360° Architecture/Requirements Traceability

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Biography

- **Peter Forsch** is the Northrop Grumman Systems Engineering Lead for all Department of Defense Architecture Framework (DoDAF) architecture analysis, design, and development for the Broad Area Maritime Surveillance Unmanned Aircraft System (BAMS UAS) Program. He has been employed by Northrop Grumman Aerospace Systems for the past seven years and has been engaged in many programs during his career such as the E-2D Advanced Hawkeye Program, Littoral Combat Ship Mission Package Integration (LCS MPI) Program, and various research and development projects in the Advanced Concepts and Integrated Solutions IPT. His duties and responsibilities during his career have involved multiple broad areas of expertise such as systems engineering, program integration, and program management.

- **Peter Forsch** holds a Bachelor's degree in Applied Mathematics and Statistics from the State University of New York at Stonybrook and a Masters degree in Systems Engineering from Stevens Institute of Technology in Hoboken, New Jersey.

- **Northrop Grumman Corporation** is a leading global security company whose 120,000 employees provide innovative systems, products, and solutions in aerospace, electronics, information systems, shipbuilding and technical services to government and commercial customers worldwide.

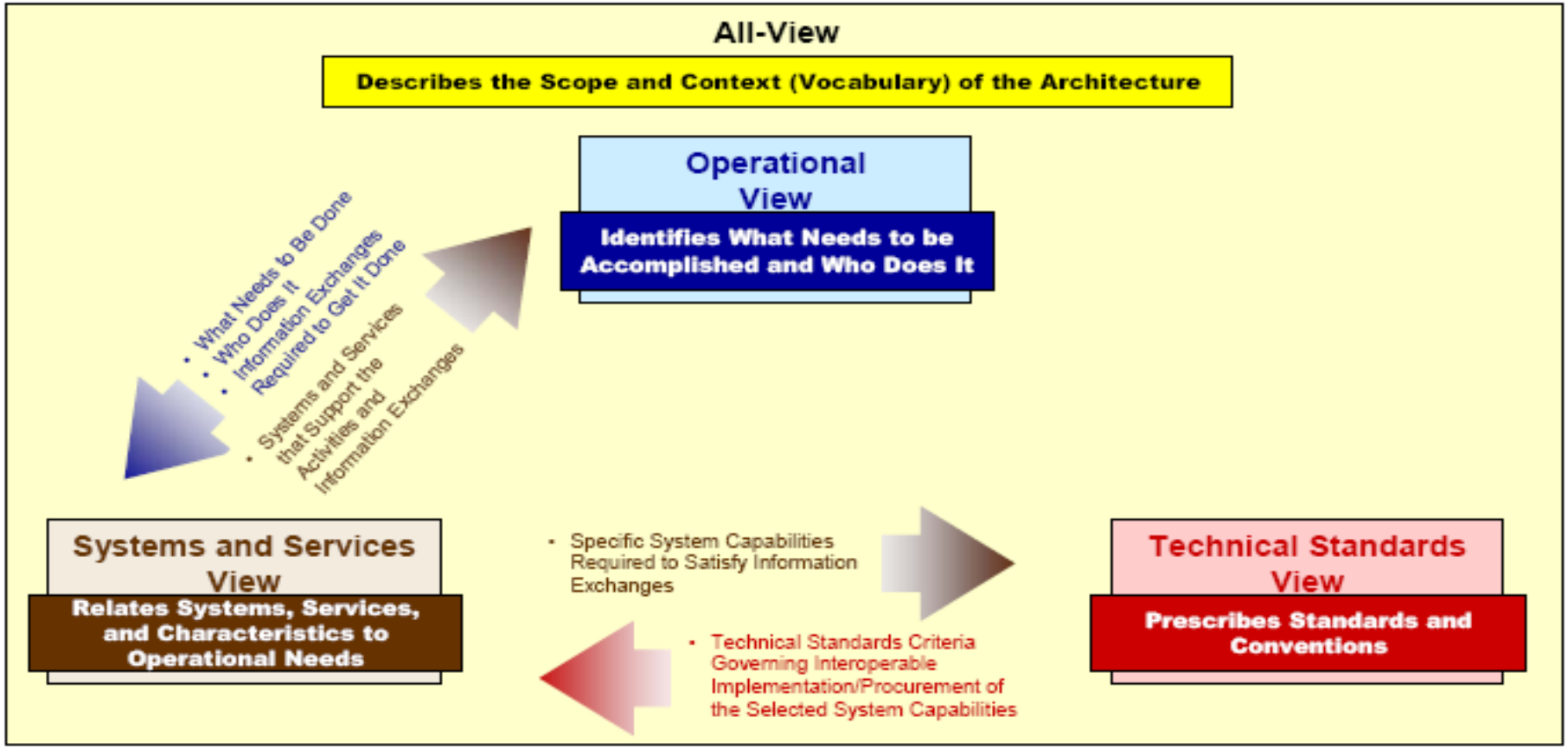
Purpose of DoDAF

- Provides a consistent method of representing elements of a complex system architecture and their relationships
  - Helps to ensure completeness and consistency of architectures
- Top-down approach that allows system architects to
  - Relate operational needs to system characteristics
  - Identify mission shortfalls, coverage gaps
  - Relate system elements to selected or mandated standards
  - Perform operational as well as system tradeoffs
- DoDAF products fully describe an integrated architecture to support Net Ready (NR) Key Performance Parameter (KPP) compliance

DoDAF Defines a Process to Organize the Outputs of System Architecture Definition Activities Into a Set of Standard Products

DoDAF – Integrated Views

DoDAF is a "notation" or "presentation" standard for presenting information on architectures within the DoD. DoDAF v1.5 consists of All Views (AV), Operational Views (OV), System/Services Views (SV), and Technical Views (TV).



DoDAF Products

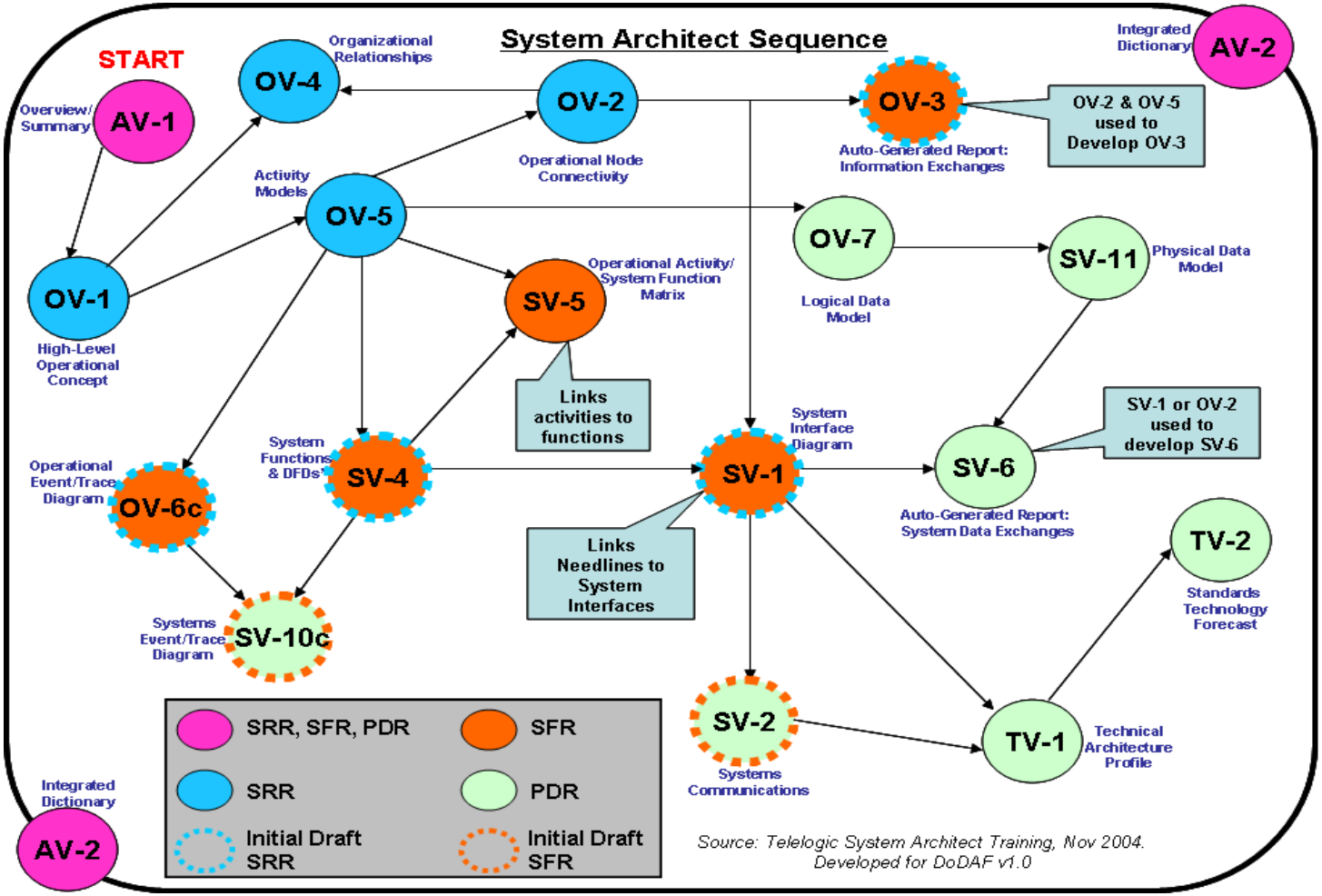
All Views (AV) and Operational Views (OV)

