First Steps in the Development of an Architecture Framework for a Product Development Process

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Research Foundation

- This presentation is based on my PhD research to develop a methodology an model to optimize the design of an organization (a complex system) for developing an Aerospace & Defense (A&D) system

- An organization is a function of the Product Development Processes and the goals & objectives of the end item system

- Therefore, the initial research is focused on the application of an Architecture Framework for a Product Development Process and its impact on the design of the organization

Where does the need for an Architecture Framework come from?

- Today's A&D systems are becoming increasingly more complex
- Today's defense acquisition process is a complex phase-gated process that forces A&D system developers to **continually restructure** its organizations in order to respond to changing demands
- Each A&D system developer needs to **redefine itself** at the start of each acquisition phase (and at key decision points within a phase) in order to accomplish the objectives of that phase in the most efficient manner possible
- In the Systems Engineering Journal, Vol. 12 No. 1 2009 p69-90, Tyson R. Browning identified Product Development Process (PDP) as a "kind of complex system" and he discussed the need for research regarding the application of Architecture Frameworks (AFs) to the development of PDPs.[1]

Response to the Need

Conway's Law

- Melvin Conway stated in his paper, *How Do Committees Invent?*[2]
  - Any organization that designs a system (defined more broadly here than just information systems) will inevitably produce a design whose structure is a copy of the organization's communication structure.
- My research is focused on the design of organizations for the development of A&D systems.
  - These organizations are complex systems that are continually adapting and modifying their needlines in order to operate efficiently

If an AF can be defined for an organization in the PDP, then it may be possible to determine a method to optimize the design of that organization.

Purpose of this Paper

1. To address the question:

   Why do we care about developing an Architecture Framework for a Product Development Process (PDP)?

   The basic need of any system developer is determine the best application of resources that will minimize program cost and schedule while successfully executing the program.

2. The objective of this research is to determine if the same methods used to design a system can be used to design the organization following the PDP

3. In order to describe how the PDP influences the characteristics of the organization we will use the Department of Defense Architecture Framework (DoDAF) modeling methodology.

Why use DoDAF V2.0?

1. DoDAF V2.0 is the "overarching, comprehensive framework and conceptual model enabling the development of architectures to facilitate the ability of DoD managers at all levels make key decisions more effectively …"[3,pES-1]
2. The DoDAF is widely used by organizations developing system solutions for the DoD
   - Developers of A&D Systems are most likely to be the first to see the need to optimize the design of the their organizations
3. Version 2.0 added missing viewpoints necessary for modeling an evolving organization
   - Capability Viewpoint
   - Data Information Viewpoint
   - Project Viewpoint

DoDAF V2.0 is a common methodology that architects already know!

How do we Tailor DoDAF V2.0?

- The 6 steps used to tailor DoDAF V2.0 [3, p62]
  1. Define Stakeholders
  2. Document the decisions made by the stakeholders
  3. Define information requirements for decisions
  4. Define DoDAF artifacts that support Stakeholder decisions
  5. Align information requirements to the data sets for decisions
  6. Develop architectural artifacts

Use of the Zachman Framework (ZF) [4]

- By mapping the stakeholders onto the ZF it helps us to:
  - Understand each stakeholder's needs
  - Address the six interrogatives

