

The C4ISR Architecture Framework and its Impact on the System Engineering Process

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- **History and Evolution of the C4ISR Architecture Framework?**
- **Developing the C4 ISR Architecture Framework 2.0**
- **Overview: The C4ISR Architecture Framework 2.0**
- **The C4ISR Architecture Framework 2.0
Processes and Products**
- **The Zachman Enterprise Architecture Framework**
- **Summary**

What is C4ISR?

Command,

Control,

Communications,

Computers,

Intelligence,

Surveillance, and

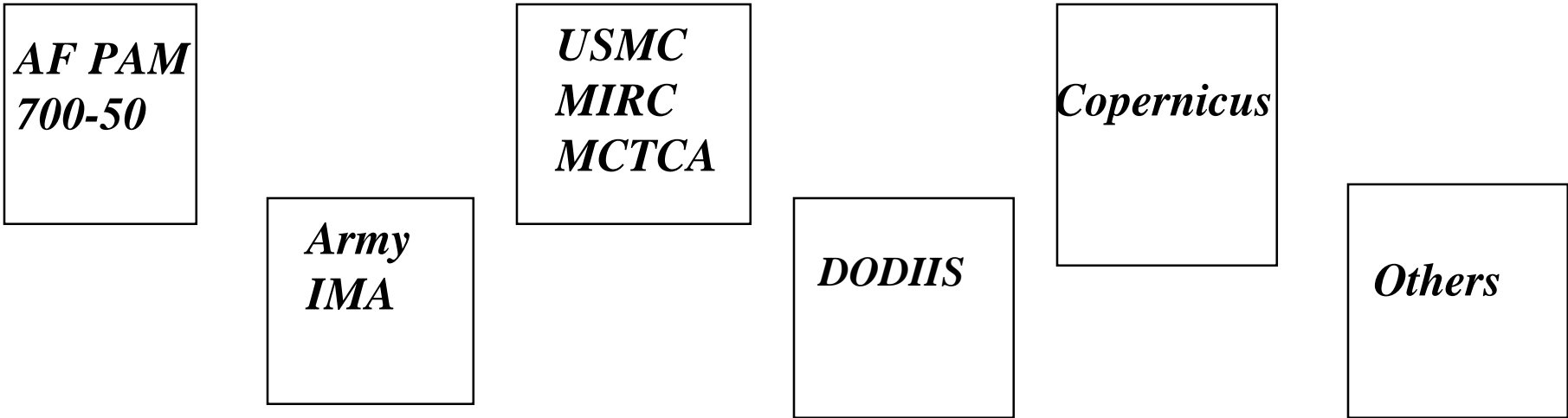
Reconnaissance

“Deep Thoughts” with Implications for Architectures

- **“... break down every problem into as many separate simple elements as might be possible.” (Descartes' second maxim of Discours de la M'ethode)**
- **Picture Principle: When speaking about a dimensional reduction, insert the words “a picture of” in whatever you were about to say.**
- **Pure scientific approach says: “Clear logical thinking requires that we vary only one factor at a time” and “All other things being equal ...”**
- **However, the Strong Connection Law states: “Systems on the average are more tightly connected than the average.”**
- **Leading to the conclusion that: “A system is a collection of parts, no one of which can be changed [without changing the core character of the system].”**
- **Therefore, the study of systems is not conducive to the “one-factor-at-a-time” strategy. (i.e., In systems, all other things are rarely equal)**

History and Evolution of the C4ISR Architecture Framework

The “Stovepipe” Environment c.1991 (Desert Storm)



No Single Structure Defines the Components or the DoD Technical Infrastructure

Different Principles Assumptions and Terminology are used in Service/Agency Architectures

Will Lead to Systems that are Non-Integratable and Non-Interoperable

The Problem

- **Disparate architecture views and approaches**
- **Current initiatives excellent, but unintegrated (Horizon, Enterprise, Copernicus, ...)**
- **DoD-Level efforts being working in parallel (ITF, JTA, AMWG, FPI, DII, ...), but not readily coupled**

We are still unable to articulate how our current and planned capabilities fit in context with Joint/Combined mission operations, the evolving infrastructure, and other CINC, Service, and Agency initiatives.

DepSecDef Tasking Memo

October 10, 1995

“...I am directing the acceleration of the development of C4I integration and architecture efforts through the creation of a DoD-wide C4I Integrated product Team. ...I have designated the ASD(C3I), in his capacity as the department’s C4I architect to sponsor, organize, and manage this effort.”

- **Outlines the Specific Purposes**

- ***“...to define and develop better means and processes to ensure C4I capabilities most effectively meet the needs of the warfighters.”***
- ***“...to outline the roles, responsibilities, and authorities required to implement these across DoD”***
- ***“...to make specific recommendations for implementation”***

- **Information Technology Management Reform Act (ITMRA)**

- » Clinger-Cohen Act, 1996 (Public Law 104-106)
- » Chief Information Officer (CIO)

- **Office Management and Budget**

- » Chairs Federal CIO Council
- » Follow on Guidance
- » M-97-16, June 1997

Definition and Direction: “Make it so...”

- ***An architecture is defined as the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time.***

IEEE STD 610.12 as extended in the C4ISR Architecture Framework v. 2.0

- ***We see the C4ISR Architecture Framework as a critical element of the strategic direction in the Department, and accordingly direct that all on-going and planned C4ISR or related architectures be developed in accordance with Version 2.0. Existing C4ISR architectures will be redescribed in accordance with the Framework during appropriate revision cycles.***

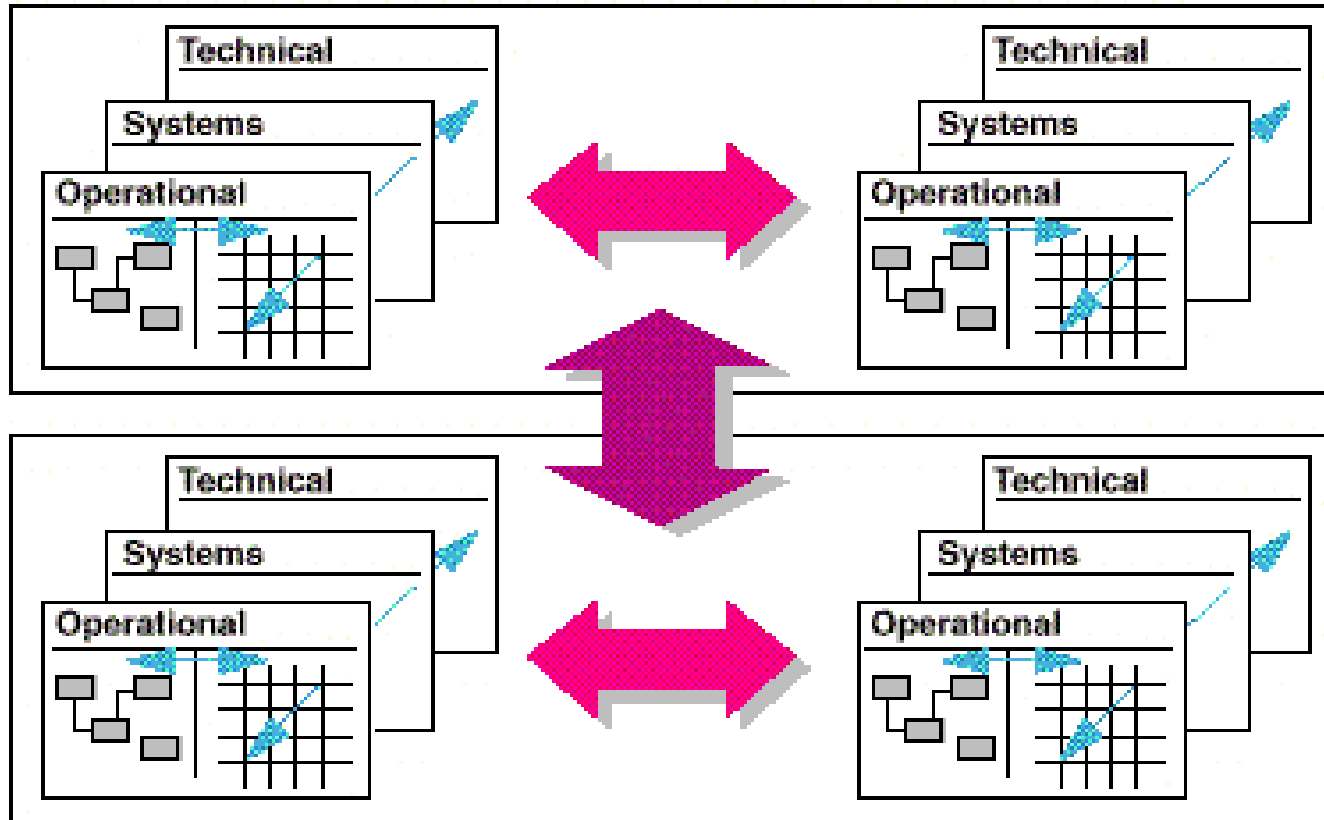
USD (A&T), ASD(C3I), Joint Staff Director for C4 Systems

