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An IBM Rational Approach to the Department of Defense Architecture Framework (DoDAF)

Chris Widney
Senior Technical Services Specialist
Rational Brand Services
IBM Software Group

Contents

"The Department of Defense (DoD) Architecture Framework (DoDAF) defines a common approach for DoD architecture description development, presentation, and integration for both warfighting operations and business operations and processes. The Framework is intended to ensure that architecture descriptions can be compared and related across organizational boundaries, including Joint and multinational boundaries." (DoD Architectural Framework, Version 1.0, 15 August 2003)

DoDAF's primary objective is to produce a standardized report describing a complex systems architecture. Operational decision-makers can then use this report in the DoD to compare the architecture of alternative systems and manage the evolution of existing systems. The report consists of views that describe a systems architecture well enough to justify procurement of the system to DoD management and the Congressional Budget Office (CBO).

Companies doing business with the DoD are tasked to comply with some or all of the DoDAF as they propose their systems. In this paper, we discuss an approach to modeling complex systems architecture in conjunction with constructing appropriate DoDAF views. While exploring DoDAF semantics, we leverage the architectural model, Unified Modeling Language (UML) notation, and IBM Rational tooling to support the production of complete, correct and consistent DoDAF views of a well-formed enterprise architecture model.

Background

Architecting complex systems and operational enterprises demands an extraordinary capacity to understand and manage complex relationships. A thorough understanding of the enterprise's architecture is crucial to effective design, implementation, deployment, and maintenance of evolving systems.

A complete, consistent model of that architecture is the key to mitigating risk and managing the systems' complexity. DoDAF content provides us with a "window" into the architecture that we can leverage as we incrementally define the system.

DoDAF and operational approaches to enterprise architecture have typically supported the search for **sponsorship** and **funding** of major mission-oriented systems. You can realize much more from that investment by identifying your architecture early. You can manage key decisions throughout the systems lifecycle more effectively through early recognition of **integration challenges** and **operational dependencies**. Producing the following DoDAF products substantially enhances executive ability to make decisions impacting the evolution of their current and future operational enterprises.

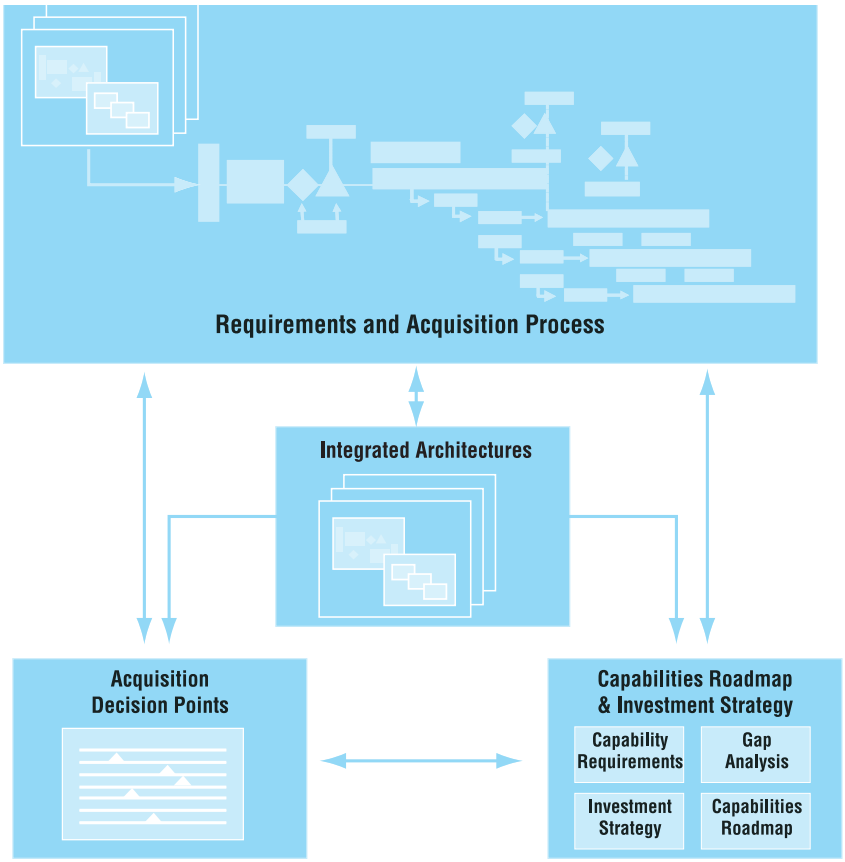


Figure 1. Integrated Architecture Supports the Entire Acquisition Lifecycle (LtGen James F. Cartwright, "Changing the Mindset, Innovation and Changing the Military Culture Seminar". www.oft.osd.mil/library/library_files/briefing_86)

Leveraging IBM's Software Development Platform for DoDAF

The IBM Rational approach to DoDAF is comprehensive. Our total solution incorporates an integrated toolset, a proven systems engineering process, and a robust enablement capability designed to facilitate discovery, description, implementation, and evolution of the complex enterprise architecture associated with DoD's operational missions.

Our tooling builds upon capabilities supported by the optional, downloadable DoDAF feature for the the IBM Rational Eclipse-based modeling solution family of tools (IBM Rational Software Architect, IBM Rational Software Modeler and IBM Rational Systems Developer). This paper's discussion assumes that the optional DoDAF feature is being implemented. Integrations with IBM Rational RequisitePro® for requirements management, IBM Rational ClearCase® for configuration management, IBM Rational ClearQuest® for change management, and other IBM Rational products empower the entire systems development team. Extended capabilities and plug-ins provided by Ready for Rational Partners can further enhance capability, such as with SysML modeling and state-machine-based executable models.

Strictly speaking, the DoDAF is all about content. However, the optimal approach to DoDAF compliance should not require divergent effort from the primary objective of developing the system. The IBM Rational approach incorporates DoDAF product generation into the overall architectural effort, allowing the DoDAF views to represent an evolving enterprise architecture that is ***consistent*** with, and ***traceable*** to the systems necessary to implement that architecture.

As with any complex activity, learning to create and maintain an enterprise architecture using DoDAF requires skilled application of systems engineering and DoDAF-specific knowledge. IBM Rational is ideally positioned to offer enablement services to optimize your architectural efforts. The following material introduces you to DoDAF, and shows how you can address it within the context of developing an enterprise architecture.

DoDAF Syntax and Semantics

- ***DoDAF focuses on relationships.*** *The DoDAF content focuses on relationships between significant architectural elements of the operational enterprise. The model's core semantic elements are* nodes, needlines, services, *and* information exchanges. *Collectively, these elements describe the structure and allocation of significant behavior in the operational enterprise.*
- ***Nodes – systems, actors and workers.*** *The principle element of the DoDAF is the node, which represents a logical or physical entity operating within the enterprise, or operational environment. These entities could represent collections of workers, systems or subsystems, within or outside the enterprise, whose role is to interact in some manner with one or more elements of that enterprise. An understanding of both the internally and externally visible characteristics of these nodes provides the foundation for the architecture and design of this system-of-systems, the operational enterprise. The architecture will tend to focus more on the relationships between the nodes, while the design deals more with the internal structure and behavior of the nodes. Accordingly, the DoDAF's primary objective and the benefit of architectural modeling of the operational enterprise, is a characterization of the manner in which nodes cooperate to fulfill the mission. In DoDAF, we deal with three types of nodes:* operational nodes, *which are described in the operational view, and reflect combinations of actors, workers and systems,* systems *which are logical elements that implement the behavior of the operational nodes, and* system nodes, *which represent physical elements or localities, that host logical systems or subsystems.*

- ***Needlines – relationships and dependencies.*** *In the DoDAF, relationships between collaborating operational nodes are represented as needlines. Each needline represents the requirement for one node to provide one or more operationally necessary services and associated information to another node. Needlines are abstractions, in that they may represent a single service/ information exchange, or a group of services/information exchanges. In either case, the needline specifies a dependency of one operational node on another, and the direction of flow of service(s) or information.*
- ***Services – significant operational functionality.*** *Services represent one or more operationally significant functions that are rendered by one node, to another. Each service, implicitly or explicitly, also represents the transfer of information between nodes, and is characterized as a message or operation.*
- ***Information Exchanges – characteristics of information transferred.*** *Information exchange is associated with a set of functional and non-functional requirements characterizing the constraints under which information is captured, transferred or used.*

Best Practices for Complex Systems Development

Production of the required DoDAF products has been fully incorporated into the overall process of elaborating the Enterprise Architecture (EA) and its associated requirements. This approach negates the perceived burden of DoDAF compliance in the context of complex systems development by leveraging the value of engineering information captured in the DoDAF products.

The IBM Rational approach to detailing the structure and behavior of an architecture is based on proven principles. Those principles provide the foundation for a well-managed system evolution.

- ***Decompose systems, not requirements.*** *Develop each abstraction level before proceeding to the next lower level. Elaborate use cases fully and captured behavior explicitly. Be sure to consider not only the logical architecture, but the physical/locality-oriented aspects of the architecture as well. Discover and document the relationships between the logical and physical architectures for each level of abstraction addressed. Iterate to the next lower level of abstraction until the architecture is sufficiently captured to meet the needs of the development organization*
- ***Enable both separation and integration of concerns.*** *Examine both black box and white box views for each level of abstraction addressed. Strive for balance between perspectives to avoid overcooking in either direction. Too much separation results in functional decomposition and its associated integration issues; too much emphasis on integration and you risk missing important functional issues.*
- ***Systems and components collaborate; so should development teams.*** *Developers of components and systems /subsystems that need to collaborate, depend on thorough knowledge of dependencies. Without developer collaboration, you increase the risk to successful integration.*
- ***Specifications flow up and down the architecture.*** *You should understand the requirements at each level of abstraction, and use them to derive the capabilities of the elements that collaborate at that level of abstraction.*
- ***Base the lifecycle on removing risk and adding value.*** *Minimize the obstacles to success when the resources are there.*
- ***Development organization should reflect product architecture.*** *Optimal application of development team skills calls for shifting responsibilities from one role to another throughout iterations. Organizing teams with multiple complementary skills provides for more management flexibility, and increases the overall capabilities of individuals to the organization.*

Risk management drives the overall process for development of an enterprise architecture. This enables a logical, systematic capture of the essential architecture of a complex system. Rigorous application of an iterative process and use of a standard notation (Unified Modeling Language or UML),results in a comprehensive visual representation of multiple perspectives of system structure and behavior, at successively lower levels of abstraction. Recursively applying the process to the level of subsystems definition and internal design results in a complete, consistent engineering model of the architecture. This, in turn, provides a foundation for design, implementation, deployment, management and controlled evolution of an enterprise or complex system.

