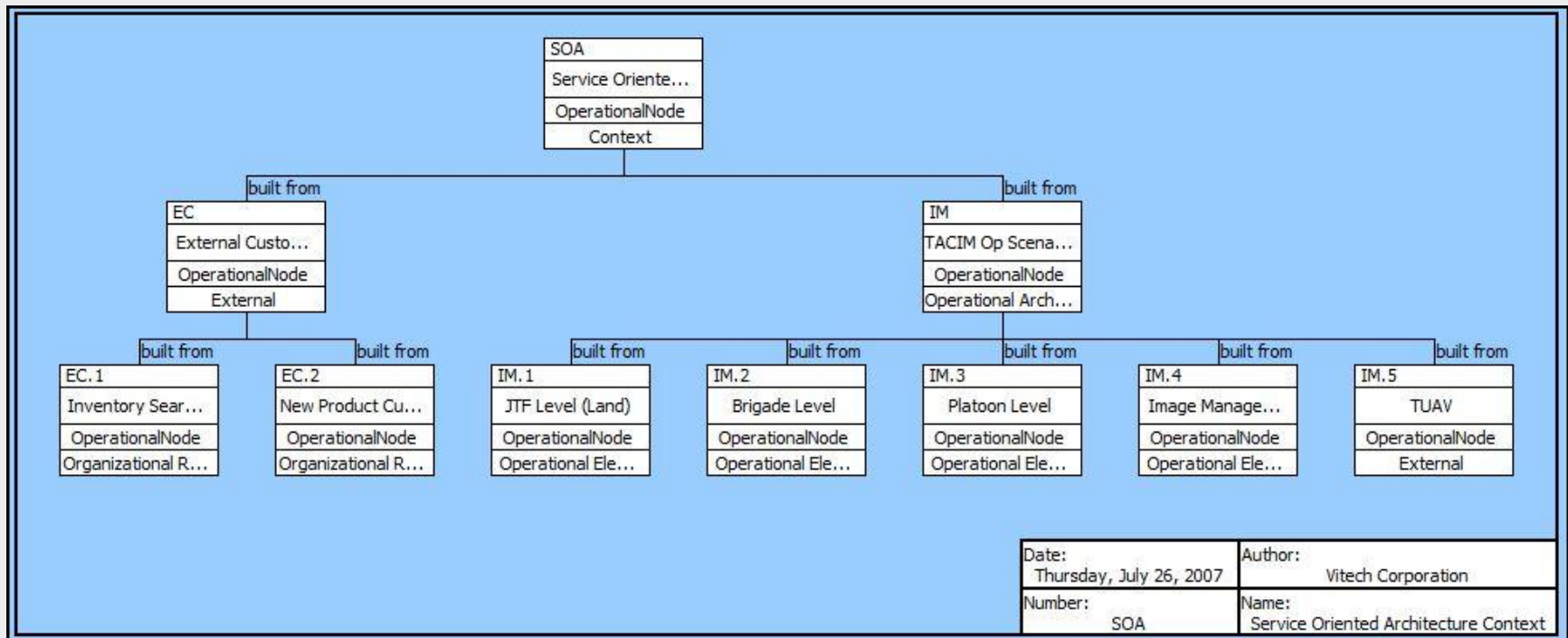


Architectures & Domains





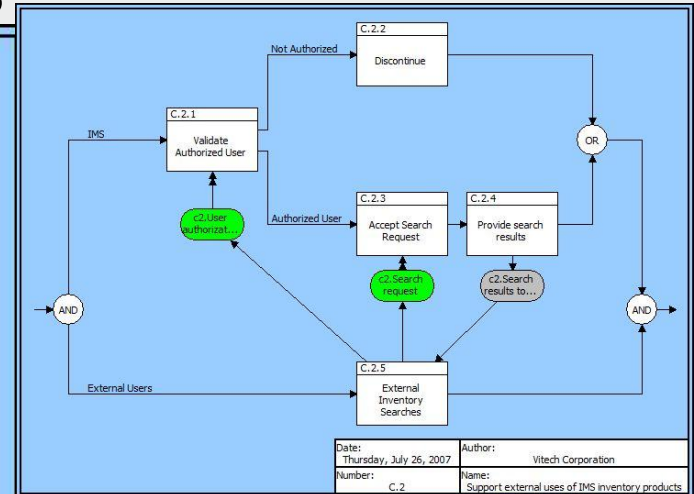
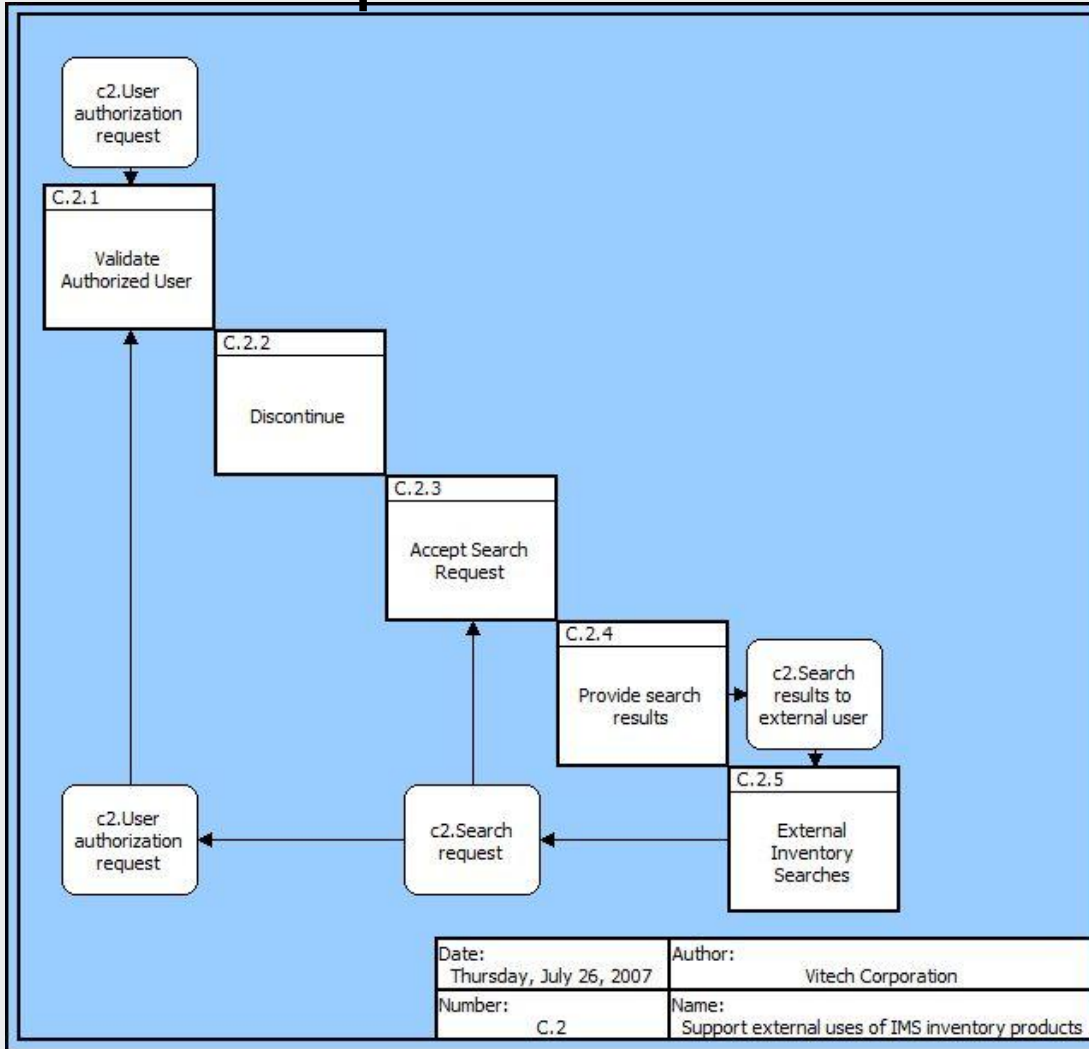
Hierarchy of Operational Nodes