23 February 1998 Memorandum

Subject: Strategic Direction for a DoD Architecture Framework

Developing the C4ISR Framework ***v. 2.0***

Integrating Architectures



Integration within and across architecture views

Integration between architectures of the same level

Integration between different level architectures

» **Operational Architecture**

- » *Descriptions of the tasks, operational elements, and information flows required to accomplish or support a warfighting function.*

» **Systems Architecture**

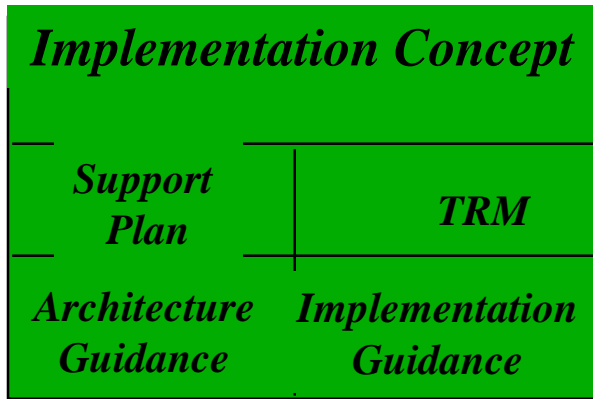
- » *Descriptions, including graphics, of systems and interconnections providing for or supporting warfighting functions.*

» **Technical Architecture**

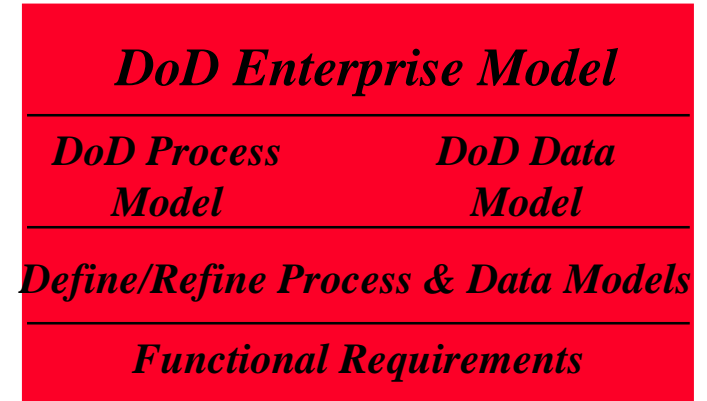
- » *A minimal set of rules governing the arrangement, interaction, and interdependence of the parts or elements whose purpose is to ensure that a conformant system satisfies a specified set of requirements.*

Two Approaches, One Solution

Technical AFIM*

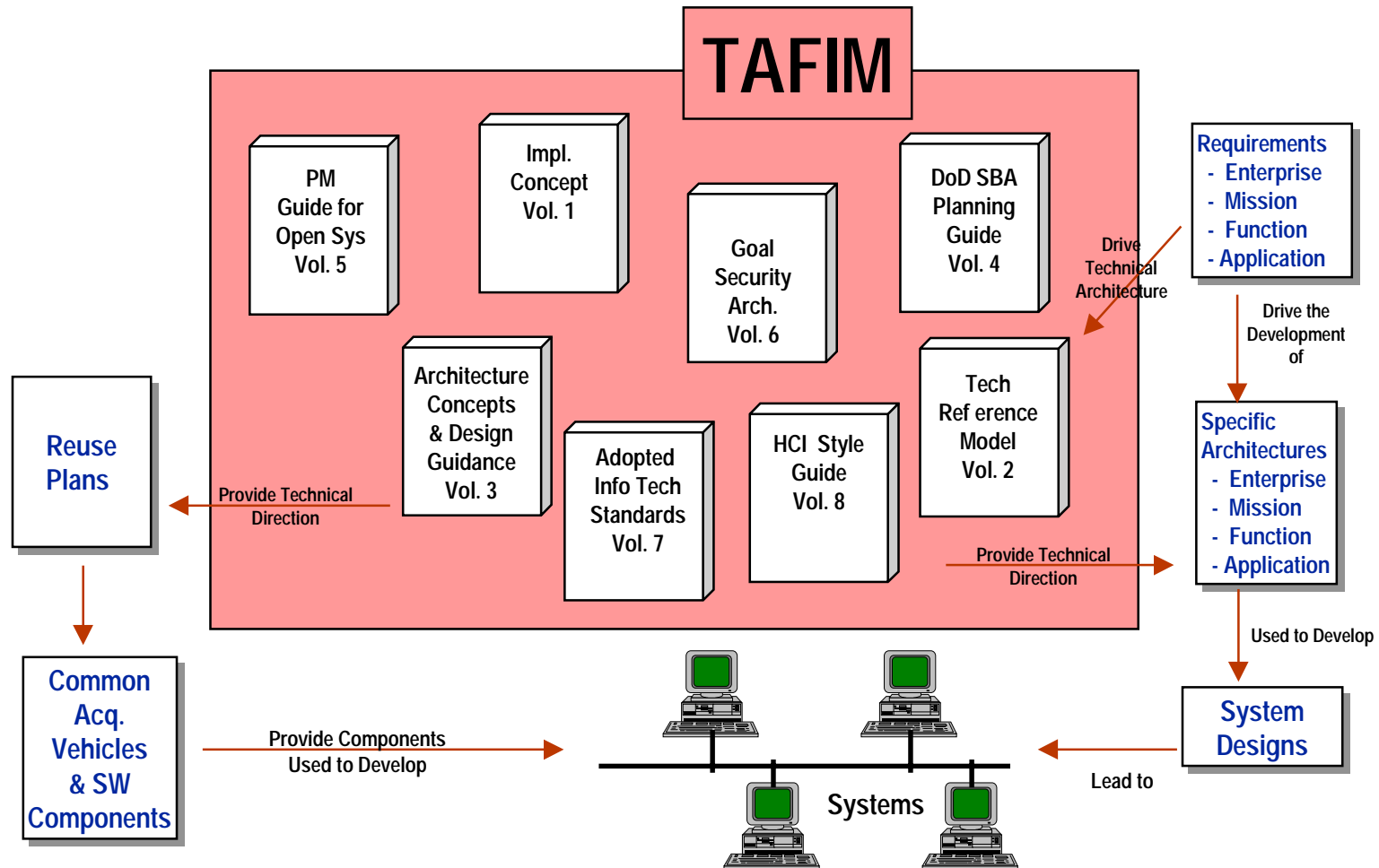


Functional AFIM*



* AFIM=
Architectural Framework for
Information management

Technical Architecture Framework for Information Management (TAFIM)



What Drives C4ISR?

- **The *Joint Technical Architecture (JTA)* draws on the *Technical Architecture Framework for Information Management (TAFIM)* to identify a common set of mandatory information technology standards and guidelines to be used in all new and upgraded C4I acquisitions across DoD.**

How Will DoD Address the OMB Guidance?

*“Agencies may...create a **model** that suits the agency’s organizational needs.”*

The Proposed DoD Model

- *DoD C4ISR Architecture Framework*
 - *OMB, ITA, Appendix I*
 - *Operational, Systems, and Technical Architectures*
 - *Version 2.0 Approved Dec 18, 1997*
- *DoD Technical Reference Model*

An Agency-Wide Model

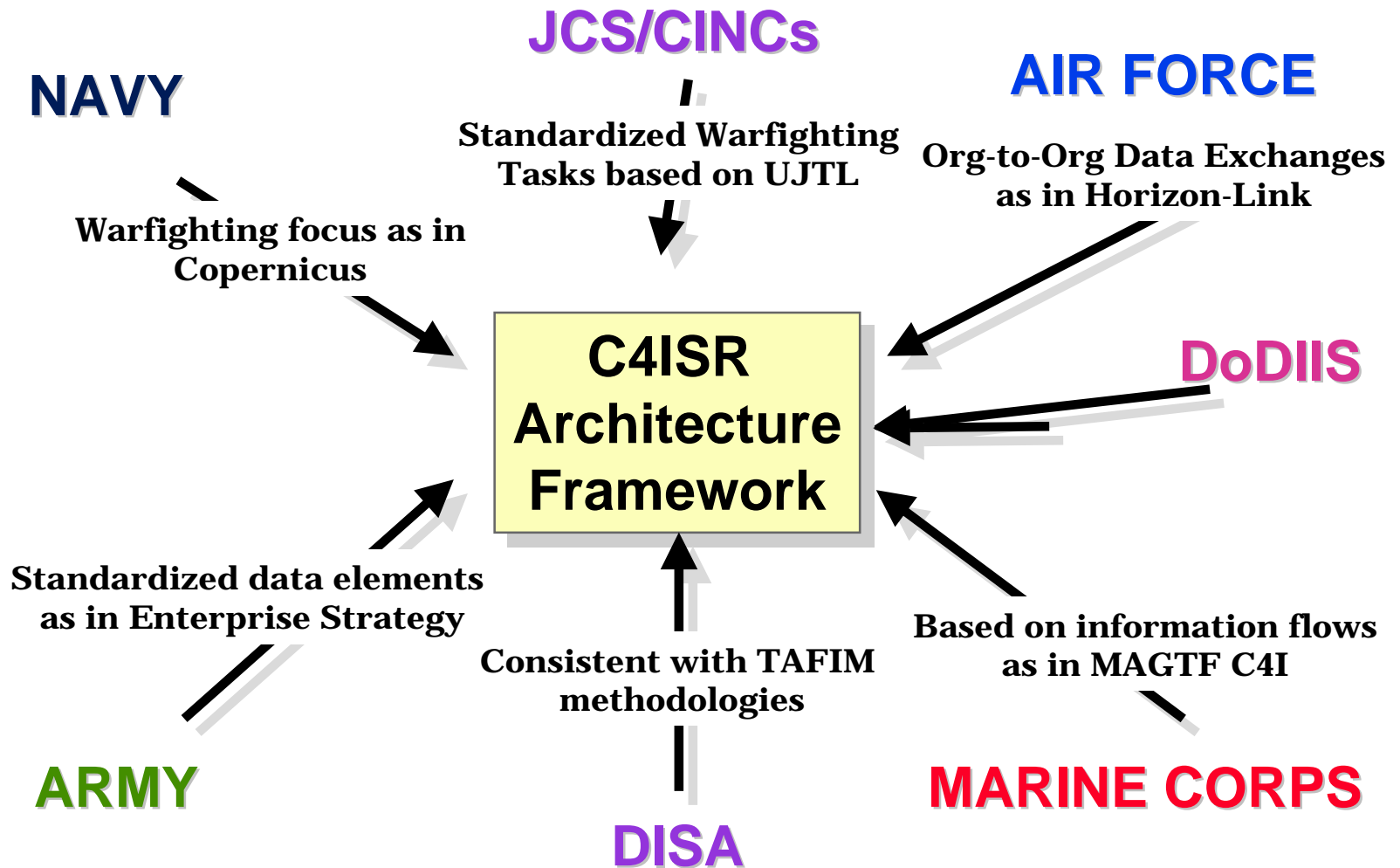
- *shall Conform or “map” to elements of ITA*
- *shall define how to describe an ITA*

