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A Systems Thinking Approach to Building and Updating C4ISR Architecture Views

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29 January 2003

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C4ISR Architecture View Update Process

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PURPOSE

- Describe the outcomes of a systems thinking analysis to understand the dynamics of building and updating C4ISR architecture views
- Present a process model and checklist for required key information at each step in the model
- Identify critical success factors for life cycle architecture update mechanisms

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Benefits of C4ISR System Architectures

- Picture of SPO's program objectives
- Program architecture integration and transition tool
- Support of DoD Acquisition Over Site

High Level Executive Usage

- Source of system requirements specification
- Source of system design specification
- Execution model for system architecture

Detailed Level Implementer Usage

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Rationale for Documenting the Investigations in the Paper

- **C4ISR architecture views provide a method for IT programs to communicate**
  - **Who they are, what they do, and**
  - **How, in general, SPOs want to be viewed by other organizations**
- **High-level architectures support enterprise decision makers who might be unfamiliar with the technical details of a system**
  - **Understanding commonalities and inconsistencies between (a) merging systems, (b) systems on a collision course, and (c) major transitional stages in a single system's evolution**
- **Low-level architecture views, on the other hand, allow IT experts to identify, analyze, and specify potential and real integration issues**
  - **Provides comparable detailed structured archives that they can manipulate to characterize specific current architectural conflicts**
- **Within the limitations of time, funding, and political will, analyzing architecture views can identify future integration issues by executing detailed systematic comparative analyses**
- **Keeping C4ISR architecture views updated—and therefore an accurate living representations of a system architecture—is *the name of the game***

Examples of GCSS-AF SPO Usage of High Level Architecture Views

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- **Executive level programmatic and technical interchanges**
- **Program funding negotiations**
- **Customer OutReach: over 600 programs and customer organizations**
- **DoD Acquisition Oversight**
  - **Clinger-Cohen Act Compliance**
  - **C4ISP Approvals**
  - **Certificate of Networthiness**

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C4ISR Architecture Products Required for Acquisition

Architecture Products		COAC		Guidance		
		Domain	Acq Pgm	C4ISR Arch - Mandatory	C4ISP	ESC/CC
All Views Architecture						
AV-1	Overview & Summary Information	C	P	X	X	X
AV-2	Integrated Dictionary	A*	P	X	X	X
Operational Architecture						
OV-1	High Level Operational Concept Graphic	A*	P	X	X	X
OV-2	Operational Node Connectivity Description	A*	P	X	X	X
OV-3	Operational Information exchange Matrix	A*	P	X	X	X
OV-4	Command Relationships	A*				
OV-5	Activity Model	A	P	AFI, V	X	
OV-	Operational Activity Sequence (Rule Model)					
OV-	Operational Activity Sequence (State Transition)				O	
OV-	Operational Activity Sequence (Event Trace)	A	P		X	
OV-7	Logical Data Model	A	P	AFI	X	
Systems Architecture						
SV-1	System Interface Description	C	P	X	X	X
SV-2	System Communications Description	C	P		X	X
SV-3	Systems (N2) Matrix					
SV-4	Systems Functionality Description	C	P			X

A - AC2ISRC Responsibility, COAC Develop
A* - AC2ISRC Initial, COAC Further Development
C - Combat Operations Architecture Council Responsibility
P - Program Responsibility
X - Mandated Product
O - Optional
V - C4ISR Arch Framework Version 2.1
AFI - AFI 33-124 Required for Air Force Architectures
COAC - Combat Operations Architecture Council Sponsoring Programs

C4ISR Architecture Products Required for Acquisition (concluded)

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Architectures Products (concluded)		COAC		Guidance		
		Domain	Acq Pgm	C4ISR Arch - Mandatory	C4ISP	ESC/CC
Systems Architecture (concluded)						
SV-8	System Evolution Description	C	P		O	X
SV-9	System Technology Forecast	C	P			X
SV-10a	System Activity Sequence & Timing description (Rule Model)					
SV-10b	System Activity Sequence & Timing description (State Transition)					
SV-10c	System Activity Sequence & Timing description (Event Trace)				O	
SV-11	Physical Data Model					
Technical Architecture						
TV-1	Technical Architecture Profile	C	P	X	X	X
TV-2	Standards Technology Forecast (TV-2)					