... Relates to the Next ...

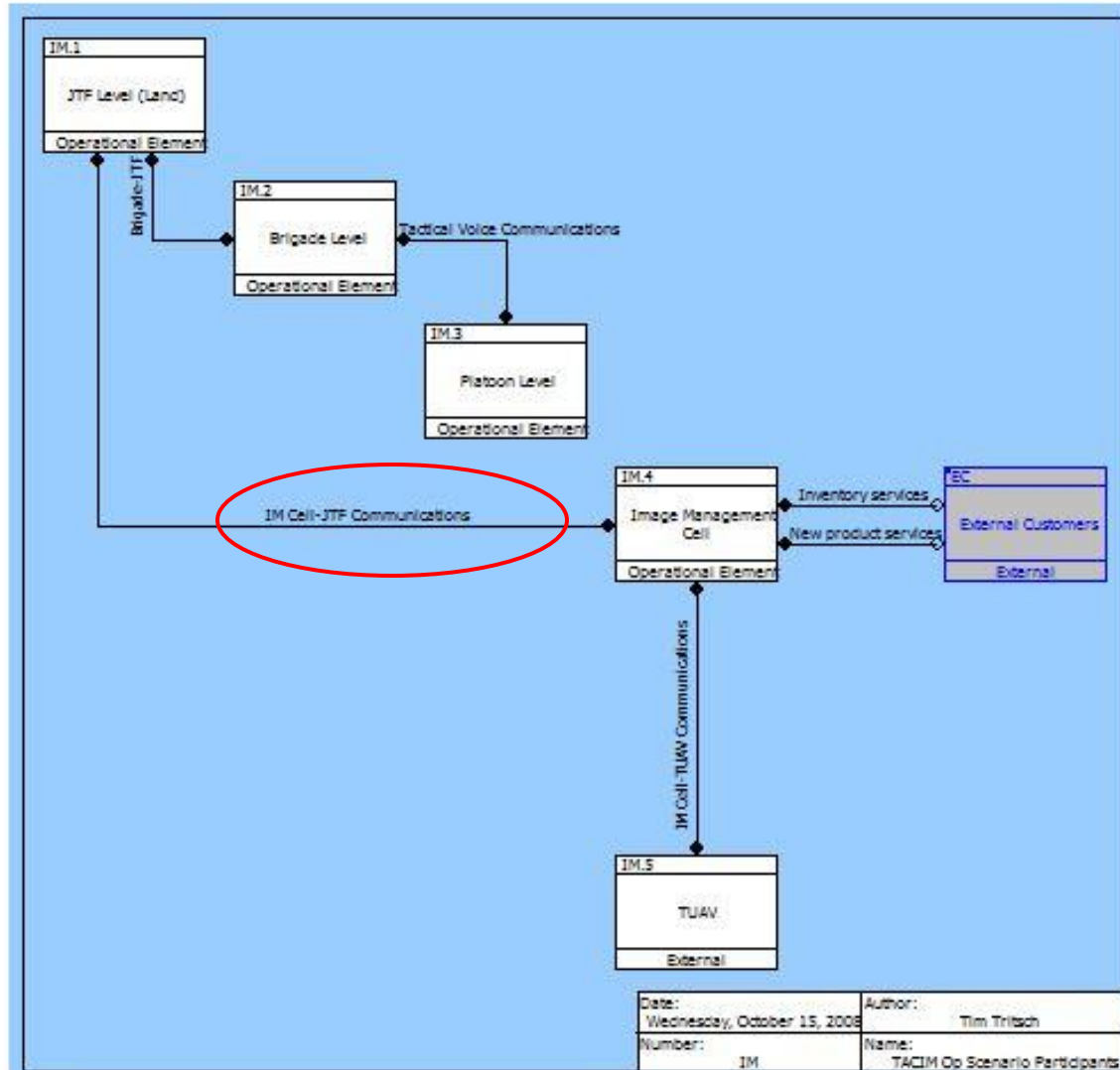
I/O of Operational Activities





... Relates to the Next ...

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





... And From Our Integrated Architecture ...

The screenshot displays the 'Project Explorer' window for 'Tactical Image Management NDIA (DoDAF v1.5)'. The interface includes a menu bar (File, Edit, View, Project, Data, Schema, Utilities, Diagram, Tools, Help) and a toolbar. The 'Project' pane on the left shows a hierarchical tree of elements, with 'Needline (6/6)' circled in red. The 'Elements' pane in the center lists 'All Elements' and includes 'IM Cell-JTF Communications', which is selected. The main area shows the 'IM Cell-JTF Communications' property sheet, with the 'Name' field circled in red. The 'Relationships' pane at the bottom left is also circled in red, showing a list of relationships including 'exhibits'. The 'Targets & Attributes' pane at the bottom right shows a relationship between 'ExchangeCharacteristic' and 'IM Cell - JTF Exchange Characteristics'.