DoDAF Model Organization

The DoDAF is a structured set of architectural information, organized around views. The **All Views (AV)** products are intended to provide an overall perspective of the subject system in the context of the operational enterprise, and would address overarching concerns like CONOPS (Concept of Operations), critical mission objectives and strategies, as well as an integrated dictionary of architecturally significant terms. The **Operational View (OV)** focuses on externally visible structure and behavior of the subject system. Operational nodes and their relationships are described and dependencies reflecting mission requirements are identified, providing an overall context for enterprise definition and evolution. Realization of internal structure and behavior is the focus of the **Systems View (SV)**, and incorporates a rigorous allocation of functional and non-functional requirements (from the Operational View) to both logical and physical system elements and interfaces. Standards constraining the operational architecture of the enterprise are reflected in the **Technical Standards View (TV)**, and address both current and future states of the system(s).

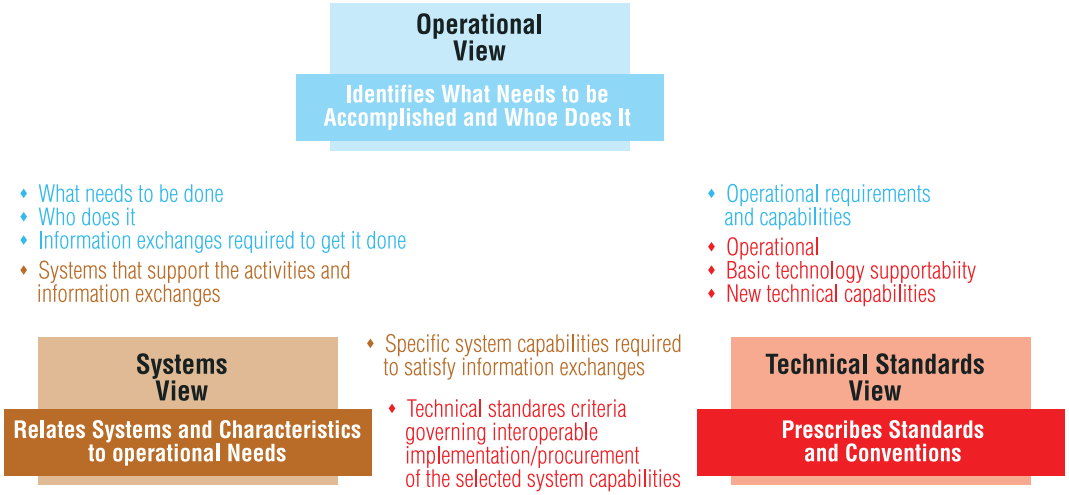


Figure 2. Fundamental Linkages Between the DoDAF Views (Department of Defense Architecture Framework Working Group, "DoD Architectural Framework", Version 1.0, Volume I, August 2003)

DoDAF View Relationships

Consistency within and between DoDAF views is critical. Optimal derivation of DoDAF views necessitates consistent modeling at multiple levels of abstraction (systems decomposition). As we drill down in an architectural model, recursively applying a rigorous systems architecture discovery process to successive levels of abstraction of an enterprise, we learn more about an element, and may employ alternative means to represent its characteristics. For example, we may initially represent a complex system that satisfies the needs of its users, by way of a use-case or context diagram. As we learn more of the supporting activities (system white-box behavior), class, activity and/or sequence diagrams may be added to reflect the additional detail. ***Nodes***, portrayed as actors in one diagram, may be more appropriately represented as classes or objects in other diagrams. ***Services*** may be implemented or realized by collections of class operations making up a subsystem. In determining

how best to model each of the core DoDAF elements, we must first understand the essential semantics underlying that element (along with any applicable constraints) and then apply the appropriate notation, given the context of the overall engineering effort. Context includes risk, complexity, tools, notation, and objective(s) for the modeling effort.

The overall process of DoDAF view production is both ***iterative*** and ***incremental***. As more breadth and depth of architectural information is captured, evolution of the AV-1 and AV-2 progresses. Using the AV-1 as a foundation, the architectural interactions of the operational enterprise and the subject system are examined, resulting in discovery of the high-level interactions between the system and the operational nodes. Full characterization of these high-level relationships is the focus of the Operational View.

Only after we fully understand the external systems behavior (Operational View), do we proceed with the elaboration of the Systems View. This is where we begin to design and organize the internal behavior and subsystems interactions that provide the foundation for full-scale development. At this point, we also reconcile multiple viewpoints that allow us to deal with the necessary physical and logical realization of operational behavior through joint realization practices and use case flowdown.

Checkpoints for Overall DoDAF Relationships between Products[2]

- ☐ Do OV-2 operational nodes map to operational activities in the OV-5 that are associated with those operational nodes?
- ☐ Do OV-2 needlines in the map to IERs (Information Exchange Requirements) in the OV-3?
- ☐ Are the OV-3 data elements of the IERs mapped to the IO Entities reflected in the OV-7?
- ☐ Do the OV-6a operational rules relate to the activity logic addressed in the OV-5?
- ☐ Are rules applicable to the OV-7 data captured in the OV-6a?
- ☐ Are rules applicable to the SV-4 contained in the SV-10a?
- ☐ Do OV-2 operational nodes map to systems identified in the SV-1 to support those nodes?
- ☐ Do OV-2 operational nodes map to system nodes identified in the SV-1 to support those nodes?
- ☐ Do OV-2 operational nodes map to interfaces identified in the SV-1 to support those nodes?
- ☐ Do OV-2 needlines map to interfaces identified in the SV-1 that support those needlines?
- ☐ Do interfaces in the SV-1 map to system data elements identified in the SV-6 and the system functionality identified in SV-4?
- ☐ Do SV-4 system operations map to the interfaces in SV-1?
- ☐ Do SV-4 system operations map to operational activities identified in the OV-5, and does the SV-5 document that relationship?
- ☐ Do SV-6 data exchanges map to the IERs of the OV-3?
- ☐ Do OV-2 operational nodes map to systems identified in the SV-1 to support those nodes?
- ☐ Does the SV-11 Physical Data model support the implementation of the OV-7 Logical Data model?
- ☐ Are the TV-1 standards and constraints mapped to the applicable SV-1,SV-2, SV-4, SV-6, OV-7, and SV-11 elements?
- ☐ Do the technology forecasts of the SV-9 and the standards forecasts of the TV-2 correlate/trace to system evolution timelines and milestones of the SV-8?

All Views Products

The following table briefly describes the All Views products and the order in which you might create them following this process.

Product	Title	Description	Representation	Creation Order
AV-1	Overview and Summary Information	Textual document describing scope, purpose, intended users, operational environment for the subject system. Provide an overall understanding of the nature of the enterprise and how it interacts with the subject system. Supports the strategic vision for system usage	Model referenced text document	1
AV-2	Integrated Dictionary	Definitions for all terms used to describe the architecture. Provide an set of standard reference terms to maintain consistency of meaning to all consumers of the architecture	Model resident, repository-based text Exportable to XML	Ongoing

The DoDAF **All Views (AV)** products provide a summary of the environment in which the subject systems are to be developed, deployed, and managed during their evolution. The summary describes mission objectives, strategies, operational concepts, the general context for operations and relevant terminology.

AV-1 Overview and Summary Information

The AV-1 is a textual summary of the operational environment and the mission capabilities to be exercised in the context of the evolving systems. Focus is on the subject system or enterprise in an operational context. Relevant Concepts of Operations (CONOPS) and strategies are presented at a level of abstraction appropriate to executive leadership, in order to facilitate decision making. The content of the AV-1 represents the guidance or vision that reflects essential business drivers and the need for the subject system under development.

The acquirer or development organization may prepare the AV-1, although, as with all DoDAF view products, substantial interaction with Subject Matter Experts (SMEs) will be required. In our approach, we produce the AV-1 document using a standard word processing tool and associate (via a the document reference link) with the model containing the visual DoDAF products.

Tool Tip: Create the AV-1 document using the template by selecting the AV-1 in the Rational's Eclipse-based modeling solutions DoDAF model, clicking on the right mouse button, and selecting DoDAF > AV-1

AV-2 Integrated Dictionary

The AV-2 represents a simple, but essential concept to systems and software development. The need for consistency and clarity of meaning is substantially met through establishing a single, centralized glossary of architecturally relevant definitions and potentially ambiguous terms. Our approach incorporates continuous evolution of this integrated dictionary within the model repository managed via IBM Rational's Software Development Platform Eclipse based modeling tools. As you create model elements, you incorporate them into the engineering model repository, from which you can extract an AV-2 at any time. All graphical model elements associated with DoDAF stereotypes are automatically captured in this manner. You will need to add textual references manually, or alternately access them via some other tool, such as IBM Rational RequisitePro.

Operational View Products

Externally visible structure and behavior necessary to support mission capabilities by the subject system and operational nodes in the enterprise context.

The DoDAF Operational View (OV) is comprised of various products, intended to provide multiple perspectives of the external structure and behavior of the subject system in the overall enterprise context. We characterize the interactions between the system and its actors, the mission objectives required of the system, and the necessary dependencies and interactions for achieving those objectives. The focus of the OV is on those requirements and capabilities that impact the mission. Details of how the OV is realized reflect the content of the Systems View. The following table briefly describes the Operational View products and a suggested order of creation.