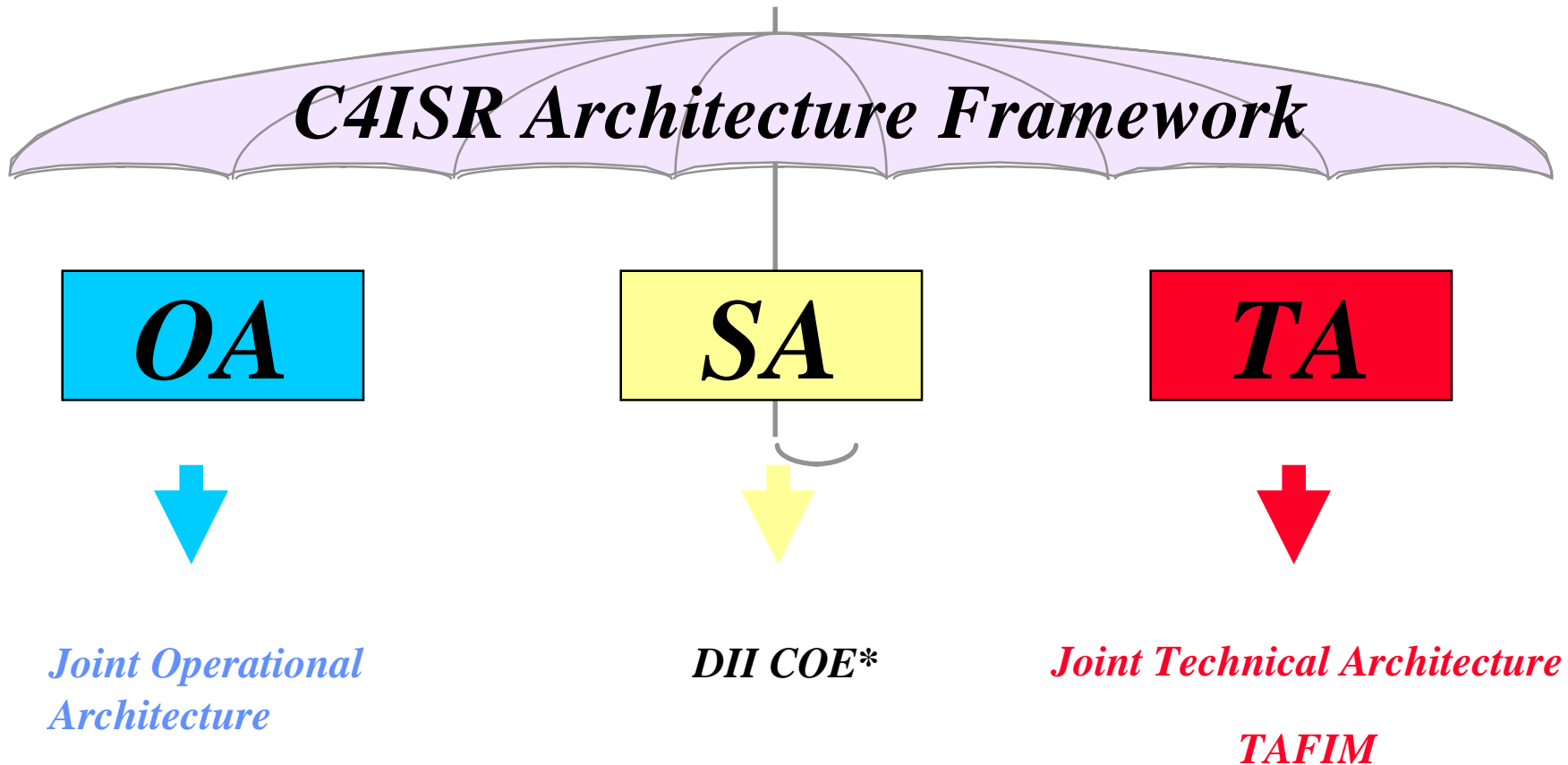
An Agency-Wide IT Architecture

- *shall develop a description based on Agency-Wide Model*
- *shall support Sub Agency Architectures*

Overview:
The C4ISR Architecture Framework 2.0

Leveraging Other Efforts





*Defense Information Infrastructure Common Operating Environment

What is it?

A minimal set of rules and guidance that will improve the development, integration, and assessment of C4ISR architectures in context with joint/combined mission operations

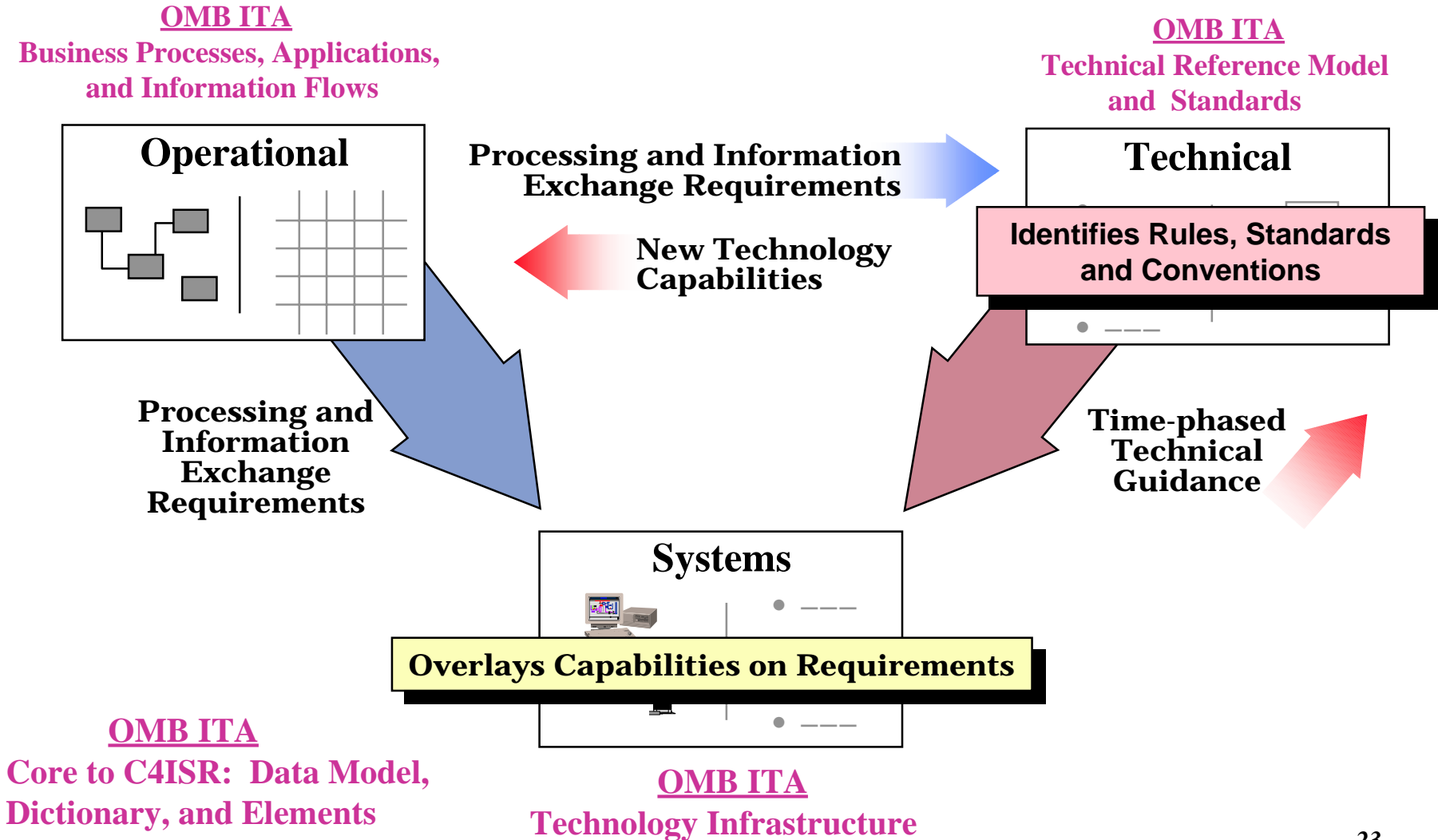
What will it do?