Project Explorer (Tactical Image Management NDIA (DoDAF v1.5))

File Edit View Project Data Schema Utilities Diagram Tools Help

All Classes

Project Elements

ExchangeCharacteristic (0/16) Exit (14/14) ExternalFile (0/7) Function (51/134) Guidance (9/9) Interface (7/7) Issue (3/3) Item (25/47) Link (15/18) Mission (1/1) **Needline (6/6)** OperationalActivity (0/52) OperationalInformation (0/30) OperationalNode (10/10) OperationalTask (26/26)

All Elements

Brigade-JTF Communications
IM Cell-JTF Communications
IM Cell-TUAV Communications
Inventory services
New product services
Tactical Voice Communications

Sort: Numeric

IM Cell-JTF Communications PropertySheet

Name: IM Cell-JTF Communications

Number:

Description: Networked communications between the IM-cell and the joint task force.

Doc. PUID:

Title:

Capacity:

Capacity Units:

Delay:

Delay Units:

Relationships

augmented by
categorized by
connects thru
connects to
documented by
exhibits
implemented by
reported by
served by
specified by
transfers

Targets & Attributes

ExchangeCharacteristic IM Cell - JTF Exchange Characteristics

RWDA Last Modified: Wednesday, June 06, 2007 at 08:27:45 AM



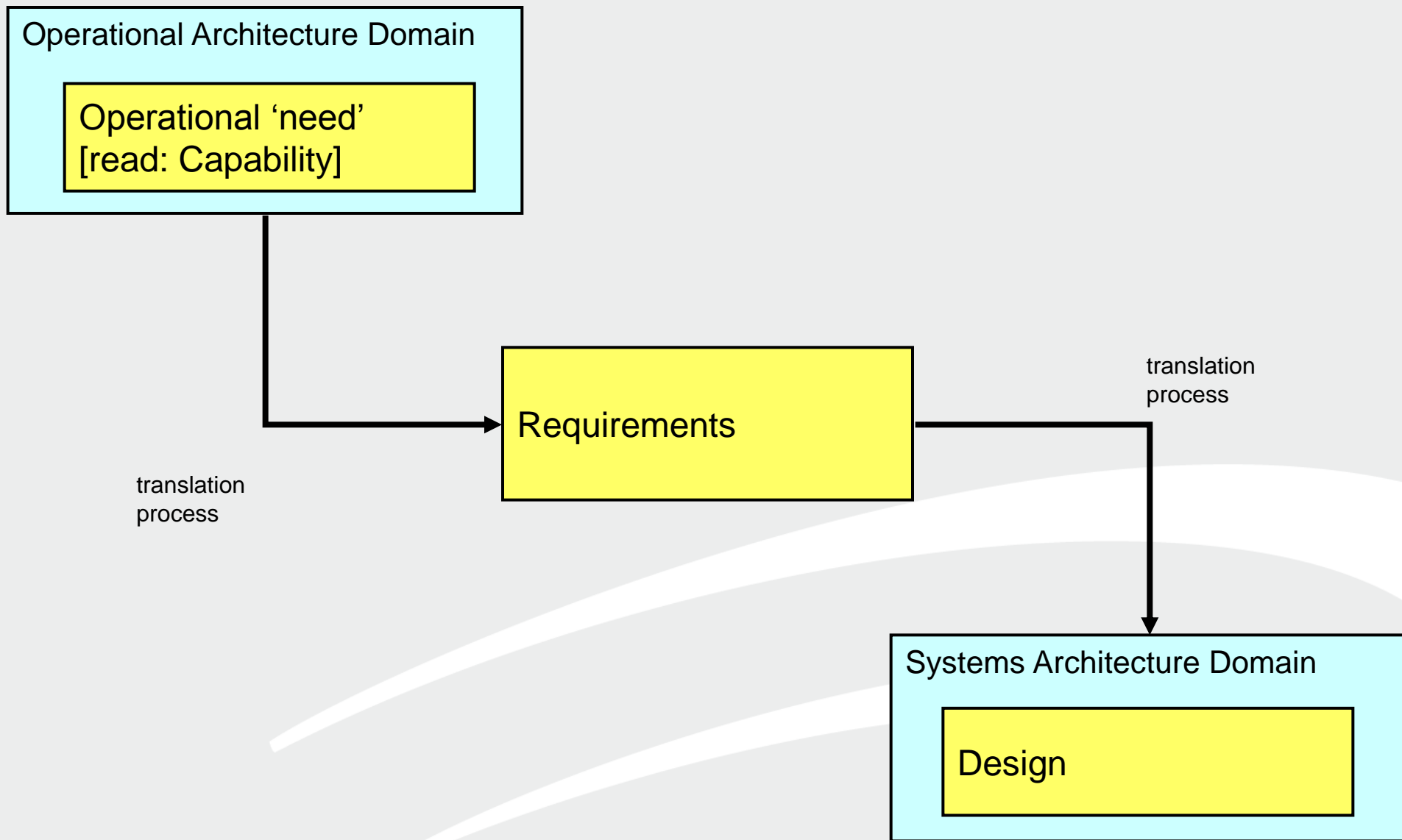
... The Resulting OV-3

**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) <i>Transmit Collected Information(As-Is)</i>	Brigade Level <i>Translate Information into Verbal Commands(As-Is)</i>
		c1. Formatted RFI Description: Formatted Request for Information requesting intelligence on a target at a specified location. Accuracy: High	Brigade Level <i>Request Latest Information for Location(As-Is)</i>	JTF Level (Land) <i>Receive Formatted RFI(As-Is)</i>
IM Cell-JTF Communications	IM Cell - JTF Exchange Characteristics	c1. Tactical Image Products Description: Processed imaging products. Accuracy: Medium	Image Management Cell <i>Provide Current Target Imaging Product(As-Is)</i>	JTF Level (Land) <i>Process Tactical Operational Information(As-Is)</i>
		c1. Tactical Tasking Imaging Request Description: Tasking request to acquire imaging intelligence for tactical commanders. Accuracy: High	JTF Level (Land) <i>Receive Formatted RFI(As-Is)</i>	Image Management Cell <i>Accept Tasking for Tactical Operations(As-Is)</i>
IM Cell-TUAV Communications		c1. Target Imaging	TUAV <i>TUAV Ops(As-Is)</i>	Image Management Cell <i>Acquire Target Imaging(As-Is)</i> Image Management Cell <i>Subscriber(s) for this</i>



Architectures & Requirements





Capability to Requirement Traceability

Support external uses of IMS inventory products asPropertySheet (Tactical Image Management NDIA (Do...

