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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**

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



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# ***Benefits of C4ISR System Architectures***

- n **Picture of SPO's program objectives**
- n **Program architecture integration and transition tool**
- n **Support of DoD Acquisition Over Site**
- n **Source of system requirements specification**
- n **Source of system design specification**
- n **Execution model for system architecture**

High Level  
Executive  
Usage

Detailed Level  
Implementer Usage



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# ***Rationale for Documenting the Investigations in the Paper***

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

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

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



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# C4ISR Architecture Products Required for Acquisition

Architecture Products		COAC		Guidance		ESC/CC
		Domain	Acq Pgm	C4ISR Arch - Mandatory	C4ISP	
<b>All Views Architecture</b>						
AV-1	Overview & Summary Information	C	P	X	X	X
AV-2	Integrated Dictionary	A*	P	X	X	X
<b>Operational Architecture</b>						
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	
<b>Systems Architecture</b>						
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

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# C4ISR Architecture Products Required for Acquisition (concluded)

		COAC		Guidance	
		Domain	Acq Pgm	C4ISR Arch - Mandatory	C4ISP
<b>Architectures Products (concluded)</b>					
<b>Systems Architecture (concluded)</b>					
SV-8	System Evolution Description	C	P		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				
<b>Technical Architecture</b>					
TV-1	Technical Architecture Profile	C	P	X	X
TV-2	Standards Technology Forecast (TV-2)				

- A - AC2ISRC Responsibility, COAC Develop
- A\* - AC2ISRC Initial, COAC Further Development
- C - Combat Operations Architecture Council Responsibility
- P - Program Responsibility
- X - Mandated Product
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- AFI - AFI 33-124 Required for Air Force Architectures
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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**

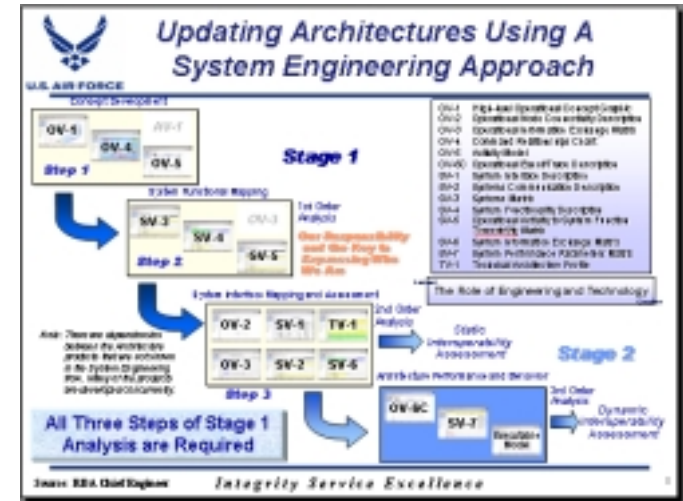
n Re-use of work by Ellen Conway and the MITRE COAC on dynamic interoperability assessments of architectures

n Two stages

n Three step Stage 1 to assess completeness of architecture

n Added interrelationships of architecture views and data collection requirements for selected views

n Developed a static update process flow for Stage 1





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

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## **HIGH LEVEL EXECUTIVE VIEWS**

- n **GCSS-AF High-Level Operational Concept Description (Operational View-1)**
- n **GCSS-AF System Interface Description (System View-1)**
- n **GCSS-AF System Communications Description (SV-2)**
- n **GCSS-AF Systems Functionality Description (SV-4)**
- n **GCSS-AF Operational Node Connectivity Description (OV-2)**
- n **GCSS-AF Operational Node Connectivity Description (OV-2)**
- n **GCSS-AF Systems<sup>2</sup> Matrix (SV-3)**