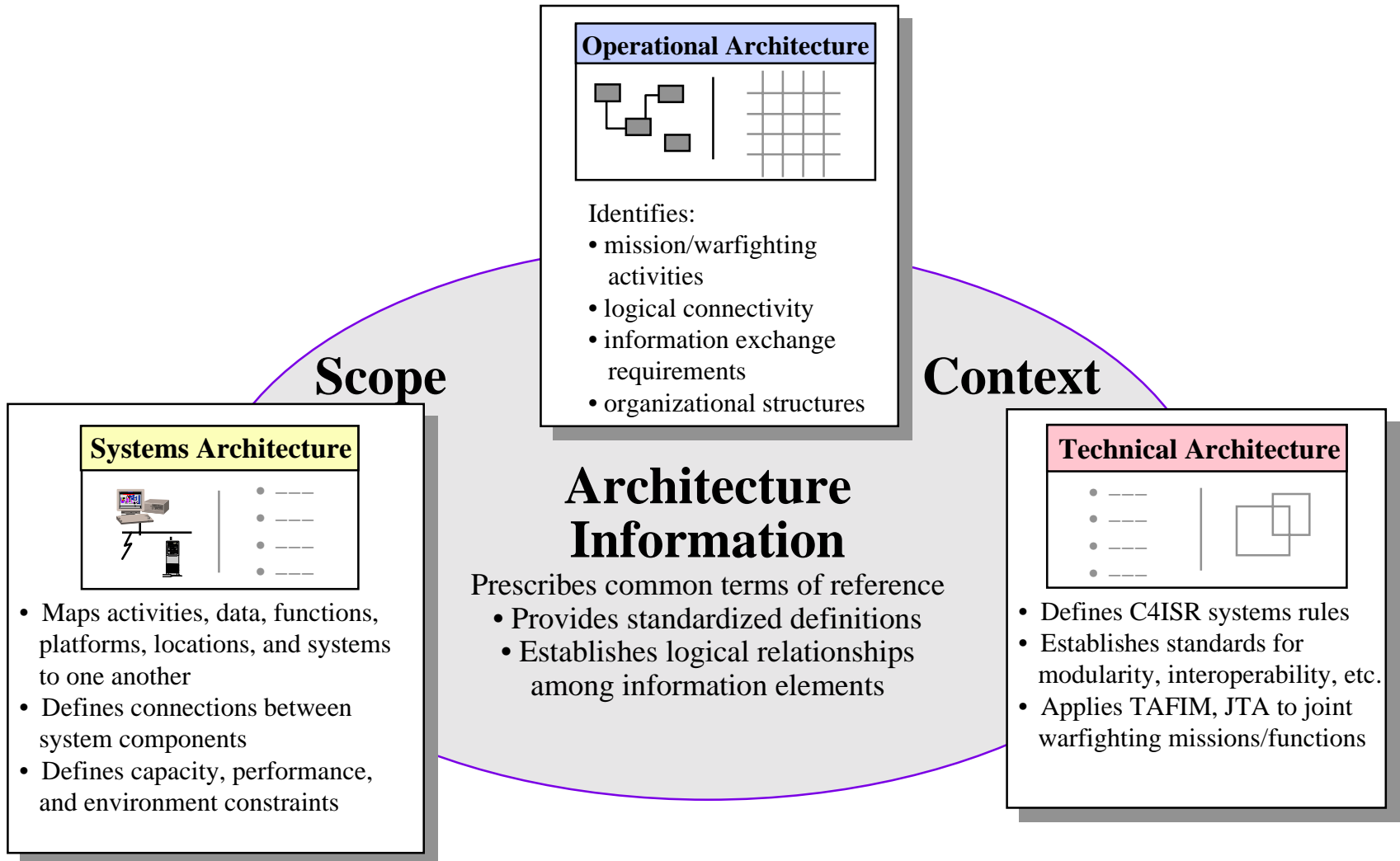
Provide the capability to leverage, compare, contrast, and integrate different architectures

Make architectures more understandable across the community and improve our capability to create a joint, integrated C4ISR environment

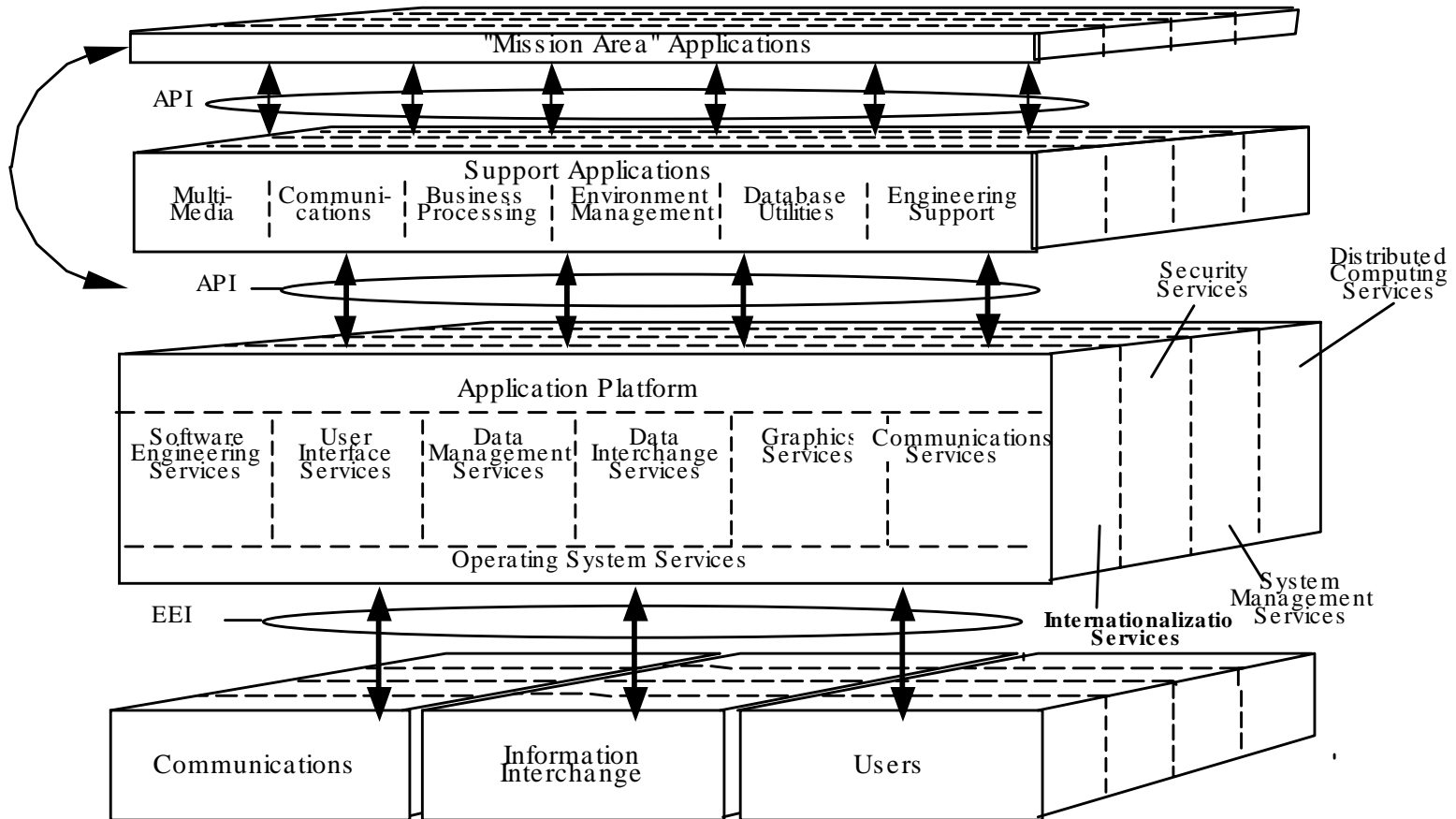
Enable the use of architectures to improve operational effectiveness, interoperability, efficiency, etc.