A - **AC2ISRC Responsibility, COAC Develop**
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C - **Combat Operations Architecture Council Responsibility**
P - **Program Responsibility**
X - **Mandated Product**
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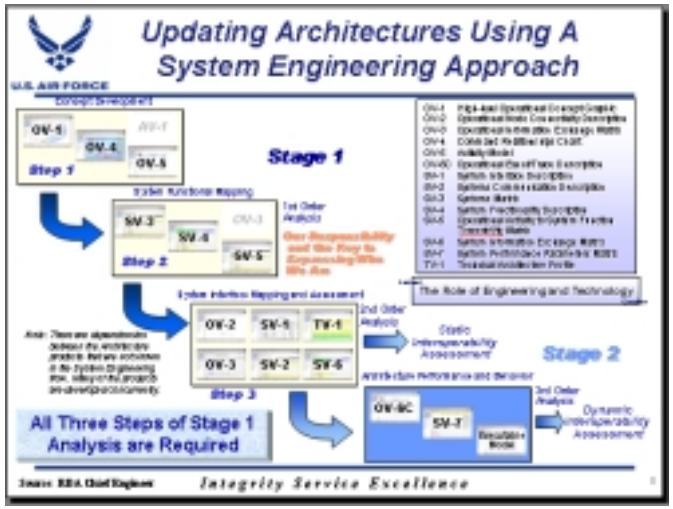
Creating and Updating C4ISR Diagrams

Key to the Process: Architecture documentation is valid only if it kept up to date on the shelf

- **Re-use of work by Ellen Conway and the MITRE COAC on dynamic interoperability assessments of architectures**
  - **Two stages**
  - **Three step Stage 1 to assess completeness of architecture**



- **Added interrelationships of architecture views and data collection requirements for selected views**
- **Developed a static update process flow for Stage 1**

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A Rapid Jog Through Some High Level GCSS-AF Architecture Examples