Framework Products	Framework Product Name	General Description
AV-1	Overview and Summary Information	Scope, purpose, intended users, environment depicted, analytical findings.
AV-2	Integrated Dictionary	Architecture data repository with definitions of all terms used in all products.
OV-1	High-Level Operational Concept Graphic	Executive-level graphical or textual description of the operational concept(s).
OV-2	Operational Node Connectivity Description	Operational nodes, operational activities performed at each node, and connectivity and information exchange need lines between nodes.
OV-3	Operational Information Exchange Matrix	Identification of information elements and relevant attributes of the information exchange. The information exchanges are associated with the producing and consuming operational nodes and activities and to the needline that the exchange satisfies.
OV-4	Organizational Relationships Chart	Organizational role or other relationships among organizations.
OV-5	Operational Activity Model	Operational activities, relationships among activities, inputs and outputs. Overlays can show cost performing nodes or other pertinent information.
OV-6c	Operational Event-Trace Description	One of three products used to describe operational activity sequence and timing – traces actions in a scenario or sequence of events and specifies timing of events.
OV-7	Logical Data Model	Documentation of the system data requirements and structurally business process rules of the operational views.

System Views (SV) and Technical Views (TV)

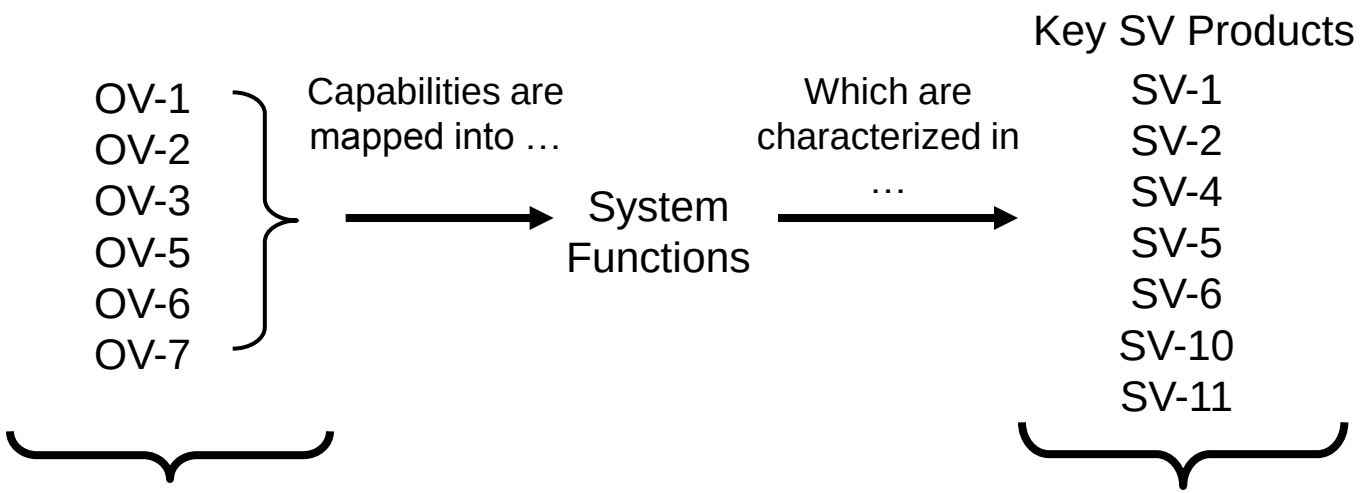
Framework Products	Framework Product Name	General Description
SV-1	Systems Interface Description	Depiction of the systems nodes and systems that support operational nodes.
SV-2	Systems Communications Description	Systems nodes, systems, and system items, and their related communications lay-downs
SV-4	Systems Functionality Description	Functions performed by systems and the information flow among system functions, including Information Assurance (IA) functions.
SV-5	Operational Activity to System Function Traceability Matrix	Mapping of systems back to operational capabilities or of system functions back to operational activities.
SV-6	Systems Data Exchange Matrix	Provides details of systems data being exchanged between systems.
SV-10c	Systems Event-Trace Description	A time-ordered examination of the system data elements exchanged between participating systems (external and internal), system functions, or human roles as a result of a particular scenario/mission.
SV-11	Physical Schema	Depicts the structure of the various kinds of system data that are utilized by the systems in the architecture.
TV-1	Technical Standards Profile	Extraction of standards that apply to the given architecture, including IA functions.
TV-2	Technical Standards Forecast	Description of emerging standards and potential impact on current Systems View elements, within a set of time frames.

Architecture Development Sequence



BAMS UAS DoDAF Products Represent the Standard Architecture Products Required for JITC Certification

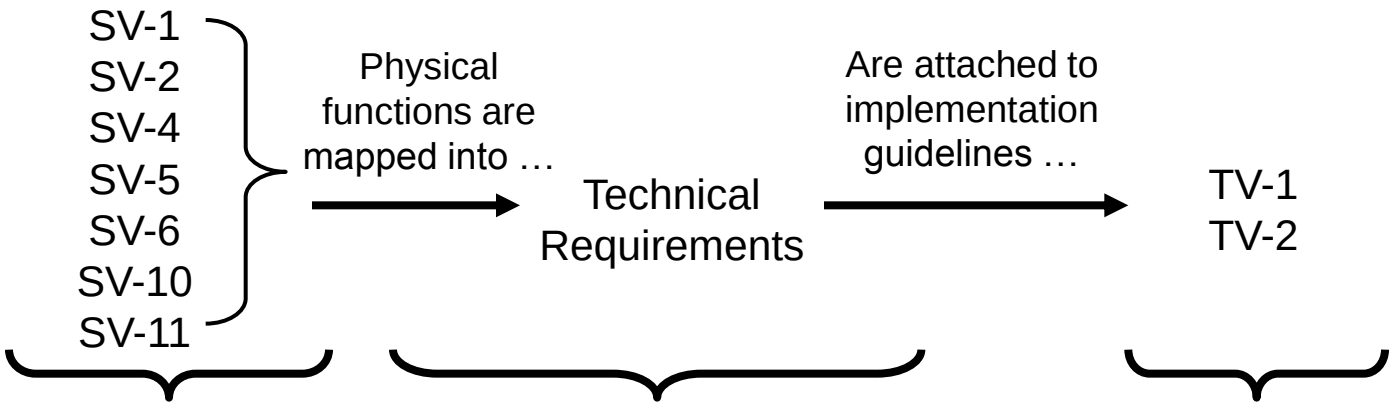
OV to SV Links (Operations to Functions)



OV products are logical constructs only that do not necessarily have a direct physical realization. They are essentially a compilation of desired capabilities.

The SV products are the physical implementation of the OV capabilities. Internal consistency and traceability back to OV products is absolutely essential.