C4ISR Architecture Framework -- Architecture Relationships





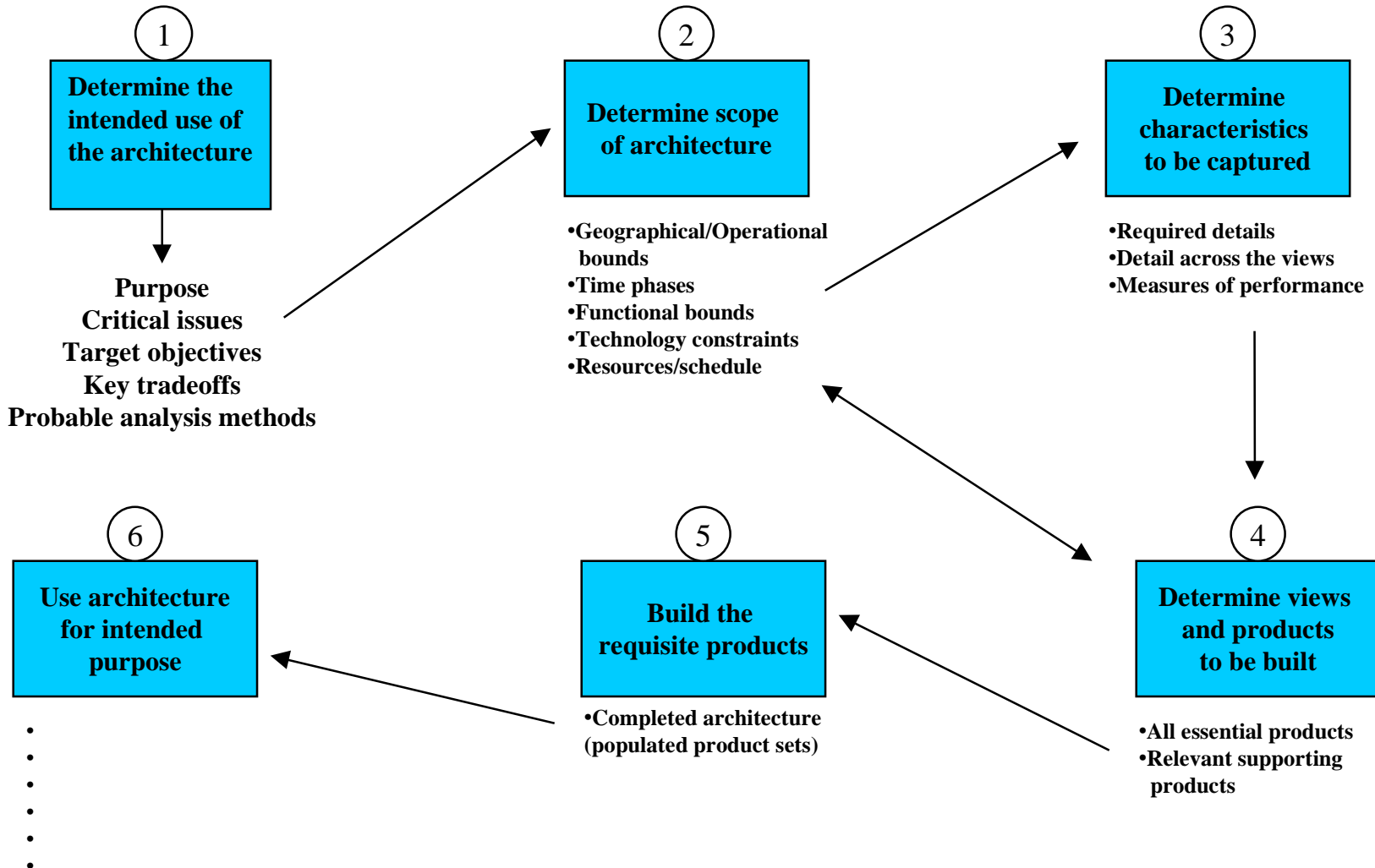
DoD Technical Reference Model



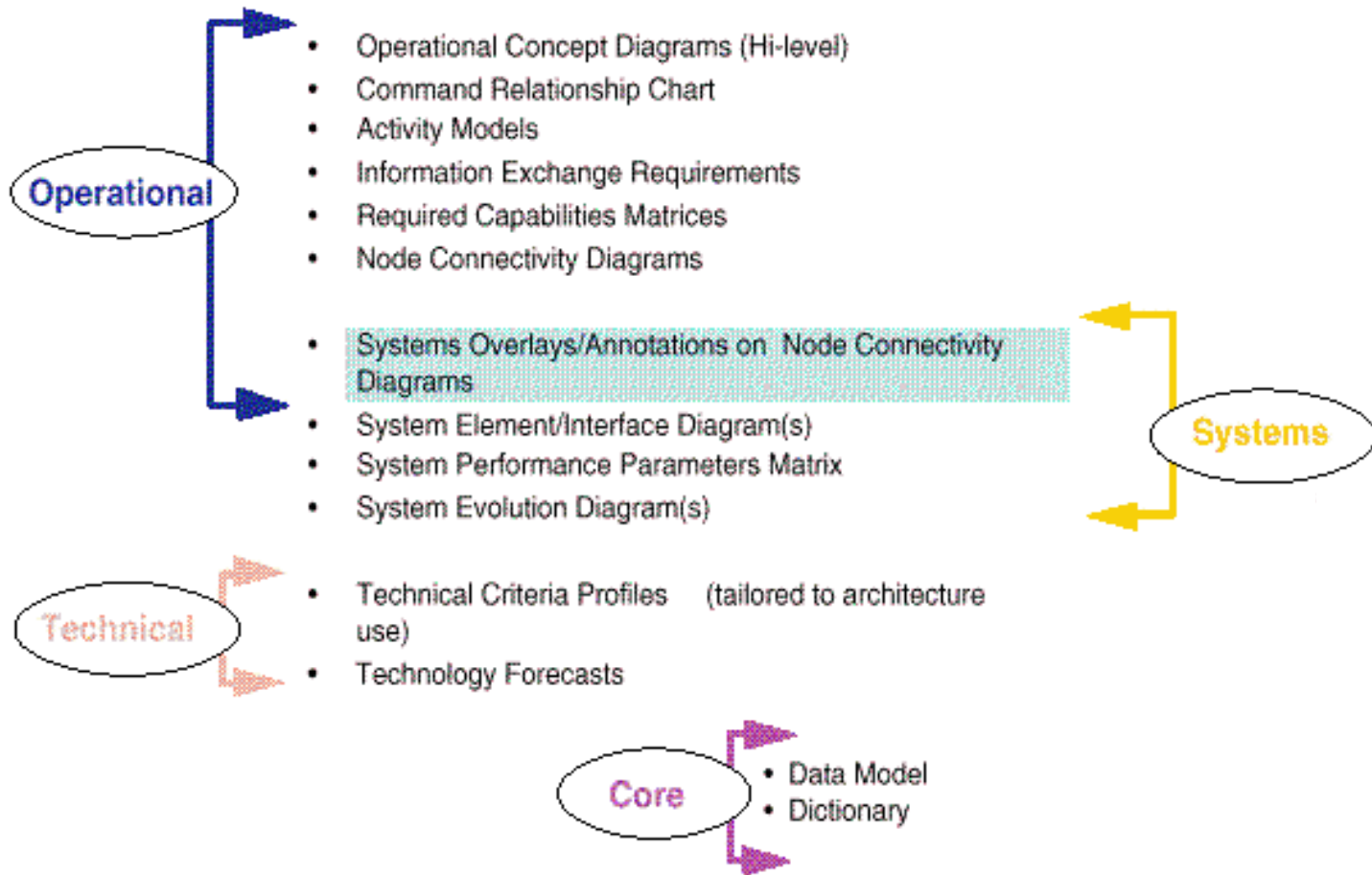
Modeled after IEEE 1003.0 Ref Model

The C4ISR Architecture Framework 2.0 Processes and Products

Six Step Process for Building a C4ISR Architecture



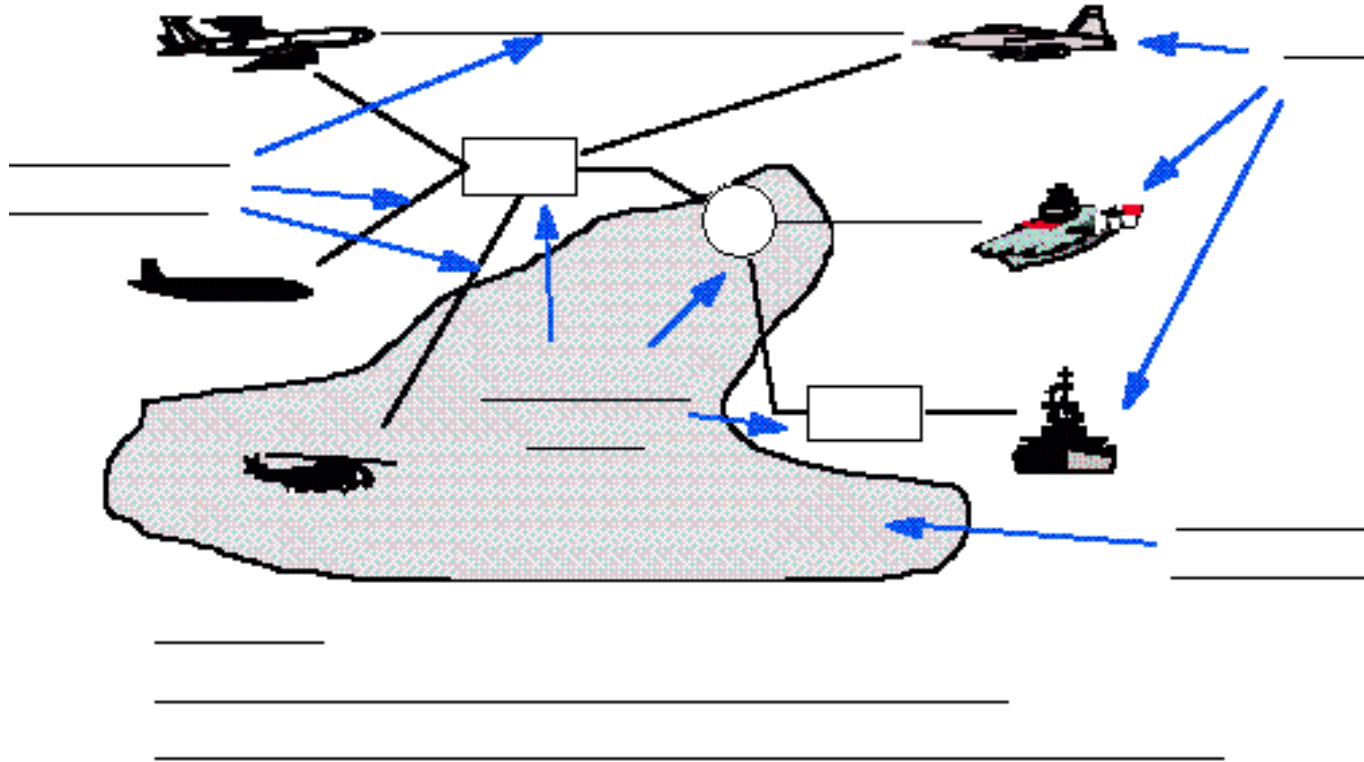
Initial C4ISR Architecture Product Sets



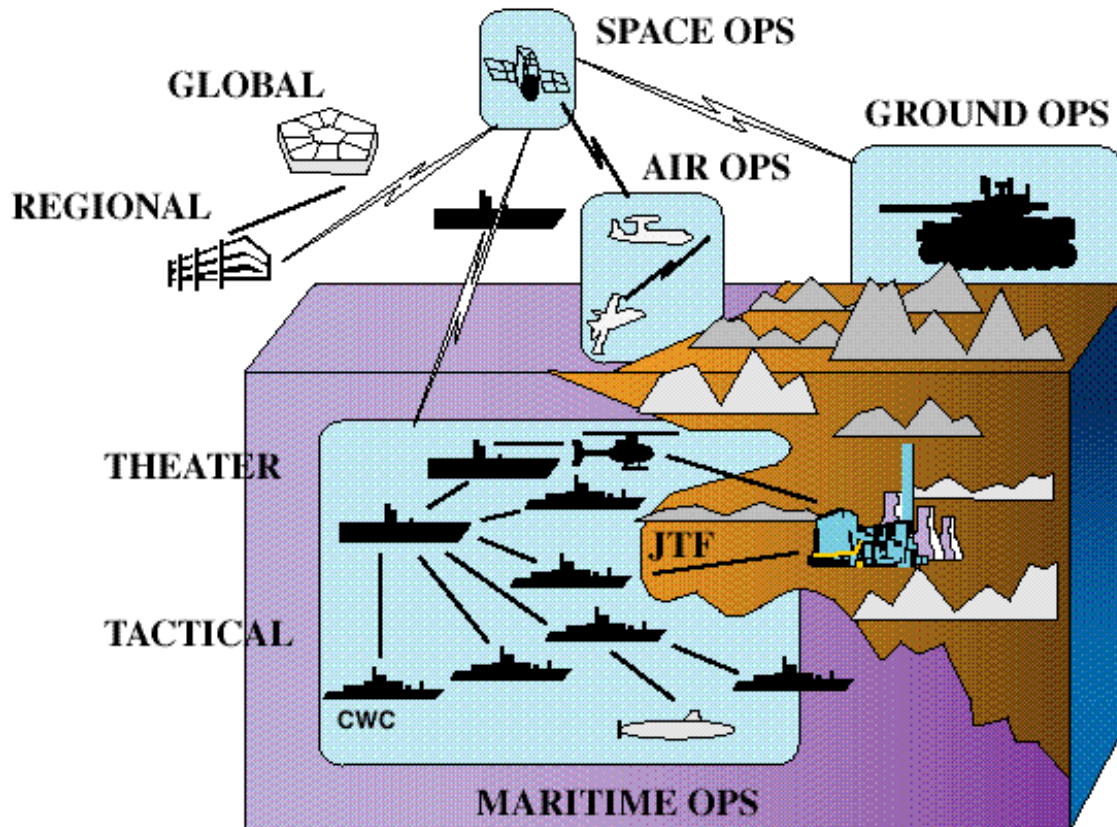
Sample Use of Architectural Products

Sample Questions	Typical Applicable Architecture Products		
	Operational	Systems	Technical
Who needs the information?	Operational Concept Diagrams Command Relationship Charts		
Who produces the information?	Operational Concept Diagrams Command Relationship Charts	Supporting Systems Diagrams/Descriptions	
Do the means exist to convey the information from the producers to the users?	Operational Concept Diagrams Node Connectivity Diagrams	System Data Flow Diagrams	Information Standards Descriptions