File Edit View Data Tools Help

Name: Support external uses of IMS inventory products

Number: C.2

Description: Allow authorized external [outside the boundary of existing TUAV] customers to query for existing image products.

Doc. PUID:

Title:

Duration: Edit

Exit Logic: Edit

Relationships

- decomposes
- documented by
- exits by
- guided by
- implemented by
- inputs
- outputs
- performed by
- produces
- relates to
- reported by
- results in
- services
- specified by
- triggered by

Targets & Attributes

- Requirement MR.3 Provide Inventory Search Capability

Sort: Numeric by class

RWDA Last Modified: Thursday, July 26, 2007 at 12:32:52 PM



Requirement to Function Traceability

Provide Inventory Search Capability asPropertySheet (Tactical Image Management NDIA (DoDA...)

File Edit View Data Tools Help

Name: Provide Inventory Search Capability

Number: MR.3

Description: The system shall provide the capability for non-tactical customers to search existing product inventory and retrieve existing products.

Doc. PUID:

Title:

Type: Functional

Value:

Relationships

- augmented by
- basis of**
- categorized by
- causes
- documented by
- generates
- guided by
- refined by
- refines
- reported by
- result of
- specifies
- utilized by
- verified by

Targets & Attributes

Function Inv Inventory Search

Sort: Numeric by class

RWDA Last Modified: Sunday, August 26, 2007 at 09:45:28 PM



Op Activities implemented by System Functions

The screenshot displays the Project Explorer interface for Tactical Image Management NDIA (DoDAF v1.5). The main window shows the definition of the function "Support external uses of IMS inventory products asPropertySheet".

Function Definition:

- Name:** Support external uses of IMS inventory products
- Number:** C.2
- Description:** Allow authorized external [outside the boundary of exist TUAV] customers to query for existing image products.
- Doc. PUID:**
- Title:**
- Duration:**
- Exit Logic:**
- Timeout:**
- Execute Decomposition:** true

Relationships:

- decomposed by
- decomposes
- documented by
- exits by
- guided by
- implemented by** (highlighted)
- inputs
- outputs
- performed by
- produces
- relates to
- reported by

Targets & Attributes:

- Function IMS.16 Validate User (Status: Planned)
- Function IMS.17 Authorize User (Status: Planned)
- Function IMS.21 Get Search Parameters (Status: Planned)
- Function IMS.22 Perform Inventory Search (Status: Planned)
- Function IMS.23 Return Search Results (Status: Planned)

The status bar at the bottom indicates "RWDA" and "Last Modified: Thursday, July 26, 2007 at 12:32:52 PM".



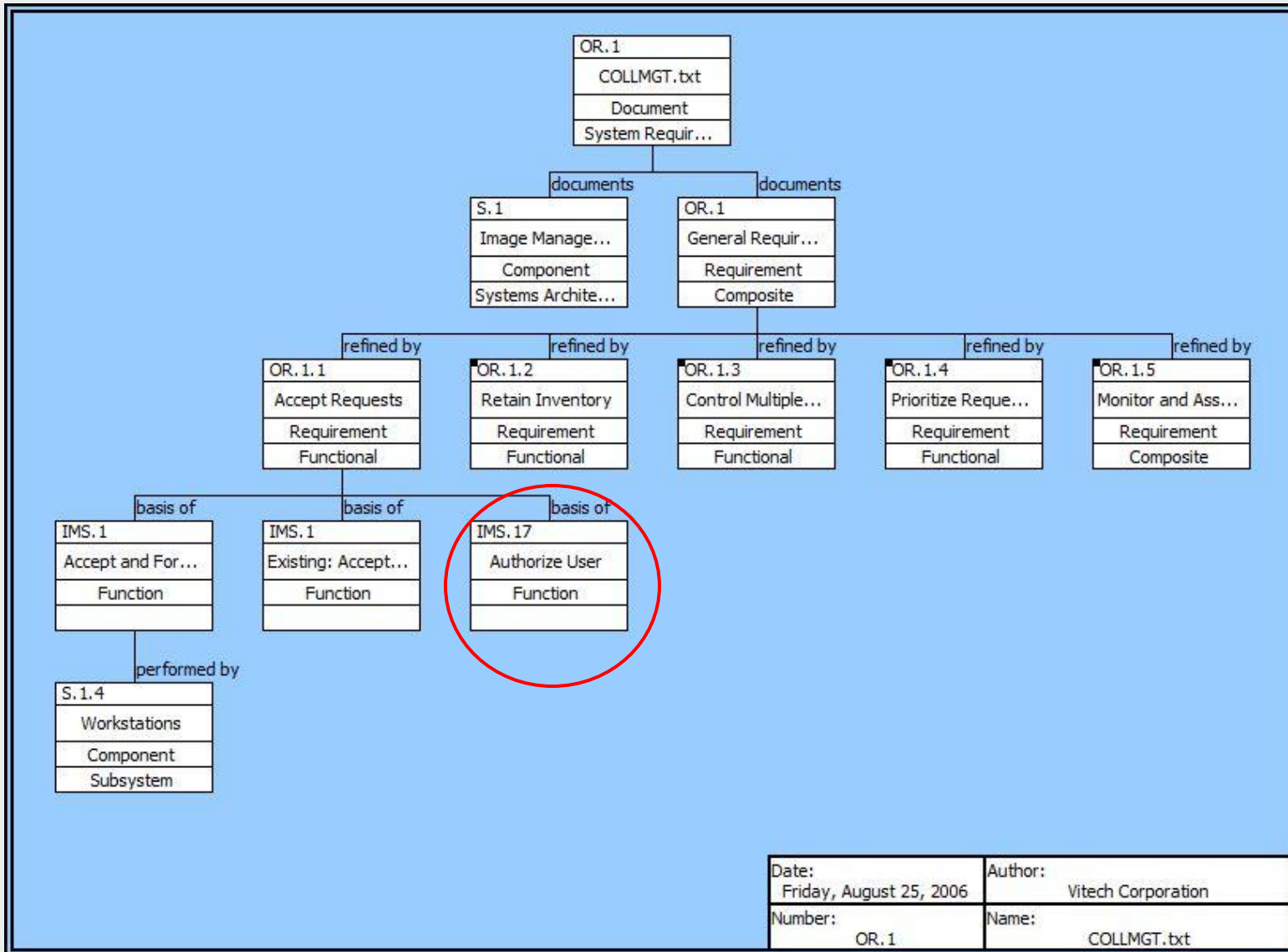
SV-5a Operational Activity to Systems Function Traceability Matrix