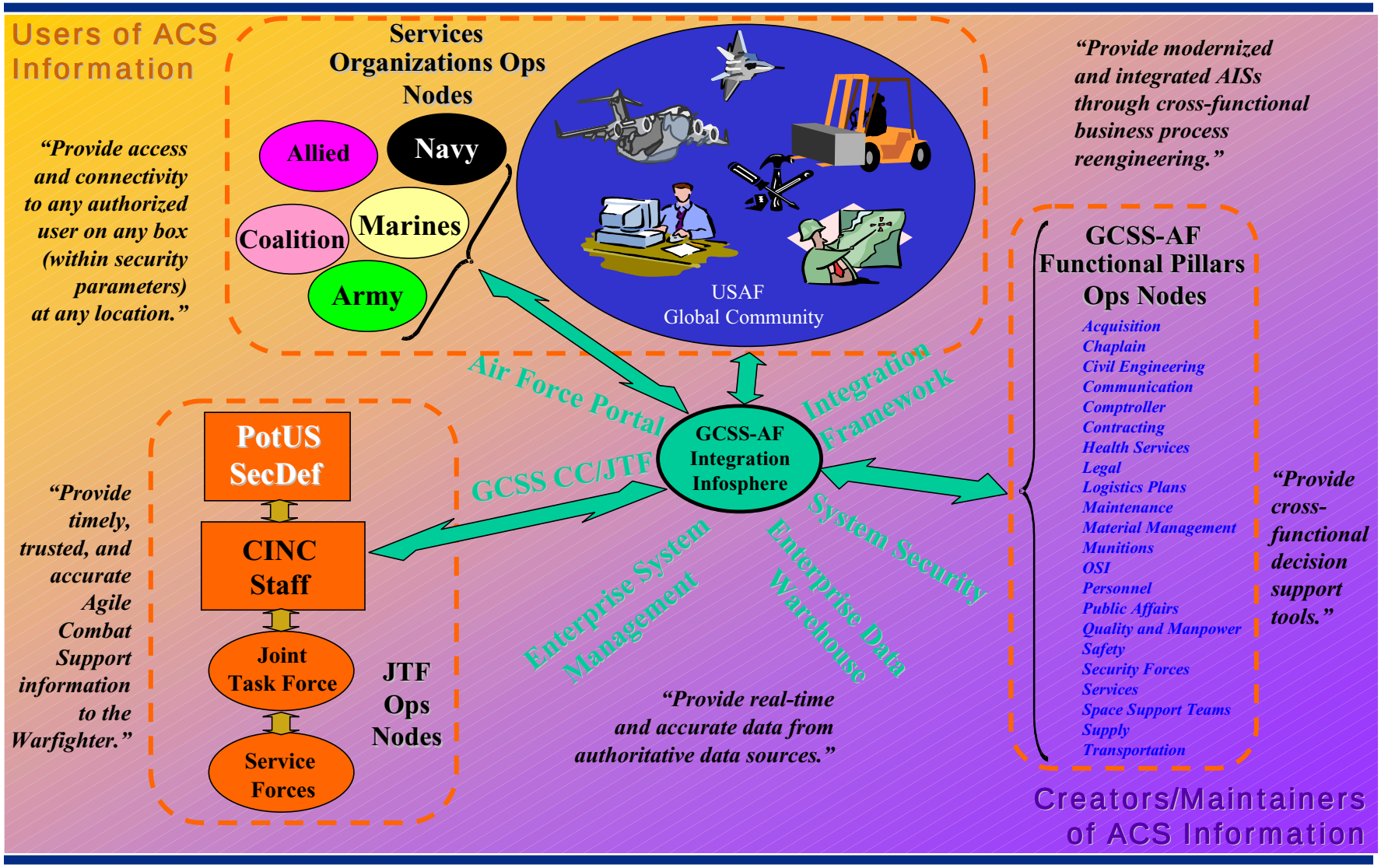
HIGH LEVEL EXECUTIVE VIEWS

- GCSS-AF High-Level Operational Concept Description (Operational View-1)
- GCSS-AF System Interface Description (System View-1)
- GCSS-AF System Communications Description (SV-2)
- GCSS-AF Systems Functionality Description (SV-4)
- GCSS-AF Operational Node Connectivity Description (OV-2)
- GCSS-AF Operational Node Connectivity Description (OV-2)
- GCSS-AF Systems^2 Matrix (SV-3)

DETAILED LEVEL IMPLEMENTER VIEW

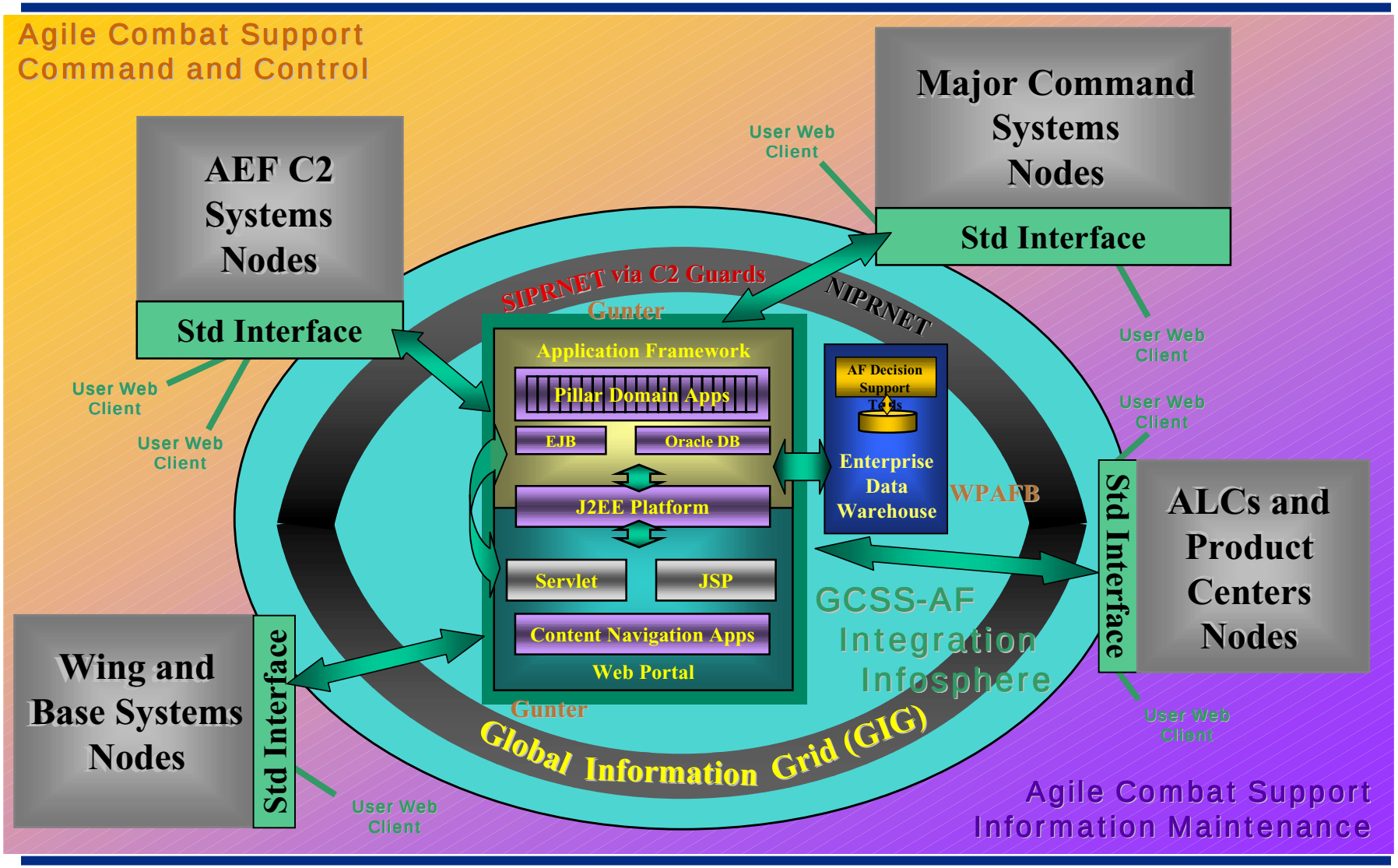
- Overview of GCSS-AF System Data Exchange Matrix (SV-6)