SV to TV Links (Functions to Implementation)

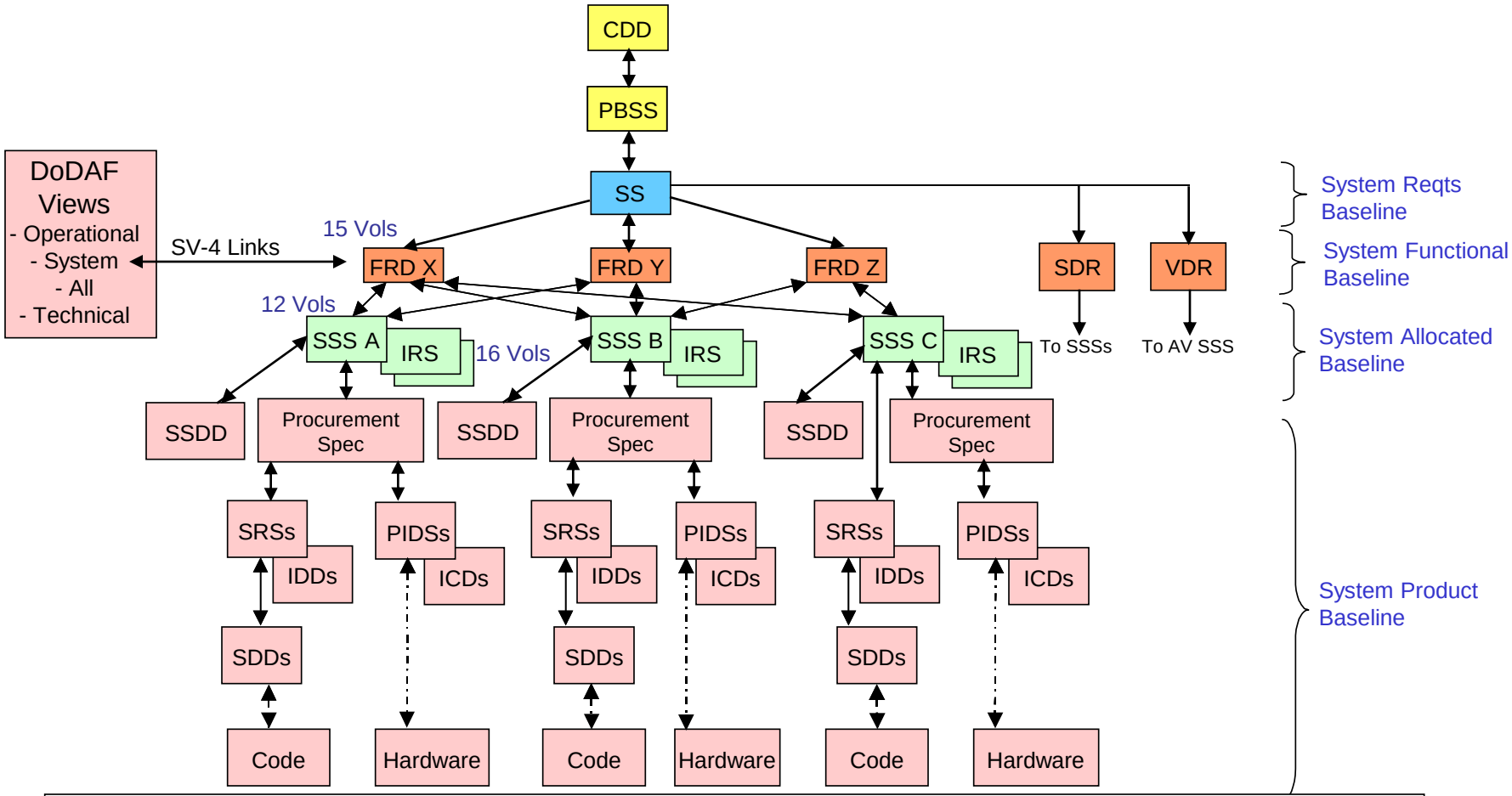


SV products identify affected system components required to implement a desired capability.

It is not sufficient to merely generate a catalog of standards without specifying their application. The SV-TV bridge uses the SV-1 and SV-2 to attach system segments and interfaces to specific standards.

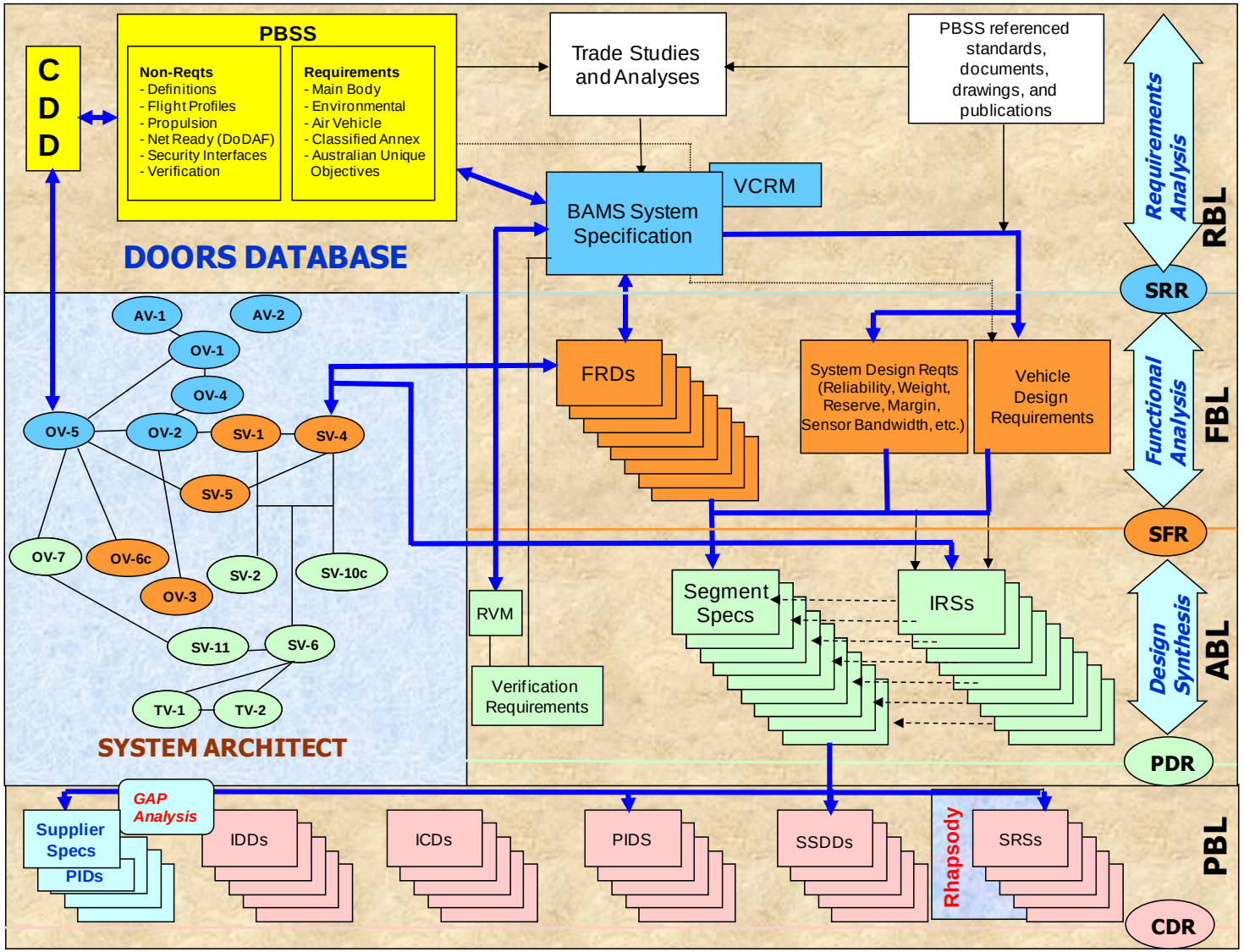
TV products specify the proper use and tailoring of standards. Since the standards are quantitative in nature, they will ultimately set performance limits for the system. Therefore, careful selection of standards is paramount.