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					



SE Traceability





Function Appears in the SSS

Wednesday, October 15, 2008

**SYSTEM SPECIFICATION
FOR THE
IMAGE MANAGEMENT SYSTEM WITH SERVICES**

Prepared For:

Tutorial Participants
1441 Quivera Rd
San Diego, CA 92109

Prepared By:

NDIA Presenter
123 Main Street
SpringLake, 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.

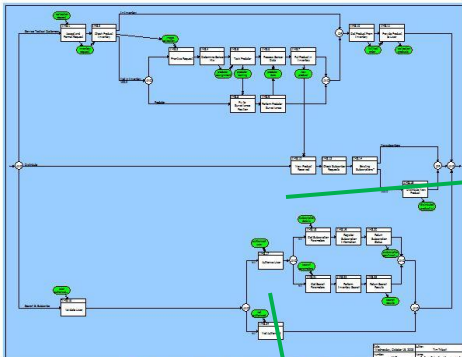
3.2.1.18 Get Subscription Parameters

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

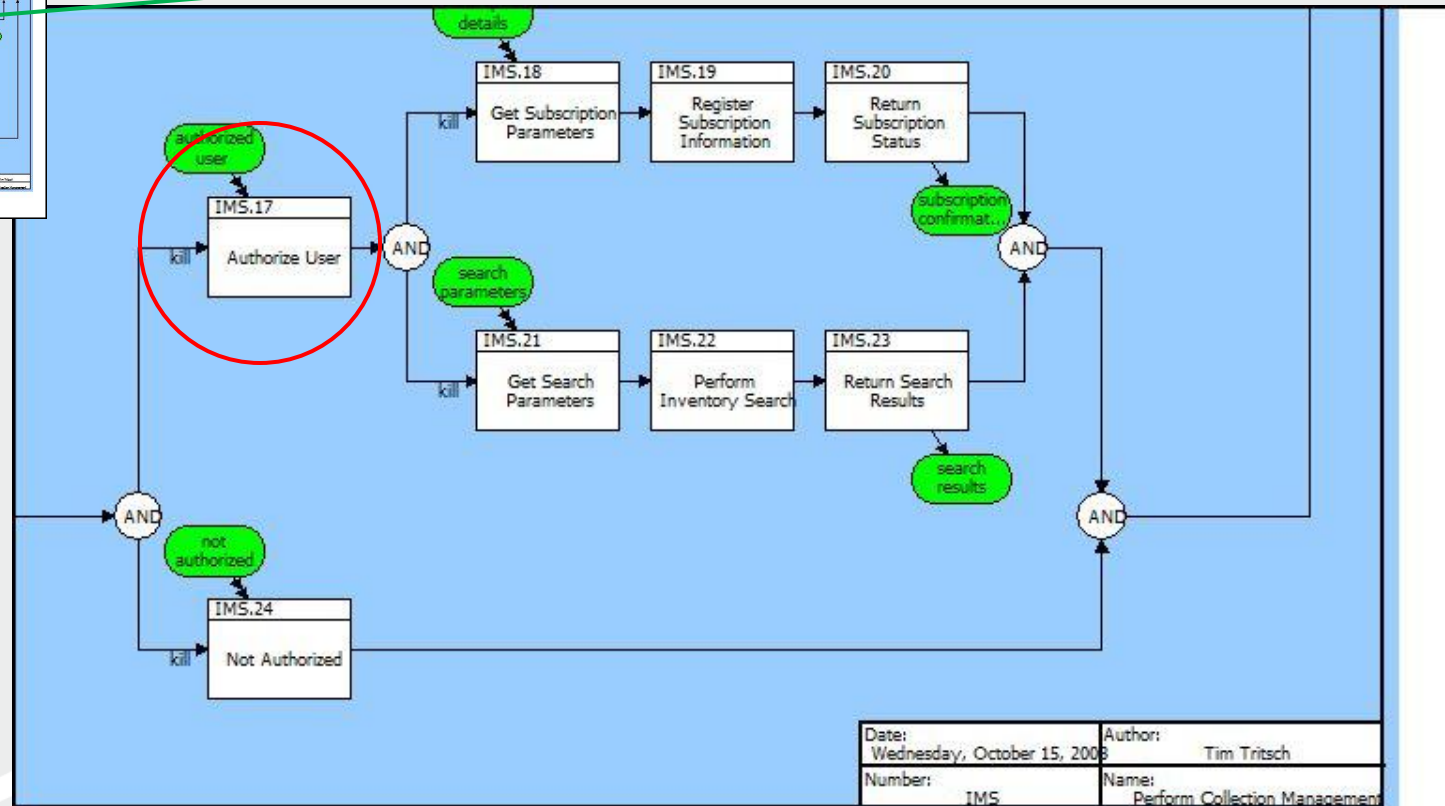


Function As Part Of SV-4

Perform Collection Management
Systems/Services Functionality Description (SV-4)



IMS - Perform Collection Management Enhanced FFBD



Management Enhanced FFBD



Inside the Data Model . . .

The screenshot displays the Project Explorer interface for Tactical Image Management NDIA (DoDAF v1.5). The 'Function' folder is selected, showing a list of functions including 'Authorize User'. The 'Authorize User' function is highlighted, and its properties are shown in the right-hand pane. The 'Name' is 'Authorize User' and the 'Number' is 'IMS. 17'. The 'Description' is 'Supplied credentials indicate the user is authorized access, so acknowledge the access.' The 'Relationships' pane shows the function is 'triggered by' another function, 'Item authorized user'. The 'Targets & Attributes' pane shows the function is 'governed by' and 'implements' other functions, and 'produces' and 'relates to' other functions. The 'Sort' dropdown is set to 'Numeric by class'.

