

The C2 Constellation
A US Air Force
Network Centric Warfare Program

Network Centric Applications and C4ISR Architecture

Col Norman Sweet
Material Group Leader, C2 Constellation
And Space Based Radar BMC3

Additional Author: Stu Kanefsky

Electronic Systems Center, C2 Enterprise Planning and Integration - ESC/CX
15 Eglin Street, Bldg 1607
781-377-6420
Fax: 781-377-7018
norm.sweet@hanscom.af.mil

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE JUN 2004		2. REPORT TYPE		3. DATES COVERED 00-00-2004 to 00-00-2004	
4. TITLE AND SUBTITLE The C2 Constellation A US Air Force Network Centric Warfare Program				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Electronic Systems Center (ESC/CX),C2 Enterprise Planning and Integration ,15 Eglin Street Bldg 1607,Hanscom AFB,MA,01731				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 31	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Abstract

The Department of Defense (DoD) released Joint Vision 2020 in late 2000. JV2020 states “The evolution of information technology will increasingly permit us to integrate the traditional forms of information operations with sophisticated all-source intelligence, surveillance, and reconnaissance in a fully synchronized information campaign.” Network Centric Warfare (NCW) was coined to describe how we will fight using integrated information technology. NCW networks connect various weapon systems, information flows, sensors, and decision makers in a peer based, machine to machine (M2M) structure which enhances information flow efficiency, quality, and timeliness. NCW is a means to achieve JV2020. The end result is a more lethal fighting force.

The C2 Constellation is an Air Force program designed to support NCW and JV2020. The C2 Constellation will facilitate the development of decisive information superiority, collaborative planning, and synchronized operations for the warfighters by promoting interoperability and integration between systems that support Command, Control, Computing, Communication, Intelligence, Surveillance, and Reconnaissance (C4ISR). The C2 Constellation promotes rapid access to data stores that support situational awareness, effects based operations, and predictive battlespace awareness.

Table of Contents

Abstract:	Page 2
<u>Section 1: Overview</u>	Pages 4
Section 1.1 History, Doctrine & Direction	Pages 4-5
Section 1.2 Network Centric Operations	Pages 5-6
Section 1.3 Military Systems & Nodes	Pages 6-7
Section 1.4 The ConstellationNet	Page 8
<u>Section 2: C2 Constellation Approach</u>	Pages 9
Section 2.1 Understanding Architecture	Pages 9-12
Section 2.2 Understanding SOA	Pages 12-13
Section 2.3 Understanding the Contract	Pages 14
<u>Section 3: Defining the Constellation (Top Tier)</u>	Page 15
Section 3.1 Version 2.0 Architecture	Pages 15-16
Section 3.2 Cross Service Architecture	Pages 16-18
Section 3.3 SOA	Pages 18
Section 3.4 Common Terminology	Page 19
<u>Section 4: Building the Constellation (Bottom Tier)</u>	Page 20
Section 4.1 C2 Constellation PoC	Page 20-22
Section 4.2 Task Force Paul Revere	Page 22
Section 4.3 Horizontal Initiatives	Page 23-25
Section 4.4 Common Info Infrastructure	Page 25-26
<u>Conclusion</u>	Page 27-28
Appendix A: Endnotes	
Appendix B: References	
Appendix C: Footnotes	

1.) Overview:

Military systems have a long record of successfully integrating many different technologies into an operational capability able to project force for a desired outcome. For example, an F-16 is a technological marvel capable of traveling several times the speed of sound and delivering pinpoint lethality. Weapon systems, avionics, radar, engines all efficiently interact. What has been lacking in military technology development is the ability of multiple systems, with multiple missions, to interact seamlessly together.

The C2 Constellation program has been created to assist the Air Force in building a network centric, peer based, system of systems, which operate in a seamless and fully interoperable framework. This Air Force effort is based upon the vision established by Chief of Staff of the Air Force (CSAF), Gen John P. Jumper. His vision is a connected array of land, platform, and spaced based sensors that use common standards and communication protocols to relay information automatically in what he refers to as “machine to machine interface.” This effort to integrate systems is referred to as enterprise integration.

The C2 Constellation is tackling the networking solutions and connectivity issues in a two-tiered approach. At the top tier the C2 Constellation seeks to define C4ISR enterprise integration. At the bottom tier the C2 Constellation solves near term, quick turnaround integration solutions for the Air Force.