Do systems have the set of enabling functions necessary to conduct the required information transactions?	Activity Diagrams/ Data Models	Systems Overlays/ Annotations on Node Connectivity Diagrams Activity Allocation to System Component Descriptions	
Are the enabling functions implemented in accordance with approved DoD-wide standards, conventions, product-based solutions, etc.?		Supporting Systems Diagrams/Descriptions	Information Standards Descriptions

Operational Concept Diagram Template



Completed Operational Concept Diagram



Common Basis for Defining Missions and Tasks

Universal Joint Task List (JCS)

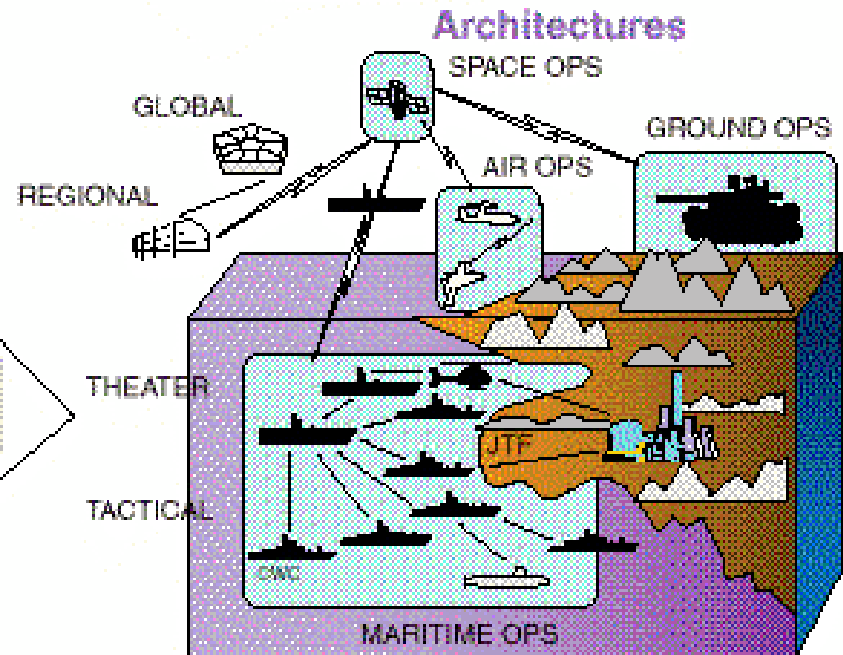
- Strategic National
- Strategic Theater
 - Operational
 - Tactical

Joint Mission Essential Task List (CINCLANTFLT)

Mission Essential List (Service)