Project Explorer (Tactical Image Management NDIA (DoDAF v1.5))

File Edit View Project Data Schema Utilities Diagram Tools Help

All Classes

Project Elements

Authorize User asPropertySheet

Name: Authorize User

Number: IMS. 17

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

Doc. PUID:

Title:

Duration: Edit

Relationships

governed by

implements

inputs

outputs

performed by

produces

relates to

reported by

result of

services

specified by

triggered by

utilized by

verified by

Targets & Attributes

Item authorized user

Queue Type: FIFO

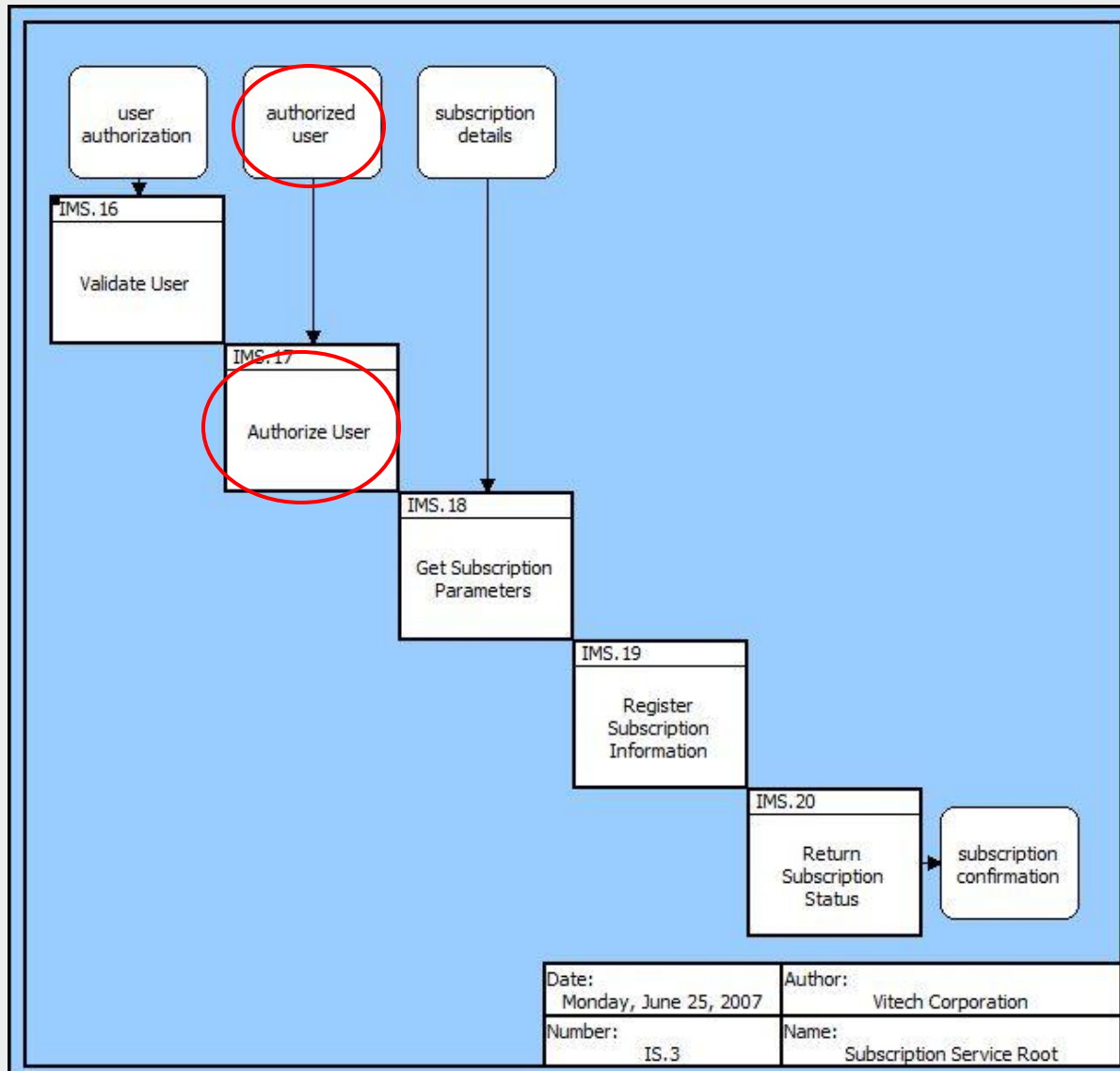
Sort: Numeric by class

Properties ER Hierarchy FFBD EFFBD N2 IDEF

RWDA Last Modified: Monday, October 20, 2008 at 09:37:34 AM



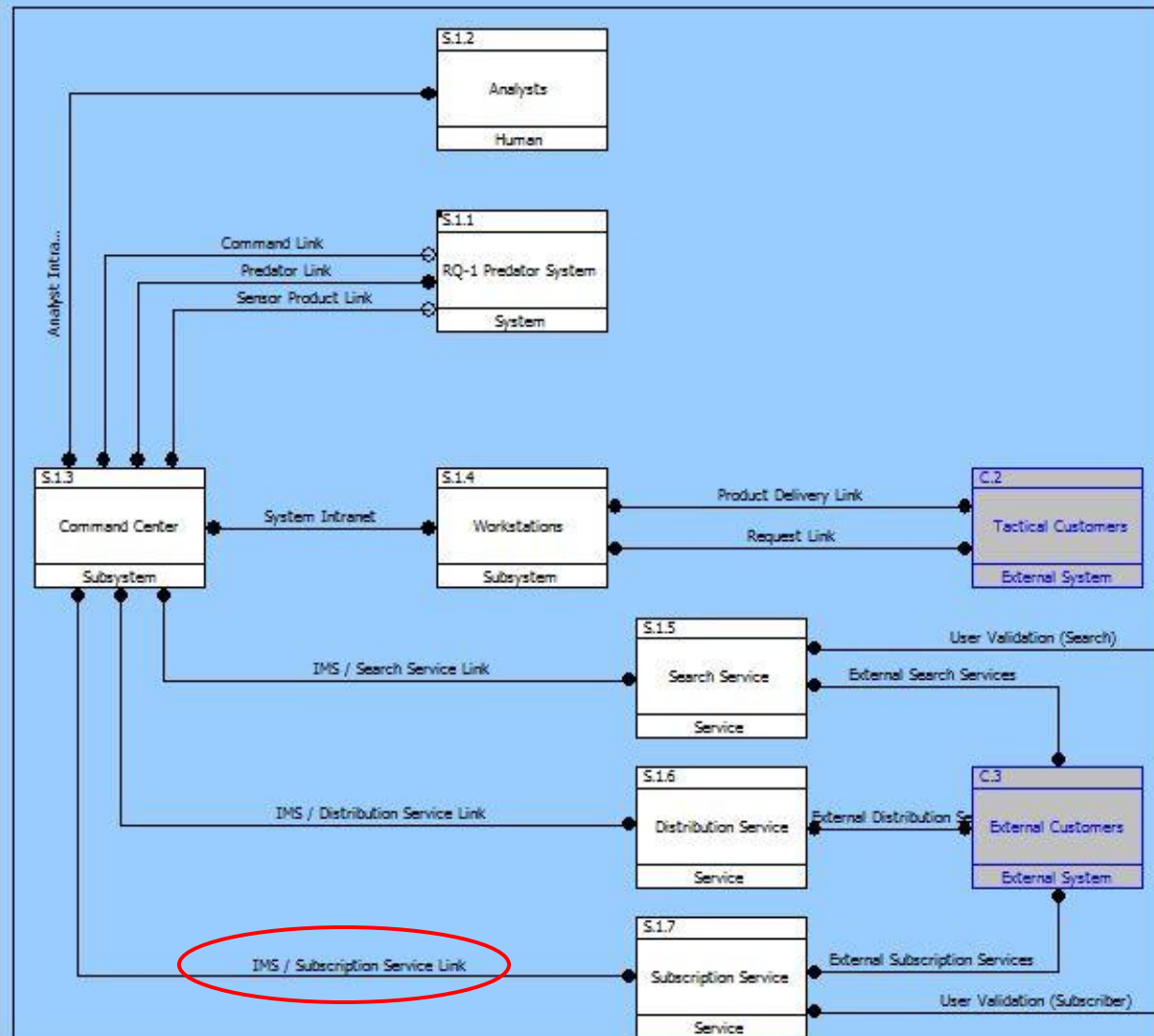
N2 Diagram Provides a Snapshot of System I/O





Functional Allocation to System Components Reveals Required Connectivity

Image Management System with Services
Systems/Services Communications Diagram (SV-2)





System Interoperability Also Used In Interface Requirement Specifications

Wednesday, October 15, 2008

INTERFACE REQUIREMENTS SPECIFICATION FOR THE NEW PRODUCTS / IMS INTERFACE

Prepared For:

Tutorial Participants
1441 Quiviera Rd.
San Diego, CA 92109

Prepared By:

NDIA Presenter
123 Main Street
Spring Lake, NJ 08736

Authenticator by: _____ Approved by: _____

Wednesday, October 15, 2008

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:	



SV-3 Systems-Systems Matrix

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

	Analysis	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	



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 connected and entering new product requests.