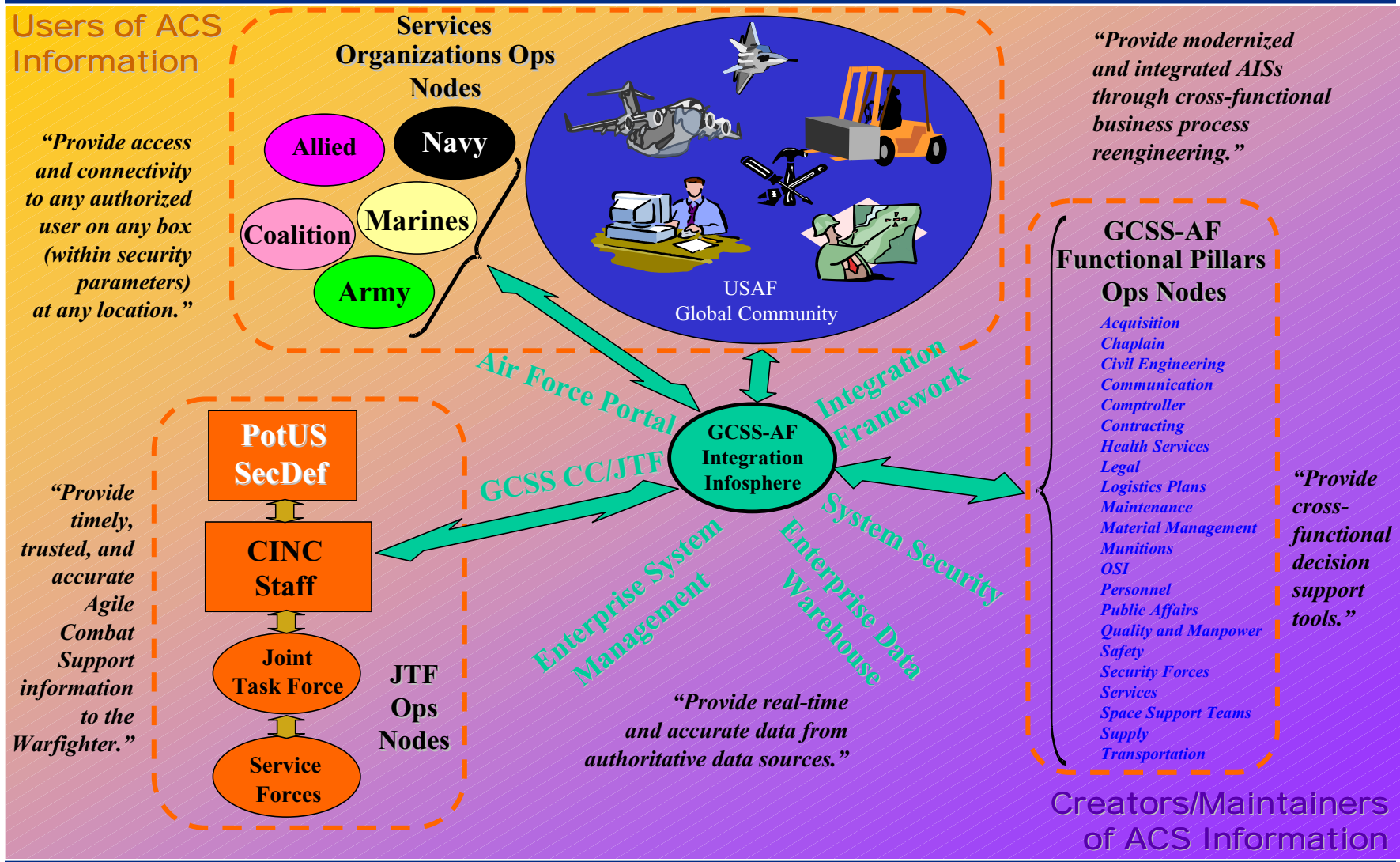
## **DETAILED LEVEL IMPLEMENTER VIEW**

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



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