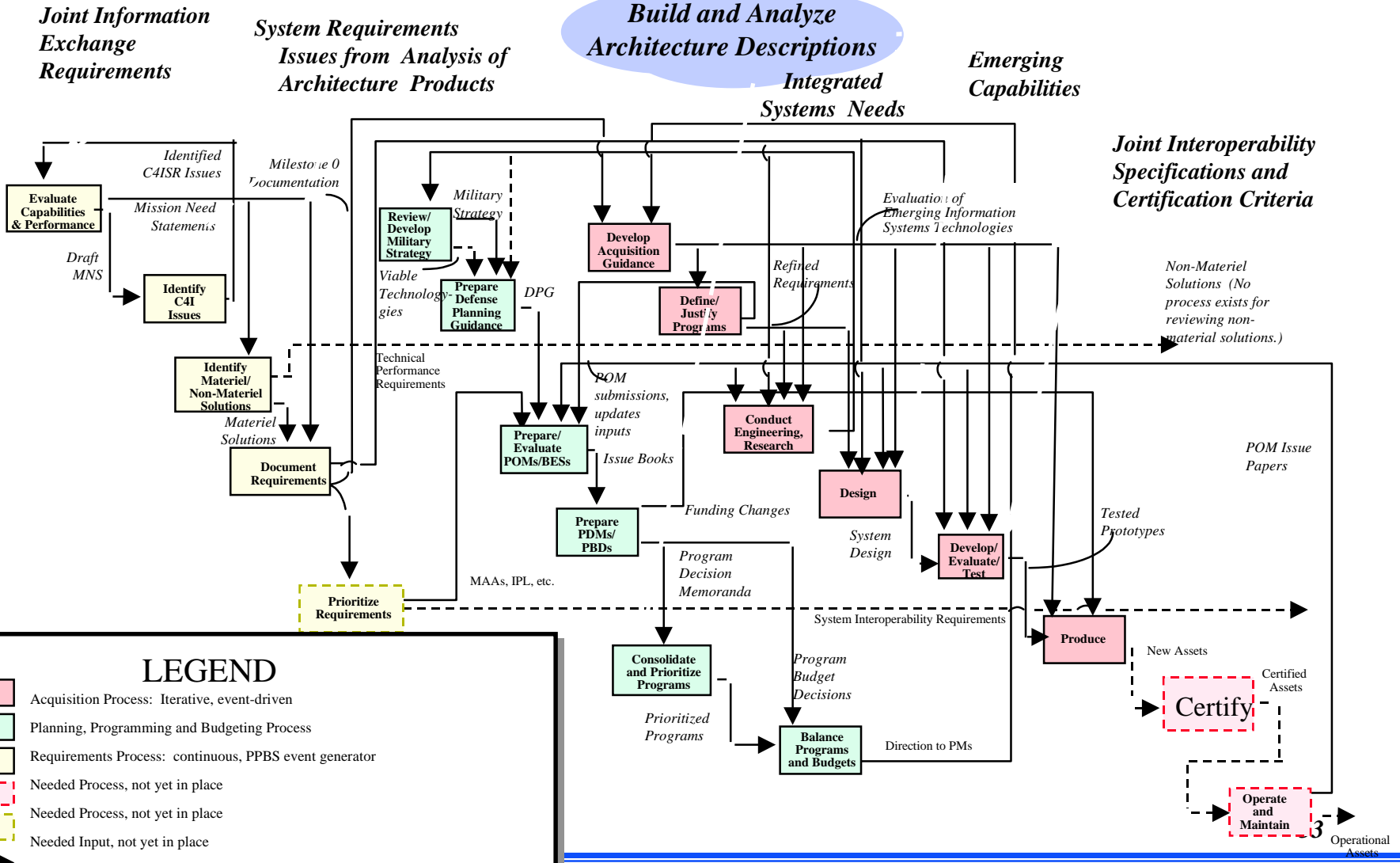
Missions/Tasks (Operational Element)