Product	Title	Description	Representation	Creation Order
OV-1	High-Level Operational Concept Graphic	Graphic abstraction of the operational concepts supporting the mission of the enterprise	High-level abstract graphic Enterprise Context Diagram Enterprise Use Case Diagram	1*
OV-2	Operational Node Connectivity Description	Operational nodes, activities, connectivity, and information flow	Enterprise Context Diagram with Needlines and IO Entities	4**
OV-3	Operational Information Exchange Matrix	Information exchanged between nodes and the attributes of the information	Model resident text matrix Exportable to XML	4**
OV-4	Command Relationships Chart	Command, control and coordination relationships between operational organizations	Freeform diagram with organizational elements	2**
OV-5	Activity Model	Activities, relationships between activities, I/Os, constraints, and mechanisms that perform activities	Enterprise Use Case	2**
OV-6a	Operational Rules Model	Identification of business rules and process constraints that impact the operational activities	Model constraints (OCL/SysML) Model referenced functional and non-functional requirements	2**
OV-6b	Operational State Transition Description	Identification of relationships between events and operational sequences	State Transition Diagrams	4**
OV-6c	Operational Event/Trace Description	Identification of externally visible operational sequences and actions that trace to scenarios or critical activities.	Sequence Diagrams	3
OV-7	Logical Data Model	Structural relationships of data supporting operational exchange of information	Class Diagram indicating IO Entities and their relationships	5

The order in which products are likely to be generated is shown in the following activity diagram, and does not necessarily reflect the order in which the products are discussed in this article. The proposed order is based on an architectural discovery process which is founded on the engineering principles discussed earlier in the paper. In this way we are able to generate DoDAF compliant products without detracting from the primary task of defining the enterprise architecture.

**OV-1 content is started first, but the OV-1 graphic cannot be completed until OV-2 is complete*

*** These products are not serially dependent and can be created in either order, or may be co-dependent and developed jointly*

**** State Transition Diagrams are optionally used to model critical real-time responses to complex events requiring special treatment*

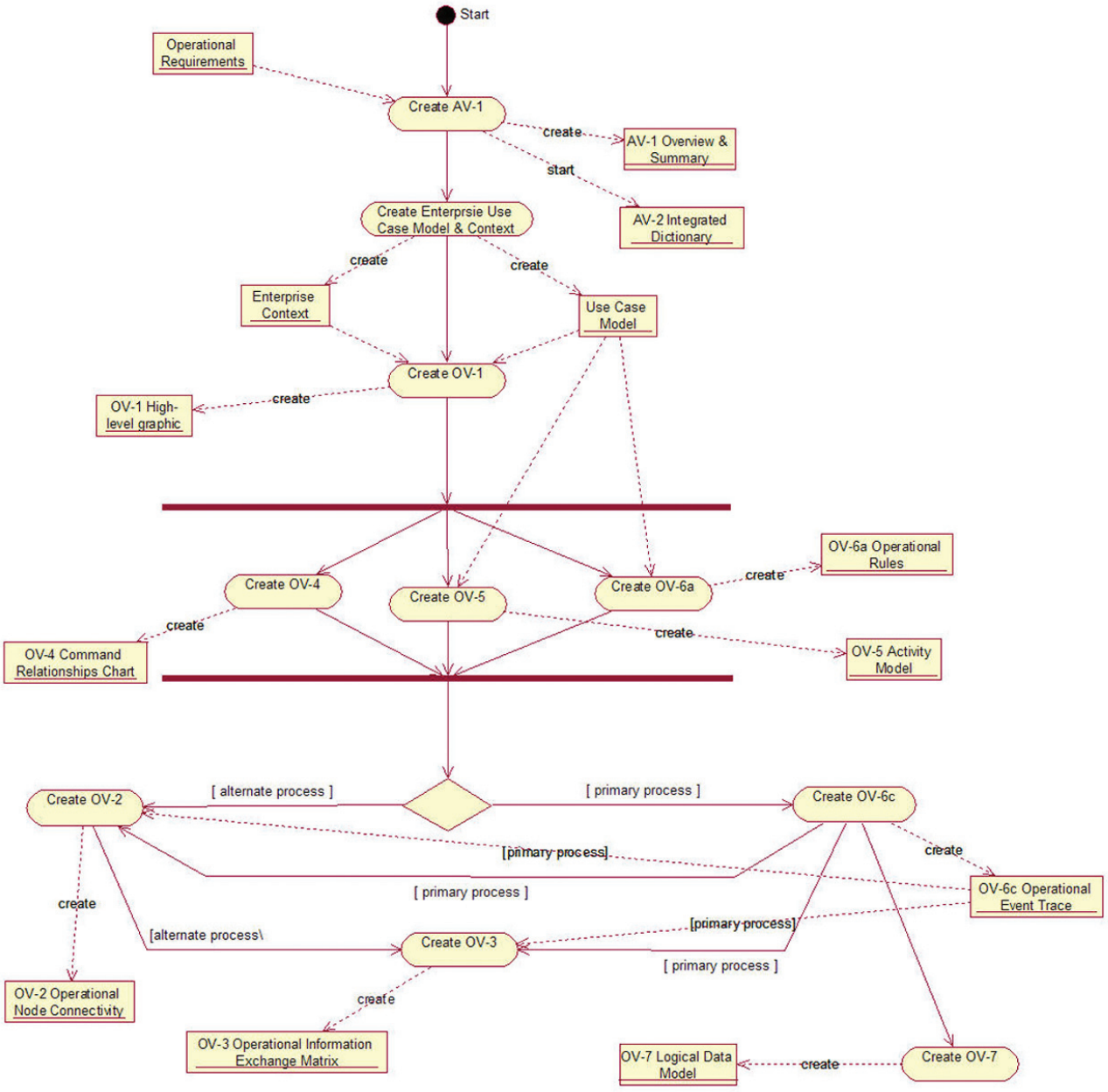


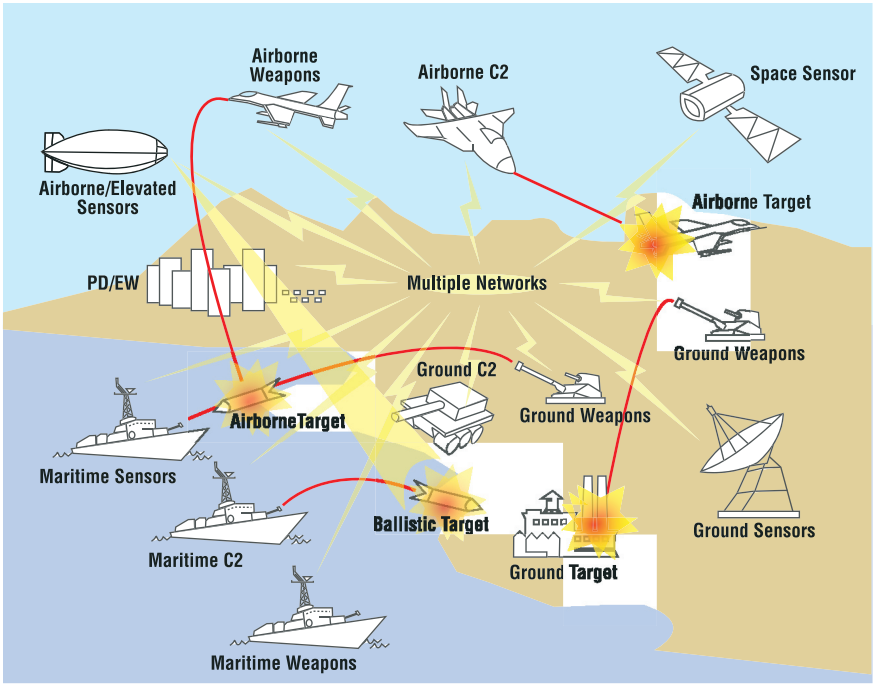
Figure 3. DoDAF AV and OV Product Generation Process

OV-1 High-level Operational Concept Graphic

The OV-1, in a clear and concise way, communicates the scope of the subject system within the context of the operational enterprise. The graphical depiction of the OV-1 is typically an artist-rendered product reflecting content derived from multiple sources. The primary information sources for the OV-1 are the AV-1 Overview and Summary document, an Operational Context Diagram, and an *Enterprise Use Case Diagram*. We construct the Enterprise Use Case Diagram starting with the subject system and identify any external systems and organizational entities that interact with that system. We characterize these interacting elements as *actors*. *Use cases* are then added to the diagram for each operational goal or objective attributed to actors. Communicates stereotyped associations are added, where appropriate.

Several actors/roles may collaborate within organizational elements in order to meet mission needs. The aggregation of actors/roles to organizational elements results in identification of *operational nodes*, which are captured using a class diagram, designated the *Operational Context Diagram*. The interactions between actors and the subject system become represented by the collective interactions, or needlines between the operational nodes (actor aggregation) and that system. The IO Entities associated with those actors transitively become associated with the specified operational node. The Systems Architect and applicable SMEs then collaborate with a graphic artist in rendering the collective content of the above products in an OV-1 graphic, tailored for an executive-level audience. This graphic will provide the foundation for the structuring the externally visible architecture of the operational enterprise, as it relates to the system under development. Content will evolve as further information is captured during subsequent DoDAF product generation.

Figure 4. Sample OV-1 High-level Graphic (LtGen James F. Cartwright, "Changing the Mindset, Innovation and Changing the Military Culture Seminar". www.oft.osd.mil/library/library_files/briefing_86)



***Sample OV-1 High-level Graphic*[9]**

- ☐ Have you accounted for all elements that interact with the subject system and identified them as Actors or Operational Nodes?
- ☐ For any operational node-subject system pair have you identified the dependency relationship and its directionality?
- ☐ Have you incorporated the needline information from the OV-2 to generate the OV-1 graphic suitable for the target audience?
- ☐ Have all uses cases been identified for the enterprise elements using the subject system?
- ☐ Have all of the flows for those use cases been outlined?
- ☐ Has an Operational Context Diagram been completed?
- ☐ Has an Enterprise Use Case Diagram been completed?