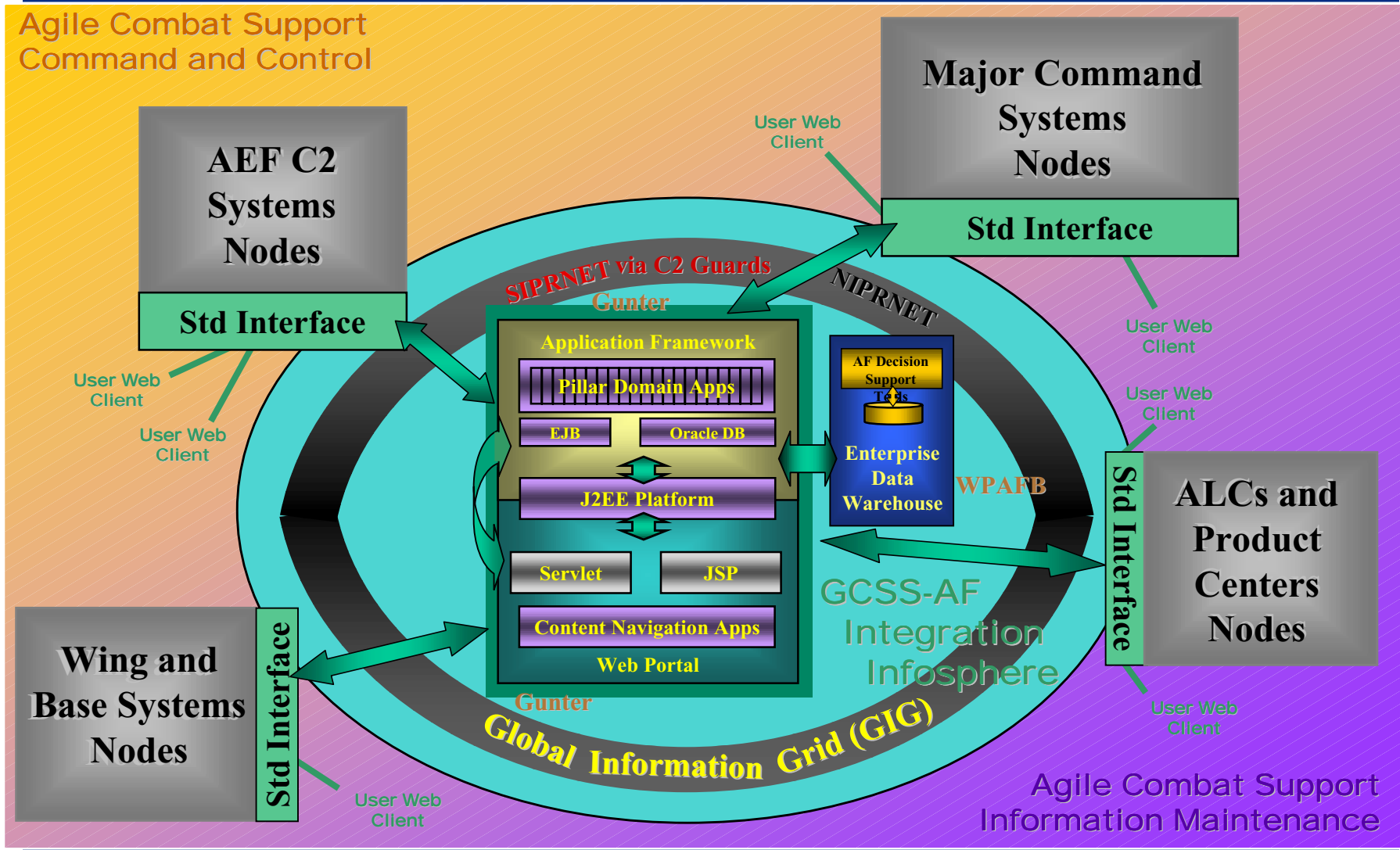
# GCSS-AF High-Level Operational Concept Description (OV-1)





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# GCSS-AF System Interface Description (SV-1)