ENTERPRISE ARCHITECTURE - A FRAMEWORK ™

	DATA *What*	FUNCTION *How*	NETWORK *Where*	PEOPLE *Who*	TIME *When*	MOTIVATION *Why*	
SCOPE (CONTEXTUAL) *Planner*	List of Things Important to the Business ENTITY = Class of Business Thing	List of Processes the Business Performs Function = Class of Business Process	List of Locations in which the Business Operates Node = Major Business Location	List of Organizations Important to the Business People = Major Organizations	List of Events Significant to the Business Time = Major Business Event	List of Business Goals/Strat Ends/Means=Major Bus. Goal/ Critical Success Factor	SCOPE (CONTEXTUAL) *Planner*
ENTERPRISE MODEL (CONCEPTUAL) *Owner*	e.g. Semantic Model Ent = Business Entity Reln = Business Relationship	e.g. Business Process Model Proc. = Business Process I/O = Business Resources	e.g. Logistics Network Node = Business Location Link = Business Linkage	e.g. Work Flow Model People = Organization Unit Work = Work Product	e.g. Master Schedule Time = Business Event Cycle = Business Cycle	e.g. Business Plan End = Business Objective Means = Business Strategy	ENTERPRISE MODEL (CONCEPTUAL) *Owner*
SYSTEM MODEL (LOGICAL) *Designer*	e.g. Logical Data Model Ent = Data Entity Reln = Data Relationship	e.g. "Application Architecture" Proc. = Application Function I/O = User Views	e.g. "Distributed System Architecture" Node = I/S Function (Processor, Storage, etc) Link = Line Characteristics	e.g. Human Interface Architecture People = Role Work = Deliverable	e.g. Processing Structure Time = System Event Cycle = Processing Cycle	e.g., Business Rule Model End = Structural Assertion Means = Action Assertion	SYSTEM MODEL (LOGICAL) *Designer*
TECHNOLOGY MODEL (PHYSICAL) *Builder*	e.g. Physical Data Model Ent = Segment/Table/etc. Reln = Pointer/Key/etc.	e.g. "System Design" Proc. = Computer Function I/O = Screen/Device Formats	e.g. "System Architecture" Node = Hardware/System Software Link = Line Specifications	e.g. Presentation Architecture People = User Work = Screen Format	e.g. Control Structure Time = Execute Cycle = Component Cycle	e.g. Rule Design End = Condition Means = Action	TECHNOLOGY CONSTRAINED MODEL (PHYSICAL) *Builder*
DETAILED REPRESEN-TATIONS (OUT-OF-CONTEXT) *Sub-Contractor*	e.g. Data Definition Ent = Field Reln = Address	e.g. "Program" Proc. = Language Stmt I/O = Control Block	e.g. "Network Architecture" Node = Addresses Link = Protocols	e.g. Security Architecture People = Identity Work = Job	e.g. Timing Definition Time = Interrupt Cycle = Machine Cycle	e.g. Rule Specification End = Sub-condition Means = Step	DETAILED REPRESEN-TATIONS (OUT-OF-CONTEXT) *Sub-Contractor*
FUNCTIONING ENTERPRISE	e.g. DATA	e.g. FUNCTION	e.g. NETWORK	e.g. ORGANIZATION	e.g. SCHEDULE	e.g. STRATEGY	FUNCTIONING ENTERPRISE

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First Primary Stakeholders & Their Decisions

1. **Planner:** Program Managers & Executive Leadership
   - The Planner's decisions are based on the scope of the effort and its impact on the enterprise
   - Mapping of the Planner's decision needs to the 6 interrogatives & DoDAF V2.0

Stakeholder	What	How	Where	When	Who	Why
Planner	Business Entity	Business Function	Location	Event (IMP)	The Org.	Goals & Strategies
Planner	DIV-1	OV-5a	OV-2	CV-3 PV-1	OV-4	AV-1 CV-1 OV-1

Second Primary Stakeholders & Their Decisions

2. **Owner:** Program Manager, Chief Engineer, Manufacturing & Logistics Leads
   - The Owner's decisions are based on the definition of the enterprise responsible for execution
   - Mapping of the Owner's decision needs to the 6 interrogatives & DoDAF V2.0

Stakeholder	What	How	Where	When	Who	Why
Owner	Relation ships of Business Entities	Process Models	Logistics of Execution	Master Schedule	Resource Groups	Business Plan or RFP
Owner	DIV-2 AV-2	OV-5b OV-6a OV-6b	OV-2	OV-6c CV-3 CV-4 CV-2 PV-2	OV-3 OV-4	AV-1 CV-1 PV-3

Third Primary Stakeholders & Their Decisions

3. **Designer:** Chief Engineer, Manufacturing & Logistics Leads
   - The Designer's decisions based on defining the day-to-day operations of the organization
   - Mapping of the Designer's decision needs to the 6 interrogatives & DoDAF V2.0