GCSS-AF High-Level Operational Concept Description (OV-1)



Source: ORD, 12/01; SPO

GCSS-AF System Interface Description (SV-1)



Source: SPO

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GCSS-AF System Comm Description (SV-2, NIPRNET to SIPRNET Connectivity)

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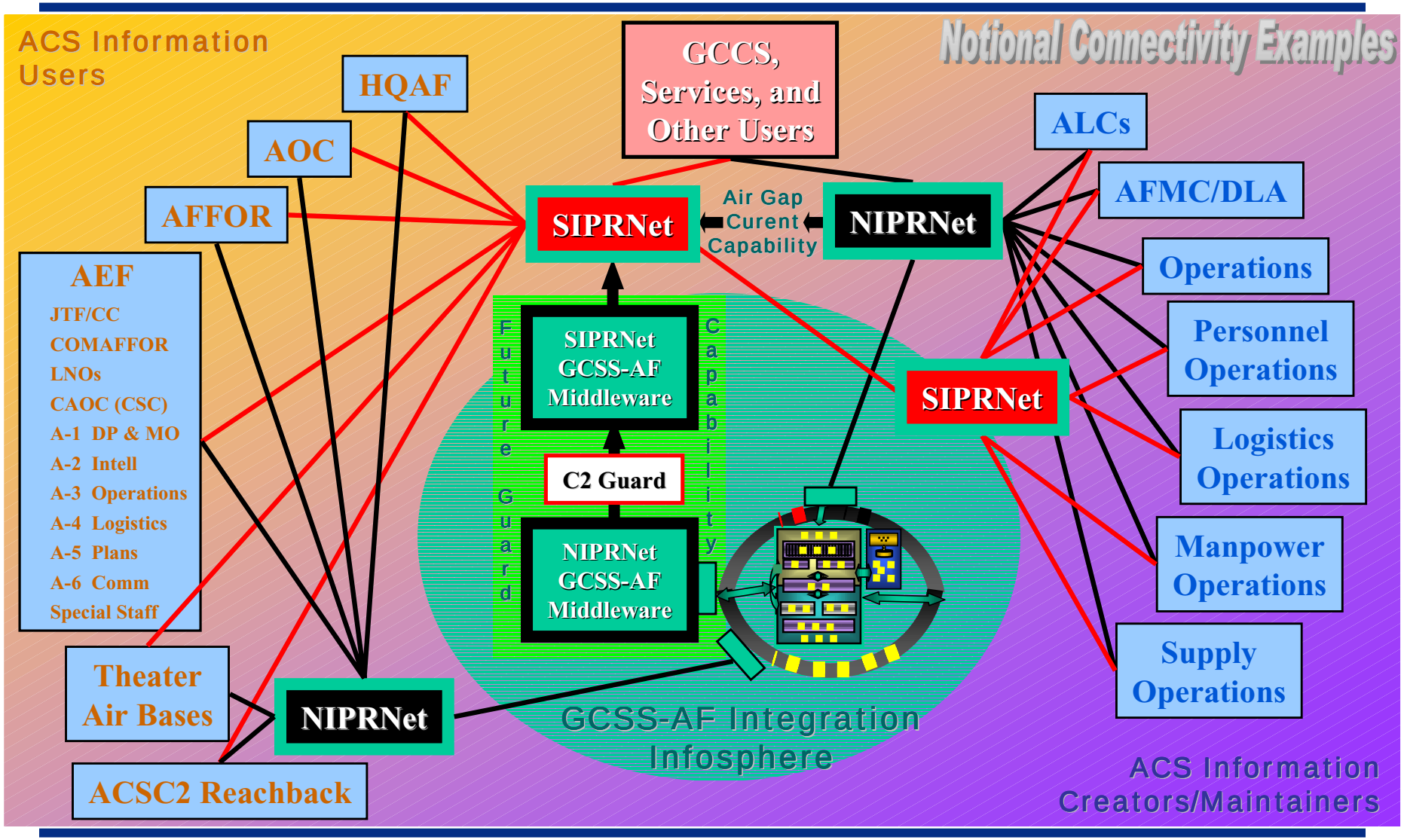