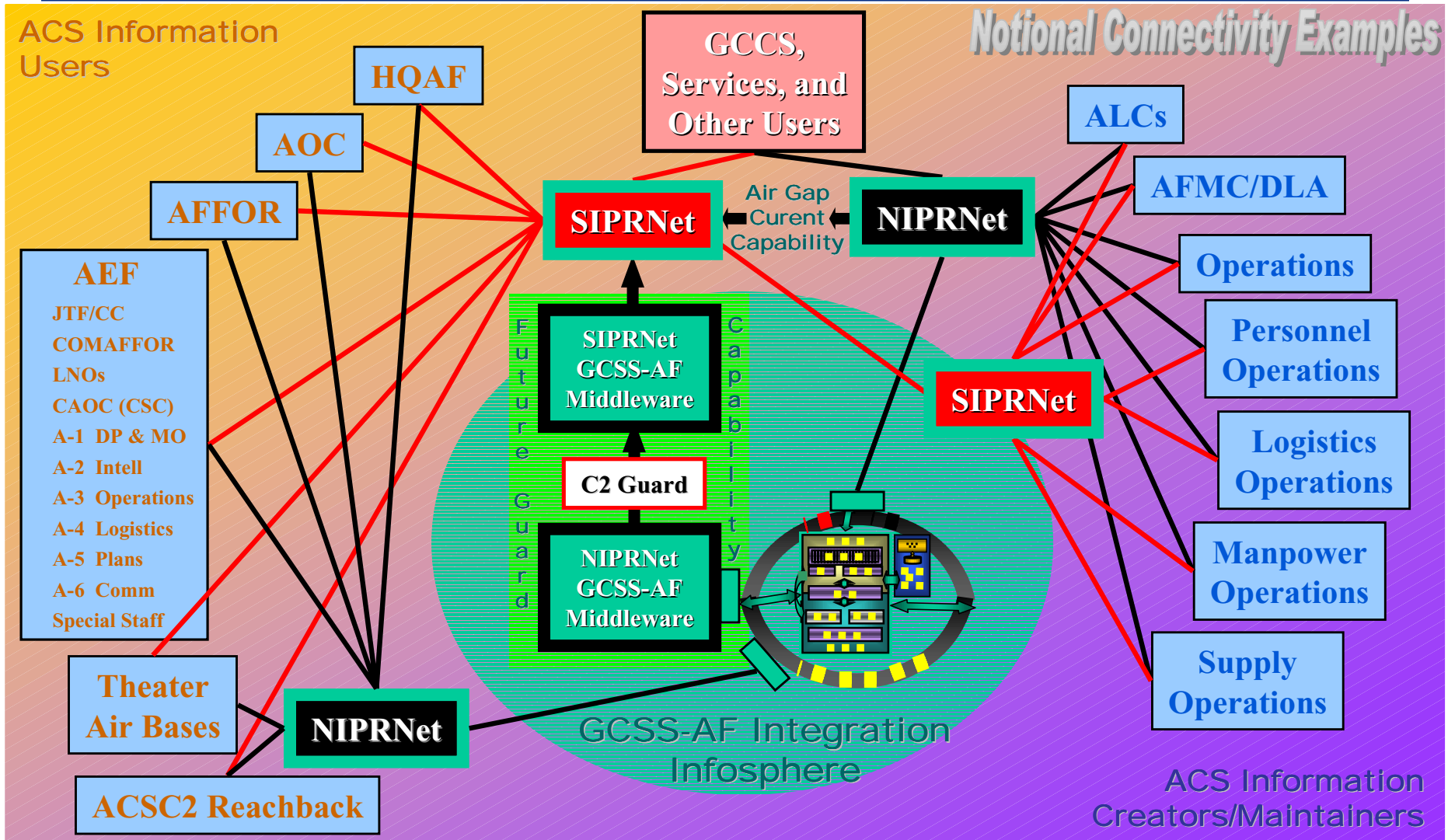
Source: SPO

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

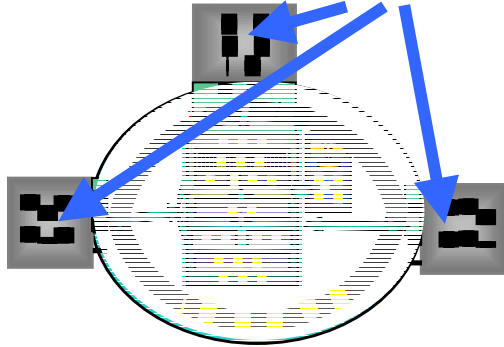




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# GCSS-AF Systems Functionality Description (SV-4)

Warfighter ACS Systems Nodes  
Supported by GCSS-AF  
Integration Infosphere



### ACS C2 Execution

- Forces Beddown
- Warfighter Requirements Coordination
- Sortie Generation

### ACS C2 Dynamic Planning

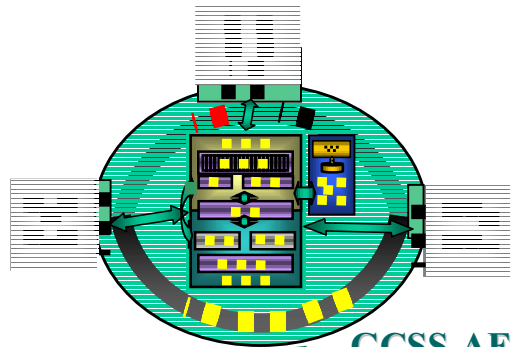
### AEF ACS C2

### Theater ACS C2

### ACS C2 Reachback

### Creation/Maintenance of Accurate Functional Data

Functional Pillars Information Flows  
(Documented by AIS SPOs)