Tool Tip: Create a use case diagram and name it Enterprise Use Case Diagram. Populate the diagram with actors, use cases, and communicates relationships
Create a class diagram in which the actors are aggregated into operational nodes
Import a suitable graphic into the diagram background (optional)
Create a class diagram and name it Operational Context Diagram. Populate the operational nodes (including subject system). Coordinate with graphic artist and generate the OV-1 graphic

OV-2 Operational Node Connectivity Description

The OV-2 identifies and models critical operational dependencies between operational nodes. The DoDAF defines these as needlines. There are two primary approaches to determining *needlines*: 1) identify the nature of the dialog represented in each *communicates* association in the Enterprise Use Case Diagram, and specify a needline, directionally oriented so that the needline is navigable from the consumer (for that relationship) to the supplier of the service or information; 2) wait until detailing the use case flows and scenarios, and capturing them in the OV-6c *sequence diagrams*, and then identify specific object/role interactions, which can be "rolled up" to representative needlines. **Option 1** is a manual process, since some level of engineering/architectural analysis is necessary. **Option 2** allows us to leverage capabilities of IBM Rational's Eclipse-based modeling tools to automatically populate the needlines (and OV-3 IERs) from content in manually produced sequence diagrams. This approach has the additional advantage of guaranteeing consistency between OV-2, OV-3, and OV-6c, since all are derived from identical model information.

A needline may represent many information exchanges or service dependencies. Accordingly, once a needline has been identified between any two context diagram elements, no other needlines, in the same direction, are appropriate

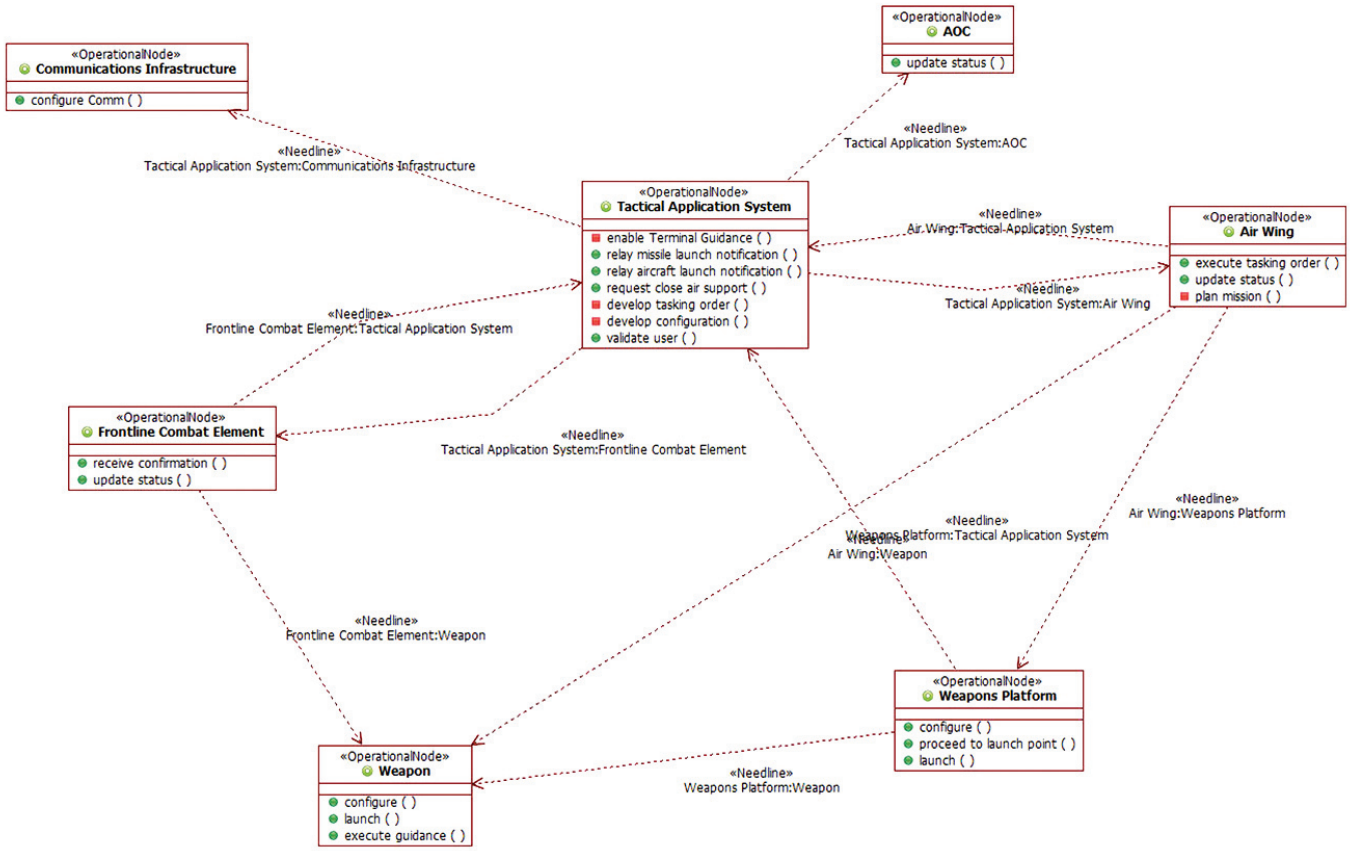


Figure 5. Sample OV-2 with needlines

Tool Tip: Select a DoDAF model element in the IBM Rational Eclipse-based modeling tool browser. Click the right mouse button, and select DoDAF > Create OV-2. The OV-2 class diagram should be displayed, with needlines between the affected operational nodes. You may need to rearrange the diagram elements for clarity. This is an evolution of the Enterprise Context Diagram, which has been generated and placed in the OV-2 model structure. You may need to manually incorporate some of this information into the OV-1 graphic.

Checkpoints for OV-2

- ☐ Is there one and only one (needline) for each direction in which an operational node sends/receives a message (in OV-6c) to/from another operational node or the subject system for the operational enterprise?
- ☐ Is there at least one message (in OV-3 and OV-6c) for each needline represented in the diagram(s)?

Advanced Topic - Use of Collaborations to enhance relationship definition and capture of needlines.

UML 2.0 introduces a new classifier, the Collaboration. The semantics associated with the Collaboration offer potential for characterizing relationships more robustly. You can specify relationship roles, patterns, templates, and associated parameters can be specified. You can also instantiate the information associated with collaborations as collaboration occurrences, further specifying each potential IER. Augmenting the minimal set of DoDAF representations with class and composite structure diagrams (referencing collaborations and collaboration occurrences, respectively), may provide utility. The UML Language Reference Manual[3] provides a thorough discussion of these UML elements.

OV-3 Operational Information Exchange Matrix

The OV-3 is a matrix of Information Exchange Requirements (IERs) that collectively represent the needlines of the OV-2. The OV-3 is generated automatically using the IBM Rational's Eclipse-based modeling tool (by sourcing the OV-6c content). Each matrix row represents an IER, which is comprised of characteristics of the data transferred between roles/objects in an interaction from the OV-6c sequence diagrams. The matrix identifies a distinct IER for each pair of objects or roles that interact and exchange information. Specific IER characteristics are typically associated with non-functional requirements or design constraints. Each IER's content represents an instantiation of an IO Entity class (see discussion of IO Entities in section covering OV-6c), where the attributes represent the data characteristics required by the DoDAF. Accordingly, each information element in the matrix should trace to the Logical Data Model, OV-7.

The OV-3 emphasizes the logical and operational characteristics of the information exchanged. The product is not intended to provide exhaustive capture of all details of information exchanged within the architecture, but as a mechanism understand the most important aspects of significant exchanges. An example of the information content from the DoDAF specification is provided below. This content would typically trace to supplemental or non-functional requirements.

Needline Identifier	IER Identifier	Information Element Description	Producer	Consumer
		• Information Element Name and Identifier • Content • Scope • Accuracy • Language	• Sending Op Node Name and Identifier • Sending Op Activity Name and Identifier	• Receiving Op Node Name and Identifier • Receiving Op Activity Name and Identifier

Needline Identifier	IER Identifier	Nature of Transaction	Performance Attributes	Information Assurance	Security
		• Mission Scenario UJTL or METL • Transaction Type • Triggering Event • Interoperability Level Required • Criticality	• Periodicity • Timeliness	• Access Control • Availability • Confidentiality • Dissemination Control • Integrity	• Accountability • Protection (Type Name, Duration, Date) • Classification • Classification Caveat

DODAF OV3

Needline	Data	Sending Node	Receiving Node
Air Wing:Weapons Platform	Configuration	Air Wing	Weapons Platform
Air Wing:Weapons Platform		Air Wing	Weapons Platform
Air Wing:Tactical Application System	Status	Air Wing	Tactical Application System
Frontline Combat Element:Tactical Application System	ID	Frontline Combat Element	Tactical Application System
Weapons Platform:Tactical Application System	Status	Weapons Platform	Tactical Application System
Tactical Application System:AOC		Tactical Application System	AOC
Tactical Application System:Air Wing	Tasking Order	Tactical Application System	Air Wing
Frontline Combat Element:Weapon		Frontline Combat Element	Weapon
Air Wing:Weapon		Air Wing	Weapon
Tactical Application System:Frontline Combat Element		Tactical Application System	Frontline Combat Element
Weapons Platform:Weapon		Weapons Platform	Weapon
Tactical Application System:Communications Infrastructure	Configuration	Tactical Application System	Communications Infrastructure
Tactical Application System:Frontline Combat Element	Status	Tactical Application System	Frontline Combat Element
Frontline Combat Element:Tactical Application System	Location	Frontline Combat Element	Tactical Application System
Frontline Combat Element:Tactical Application System	Priority	Frontline Combat Element	Tactical Application System
Air Wing:Weapons Platform		Air Wing	Weapons Platform

Figure 6. Sample OV-3 Information Exchange Matrix

Tool Tip: Select the OV-3 package in the IBM Rational Eclipse-based modeling tool browser. Click the right mouse button, and select DoDAF > Show OV-3 View. A matrix of IERs will be displayed under the OV-3 tab, in the lower right portion of the screen. You have the option of clicking in that matrix with the right mouse button, and selecting Export, which generates an XML version of the matrix.