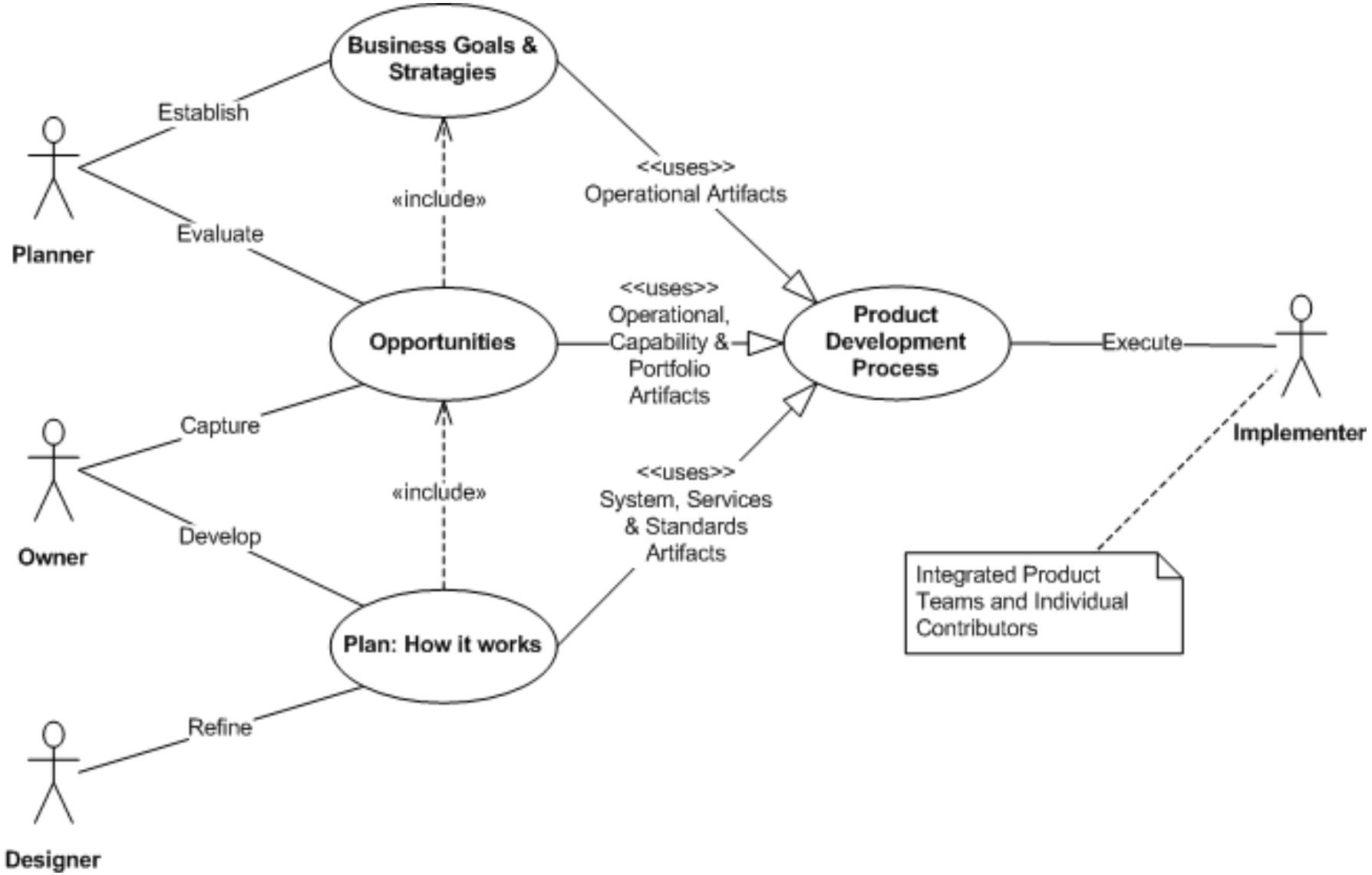
Next Slide

Third Primary Stakeholders & Their Decisions

Stakeholder	What	How	Where	When	Who	Why
Designer	Data Products	Exchange of DPs	Org Network	Sequence	Org. Resources Rq'd - Nos.	SOWs, CLINS, & Processes
Designer	DIV-3 SV-1 SvcV-1 SV-3 SvcV-3a SvcV-3b	SV-4 SvcV-4 SV-5a SvcV-5a SV-5b SvcV-5b SV-6 SvcV-6 SV-7 SvcV-7 SV-10b SvcV-10b StdV-1	SV-2 SvcV-2	SV-10c SvcV-10C CV-5	OV-2 SV-6 SvcV-6	StdV-2 SV-10a SvcV-10A CV-6 CV-7