BAMS UAS Spec Tree Architecture

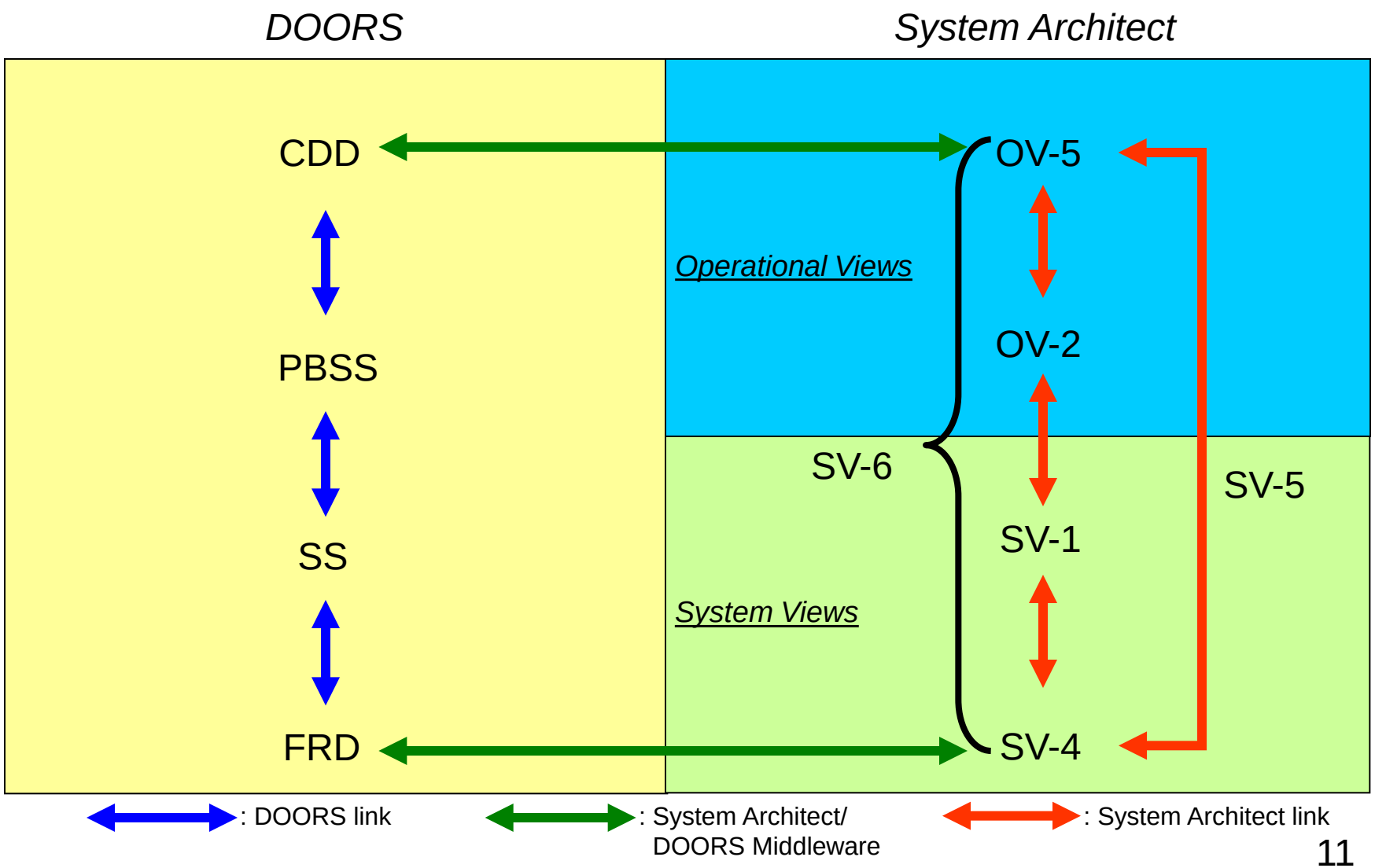


CDD	= Capability Description Document	IRS	= Interface Requirements Spec	SRS	= Software Requirements Spec
DoDAF	= Dept of Defense Architecture Framework	PBSS	= Performance Based System Spec	SS	= System Spec
FRD	= Functional Requirements Document	PIDS	= Prime Item Development Spec	SSDD	= Subsystem Development Spec
ICD	= Interface Control Spec	SDD	= Software Design Description	SSS	= System/Segment Spec
IDD	= Interface Design Description	SDR	= System Design Requirements	VDR	= Vehicle Design Requirements

System Engineering Process Requirements Flowdown



360-Degree Requirements Traceability

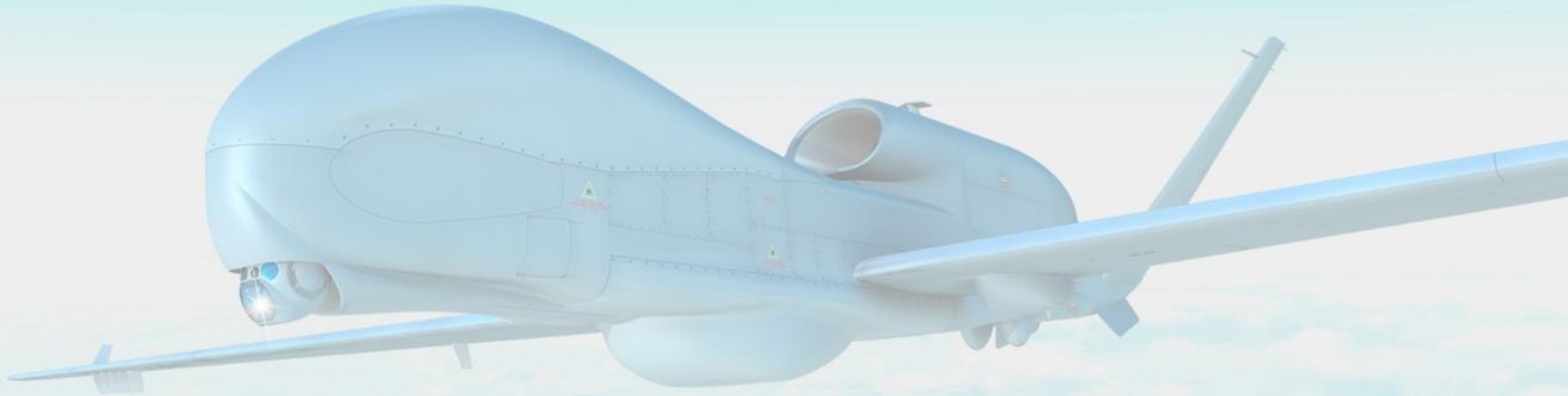


360-Degree Requirements Traceability (Contd)

- The SV-4 system functions are developed within System Architect and linked to FRD Requirements within DOORS that the functions satisfy using IBM's integration middleware
- The FRD requirements are decomposed from and linked to higher level System Specification Requirements
- The System Specification Requirements are decomposed from and linked to higher level PBSS Requirements
- The PBSS Requirements are decomposed from and linked to higher level CDD Requirements
- The CDD Requirements are linked to operational activities in the OV-5 within System Architect
- In System Architect, the SV-4 lowest leaf system functions are mapped to OV-5 lowest leaf operational activities in order to identify the transformation of an operational need into a purposeful action performed by a system. This mapping is depicted in the SV-5 matrix

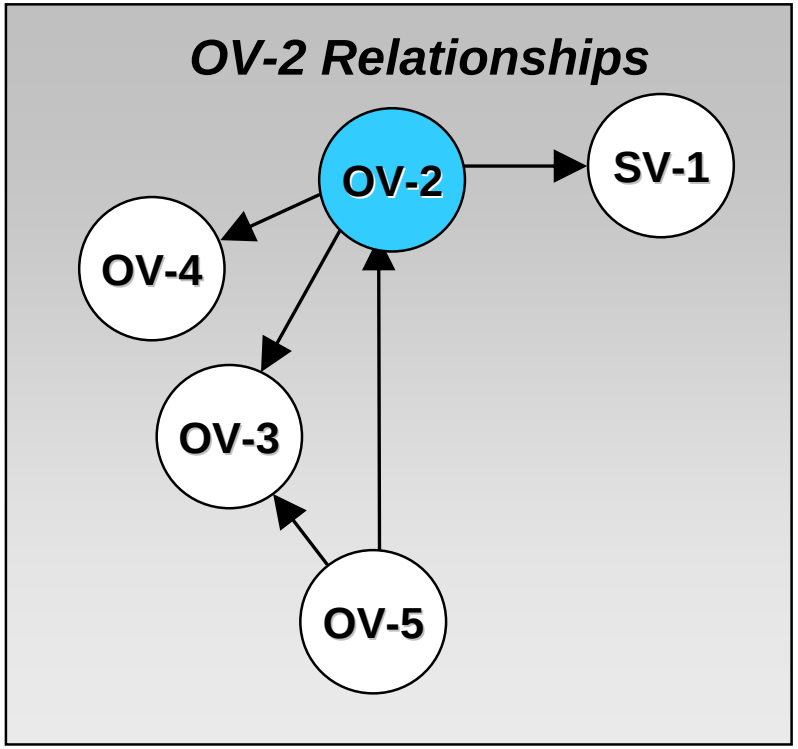
Requirement Changes Are Reflected in the Architecture Products to Fully Understand the Impact on System Functionality

DoDAF Architecture Views



OV-2: Operational Node Connectivity

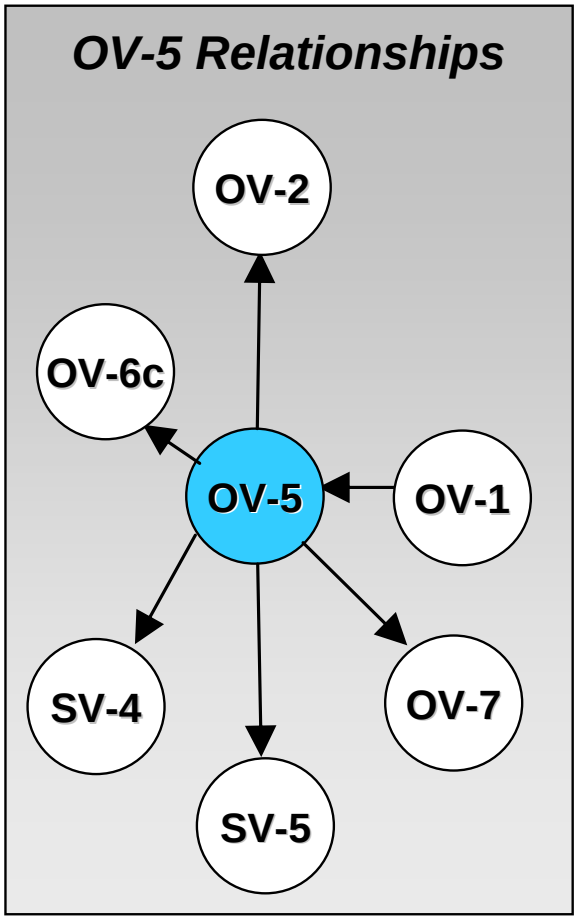
- **Purpose:** OV-2 is intended to track the need to exchange information from specific operational nodes
- **Definition:** Depicts operational nodes and needlines between them