Source: GCSS-AF ORD, S PO

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GCSS-AF Systems Functionality Description (SV-4)

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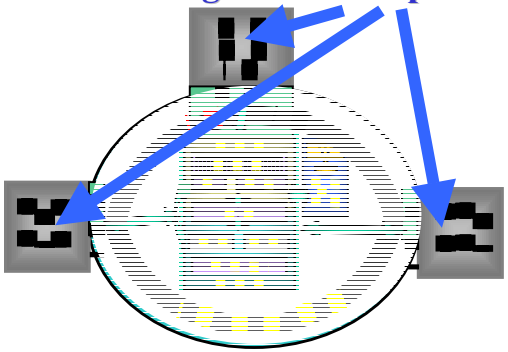
Warfighter ACS Systems Nodes Supported by GCSS-AF Integration Infosphere



ACS C2 Execution
- Forces Beddown
- Warfighter Requiremts Coordination
- Sortie Generation

ACS C2 Dynamic Planning

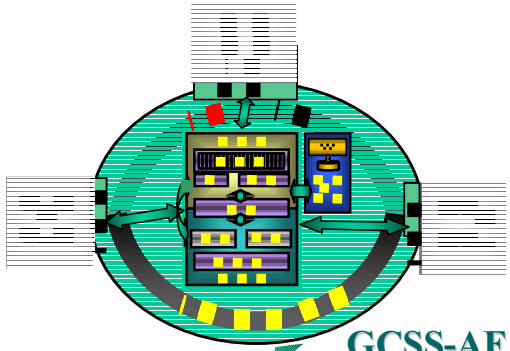
AEF ACS C2

Functional Pillars Information Flows (Documented by AIS SPOs)

Creation/Maintenance of Accurate Functional Data

Theater ACS C2

ACS C2 Reachback



GCSS-AF Integration Infosphere Supporting Warfighter ACS Systems Nodes

Integration Framework (IF) and Air Force Portal (AFP)

Enterprise Systems Management (ESM)

GCSS-AF Subsystem Information Flows (Documented by GCSS-AF SPO)

System Security

Enterprise Data Warehouse (EDW)

Source: ORD, 12/01

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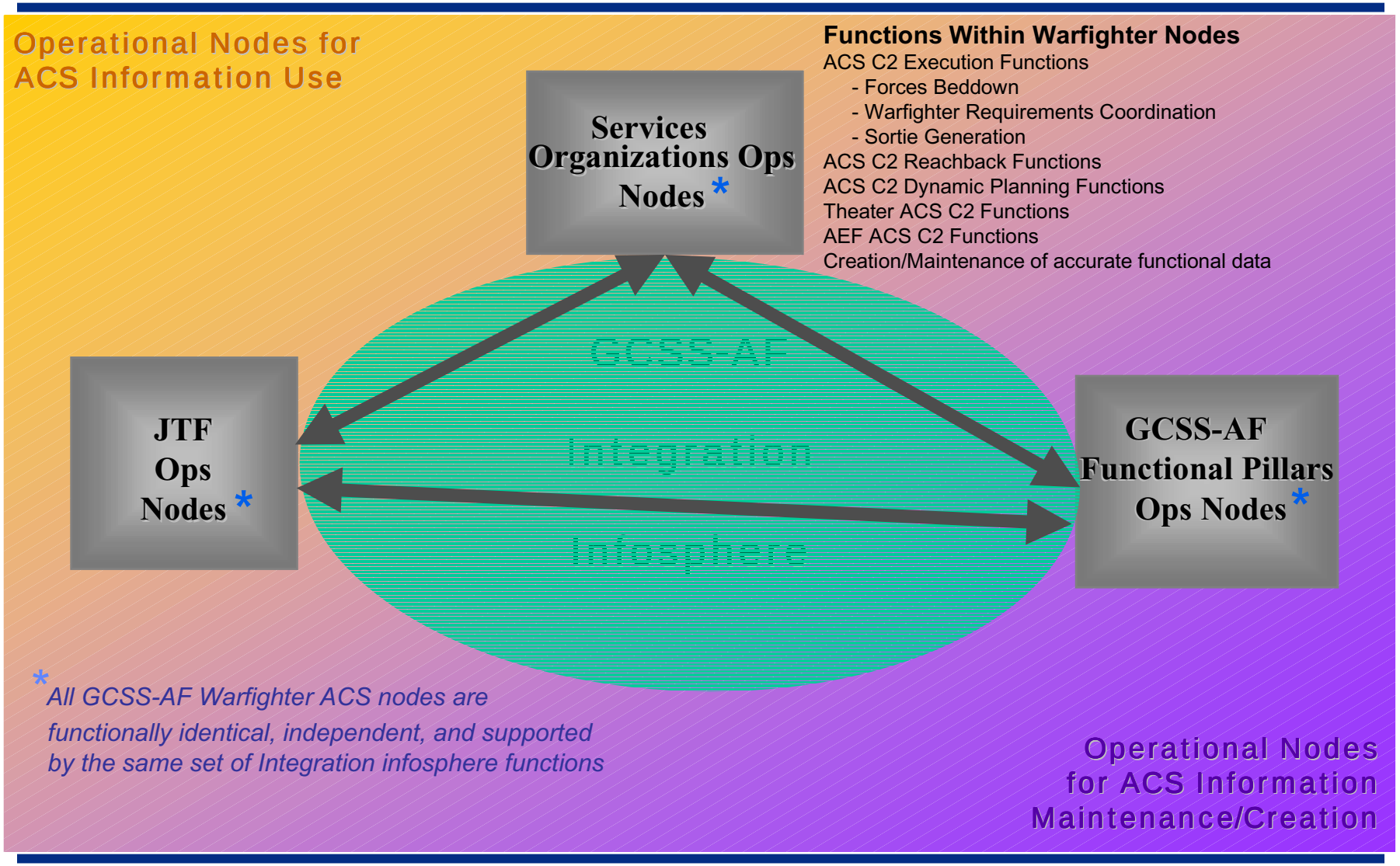
GCSS-AF Operational Node Connectivity Description (OV-2, ACS Warfighter)