GCSS-AF  
Integration  
Infosphere  
Supporting Warfighter  
ACS Systems Nodes

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

### Enterprise Systems Management (ESM)

### System Security

### Enterprise Data Warehouse (EDW)

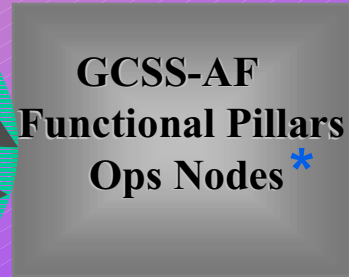
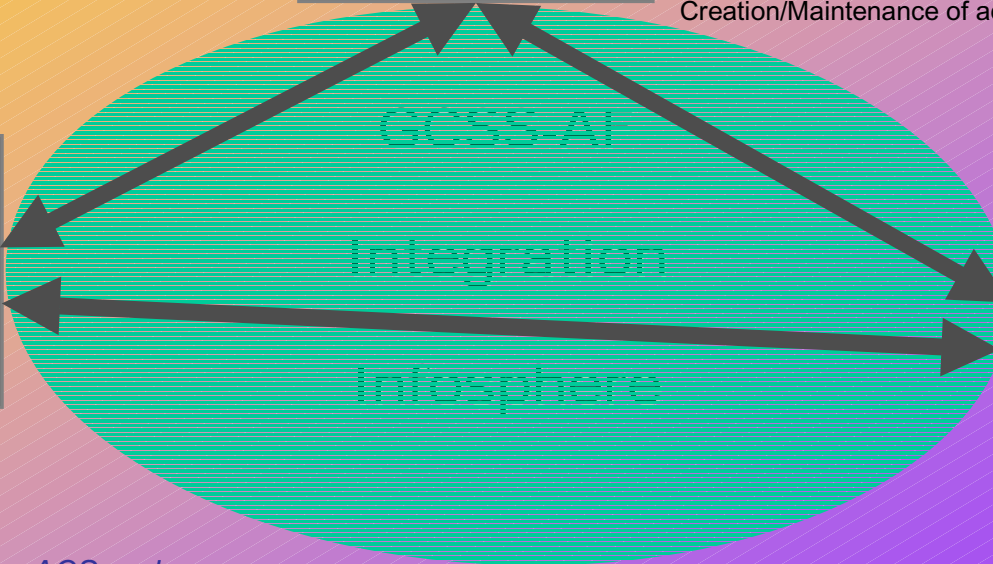
GCSS-AF Subsystem Information Flows  
(Documented by GCSS-AF SPO)



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

Operational Nodes for ACS Information Use



## Functions Within Warfighter Nodes

- ACS C2 Execution Functions
  - Forces Beddown
  - Warfighter Requirements Coordination
  - Sortie Generation
- ACS C2 Reachback Functions
- ACS C2 Dynamic Planning Functions
- Theater ACS C2 Functions
- AEF ACS C2 Functions
- Creation/Maintenance of accurate functional data