OV-2 Depicts the Operational Nodes of the Architecture (Internal as well as External)

OV-5: Operational Activity Model

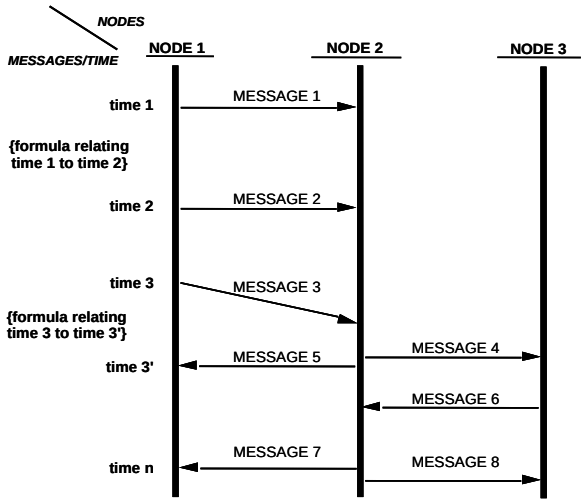
- **Purpose:** OV-5 is used to:
  - Define or flag issues, opportunities, or operational activities and information flows among the activities that need to be scrutinized
  - Make decisions about streamlining, combining, or omitting activities
- **Definition:** The OV-5 describes the operations that are normally conducted in the course of achieving a mission or a business goal

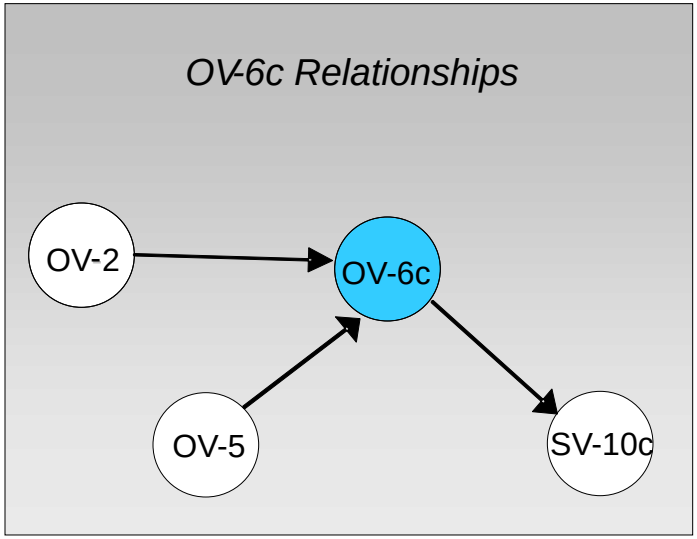


OV-5 Describes the Operational Activities Necessary to Accomplish the Mission

OV-6c: Operational Event-Trace Description

- **Purpose:** The product helps define node interactions and operational threads
- **Definition:** Provides a time-ordered examination of the information exchanges between participating operational nodes as a result of a particular scenario

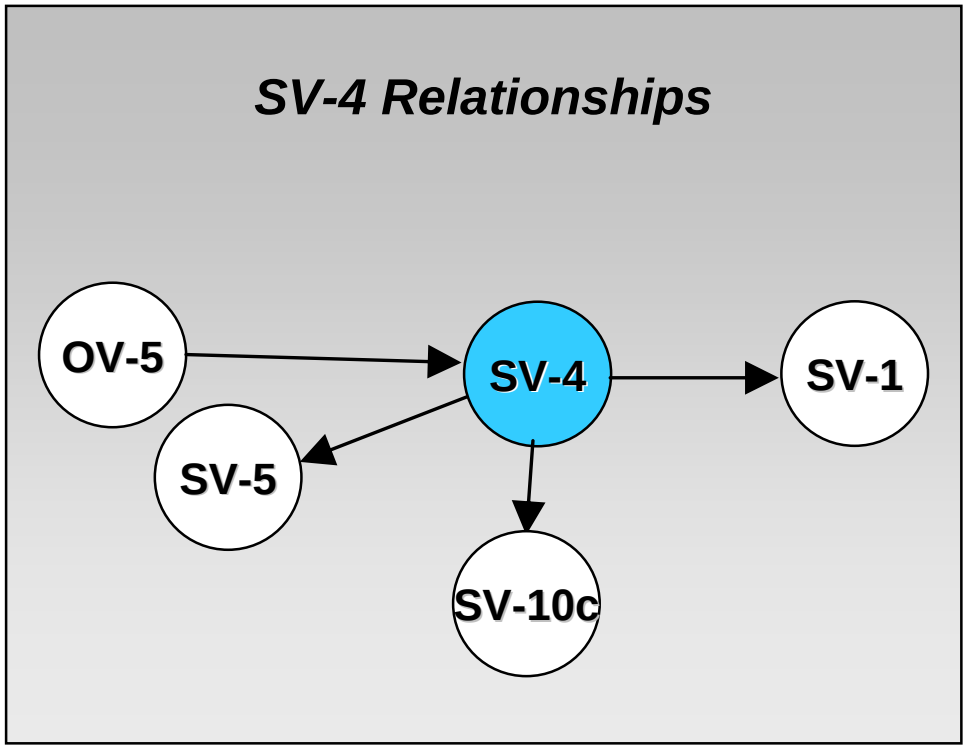




OV-6c Depicts Specific Scenarios for OV-5 Information Exchange Analysis

SV-4: Systems Functionality Description

- **Purpose:** Develop a clear description of the system data flows that are input and output by each system; a system's required inputs are satisfied; ensure functional decomposition reaches the appropriate level of detail
- **Definition:** SV-4 shows system functional hierarchies and system functions, and the system data flows between them

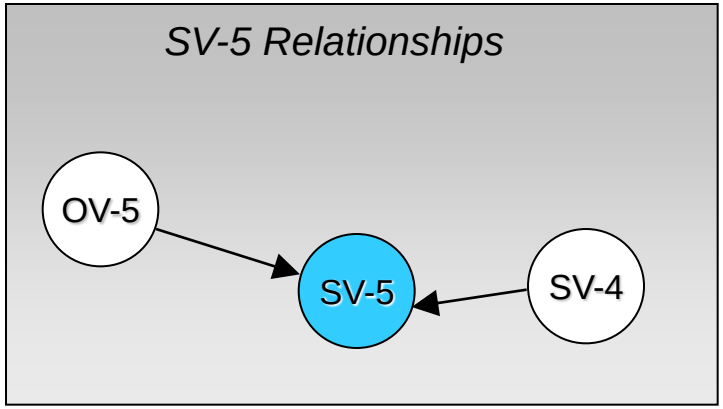


SV-4 Describes System Functions and the Data Flows Among System Functions

SV-5: System Function to Operational Activity Traceability Matrix

- **Purpose:** The SV-5 depicts the mapping of operational activities to system functions and thus identifies the transformation of an operational need into a purposeful action performed by a system.