Source: SPO

GCSS-AF Operational Node Connectivity Description (OV-2, Integration Infosphere)

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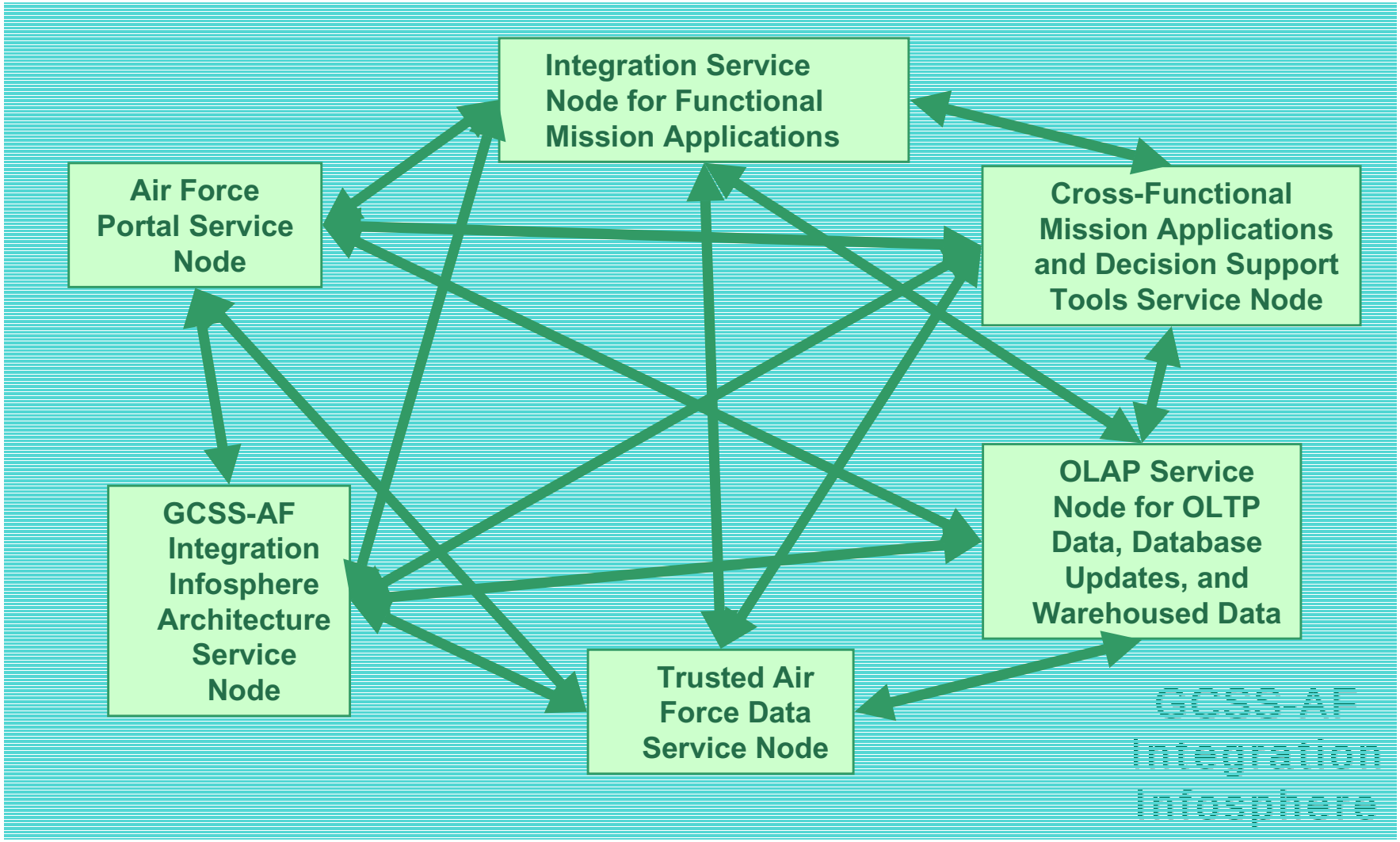