Architecture is a key element in the C2 Constellation. Architecture products and discussions can be confusing. In section 2 we will discuss architecture products and how they will be used by the C2 Constellation. Section 3 describes today’s (FY04) architectural efforts. There are three levels of architecture that will be reviewed, Services Oriented Architecture, Cross Service Architecture, and C2 Constellation Version 2.0 Architecture. Although these efforts are connected, please note that these are separate independent efforts. Before detailing the two-tiered approach of the C2 Constellation, leadership direction and key concepts will be explained.

1.1 Overview: *History, Doctrine, and Direction*

The concept of C2 integration is a long stated goal among Air Force and DoD planners. Integration and interoperability – the pillars of the C2 Constellation program, are not new or novel ideas. The push came from Secretary of Defense Donald Rumsfeld, Secretary of the Air Force, Dr. James Roche, and Chief of Staff of the Air Force, Gen John Jumper to transform the Air Force. The transformation is based upon a shift from platform-centric warfare to Network Centric Warfare – Hence the development of the C2 Constellation program.

For Gen John Jumper, many of the lessons learned on interoperability difficulties were borne out of his experience as commander in Kosovo during U.S. and NATO operations.

Gen Jumper noted that improvements have been made in the OODA Loop (Observe, Orient, Decide, and Act); however, the time it took between location of target and action was long, not efficiently organized, and frequently lacked the time criticality to engage. Gen Jumper noted: “We found out that the ISR platforms are truly responsive and capable of finding and fixing these targets. However, we also found that there was no process to integrate these assets and then exploit the information and attack the emerging target.” (Endnote 1) This vulnerability has been noted and discussed by many leading defense planners. With senior leadership providing the way ahead, Air Force doctrine began to codify Network Centric Operations / Network Centric Warfare (NCOW) concepts and stand up the C2 Constellation program.

The C2 Constellation was stood up as a future program in 2000. Titled the Multisensor Command and Control Constellation (MC2C), the name has since changed to the C2 Constellation, and the program will have an identified Air Force Program Element (PE) in Fiscal Year 2005.

The Department of Defense, Joint Vision 2020 states: “The capability to execute operations depends on a fully integrated and modernized concept of command and control for air and space forces adapted to meet the full spectrum of worldwide engagement challenges.”

The C2 Constellation CONOPS (Version 8 August 2003) directs: The C2 Constellation “will enable the development of decisive information superiority, collaborative planning, and synchronized operations for the warfighters by eliminating stovepipe system implementation...”

The C2 Constellation PMD (Version 2 in Coordination) states: “The C2 Constellation is an Air Force initiative to integrate diverse command and control (C2) and intelligence, surveillance, and reconnaissance (ISR) assets into an interoperable family-of-systems that provides seamless C2ISR capabilities across DoD, Joint and coalition boundaries.”

The next section in this paper will describe Network Centric Operations and how the C2 Constellation supports this concept.

1.2 Overview: *Network Centric Operations*

Network-centric operations (NCO) represent an environment where collaboration between platforms, systems, and devices, such as satellites, aircraft, or PDAs, are possible. These elements, Networked Centric Nodes, use common information and common communication architectures. A working definition for a node is a logically organized system and/or systems which provide a grouping of mission capabilities. The node system(s) can complete the required action, transfer subsequent action to a different node or terminate. Once an element becomes a node, it has the ability to function and collaborate with other nodes both inside and outside its resident domain. As more nodes are introduced into the environment, the network becomes more robust, much like the growth of the Internet. (Endnote 2) And like the Internet, network centric nodes depend on each other to provide multiple streams of connectivity for the movement of

information from point to point. Figure 1.1 illustrates a conceptual vision of Network Centric Warfare, and demonstrates how this concept is an overlay of the Information Domain and Physical Domain (e.g. weaponry).

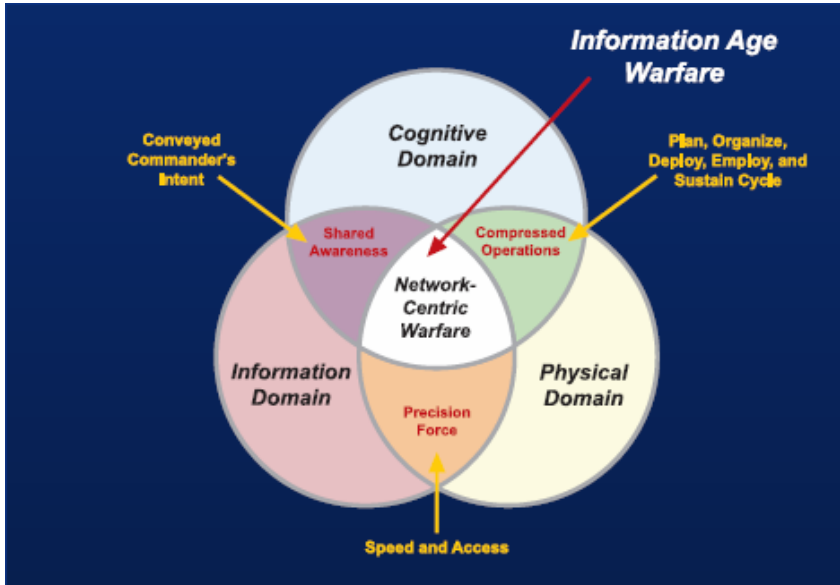


Figure 1.1 Network Centric Operations Conceptual View (Endnote 3)