Checkpoints for OV-3

- ☐ Have IO Entities been identified for each parameter specified in each inter-object message in OV-6c sequence diagrams?
- ☐ Have attributes been established for each IO Entity class, consistent with the guidance provided in volume II of the DoDAF specification?
- ☐ Is there an entry for each message in the OV-6c sequence diagrams indicating information passed as parameters?
- ☐ Is there at least one entry for each needline represented in the OV-2?

OV-4 Command Relationships Chart

The OV-4 models the relationships that exist between organizational entities that affect the operational architecture of the enterprise and its systems. Specific organizational elements are likely candidates for the roles (i.e., instantiations of operational nodes) in the interaction diagrams comprising the OV-6c. The OV-4 is represented by a freeform diagram. Note: Some implementers have elected to create this diagram but show little, if any, mapping between the OV-4 and the remainder of the DoDAF views.

Tool Tip: Create a Freeform diagram and name it Organizational Structure. Add rectangles and label them for each organizational element to be represented. Use vertical relationships via solid lines to reflect command relationships, with higher authority at the top of the diagram. Show coordinating relationships using dashed lines.

Checkpoints for OV-4

- ☐ Does the Organizational Structure identify all organizational elements that directly represent roles involved in use case flows, scenarios or other externally visible behavior within the operational enterprise.

Tool Tip: Create an activity diagram for each enterprise scenario or use case. Create activities for each major step of the flow or scenario, indicating logical choices or decision points. Add the following:

- ***Initial, Final, and Intermediate Activities***
- ***Decision Points, Guards, and other clarifications***
- ***Forks, Joins, and required Control Flows***
- ***Partitions for systems/subsystems***
- ***The Objects, Object Flows and Data Store elements that act as inputs/outputs for identified activities***

OV-5

The OV-5 clarifies roles, responsibilities and order of execution with respect to accomplishing key mission objectives in the context of the operational enterprise. The OV-5 is a graphical presentation of the externally visible behavior of the operational enterprise, represented by flows of activities allocated to component systems. Significant data flow associated with those activities is also provided in order to develop a strong sense of coupling between behavior and supporting data. The OV-5, coupled with the textual content of requirements and use case specifications significantly enhances the ability of the systems engineering team to ensure completeness, clarity and consistency in an operational perspective of the enterprise architecture and the manner in which it supports the mission.

Checkpoints for OV-5

- ☐ Is there an activity diagram for each identified enterprise use case?
- ☐ Does each activity diagram address all flows and/or scenarios associated with the specified enterprise use case?
- ☐ Have significant IO Entities been incorporated in the activity diagrams to denote information inputs and outputs associated with the activity?
- ☐ Have partitions been added to the activity diagrams reflecting organizational elements and operational nodes performing activities?
- ☐ Have all activities been allocated to applicable partitions?

Tool Tip: Select the OV-6b package in the IBM Rational Eclipse-based modeling tool browser. Click the right mouse button, and select DoDAF > Create OV-6b. This will open a Microsoft Word® template based on the content specified in Volume I of the DoDAF specification. Save the document to a convenient location in the files system. Once the file has been saved (and closed) Select File > Import > File System and navigate to the document location. Select the document and choose the model Documents package at the overall model level.

OV-6a Operational Rules Model

The OV-6a captures constraints upon the operational processes used to achieve mission results within the context of the operational enterprise and the subject system. Information is captured in text and produced in document form. A template would typically be provided and tailored to the organizational audience. Decision points in the OV-5 activity diagrams should reflect the instantiation of those constraints. Some of this content may lend itself to being expressed using SysML or Object Constraint Language (OCL) and used to validate architectural artifacts. The primary product for this view is a document.

Checkpoints for OV-6a

- ☐ DIs there sufficient information in the rules to deterministically explain the logical branching indicated in each activity diagram shown in OV-5?
- ☐ Are the rules clear, deterministic and unambiguous?

OV-6b Operation State Transition Description

When the behavior of one or more key architectural elements is event-driven, modeling with State Diagrams can be especially useful in understanding that behavior. Where this approach is warranted, the OV-6b is produced.

Tool Tip: Create State Machine diagrams for each system or operational node whose behavior is event-driven and sufficiently complex to warrant state-based analysis. Create states representing the behavioral results of responses to events. Add events, actions, and state transitions as required

Checkpoints for OV-6b

- ☐ Does the state diagram account for all behavior of the objects being considered?
- ☐ Are all impacting events accounted for?
- ☐ Are all actions and associated transitions accounted for?
- ☐ Are all resulting states accounted for?

OV-6c Operational Event/Trace Description

The OV-6c describes externally visible behavior (from the perspective of the subject system) for each flow and scenarios associated with enterprise use cases (see OV-1 Enterprise Use Case Diagram). We capture this information using sequence diagrams that focus on operational nodes (aggregations of actors) interacting with the subject system via messages. These messages represent requests of the subject system by associated operational nodes or requests by the system of one or more of those nodes. Any information exchanged as part of those requests (e.g., parameters), is represented by an instance of an IO Entity class.

Having identified node-system relationships, and associated information content, we can automatically generate content necessary for the OV-2 and the OV-3. Needlines are added to the Enterprise Context Diagram, by parsing the interactions (and parameters) identified between message sender and receiver, until each dependency relationship is identified (OV-2). We create this content by selecting *DoDAF > Create OV-2* from the IBM Rational Eclipse-based modeling tool context menu. The updated diagram is opened for inspection. We then add IO Entities manually to the diagram as associations to actors with either a <send> or <receive> stereotype (actor perspective). Each message interaction in the OV-6c is representative of an IER, and is used to populate the OV-3 matrix. You create the OV-3 matrix content by selecting *DoDAF > Create OV-3* from the IBM Rational Eclipse-based modeling tool context menu. The matrix is displayed in the OV-3 tab. For more on IERs see the OV-3 section or Volume II of the DoDAF specification.

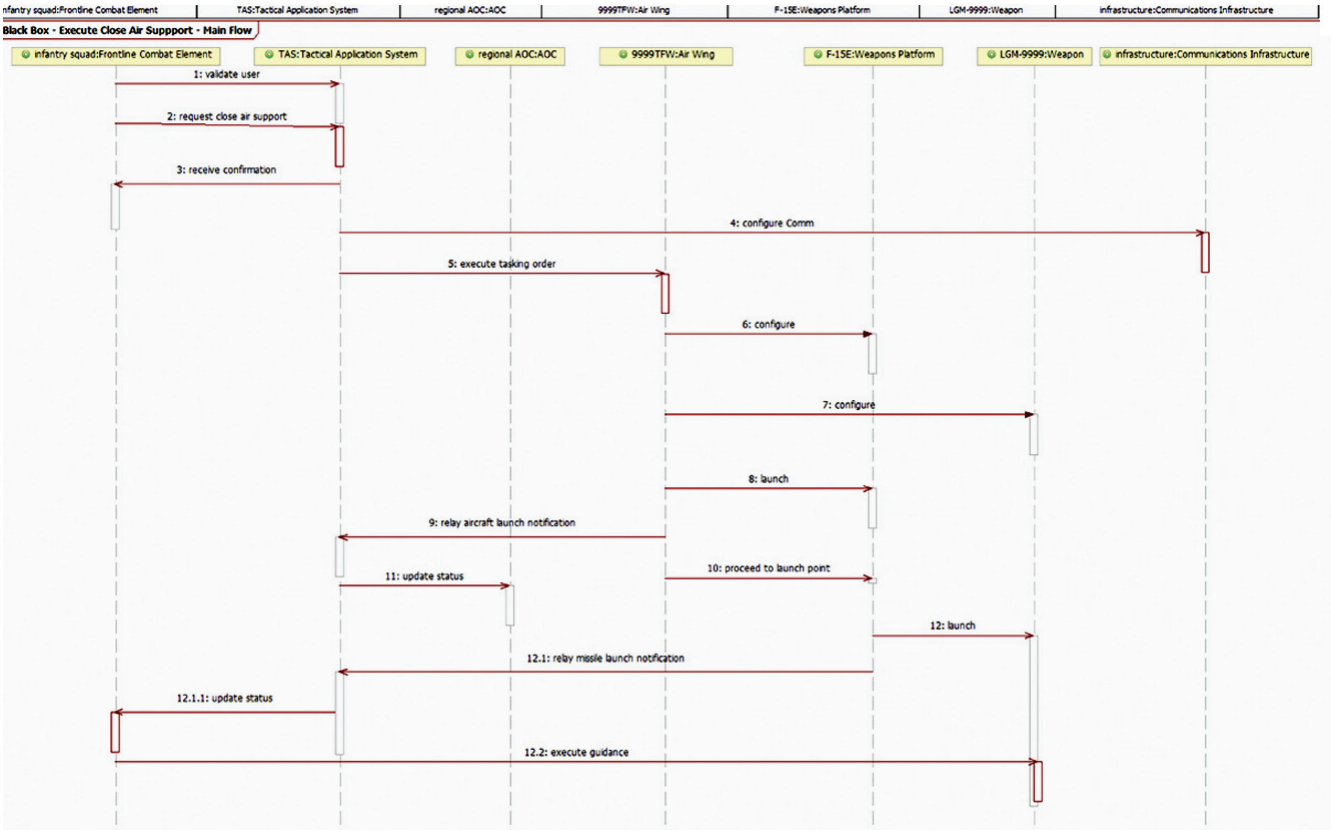


Figure 7. Sample OV-6c Operational Event Trace Description

Tool Tip: Create a sequence diagram for each use case flow or scenario. Populate the diagram with objects reflecting the systems and operational nodes that collaborate in each flow or scenario. Add messages to indicate the behavior requested of any object, by selecting from the drop down list of operations for the object. Add or adjust operation parameters as necessary.

Checkpoints for OV-6c

- ☐ Is there a sequence captured in a diagram for each use case flow or scenario identified for the subject system in the context of the operational enterprise?
- ☐ Have messages been characterized for each interaction in the flow of events being modeled?
- ☐ Do the messages and interactions reflect only external behavior (e.g., interactions between the subject system and other systems in the operational enterprise)?
- ☐ Do Operational Nodes have operations corresponding to each message called for in the sequence diagram?
- ☐ Has each message in a sequence diagram been selected from the drop down menu reflecting operations of the associated Operational Nodes?
- ☐ Is there a parameter for each operation in which information is transferred by way of a message?
- ☐ Is there an IO Entity data type associated with each parameter?