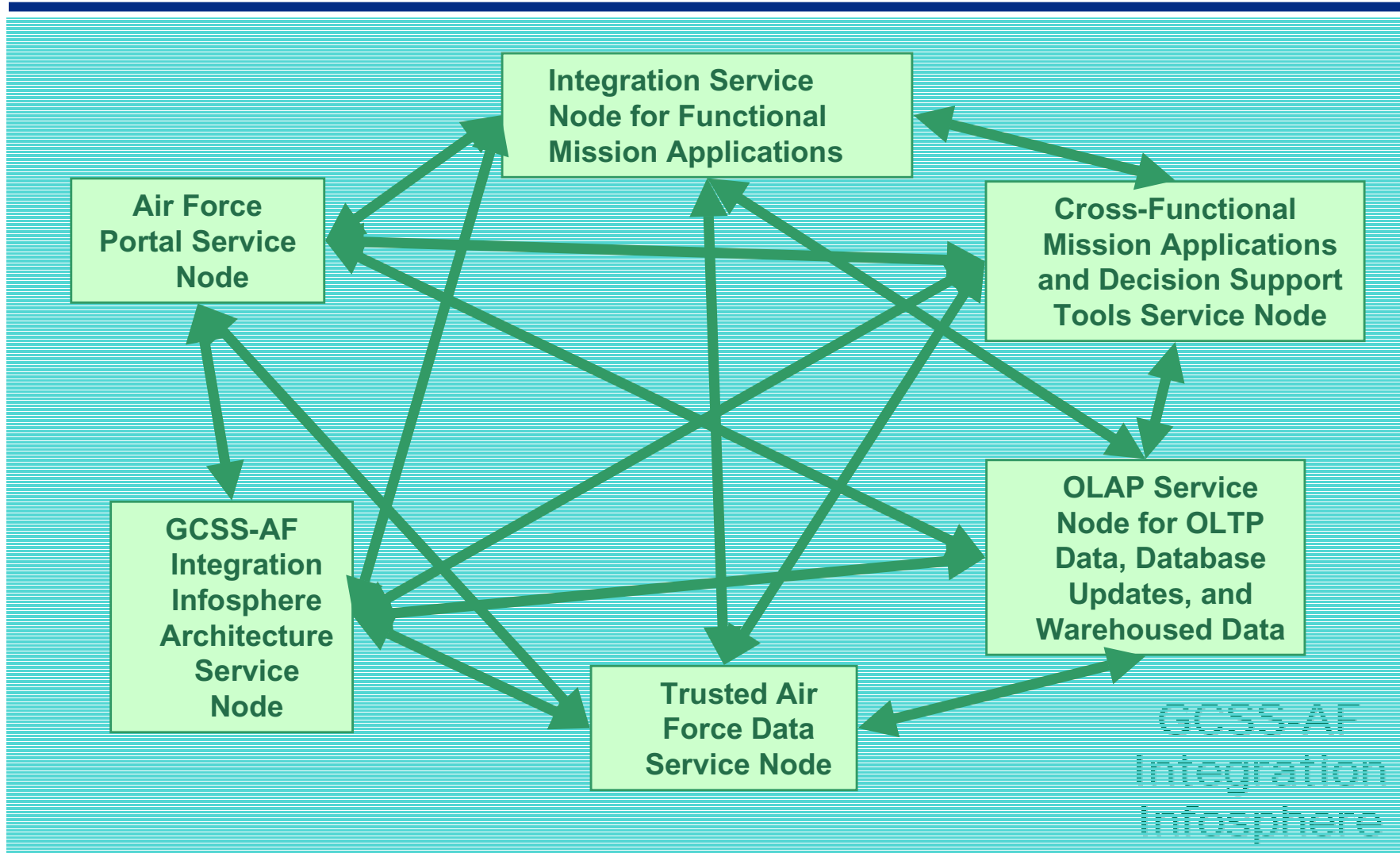
\* All GCSS-AF Warfighter ACS nodes are functionally identical, independent, and supported by the same set of Integration infosphere functions

Operational Nodes for ACS Information Maintenance/Creation



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

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GCSS-AF  
Integration  
Infosphere



# GCSS-AF Systems<sup>2</sup> 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	

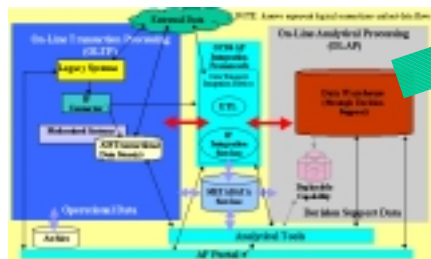
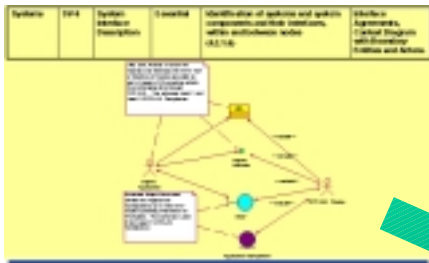
**GCSS-AF Warfighter Operational Activity to System Function Mappings**  
(To be documented by AIS SPOs)



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

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



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			
			Category	Size	Media	Format	Protocol Used	CSI Level Available	ID of Source System	Source System	Organization (Model) Where System is	ID of Recipient System	Recipient System	Organization (Model) Where System is
1														

**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)	Requirements				Assurance Attributes				Data Exchange Occurs				
		Frequency	Media	Throughput	Other	Classification/Declassification Resources	Criticality	Legacy/Current Required	Annual/Ad-hoc/Continuous/As-Needed/Retire	Physical	Electronic (passive, active, etc)	Political/Economic	Weather/Terrain	Political/Operational Constraints
1	eg. 1a													
	eg. 1b													
	eg. 1n													
2														
n														



# ***Objectives of the C4ISR Architecture View Update Process***

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



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# ***Sources of the Impact and Change on a System Architecture***