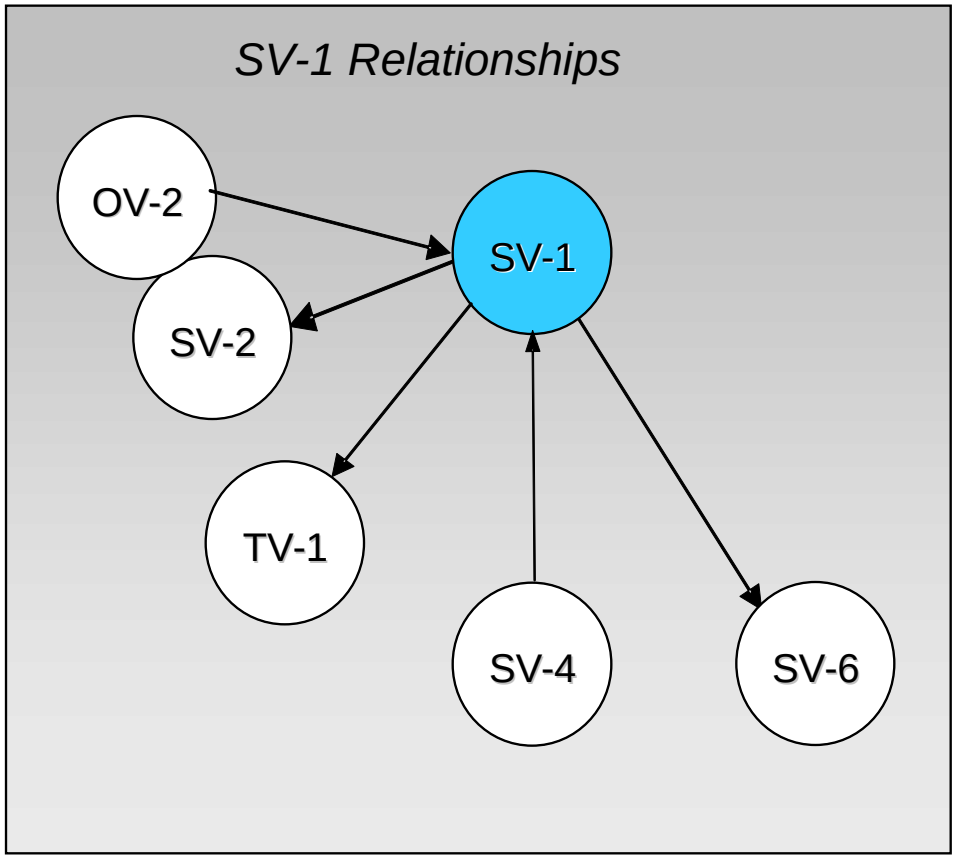
- **Definition:** Shows the relationships between the OV-5 operational activities and SV-4 system functions



The SV-5 Assists in Identifying Duplicative Functionality and Gaps in Capability

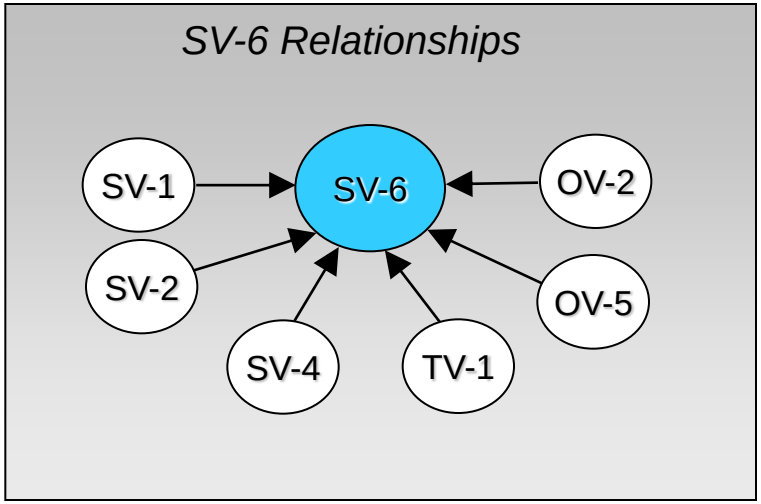
SV-1: Systems Interface Description

- **Purpose:** SV-1 identifies systems nodes and systems that support operational nodes (as defined in the OV-2)
- **Definition:** Depicts systems nodes and systems resident at these nodes



SV-1 Identifies the Interfaces Between Systems and Systems Nodes

SV-6
System Data Exchange Matrix



Need Line	Information Exchange	System Data Exchange	Interface Name	Source System/Element/Component	Source System Function	Source System Node

Source System Services	Destination System/Element/Component	Destination System Function	Destination System Node	Destination System Services	Language	Content	Size/Units

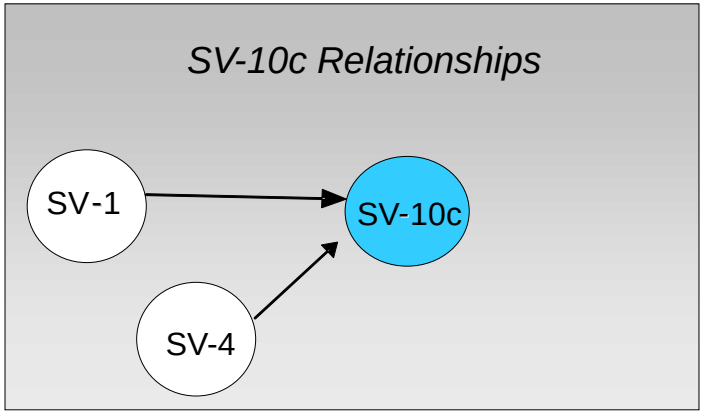
Media	Format	Protocols	Frequency	Timeliness	Throughput	Other	Classification/Declassification Restrictions	Criticality/Priority	DOORS Tracking	COMMS Path	TV Standards

- Purpose: Express the relationship across the data elements of an SV focusing on system data flow and the system data content
- Definition: Characterizes automated data exchanges between systems

SV-10c: Systems & Services Event – Trace Description

- **Purpose:** SV-10c products are valuable for moving to the next level of detail from the initial systems design, to help define a sequence of functions and system data interfaces, and to ensure that each participating system, system function, or human role has the necessary information it needs, at the right time, in order to perform its assigned functionality.

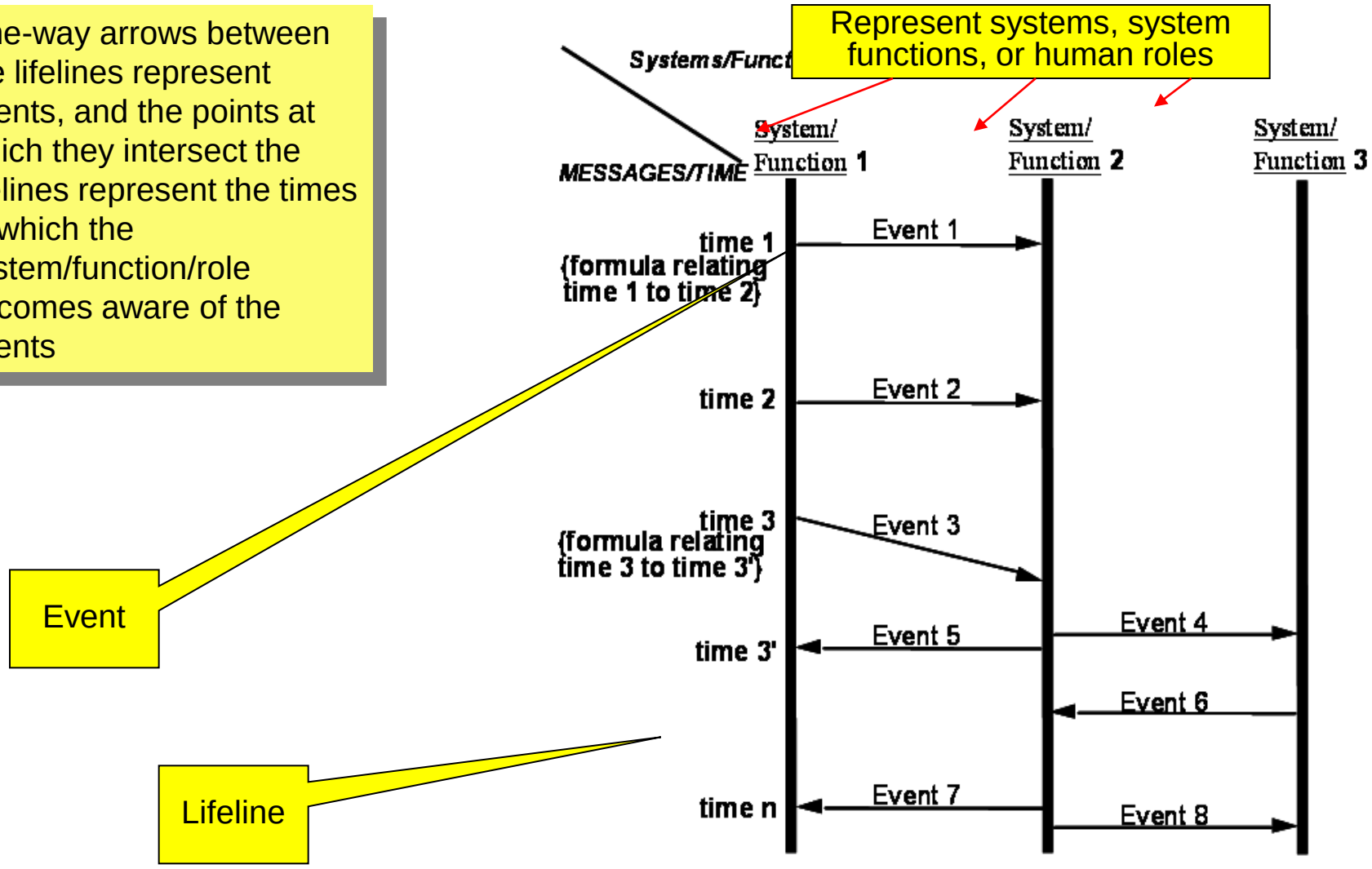
- **Definition:** Provides a time-ordered examination of the system data elements exchanged between participating systems (external and internal), system functions, or human roles as a result of a particular scenario.