UJTL covers all DoD warfighting and non-warfighting tasks

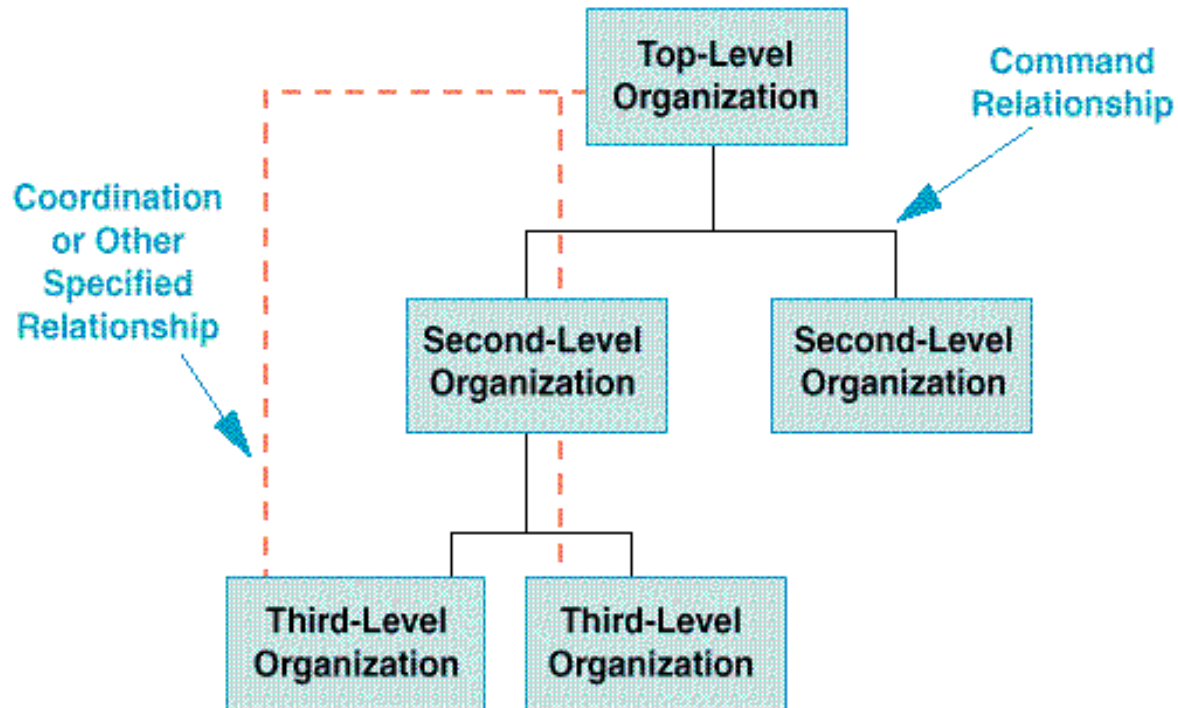


IT Architecture Must Impact the Three Major Processes

Build and Analyze Architecture Descriptions



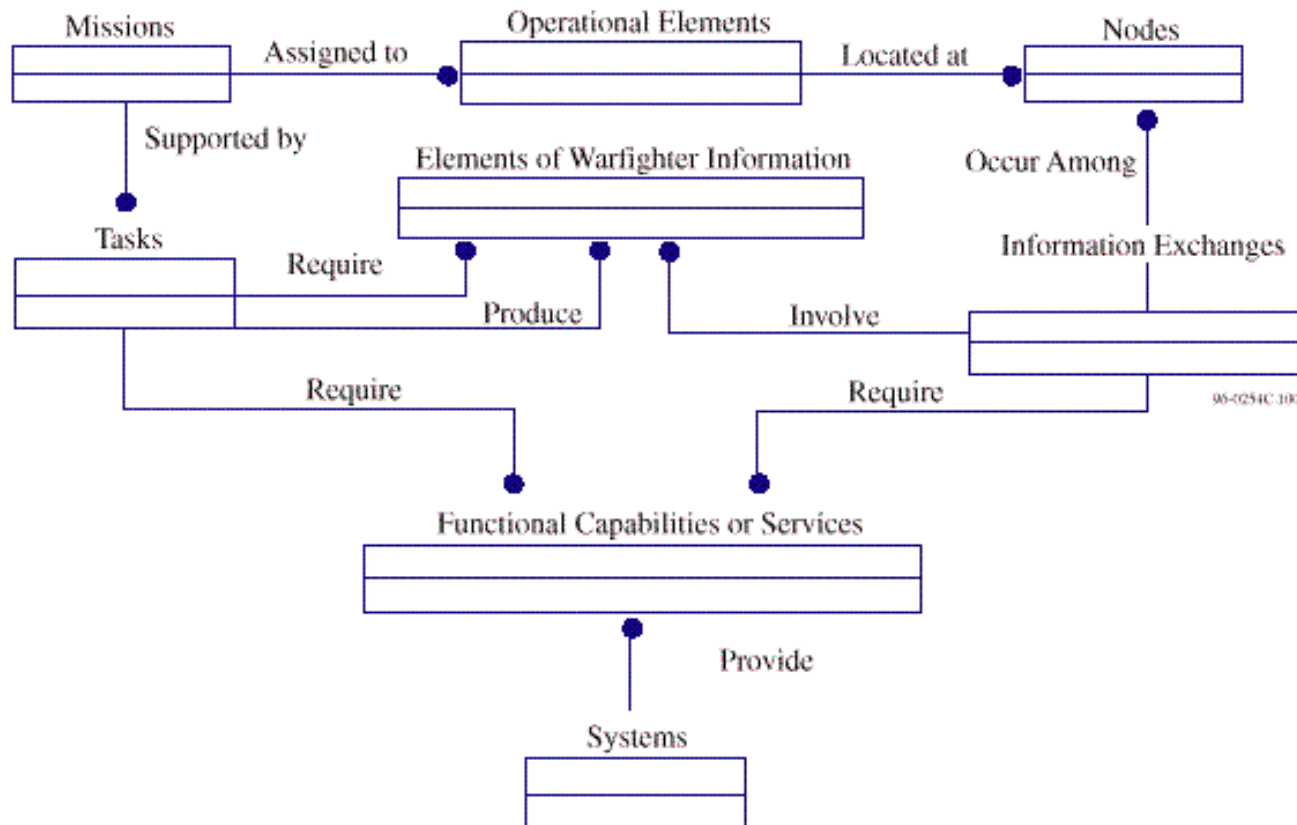
Command Relationships Chart



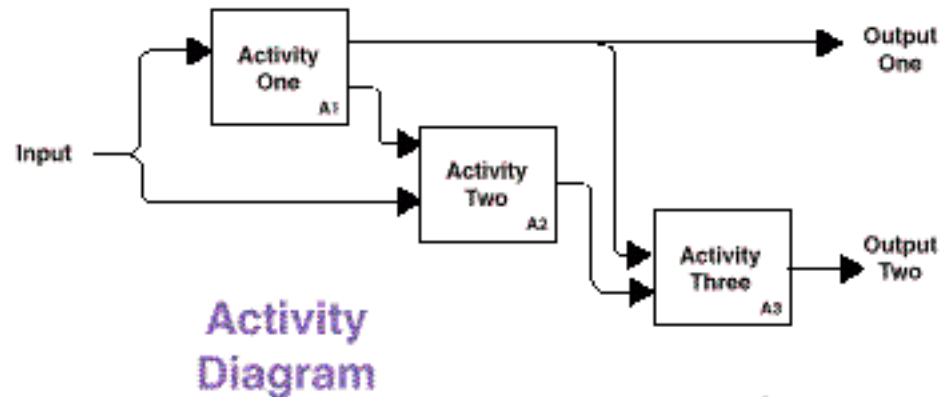
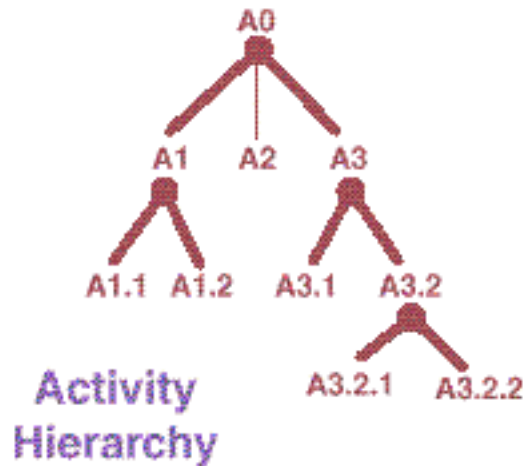
Features:

- Identifies command, control, and coordination relationships among operational elements organizations
- Level of detail commensurate with intended architecture use

Logical Data Model of Architecture Information



Operational Activity Diagram



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Features:

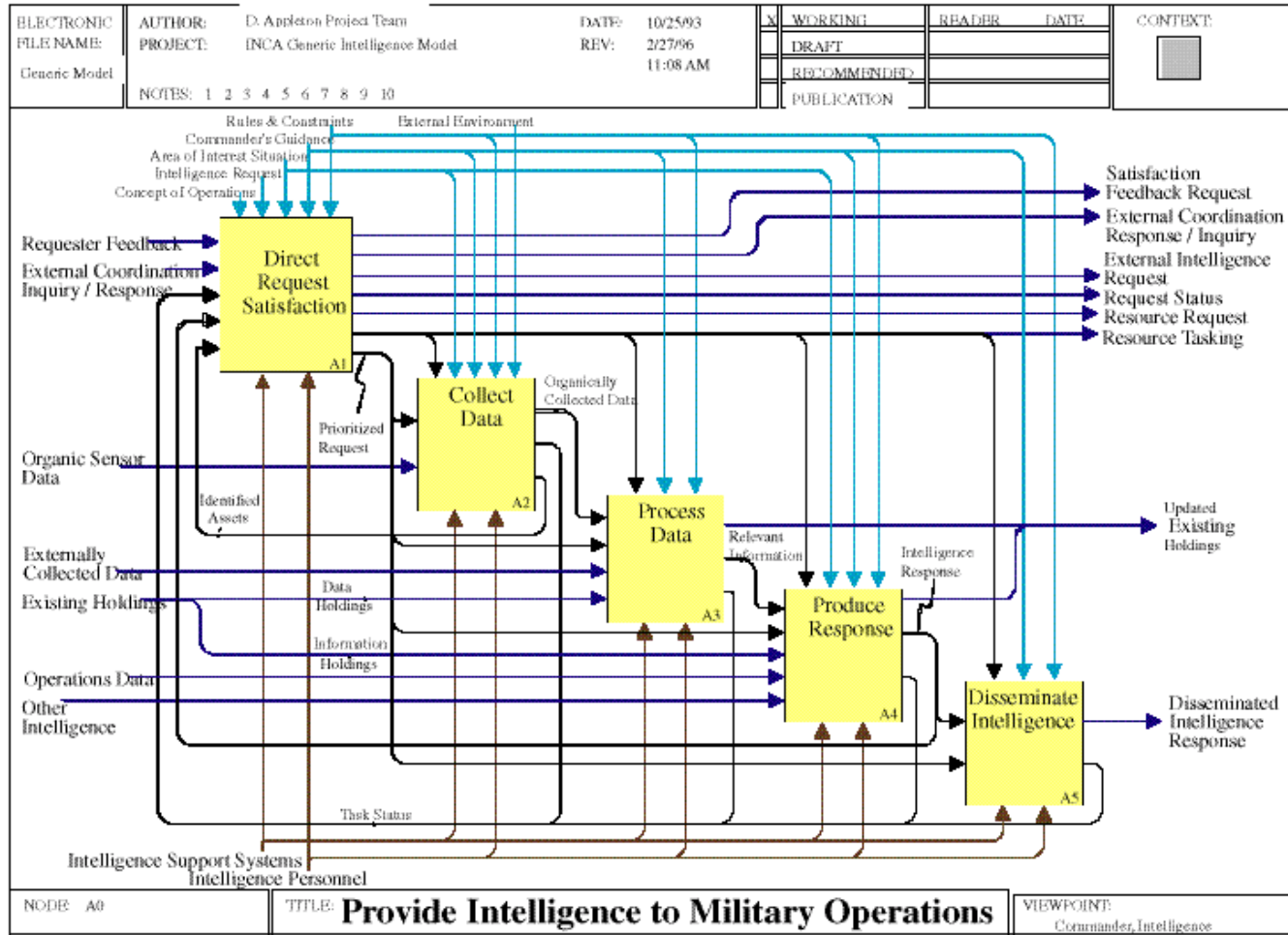
- Keyed to warfighter (e.g., UJTL) activities
- Activities assigned to nodes (organizations, facilities, workstations, etc.), depending on level of architecture



INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING

DELAWARE VALLEY CHAPTER

Sample Activity Model



The Zachman Enterprise Architecture Framework

ENTERPRISE ARCHITECTURE - A FRAMEWORK TM

	DATA <i>What</i>	FUNCTION <i>How</i>	NETWORK <i>Where</i>	PEOPLE <i>Who</i>	TIME <i>When</i>	MOTIVATION <i>Why</i>	
SCOPE (CONTEXTUAL) <i>Planner</i>	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) <i>Planner</i>
ENTERPRISE MODEL (CONCEPTUAL) <i>Owner</i>	e.g. Semantic Model Ent = Business Entity Rein = Business Relationship	e.g. Business Process Model Proc. = Business Process I/O = Business Resources	e.g. Business Logistics System 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) <i>Owner</i>
SYSTEM MODEL (LOGICAL) <i>Designer</i>	e.g. Logical Data Model Ent = Data Entity Rein = 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) <i>Designer</i>
TECHNOLOGY MODEL (PHYSICAL) <i>Builder</i>	e.g. Physical Data Model Ent = Segment/Table/etc. Rein = Pointer/Key/etc.	e.g. System Design Proc.= Computer Function I/O = Data Elements/Sets	e.g. Technology Architecture Node = Hardware/System Software Link = Line Specifications	e.g. Presentation Architecture People = User Work = Screen Format	e.g. Control Structure Time = Execute Cycle Cycle = Component Cycle	e.g. Rule Design End = Condition Means = Action	TECHNOLOGY MODEL (PHYSICAL) <i>Builder</i>
DETAILED REPRESENTATIONS (OUT-OF-CONTEXT) <i>Sub-Contractor</i>	e.g. Data Definition Ent = Field Rein = 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 Cycle = Machine Cycle	e.g. Rule Specification End = Sub-condition Means = Step	DETAILED REPRESENTATIONS (OUT-OF-CONTEXT) <i>Sub-Contractor</i>
FUNCTIONING ENTERPRISE	e.g. DATA	e.g. FUNCTION	e.g. NETWORK	e.g. ORGANIZATION	e.g. SCHEDULE	e.g. STRATEGY	FUNCTIONING ENTERPRISE

Architectures Impact the SE Processes by:

- **Providing a mechanism for understanding and managing complexity**
 - » **Provides a Concept of Operations for “System of Systems”**
 - » **Who, what, when, where why and how defined and documented at logical/physical levels**
- **Telling a story**
 - » **Defines requirements -- drills down to system interfaces**
- **Defining specific SE products**
 - » **Task specific algorithms**
 - » **Diagramming requirements**
 - » **Configuration Management support**
 - » **Report outputs**
- **Identifying critical requirements early in the SE process**
 - » **Can requirements be achieved?**
 - » **Drives future requirements definitions as technology evolves**
 - » **Supports technology refresh**

"The big thing we learned was that the first thing you have to have is the right system architecture across the joint environment."

Lt. Col. Bill Riley, USAF

TBMCS Program Manager

Aerospace Command, Control & Intelligence Surveillance and Reconnaissance Center

Langley AFB, VA

The future of architectures?

"The system was so swift that human beings simply could not handle the target volume without extensive automated support, and the system was designed to fight on full automatic, relying on its human masters for key decisions. For overall guidance, for setting or revising priorities, and for defining operational parameters. Technically, this most potent warfare machine ever built had the capability to carry on the fight indefinitely."

-Ralph Peters

The War in 2020

BACKUP

Architecture Coordination Council

Council