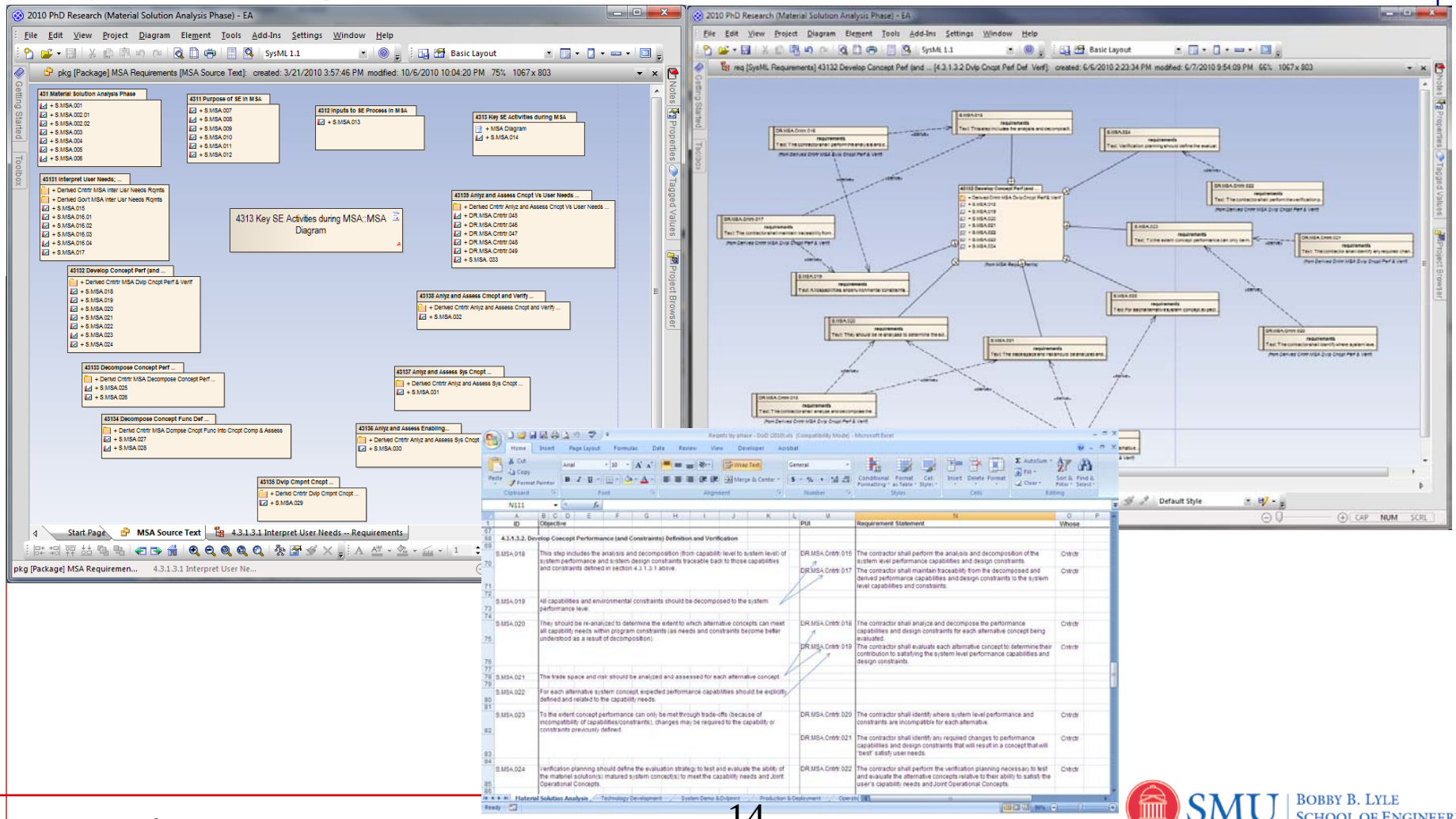
Note 1: Select either a System or Service view of the organization
Note 2: SV-6 & SvcV-6 emphasis is on data & products flowing from/to org. needs
Note 3: OV-2 definition is expanded at this level

A Use Case Example for Developing a PDP



Definition of Scope of First Application

- Analysis of Material Solution Analysis Phase to define generic requirements for a SOW



Mapping of Requirements to AF Artifacts

Requirement	OV-5a	OV-5b	SvcV-5	SV-5a	SV-5b
DR.MSA.Cntrtr.001	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.002	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.003	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.004	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.005	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.006	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.007	↑	↑	↑	↑	↑

The requirements derived from the description of the MSA phase in the Defense Acquisition Guidebook (DAG)[5] map to those artifacts associated with defining the activities to be performed.