Source: SPO

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GCSS-AF Systems² Matrix (SV-3)

High-Level GCSS-AF Integration Infosphere System Components Matrix

High-Level System Component	Integration Framework (IF) and AFP	System Security	Enterprise Systems Management (ESM)	Enterprise Data Warehouse (EDW)
Integration Framework (IF) and Air Force Portal (AFP)		x	x	Future
System Security	x		x	Future
Enterprise Systems Management (ESM)	x	x		Future
Enterprise Data Warehouse (EDW)	Future	Future	Future	

GCSS-AF Warfighter Operational Activity to System FunctionMappings
(To be documented by AIS SPOs)

Source: SPO

GCSS-AF System Data Exchange Matrix (SV-6, Integration Infosphere)

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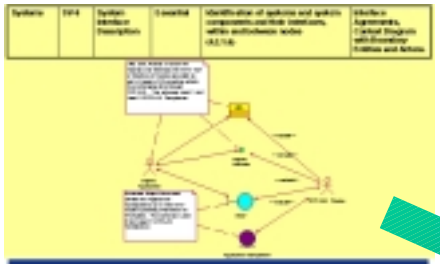

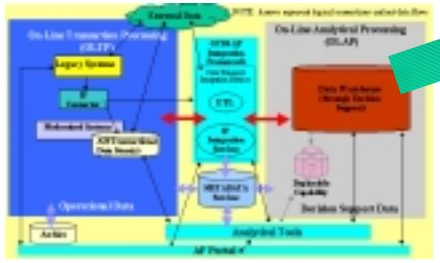

Mapping of Underlying Detailed System Data to the SV-6 Architecture View

C4ISR Template to Document As-Built Integration Infosphere System Information Exchange Data

Identifier/ Name of Operational Needline Supported (from OV-2)	Identifier/ Name of Operational Information Exchange Supported (from OV-3)	Identifier/ Name of System Data Exchange	Nature of Transaction						Data Source			Data Destination		
			Content	Size	Media	Format	Protocols Used	C4ISR Level Achievable	ID of Source System & System Element	Source System Function	Operational Node(s) Where Source System Resides	Identity of Receiving System Element	Receiving System Function	Operational Node(s) Where Receiving System Resides
1														
	e.g. 1-a													
2	e.g. 1-b													
	e.g. 1-n													
n														

CONTINUED

Identifier/ Name of Operational Needline Supported (from OV-2)	Identifier/ Name of Operational Information Exchange Supported (from OV-3)	Identifier/ Name of System Data Exchange	Requirements				Assurance Attributes								Data Exchange Occurs		
			Frequency	Timeliness	Throughput	Other	Classification/ Declassification Requirements	Crypto	Integrity Checks Required	Assured Authentication via Secret Key(s)	Physical	Security (passage, barriers, etc.)	Personnel Security	Where	Time	Policy/ Doctrine Constraints
1	e.g. 1-a															
	e.g. 1-b															
	e.g. 1-n															
2																
n																

Source: DoD Arch Framework v1.1

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Objectives of the C4ISR Architecture View Update Process

- **Maintain a clean requirements specification (System Data Exchange Product View)**
  - **Describes, in tabular format, system functional data exchanges between systems within a node and across nodes**
  - **Keys system functional data exchanges back to the operational activity information exchange it helps to satisfy (i.e., system functions Ł an operational activity**
- **Need to support many-to-many linkages in <u>both</u> directions (i.e., ops activities Ł system functions)**

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Sources of the Impact and Change on a System Architecture