OV-7 Logical Data Model

The OV-7 reflects the structure and flow of key information being used to achieve the functionality expressed in the Enterprise Use Cases. The content of this product is should be directly attributable to the IO Entities identified during construction of the OV-6c.

Checkpoints for OV-7

- ☐ Are all IO Entities represented in the OV-7 Logical Data Diagram?
- ☐ Have associations been added to show relationships between IO Entities?
- ☐ Have attribute values been provided for each parameter to meet the needs specified by the OV-3?

Tool Tip: Create a class diagram in the OV-7 package by selecting the package with the right mouse button and clicking on Add Diagram > Class Diagram. Add all of the identified IO Entity classes by dragging them from the Model Explorer to the diagram. Add association relationships as necessary.

Systems View Products

Internally visible structure and behavior related to the realization by system and system nodes

The systems that comprise the operational architecture must collaborate to implement the mission capability specified in the operational view. The purpose of the Systems View is to provide multiple perspectives of the system under consideration, and describe how the system(s) interact with other elements of the enterprise architecture.

We start with a white box expansion of the subject system architecture by identifying the logical and physical components of the system that must interact in order to achieve the desired behavior. These systems (logical) and system nodes (physical) are stereotyped classes, and are represented in a System Context Diagram. Relationships between these elements are indicative of operations/request messages that are specified when creating the SV-10c. Other view products are used to provide further information related to the physical and logical system interfaces, the system interactions, and the planned evolution of the of the system in the context of the operational enterprise.

Product	Title	Description	Representation	Creation Order
SV-1	System Interface Description	Identifies systems and system components and their interfaces, within and between nodes. Models reconciliation of both logical and physical perspectives through realization of common interfaces.	Class diagram with classes, localities, and interfaces	3
SV-2	Systems Communications Description	Models physical nodes and their related communications infrastructure	Composite Structure Diagram Deployment Diagram	6
SV-3	Systems Matrix	Models relationships between systems & subsystems in the context of the overall architecture of the enterprise.	Model resident text matrix Exportable to XML	5
SV-4	Systems Functionality Description	Identifies system behavior and the information flow related to that behavior.	Activity Diagram for each system use case	8
SV-5	Operational Activity to System Function Traceability Matrix	Maps system internal behavior (realizations) to operational external activities (specification).	Model resident text matrix Exportable to XML	9
SV-6	System Information Exchange Matrix	Details information exchanges between system elements (including applications and hardware allocated to those elements).	Model resident text matrix Exportable to XML	10
SV-7	System Performance Parameters Matrix	Describes performance characteristics of system elements.	Model resident text matrix Exportable to XML Joint Realization Table(s)	11
SV-8	System Evolution Description	Describes planned evolution increments toward a specific future implementation.	Schedule or project plan with timelines	12
SV-9	System Technology Forecast	Describes emerging technologies that are likely to impact the current or specified future state of the system(s).	Text document	13
SV-10a	Systems Rules Model	Describes constraints imposed on system functionality by business needs or operational mission requirements.	Architectural constraints that may or may not be incorporated in the model (OCL/SysML) Model referenced functional and non-functional requirements in text document	1
SV-10b	Systems State Transition Description	Describes systems response to events.	State Transition Diagram(s)	##
SV-10c	Systems Event/Trace Description	Describes internal systems behavior in terms of operational sequences and actions that realize operational scenarios or critical activities that reflect behavior identified in OV-6c..	Sequence Diagrams for both logical and physical realizations of behavior	2 – logical 4 - physical
SV-11	Physical Data Model	IDescribes physical implementation of data storage and movement.	Class Diagram indicating schema relationships to the logical data elements in OV-7	7

State Transition Diagrams are optionally used to model critical real-time responses to complex events requiring special treatment.

Tool Tip: Add the following UML packages to the IBM Rational Eclipse-based model under the System Nodes package.

- ***Systems (logical subsystems)***
- ***System Nodes (localities-physical)***
- ***Interfaces***

SV-1 System Interface Description

The SV-1 creates the foundation for the subject system's internal architecture. It depicts systems, system nodes, and the interfaces that exist within and between them. The SV-1 provides the linkage between the Operational View and the Systems View. This means dealing with both the logical decomposition of the system and the allocation of logical functionality to physical components. The classifiers in this view represent objects in both logical and physical versions of sequence diagrams for each system use case flow or scenario (derived from operations/messages to the subject system) identified in the Operational View.

We start with identifying candidate logical elements comprising the subject system. The initial discovery process may be intuitive and based on domain experience. The focus, at this point, is to start thinking about the components likely to comprise the logical subsystems. These may eventually turn out to be subsystems, or even primitives, but that distinction is not important at this time. Later, as a result of use-case flowdown and joint realization activities, we identify remaining localities (as well as additional logical elements as we discover a need) to which we allocate logical functionality in order to realize specified behavior. From that information we can allocate operations indicated on sequence diagrams to interfaces, each of which is realized by both logical (class) and physical (locality) elements. The SV-1 diagram contains the classes, localities, interfaces, and connections between those systems and systems nodes.

- ☐ Are all the systems (logical elements) that interact with the subject system included in the diagram(s)?
- ☐ Are all the systems nodes (physical elements/localities that interact with the subject system node included in the diagram(s)?
- ☐ Are all the significant subsystems (belonging to the subject system) and their internal and external interactions represented?
- ☐ Is there at least one interface class for each system-system node "pair"?
- ☐ For each system-system node pair, have the operations been "moved" or allocated to the corresponding interface class?
- ☐ For each system-system node pair, have appropriate <implement> relationships been drawn to the applicable interface class?

Tool Tip: Create a new class diagram, named System Context, and add the following UML elements:

- ***System (logical) candidates***
- ***System Nodes (localities-physical) candidates***
- ***Interfaces***
- ***Implements Relationships – later, from information revealed in SV-10c***
- ***Associations***

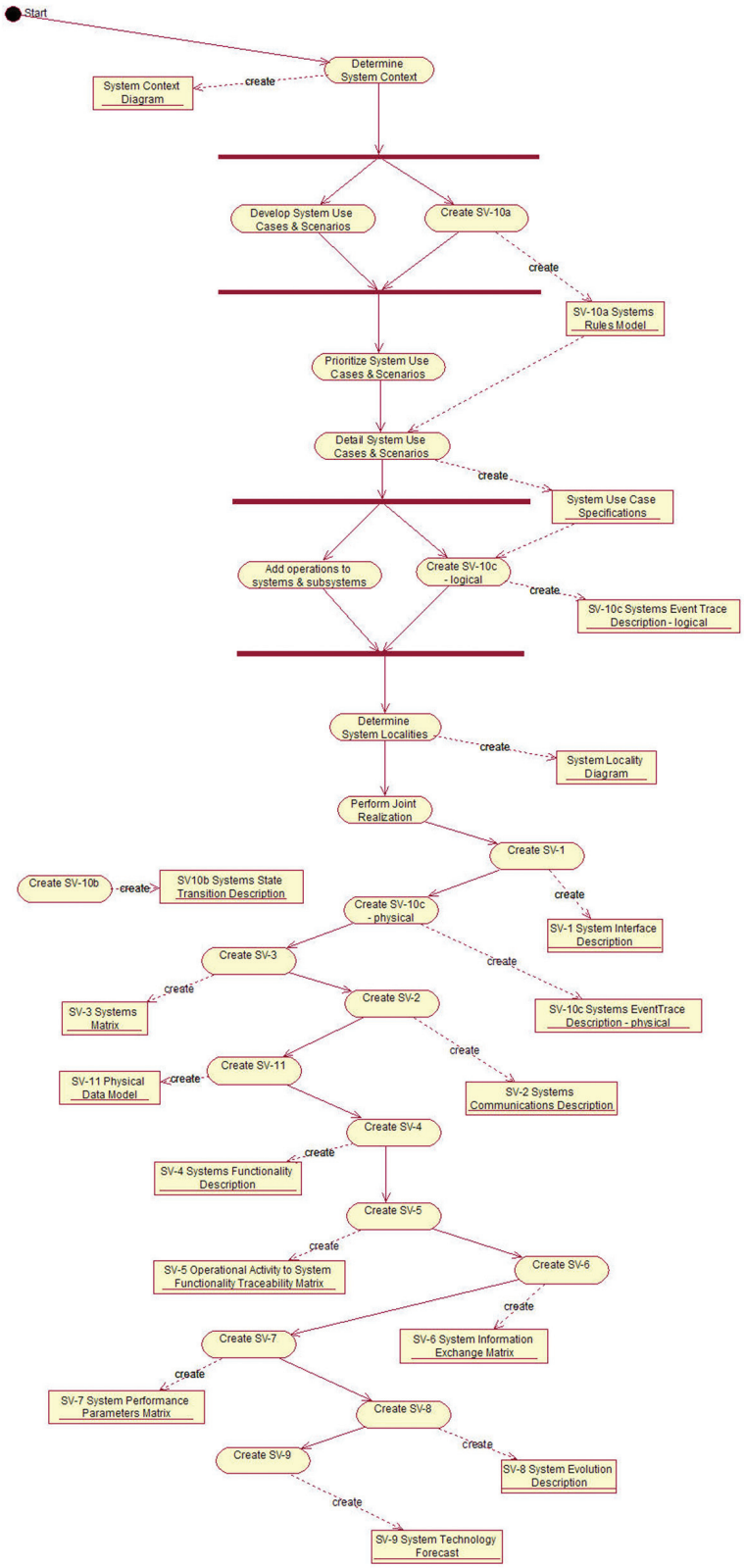


Figure 8. DoDAF SV Product Generation Process

Tool Tip: Create a new composite structure diagram, named System Communications Description, and add the following UML elements:

- ***System Nodes (localities-physical elements)***
- ***Internal and External Ports – between elements comprising the subject system, and the enterprise***
- ***Connectors – Communication Paths***