Next Step

- Develop example artifacts to guide an application of the process
  - In work, initial artifacts are being created in the modeling environment
- Identification of program to support creation of an applied architecture
  - Initial discussions with an Aerospace & Defense developer were initiated on 8 Oct 2010
- Development of the resultant network model to optimize the program execution for the given constraints
- Analysis of the optimized network model to determine ideal organizational structure

Summary

- An initial evaluation of the DoDAF 2.0 indicates that it has sufficient breadth to support the development of a System Architecture of a Product Development Process

- The Viewpoints of the DoDAF 2.0 provide artifacts that address each of the decisions the primary stakeholders must address

- Final Observation – An extrapolation from Conway's Law
  - If an AF is not used to produce a System Architecture of an organization in the PDP, design flaws imposed on the organization will reflect the weaknesses of both the structure and process model of the enterprise.

References

[1] *The Many Views of a Process: Toward a Process Architecture Framework for Product Development Processes*, System Engineering Vol. 12, No. 1, 2009, p69-90.

[2] *How Do Committees Invent?,* Datamation, April 1968. Copy available at: http://www.melconway.com/Home/Committees_Paper.html

[3] *DoD Achitecture Framework Version 2.0, Volume 1: Introduction, Overview, and Concepts, Manager's Guide*, 28 May 2009. The DoDAV C2 guides are available at: http://cio-nii.defense.gov/sites/dodaf20/index.html

[4] *The Zachman Enterprise Framework™ .* Available at: http://zachmaninternational.com/index.php and https://apps.adcom.uci.edu/EnterpriseArch/Zachman/

References

[5] *Defense Acquisition Guidebook*. Available at: https://dag.dau.mil/Pages/Default.aspx

Other papers of interest not references

The Use of Zachman Framework Primitives for Enterprise Modeling, Gundars Osvalds, Senior Principal Member of Technical Staff, Litton/TASC, 26 October 2000

A framework for information systems architecture, J.A. Zachman, IBM Systems Journal, Vol 26, No. 3, 1987.

Backup Slides

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
AV-1: Overview and Summary Information	Describes a Project's Visions, Goals, Objectives, Plans, Activities, Events, Conditions, Measures, Effects (Outcomes), and produced objects.
AV-2: Integrated Dictionary	An architectural data repository with definitions of all terms used throughout the architectural data and presentations.
CV-1: Vision	The overall vision for transformational endeavors, which provides a strategic context for the capabilities described and a high-level scope.
CV-2: Capability Taxonomy	A hierarchy of capabilities which specifies all the capabilities that are referenced throughout one or more Architectural Descriptions.
CV-3: Capability Phasing	The planned achievement of capability at different points in time or during specific periods of time. The CV-3 shows the capability phasing in terms of the activities, conditions, desired effects, rules complied with, resource consumption and production, and measures, without regard to the performer and location solutions.
CV-4: Capability Dependencies	The dependencies between planned capabilities and the definition of logical groupings of capabilities.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
CV-5: Capability to Organizational Development Mapping	The fulfillment of capability requirements shows the planned capability deployment and interconnection for a particular Capability Phase. The CV-5 shows the planned solution for the phase in terms of performers and locations and their associated concepts.
CV-6: Capability to Operational Activities Mapping	A mapping between the capabilities required and the operational activities that those capabilities support.
CV-7: Capability to Services Mapping	A mapping between the capabilities and the services that these capabilities enable.
DIV-1:Conceptual Data Model	The required high-level data concepts and their relationships.
DIV-2: Logical Data Model	The documentation of the data requirements and structural business process (activity) rules. In DoDAF V1.5, this was the OV-7.
DIV-3: Physical Data Model	The physical implementation format of the Logical Data Model entities, e.g., message formats, file structures, physical schema. In DoDAF V1.5, this was the SV-11.
OV-1: High-Level Operational Concept Graphic	The high-level graphical/textual description of the operational concept.
OV-2: Operational Resource Flow Description	A description of the Resource Flows exchanged between operational activities.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
OV-3: Operational Resource Flow Matrix	A description of the resources exchanged and the relevant attributes of the exchanges.
OV-4: Organizational Relationships Chart	The organizational context, role or other relationships among organizations.
OV-5a: Operational Activity Decomposition Tree	The capabilities and activities (operational activities) organized in a hierarchal structure.
OV-5b: Operational Activity Model	The context of capabilities and activities (operational activities) and their relationships among activities, inputs, and outputs; Additional data can show cost, performers, or other pertinent information.
OV-6a: Operational Rules Model	One of three models used to describe activity (operational activity). It identifies business rules that constrain operations.
OV-6b: State Transition Description	One of three models used to describe operational activity (activity). It identifies business process (activity) responses to events (usually, very short activities).
OV-6c: Event-Trace Description	One of three models used to describe activity (operational activity). It traces actions in a scenario or sequence of events.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
PV-1: Project Portfolio Relationships	It describes the dependency relationships between the organizations and projects and the organizational structures needed to manage a portfolio of projects.
PV-2: Project Timelines	A timeline perspective on programs or projects, with the key milestones and interdependencies.
PV-3: Project to Capability Mapping	A mapping of programs and projects to capabilities to show how the specific projects and program elements help to achieve a capability.
SvcV-1 Services Context Description	The identification of services, service items, and their interconnections.
SvcV-2 Services Resource Flow Description	A description of Resource Flows exchanged between services.
SvcV-3a Systems-Services Matrix	The relationships among or between systems and services in a given Architectural Description.
SvcV-3b Services-Services Matrix	The relationships among services in a given Architectural Description. It can be designed to show relationships of interest, (e.g., service-type interfaces, planned vs. existing interfaces).
SvcV-4 Services Functionality Description	The functions performed by services and the service data flows among service functions (activities).