- **Immaturity of the system architecture**
- **Generating the first instance (AV needed; high level data for OVs, SVs, and TVs to get started)**
- **Adding, deleting, swapping out technologies**
- **Adding, deleting, swapping out major system functions**
- **Adding, deleting, swapping out major operational activities**
- **Adding, deleting, swapping out both major operational activities and major system function at the same time**

Simplified C4ISR Architecture View Update Process

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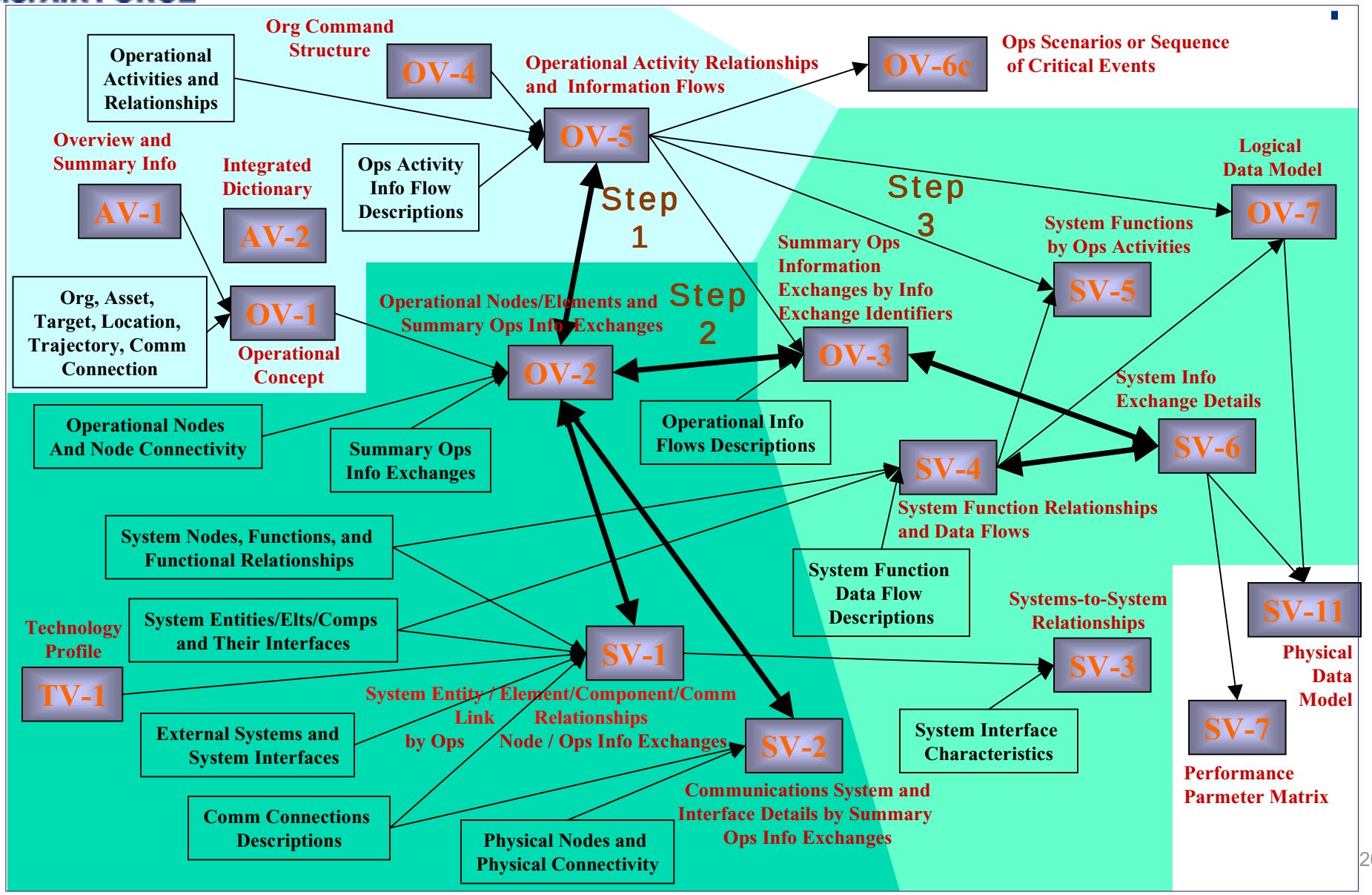

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Insights on the Dynamics of the Update Process

- Critical Success Factors Identified by the Systems Thinking Analyses
  - Thick lines identify critical dynamic linkages
  - Maturity of the a general system architecture
  - Maturity of your architectural data and data collection process
  - Volatility of the As-Is or To-Be architecture
  - Completeness of your implementation plan for life cycle updates
- Eager to hear reviews of my paper at wbc@mitre.org