Test Equipment

System Context

Description

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

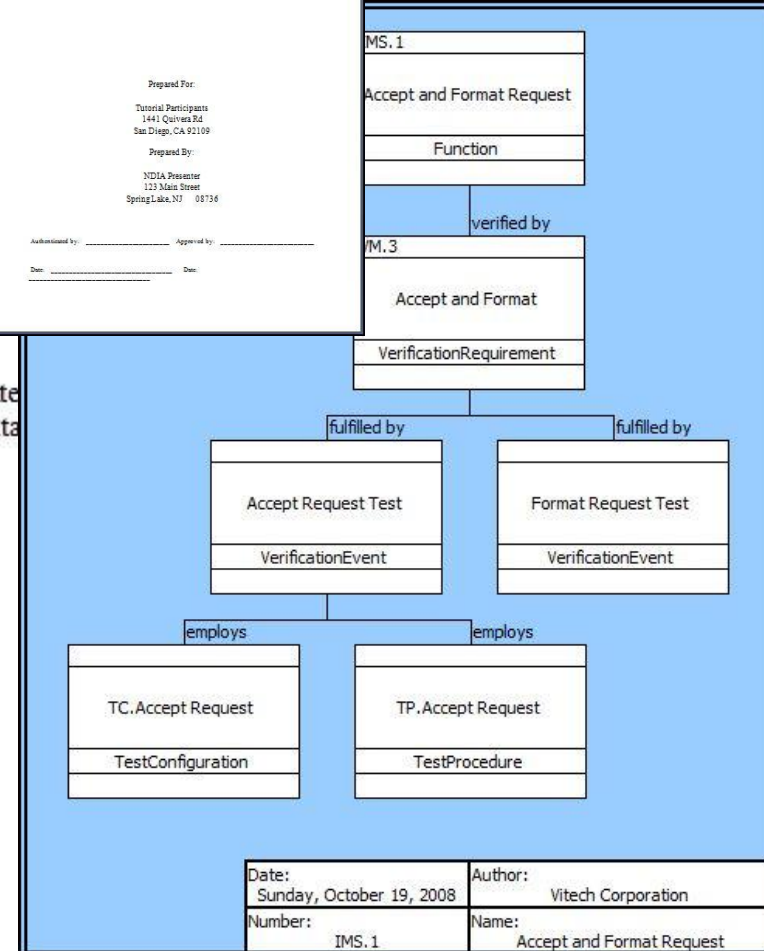
**TEST AND EVALUATION PLAN
FOR THE
IMAGE MANAGEMENT SYSTEM WITH SERVICES**

Prepared For:
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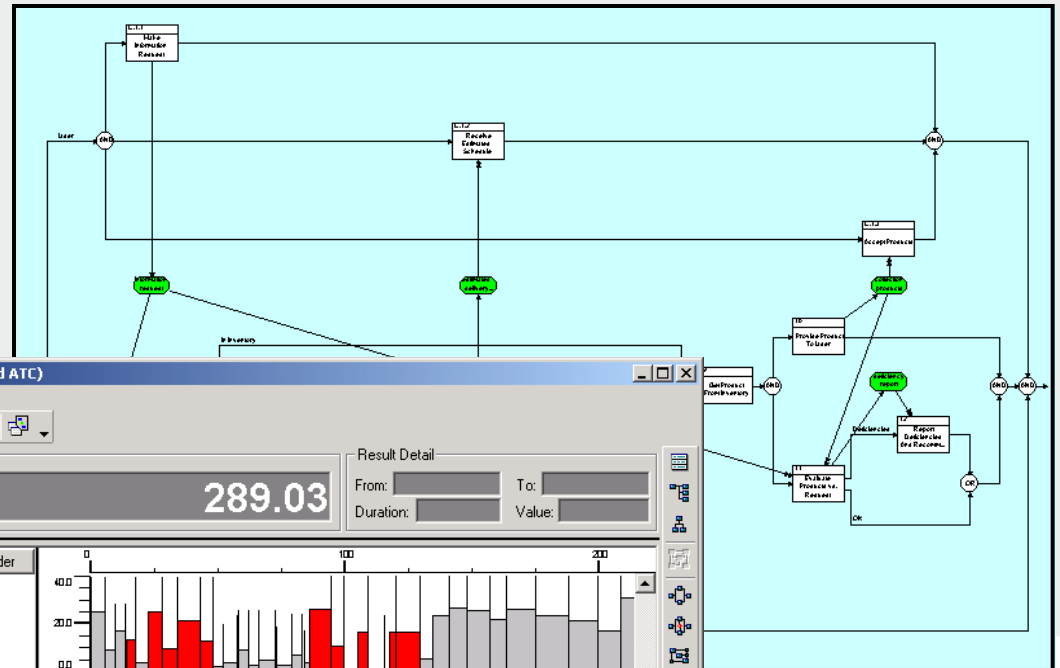
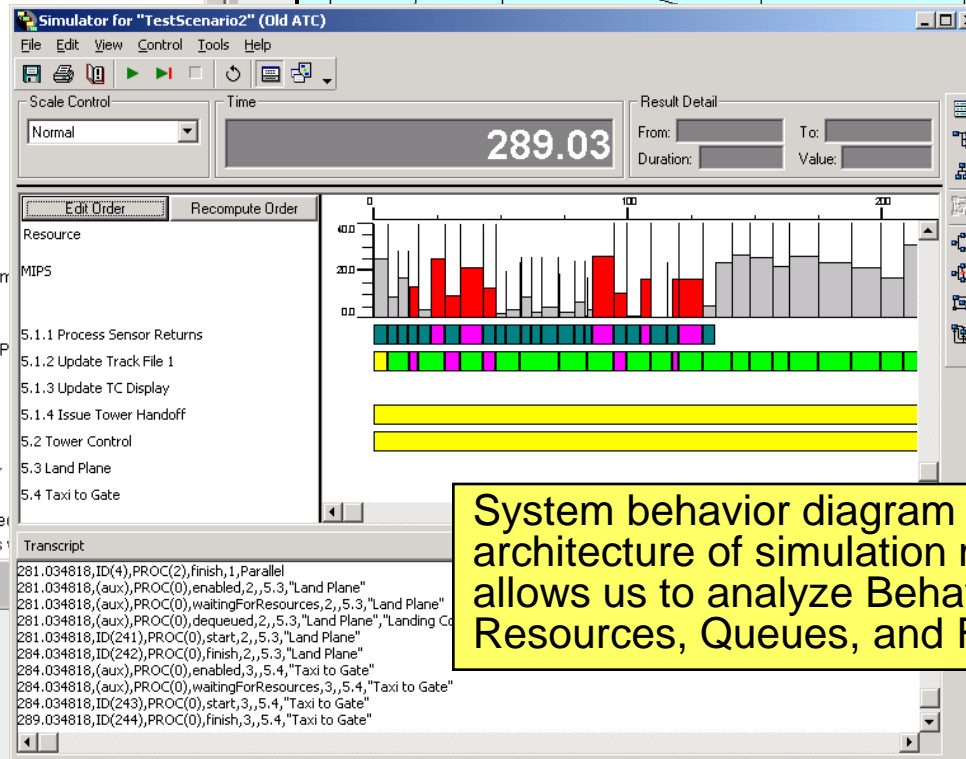