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
SvcV-5 Operational Activity to Services Traceability Matrix	A mapping of services (activities) back to operational activities (activities).
SvcV-6 Services Resource Flow Matrix	It provides details of service Resource Flow elements being exchanged between services and the attributes of that exchange.
SvcV-7 Services Measures Matrix	The measures (metrics) of Services Model elements for the appropriate time frame(s).
SvcV-8 Services Evolution Description	The planned incremental steps toward migrating a suite of services to a more efficient suite or toward evolving current services to a future implementation.
SvcV-9 Services Technology & Skills Forecast	The emerging technologies, software/hardware products, and skills that are expected to be available in a given set of time frames and that will affect future service development.
SvcV-10a Services Rules Model	One of three models used to describe service functionality. It identifies constraints that are imposed on systems functionality due to some aspect of system design or implementation.
SvcV-10b Services State Transition Description	One of three models used to describe service functionality. It identifies responses of services to events.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
SvcV-10c Services Event-Trace Description	One of three models used to describe service functionality. It identifies service-specific refinements of critical sequences of events described in the Operational Viewpoint.
StdV-1 Standards Profile	The listing of standards that apply to solution elements.
StdV-2 Standards Forecast	The description of emerging standards and potential impact on current solution elements, within a set of time frames.
SV-1 Systems Interface Description	The identification of systems, system items, and their interconnections.
SV-2 Systems Resource Flow Description	A description of Resource Flows exchanged between systems.
SV-3 Systems-Systems Matrix	The relationships among systems in a given Architectural Description. It can be designed to show relationships of interest, (e.g., system-type interfaces, planned vs. existing interfaces).
SV-4 Systems Functionality Description	The functions (activities) performed by systems and the system data flows among system functions (activities).
SV-5a Operational Activity to Systems Function Traceability Matrix	A mapping of system functions (activities) back to operational activities (activities).

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
SV-5b Operational Activity to Systems Traceability Matrix	A mapping of systems back to capabilities or operational activities (activities).
SV-6 Systems Resource Flow Matrix	Provides details of system resource flow elements being exchanged between systems and the attributes of that exchange.
SV-7 Systems Measures Matrix	The measures (metrics) of Systems Model elements for the appropriate timeframe(s).
SV-8 Systems Evolution Description	The planned incremental steps toward migrating a suite of systems to a more efficient suite, or toward evolving a current system to a future implementation.
SV-9 Systems Technology & Skills Forecast	The emerging technologies, software/hardware products, and skills that are expected to be available in a given set of time frames and that will affect future system development.
SV-10a Systems Rules Model	One of three models used to describe system functionality. It identifies constraints that are imposed on systems functionality due to some aspect of system design or implementation.
SV-10b Systems State Transition Description	One of three models used to describe system functionality. It identifies responses of systems to events.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
SV-10c Systems Event-Trace Description	One of three models used to describe system functionality. It identifies system-specific refinements of critical sequences of events described in the Operational Viewpoint.