1.3 Overview: *The C2 Constellation – Military Systems and Nodes*

The C2 Constellation will exploit advances in open systems architecture, information processing, expanded bandwidth, and sensor technologies. These advances will further the integration of C2 and ISR nodes to unprecedented levels. The result will be the seamless linkage of information between horizontal and vertical C2 and ISR elements to optimize personnel, functions and support system capabilities.

The C2 Constellation includes all the Air Force systems that provide input or receive and correlate Command and Control, Computing, Communications, Intelligence, Reconnaissance, Surveillance (C4ISR) information. Also included are joint and coalition nodes that must exchange information with Air Force Systems.

NCOW cannot be created without the common vision, lexicon, definitions, and understanding of whom will provide what. Standards need to be established and the acquisition of future C4ISR capability established. The C2 Constellation supports these NCOW requirements. A pictorial representation of the C4ISR systems within the C2 Constellation is presented in figure 1.2

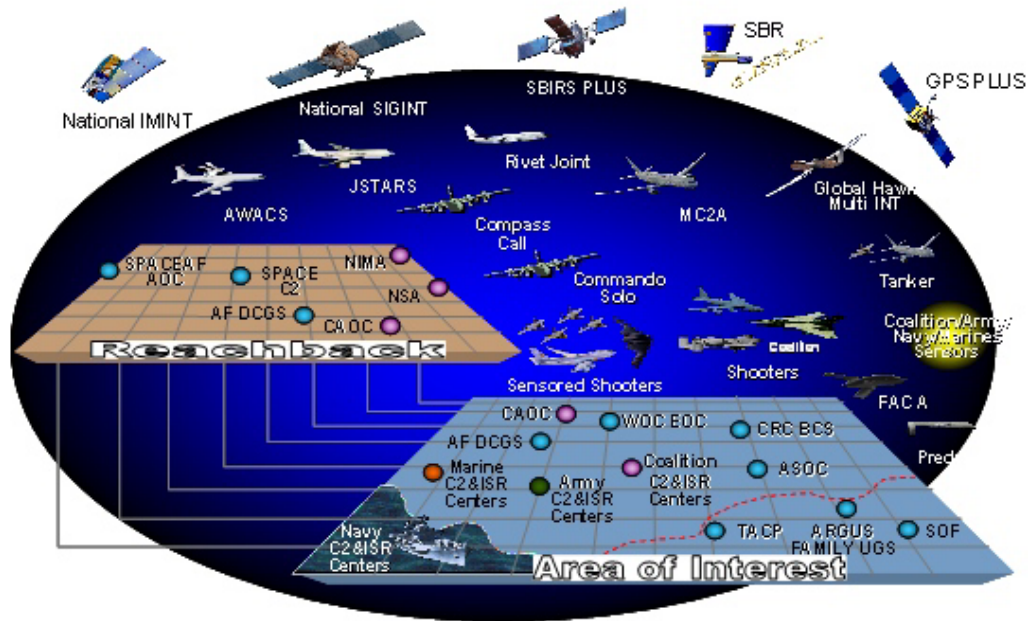


Figure 1.2 C2 Constellation – C4ISR Systems

A program management decision was made to identify key systems and services as the first “block” (starting FY04) of the C2 Constellation program. It is important to note that this decision does not imply that systems outside the FY04 Block nodes and services are less valuable to the concept of network centric operations; the program is not scoped to encompass all systems in the first iteration.

The focus of the C2 Constellation is to support “operations for the warfighters by eliminating stovepipe system implementation in the Theater Air Control System and between systems used by the (and) supporting Air and Space Operations Centers (AOCs)” (C2 Constellation CONOPS).