SV-2 Systems Communications Description

The SV-2 is referred to as the System Communications Description. Intended to reflect the physical nodes (localities) and their communications infrastructure, the SV-2 is represented using a composite structure diagram (new to UML 2.0). A composite structure diagram is represented as a container of roles or objects that are explicitly connected at ports associated with roles (see example in the figure below). Due to the potential volume and variety of information associated with communications connectivity, it may be desirable to associate these model elements with entries in a requirements repository (e.g., IBM Rational RequisitePro) to take advantage of attribute values as supporting information

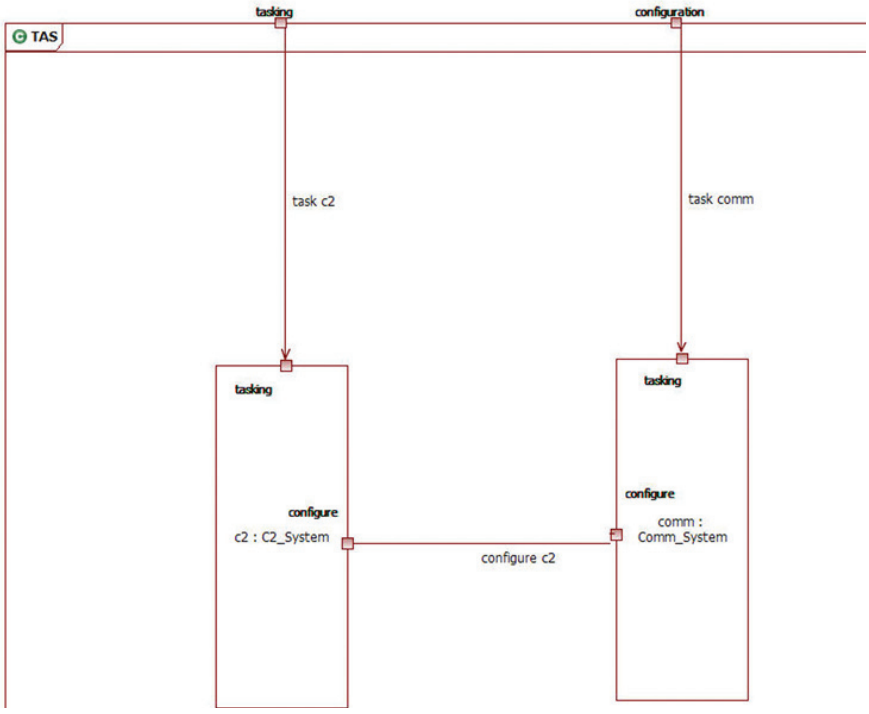


Figure 9. Composite Structure Diagram depicting physical nodes and their communications infrastructure

Tool Tip: Select the SV-3 package in the IBM Rational Eclipse-based modeling tool browser. Click the right mouse button, and select DoDAF > Show SV-3 View. A matrix of systems will be displayed under the SV-3 tab, in the lower right portion of the screen. You have the option of clicking in that matrix with the right mouse button, and selecting Export, which results in generation of an XML version of the matrix.

- ☐ Have all system nodes (physical elements/localities) associated with the subject system been included in the diagram(s)?
- ☐ Are ports defined for each specified connection between system nodes?
- ☐ Are connectors defined for each communications path between ports?

SV-3 Systems Matrix

The SV-3 is a matrix view of the system-to-system relationships that exist at any specified level of system decomposition. At a minimum, the matrix should identify which systems have relationships with other systems. Additional content regarding characteristics of those relationships may be included, as necessary. The information content to create the SV-3 is derived from the relationships established in the logical and physical realizations of behavior present in the SV-10c sequence diagrams

- ☐ Are all systems/subsystems and system nodes associated with the subject system represented in the matrix?
- ☐ For any system-system interaction, is there an "X" where the column and row intersect?
- ☐ Is this information consistent with the SV-10c?

Tool Tip: Create an activity diagram for each system scenario or use case. Create activities for each major step of the flow or scenario, indicating logical choices or decision points. Add the following:

- ***Initial, Final, and Intermediate Activities***
- ***Decision Points, Guards, and other clarifications***
- ***Forks, Joins, and required Control Flows***
- ***Partitions for systems/subsystems***
- ***The Objects, Object Flows and Data Store elements that act as inputs/outputs for identified activities***

SV-4 Systems Functionality Description

The SV-4 describes the functionality and required data flows necessary to support required system behavior. We use an activity diagram with partitions allocated to system elements responsible for activities. Object flows are added to the activity flow in order to indicate data object inputs and outputs necessary to specified activities. The SV-4's information content provides an alternate perspective from the information of the SV-10c sequence diagrams with their messages and parameters.

- ☐ Is there an activity diagram for each identified use case, use case flow, and scenario?
- ☐ Does each activity diagram address all flows and/or scenarios associated with the applicable use case, use case flow, or scenario?
- ☐ Have significant Data Objects been incorporated in the activity diagrams to denote information inputs and outputs associated with the activity?
- ☐ Have partitions been added to the activity diagrams reflecting systems, subsystems, and system nodes performing activities?
- ☐ Have all activities been allocated to applicable partitions?

Tool Tip: Select the SV-5 package in the IBM Rational Eclipse-based modeler browser. Click the right mouse button, and select DoDAF > Show SV-5 View. A hierarchy of operational nodes, system/ subsystems and system nodes, and their operations and realizations will be displayed under the SV-5 tab, in the lower right portion of the screen. You have the option of clicking in that display with the right mouse button, and selecting Export, which generates an XML version of the matrix. Note that the SV-5 will show the traceability from the operational nodes' operations and the system operations only if the Operation Realization has been invoked on each operational node. This action creates a collaboration in the SV-10c package that corresponds to operational node, and populates that collaboration with an interaction (sequence diagram) for that specified operational node's operation. These sequence diagrams should then be populated per the recommendations in the SV-10c section.

SV-5 Operational Activity to System Function Traceability Matrix

The SV-5 provides traceability between operational activities (e.g., use case flow, scenarios) and the system functionality (operations) that realize the required behavior. We produce this information in the form of a hierarchical listing of the *operational nodes*, the *operations* they must support, and *realizations* of those operations. Ideally, these would be extended to encompass those systems/subsystems that collaborate to affect the realization, as well as inclusion of the messages/operations sent to those system/subsystems

- ☐ Are the systems and all externally visible operations associated with those systems represented in the hierarchy?
- ☐ Are operations associated with the correct system, subsystem, or system node?

SV-6 System Information Exchange Matrix

The SV-6 is a matrix of Data Exchanges (similar to the OV-3) that represent the behavior-based interactions between component systems and subsystems of the subject system. The SV-6 is generated automatically using the IBM Rational Eclipse-based modeling tool (by sourcing the SV-10c content). Each matrix row represents a data exchange, which is comprised of characteristics of the data transferred between roles/objects in an interaction from the SV-10c sequence diagrams. The matrix identifies a distinct data exchange for each pair of objects or roles that interact and exchange information. Specific data exchange characteristics are typically associated with non-functional requirements or design constraints. The content of each Data Exchange is representative of an instantiation of a data object, where the attributes represent the data characteristics required by the DoDAF.

The SV-6 emphasizes the logical and operational characteristics of the information exchanged. The product is not intended to provide exhaustive capture of all details of information exchanged within the architecture, but as a mechanism understand the most important aspects of significant exchanges. An example of the information content from the DoDAF specification is provided below. This content would typically trace to supplemental or non-functional requirements.

Interface Identifier	Data Exchange Identifier	Data Descriptionn	Producer	Consumer	Nature of Transaction
System Interface Name and Identifier	System Data Exchange Name and Identifier	• Data Element Name and Identifier • Content • Format Type • Media Type • Accuracy • Units of Measurement • Data Standard	• Sending System Name and Identifier • Sending System Function Name and Identifier	• Receiving System Name and Identifier • Receiving System Function Name and Identifier	• Transaction Type • Triggering Event • Interoperability Level Achieved • Criticality

Interface Identifierr	Data Exchange Identifier	Performance Attributes	Information Assurance	Security
System Interface Name and Identifier	System Data Exchange Name and Identifier	• Periodicity • Timeliness • Throughput • Size	• Access Control • Availability • Confidentiality • Dissemination Control • Integrity • Non-Repudiation Consumer	• Protection (Type Name, Duration, Date) • Classification • Classification Caveat • Releasability • Security Standard

Department of Defense Architecture Framework Working Group, "DoD Architectural Framework", Version 1.0, Volume II, August 2003

Tool Tip: Select the SV-6 package in the IBM Rational Eclipse-based modeler browser. Click the Right mouse button, and select DoDAF > Show SV-6 View. A matrix of IERs will be displayed under the SV-6 tab, in the lower right portion of the screen. You have the option of clicking in that matrix with the right mouse button, and selecting Export, which generates an XML version of the matrix

Checkpoints for SV-6

- ☐ Have data objects been identified for each parameter specified in each inter-object message in SV-10c sequence diagrams?
- ☐ Have attributes been established for each Data Object class , consistent with the guidance provided in Volume II of the DoDAF specification?
- ☐ Is there an entry for each message of sequence diagram indicating information passed as parameters?

SV-7 System Performance Parameters Matrix

The SV-7 describes characteristics considered critical to effectively attaining mission objectives assigned to the subject system. This information can best be presented as a form, table, or matrix. The application domain determines the specific content of this view. A notional example is available for reference in the DoDAF specification. A Joint Realization Form (called a System Operation Specification), specifically designed for this purpose, is also available through IBM Rational Services. When completed, we store the SV-7 in the Documents folder associated with the model or as a traceable requirements document under IBM Rational RequisitePro.

Tool Tip: Open a document using the System Operation Specification Template. Capture the significant performance characteristics of the operation as the realization is incrementally elaborated. Store the content in Requisite Pro

- ☐ Has a Joint Realization been prepared for each specified operation in the SV-10c?
- ☐ Is the information in the Joint Realization allocated to appropriate attributes of the respective data exchanges and documented in the model or associated documentation?
- ☐ Has traceability been established between model elements and the applicable set of SV-7 characteristics?