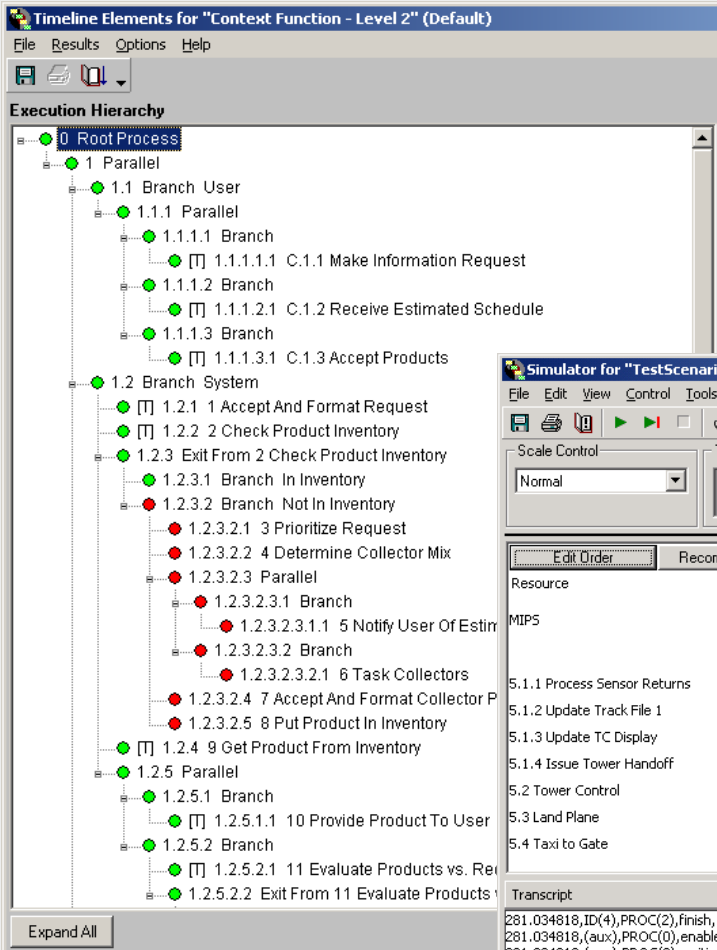
Authorized by: _____ Approved by: _____

Date: _____ Date: _____





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



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



- 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?



- 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)



The End