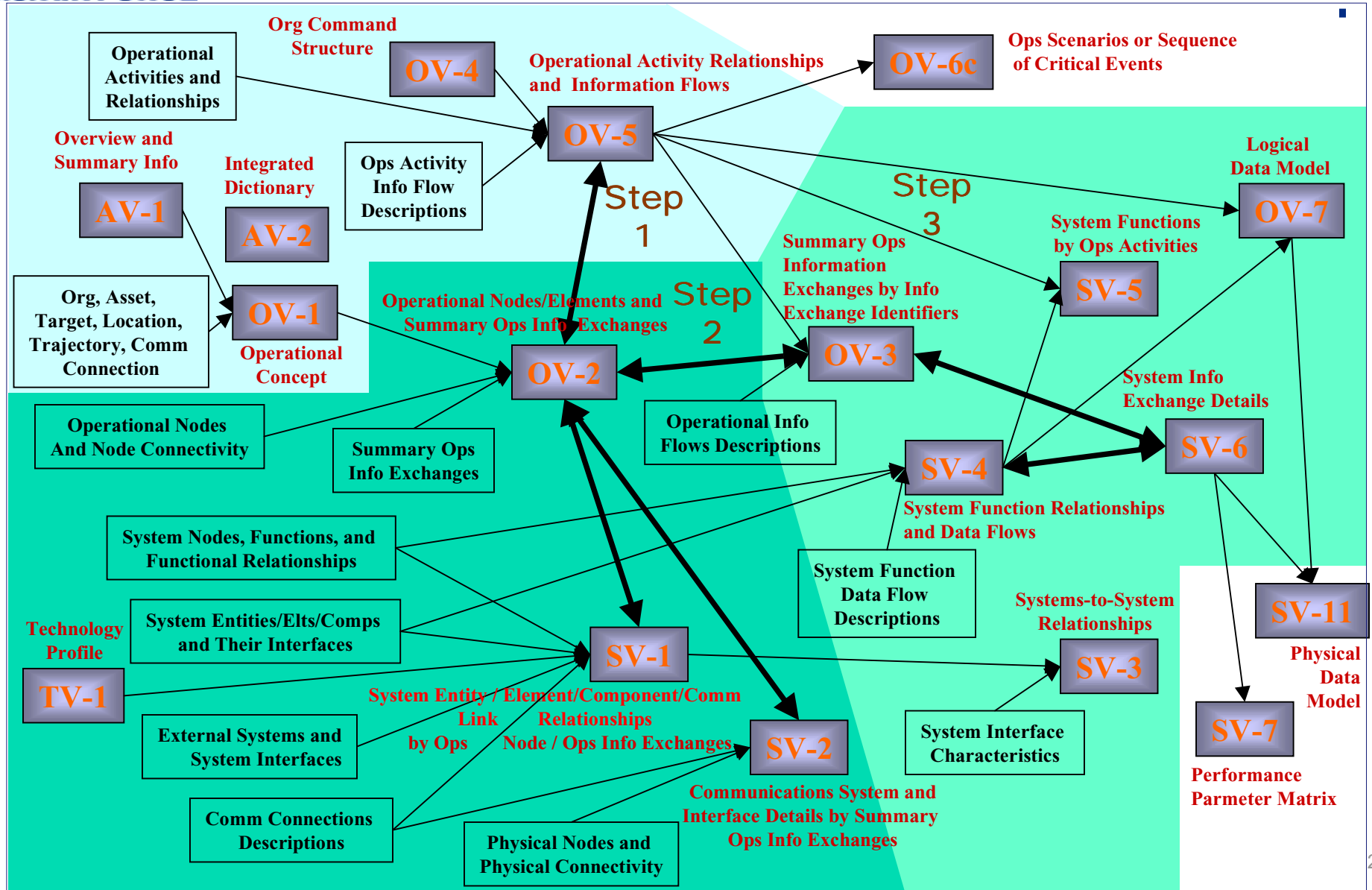
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- n **Immaturity of the system architecture**
- n **Generating the first instance (AV needed; high level data for OVs, SVs, and TVs to get started)**
- n **Adding, deleting, swapping out technologies**
- n **Adding, deleting, swapping out major system functions**
- n **Adding, deleting, swapping out major operational activities**
- n **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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# Insights on the Dynamics of the Update Process

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