(Sub) System Name: Enter system or subsystem name	
Service Name: Enter service name	
Brief Description: Enter brief description	
Trace From: Enter name of system use case that traces to the service	
Supplementary Requirements: Enter supplementary requirements that apply to the service	
Preconditions: Enter any conditions that are assumed to be true to invoke the service	
Associations: Actor, Uses	**Sequence Diagram:** Enter name of associated sequence diagram

Main Flow

System Actor Action	Black Box Budgeted Requirements	Step	Subsystem Action	White Box Budgeted	Locality	Process

Tool Tip: Create a schedule using an appropriate planning tool. Identify key milestones associated with specified evolutionary points for the system in its enterprise context. Add other applicable planning factors as necessary.

SV-8 System Evolution Description

The SV-8 is a plan/schedule for the system's evolution, in the context of the evolving enterprise. The SV-8 is typically captured in a scheduling tool (e.g., Microsoft Project). Key milestones are associated with incremental implementations of changes to the structure and/or behavior of the system. We recommend storing the file associated with the schedule in the Documents folder associated with the the architectural model.

- ☐ Have architectural increments been defined and associated with milestones identified in the plan or schedule?
- ☐ Have dependencies between enterprise system components been identified and addressed by the plan or schedule?

SV-9 System Technology Forecast

The SV-9 identifies emerging technology that is likely to impact the structure or behavior of the system in its enterprise context. Ideally, incremental changes in technology are correlated with the milestones in the SV-8 to facilitate overall decision–making and enterprise management. We recommend storing the file associated with the schedule in the Documents folder associated with the architectural model.

Tool Tip: There is no specified format for this product. One option would be to use a similar planning tool to that for the SV-8. We chose to create a document with entries for each technology, captured as a requirement in IBM Rational RequisitePro, and then assign attributes for the relevant characteristics of that technology. Next step is to create a trace relationship from the system element impacted to the specified requirement.

- ☐ Are all pertinent technologies and standards related to the architectural evolution in OV-8 documented?
- ☐ Are the appropriate attributes for evolving technologies and standards documented in the model?

Tool Tip: Select the SV-10b package in the IBM Rational Eclipse-based modeler browser. Click the Right mouse button, and select DoDAF > Create SV-10b. This will open a Microsoft Word template based on the content specified in Volume I of the DoDAF specification. Save the document to a convenient location in the files system. Once the file has been saved (and closed) Select File > Import > File System and navigate to the document location. Select the document and choose the model Documents package at the overall model level.

SV-10a Systems Rules Model

The SV-10a captures constraints restricting behavior of the systems/subsystems involved in satisfying operational objectives. Information is captured in text and produced in document form. A template would typically be provided and tailored to the organizational audience. The distinction between business rules/constraints and requirements can be challenging. The guidance here is that decision points in the activity diagrams should reflect the instantiation of those rules. Some of this content may lend itself to being expressed using SysML or Object Constraint Language (OCL) and used to validate architectural artifacts under the modeling tool. The primary product for this view is a document. The SV-10a is analogous to the OV-6a, but at a lower level of systems decomposition. As with the OV-6a we recommend using a document and an associated requirements management tools like IBM Rational RequisitePro.

Checkpoints for SV-10a

- ☐ Is there sufficient information in the rules to deterministically explain the logical branching indicated in each activity diagram shown in SV-4?
- ☐ Are the rules clear, deterministic and unambiguous?

SV-10b Systems State Transition Description

When the behavior of one or more key architectural elements is event-driven, modeling with State Diagrams can be especially useful in understanding that behavior. Where this approach is warranted, the SV-10b is produced.

Tool Tip: Create State Machine diagrams for each system, subsystem, or system node whose behavior is event-driven and sufficiently complex to warrant state-based analysis. Create states representing the behavioral results of responses to events. Add events, actions, and state transitions as required.

Checkpoints for SV-10b

- ☐ Does the state diagram account for all behavior of the objects being considered?
- ☐ Are all impacting events accounted for?
- ☐ Are all actions and associated transitions accounted for?
- ☐ Are all resulting states accounted for?

Tool Tip: For each operation to be realized, select the class owning the operation and click on the right mouse button, select DoDAF > Create Operation Realizations. Navigate in the Model Explorer to the For each operational realization that has been created, rename it appropriately. Populate the diagram with objects reflecting the systems and operational nodes that collaborate in each flow or scenario. Add messages to indicate the behavior requested of any object, by selecting from the drop-down list of operations for the object. Add or adjust operation parameters as necessary.

SV-10c Systems Event/Trace Description

The SV-10c describes internal behavior of the subject system for each operation identified in the OV6c. We use sequence diagrams that focus on systems/subsystems and system nodes that interact using messages. These messages represent requests of a system/subsystem/system node by associated systems, subsystems or system nodes. The operation specification exists at the level of the Operational View, and is realized in the Systems View. The structure for the realization is created by selecting the class owning the operation and click on the right mouse button, then selecting DoDAF > Create Operation Realizations. Any information exchanged as part of those requests (e.g., parameters), is represented by instances of an IO Entity class. Each message interaction also represents a data exchange, and is used to populate the SV-6 matrix. We create this content by selecting DoDAF > Create SV-6. The matrix is displayed in the SV-6 tab.

Checkpoints for SV-10c

- ☐ Is there a sequence captured in a diagram for each use case flow or scenario identified for the subject system in the context of the operational enterprise?
- ☐ Have messages been characterized for each interaction in the flow of events being modeled?
- ☐ Do the messages and interactions reflect only external behavior (e.g., interactions between the subject system and other systems in the operational enterprise)?
- ☐ Do Operational Nodes have operations corresponding to each message called for in the sequence diagram?
- ☐ Has each message in a sequence diagram been selected from the drop down menu reflecting operations of the associated Operational Nodes?
- ☐ Is there a parameter for each operation in which information is transferred by way of a message?
- ☐ Is there an Data Object class associated with each parameter?

Tool Tip: Create a class diagram in the SV-11 package, and then

- ***Populate it with existing IO Entities and Data Objects***
- ***Add classes stereotyped as <schema>, <instance>, <tablespace>, <database>, as necessary***
- ***Add associations, aggregations, composition, as necessary***

SV-11 Physical Data Model

The SV-11 is the complement to the OV-7. We use a class diagram to represent database schema relationships necessary to host the informational content represented by the OV-7 Logical Data Model and the Data Objects of the SV-4.

- ☐ Are all schemas, database instances, tablespaces, and databases represented on the diagram(s)?
- ☐ Are all the relationships between the above elements modeled on the diagram(s)?
- ☐ Is the physical organization of the data consistent with the Logical Data Model in OV-7?

Technical Standards View

Standards and constraints that impact the subject system in the context of the operational enterprise.

The Technical Standards View provides the guidance that directs or constrains the implementation of the systems described in the Systems View. The TV reflects standards and limiting factors upon which design decisions are made while incrementally developing the system(s) to meet the mission objectives specified in the Operational View. The TV reflects address standards applicable to the current architecture (TV-1) and the evolution of that architecture (TV-2).

Product	Title	Description	Representation	Creation Order
TV-1	Technical Architecture Profile	TExtraction of standards that apply to the specified architecturee	Model referenced standards and constraints in text document. Consider use of RequisitePro or equivalent requirements tool.	1
TV-2	Standards Technology Forecast	Description of emerging standards that are expected to apply to the architecture, in specified timeframes	Model referenced standards and constraints (with time/milestone criteria) in text document. Consider use of RequisitePro or equivalent requirements tool.L	2

Tool Tip: Create a Microsoft Word template tailored to the architectural characteristics of the system, the operational guidance, regulatory requirements, and technical direction driving the development of the system. Refer to the suggested template for the TV-1 in Volume II of the DoDAF specification. Create a requirement type and applicable attributes in an associated IBM Rational RequisitePro project. Add a record for each standard, setting attribute values. Establish traceability from each standard to any architectural element(s) affected.

TV-1 Technical Architecture Profile

The TV-1 describes of existing standards and operational constraints that will likely impact the operational enterprise. The DoDAF specification provides a sample template suggesting that this information would be best captured using a text-based document. We recommend incorporating relationships between specific standards and the architectural elements impacted by using of a requirements management tools like RequisitePro. We can store specific characteristics of the standard as attributes of the standard, so that establishing traceability becomes a relatively simple process.

- ☐ Have all significant standards been captured that are associated with the system in the enterprise context?
- ☐ Have necessary characteristics of each standard been established and values assigned for each standard?
- ☐ Has traceability been established between each standard and the architectural affected element?

TV-2 Standards Technology Forecast

The TV-2 describes of potential and emerging standards and operational constraints that may impact the operational enterprise and its architecture as it, and its component systems evolve. There are two categories of information captured in this product: (1) expected changes to standards or constraints referenced in the TV-1, and (2) changes to standards or new standards associated with evolution of the enterprise to accommodate new systems and capabilities. The approach to capturing this information is the same as with the TV-1, except that traceability is also necessary to the SV-8 and SV-9 for entries that fall into category (2) above.

- ☐ Have all the standards and constraints in TV-1 been reviewed for possible evolution and new associated standards?
- ☐ Where evolution is anticipated, has a TV-2 entry, with applicable attribute values, been established?
- ☐ Has appropriate traceability to TV-1, SV-8, and SV-9 been established?

Tool Tip: Create a Microsoft Word template tailored to the architectural characteristics of the system, the operational guidance, regulatory requirements, and technical direction driving the development of the system. Refer to the suggested template for the TV-1 in Volume II of the DoDAF specification. Create a requirement type and applicable attributes in an associated RequisitePro project.

- ***Add a record for each standard, setting attribute values***
- ***Establish traceability from each standard to any architectural element(s) affected***
- ***Establish traceability to affected SV-8 and SV-9 entries***

Conclusion

IBM Rational's approach to DoDAF incorporates a proven process for systems engineering with a powerful, integrated tool suite. We leverage the content of DoDAF products as enterprise architecture is incrementally elaborated from abstract capabilities to concrete logical and physical representations. A robust, scaleable process, coupled with automation, drives development of consistent architectural content in a centralized model repository. This provides necessary enablement for the larger development organization and key decision-makers of the operational enterprise.

References

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IBM Corporation
Software Group
Route 100
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