SV-10c Depicts Specific Scenarios for SV-4 Data Flow Analysis

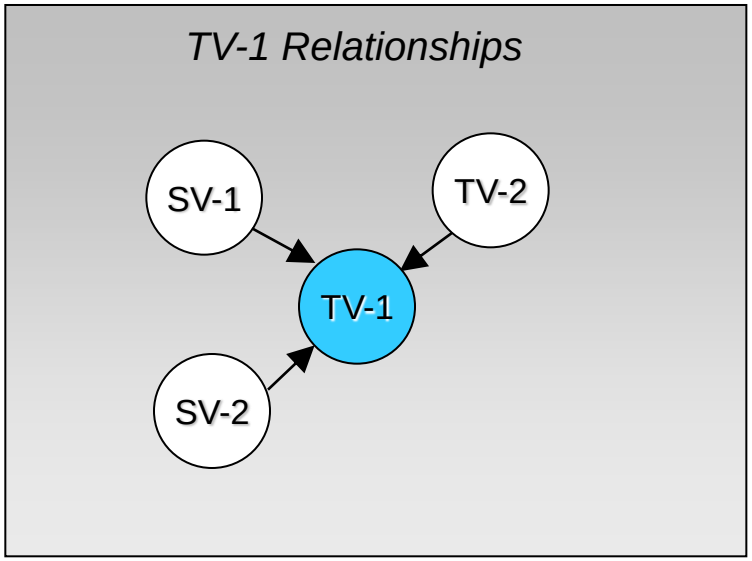
SV-10c: Systems & Services Event – Trace Description (Contd)

One-way arrows between the lifelines represent events, and the points at which they intersect the lifelines represent the times at which the system/function/role becomes aware of the events



TV-1: Technical Standards Profile

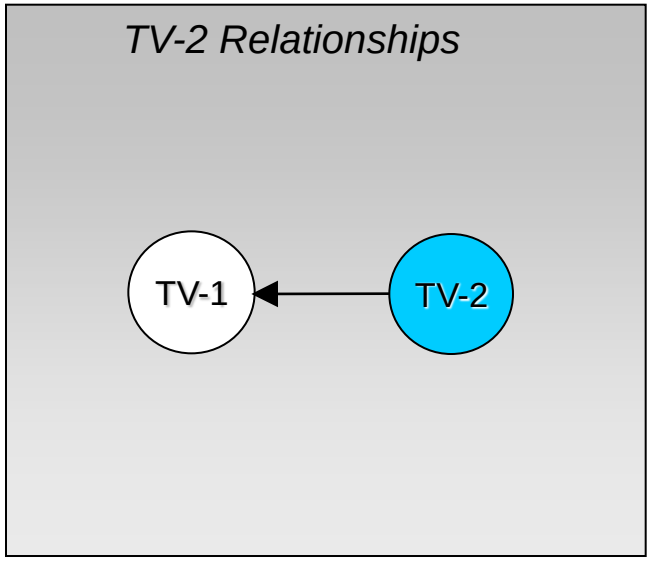
- **Purpose:** Defines systems IT standards rules and conventions that apply to architecture implementations
- **Definition:** TV-1 defines the systems IT standards rules that implement and/or constrain the design and implementation of an architecture



TV-1 Specifies the Set of IT Standards that Govern System Implementation and Operation

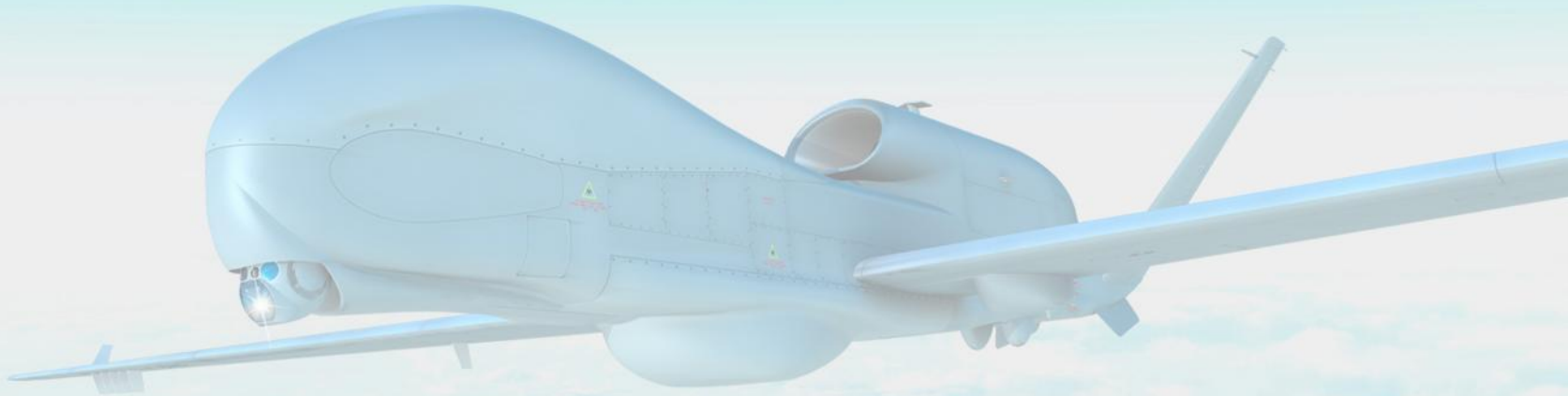
TV-2: Technical Standards Forecast

- **Purpose:** Identify critical technology standards and their impact on the future development and maintainability of the architecture
- **Definition:** TV-2 documents anticipated changes in technology-related standards and conventions which are defined in the TV-1



TV-2 Identifies Critical Standards and Their Impact on Future Evolution of the Architecture

Architecture – Requirements Traceability

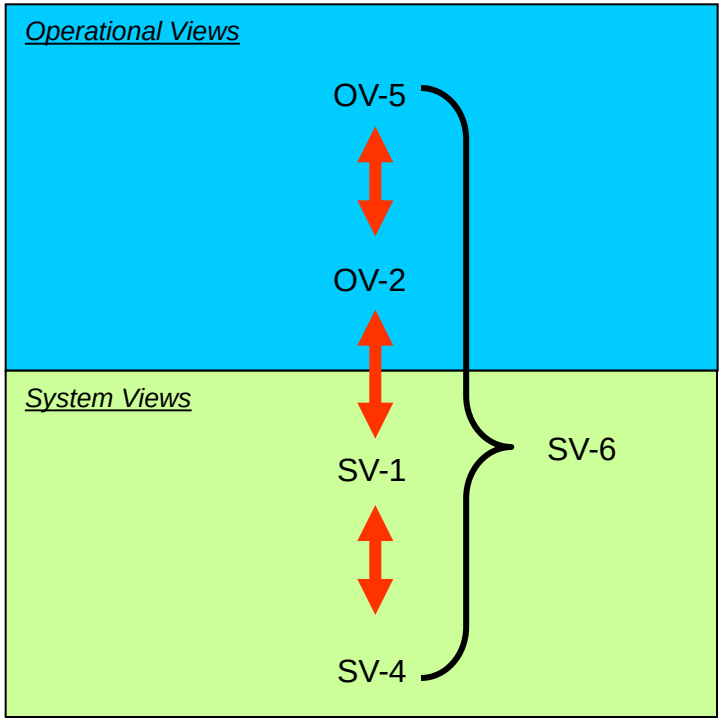


SV-1 / SV-4 / IRS Traceability

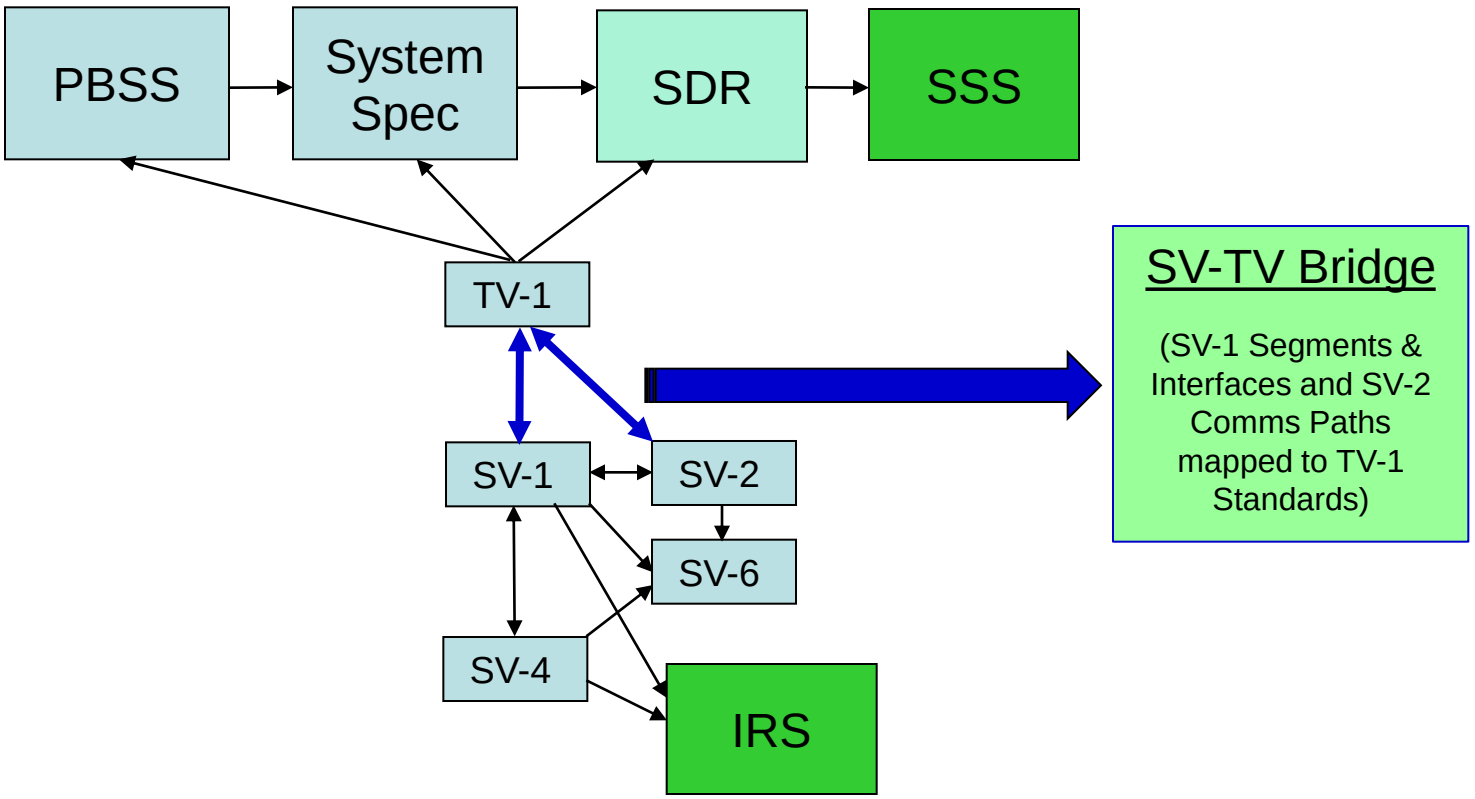
- The detailed information behind the SV-1 physical interfaces are indicated in the IRS requirements.
- The SV-1 interfaces are linked to the IRS requirements using the integration middleware tool.
- The SV-4 data flows are mapped to SV-1 interfaces.
- The SV-4 data flows represent the message fields that flow over the SV-1 interfaces.
- The SV-4 data flows are linked to the message fields within the IRS requirements using the integration middleware tool.

SV-6 Traceability

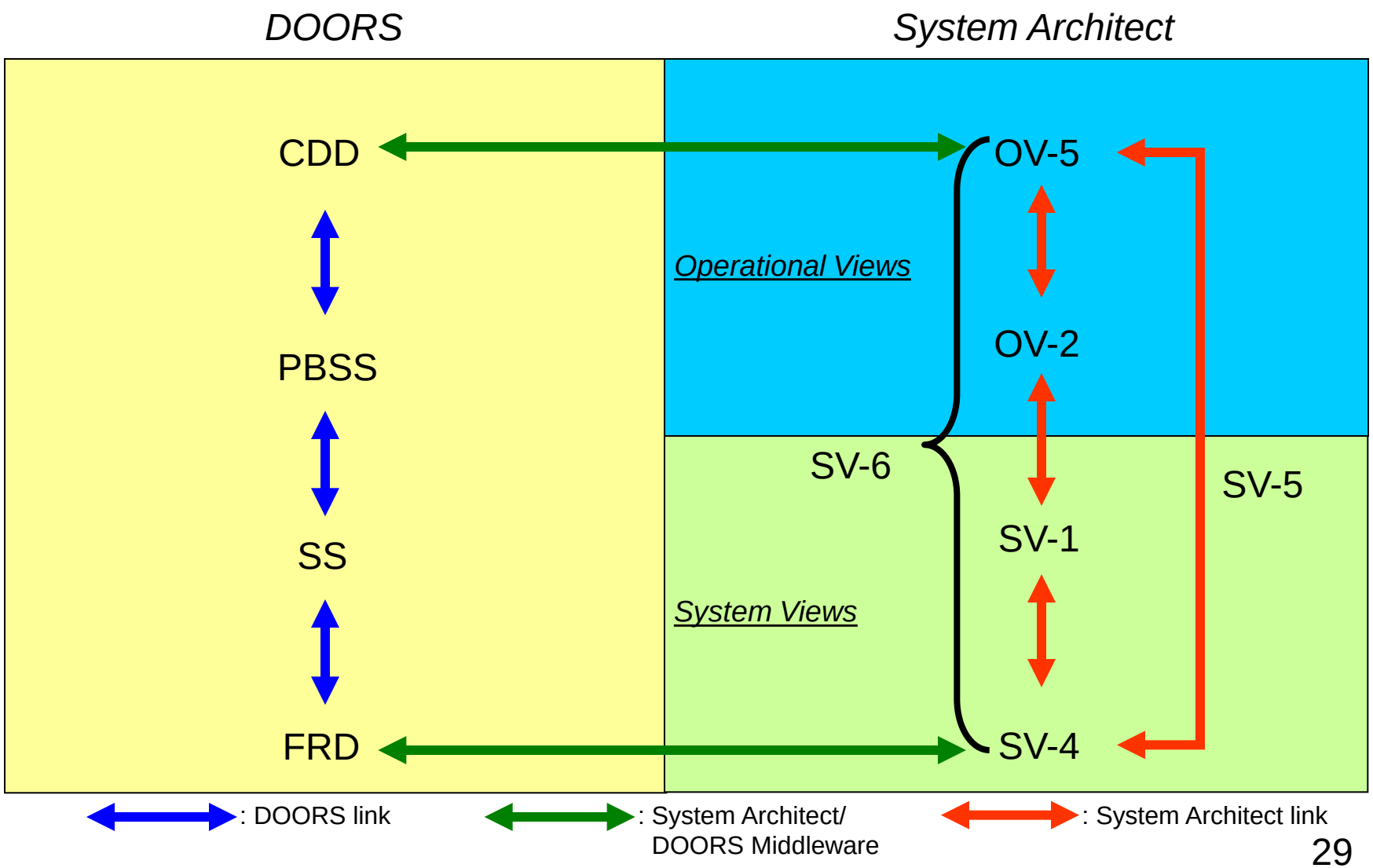
- The SV-6 Systems Data Exchange Matrix depicts the mapping of the SV-4 System Data Exchanges to the SV-1 Interfaces as well as the corresponding OV-2 Needlines to the OV-5 Information Exchanges
- The SV-6 also provides the detailed characteristics (performance attributes) behind the SV-4 data flows, SV-1 interfaces, and IRS requirements



SV to TV Traceability



360-Degree Requirements Traceability



Architecture Traceability Benefits

- Traceability is a key concept behind DoDAF to be able to trace Operational Requirements (OV) to System Performance (SV) and Technical Standards (TV)

- When properly done, the architecture allows the user to:
  - Isolate required operational capabilities for selected missions
  - Identify the system functions required to implement those capabilities
  - Decompose the functionality into physical systems and subsystems
  - Attach technical standards to the system segments and interfaces to control the end performance of the system in order to ensure interoperability

- The architecture loses significant value when traceability is not implemented

- Impact analysis can be conducted on the entire architecture as requirement changes and design changes occur

- Allows for a *fully integrated requirements-driven architecture* which should be utilized and refined throughout the entire life of the program