Hence, Block FY04 Nodes are: Air Operation Center (AOC), Joint Surveillance and Target Attack Radar System (E8 – JSTARS), Airborne Warning and Control System (E3-AWACS), Distributed Common Ground Stations (DCGS), and Rivet Joint (RC-135). Key programs that support the AOC and DCGS command centers and command information are also considered within Block FY04 context. Underpinning programs within the AOC, such as the Theater Battle Management Core System (TBMCS) are key elements providing core services, such as Air Tasking Orders (ATO). TBMCS and DCGS have been selected as “pathfinder” type systems for the C2 Constellation due to their in-place web enabled architectural products.

1.4 Overview: *The C2 Constellation and ConstellationNet*

To insure that individual Nodes can seamlessly communicate, the C2 Constellation is facilitating the development of the communication and information transportation layer for the Air Force. The C2 Constellation program has labeled these efforts as the ConstellationNet. Mr. David Tillotson, SES, Director of C4ISR Architecture AF/XI, in a report to congress, explained the C2 ConstellationNet efforts thusly:

“The ConstellationNet is the communications network—air, space, and terrestrial—that must allow a free flow of information so that it is rapidly accessible and presented to warfighters at the right time and right place to create the commander’s desired effects. GIG (Global Information Grid) transport layer components delivered under this effort are included in various USAF programs. The USAF portion of GIG-BE (GIG Bandwidth Expansion) provides expanded terrestrial service at key USAF bases globally. The Joint Tactical Radio System (JTRS) is essential to our vision for an improved airborne network, which expands genuine network operations to the airborne platforms. With the installation of Family of Advanced Beyond line of sight Terminals (FAB-T) on additional aircraft, such as AWACS, JSTARS and Global Hawk, we will have the capability to vastly extend our airborne network to all reaches of the globe. Finally, the USAF is responsible for a large portion of the space segment communication evolution including deployment of the Advanced EHF, Wideband Gapfiller System and the Transformational Satellite (TSAT) program.”

(Endnote 4)

The ConstellationNet will provide war fighters access to a globally distributed common knowledge base of shared information providing a consistent level of understanding and situational awareness between all war fighting elements.

Section 2 describes the approach that the C2 Constellation has developed to meet NCOW goals. Architecture is a crucial component in that approach and three architectural methods are being utilized in the C2 Constellation program; Popkin – Version 2.0 C2 Constellation, Services Oriented Architecture, and Cross Service Architecture. The major contractual vehicle that the C2 Constellation has issued will also be outlined.

2.) C2 Constellation Approach

The C2 Constellation will be the realization of this horizontal and vertical integration where operations, system and technical architectures will permit the C2 and ISR functions to establish machine-to-machine (M-2-M) information exchanges and fusion. The concept of integrating current and future architectures is based on the premise of forming the C2 and ISR enabling elements and procedures into a functioning and unified whole to achieve specific effects. In the C2 Constellation construct, hardware, software and operational procedures of various C2 and ISR systems will perform individual and multiple functions (or services) and seamlessly exchange information without interfering or appreciably degrading the functions of each system.

The C2 Constellation is an attempt to “programmatically” the C4ISR integration efforts. The C2 Constellation is tackling the networking solutions and connectivity issues (NCOW) from a two-tiered approach: *Defining & Building* the Constellation. In the definition tier the C2 Constellation will shape future C4ISR activities to support NCOW. In the building tier the program will support today’s NCOW operations.

The key component in establishing the vision will be building the C2 Constellation Architecture. This architecture will shape the acquisition of future C4ISR capabilities. The architecture (Version 2.0 has been released - <https://cao.hanscom.af.mil>) supports enterprise analysis, planning and programming, requirement development, and acquisition management. The specifics in defining the C2 Constellation will be discussed in Section 3.

The C2 Constellation architecture will be used to drive investment planning for the Air Force and the DoD. The architecture facilitates engineering analysis which identifies capability gaps in reaching NCOW, and highlights integration opportunities. The goal is the development of trade space recommendations for senior leadership for future acquisition and research initiatives.

The C2 Constellation will utilize mature technology, developed architectures and integration solutions for solving short term integration deficiencies. A key component in building the Constellation will be funding initiatives which solve immediate integration challenges that exist in C2 Constellation Nodes. Section 4 will detail how the C2 Constellation builds toward NCOW. The many facets and uses of architecture will be discussed in the proceeding sections.

2.1 C2 Constellation Approach - Basic Precepts *Understanding Architecture*

C2 Constellation approach starts with the definition of several basic architectural concepts. Since architecture products underpin our organizational efforts this is a logical place to start. Architecture is defined as “*the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time.*” (from *C4ISR Architecture Framework*, ver2.0, per IEEE STD 610.12) The C2 Constellation

Architecture is a subset of the AF Enterprise Architecture which follows the precepts established by Joint (DoD wide) Architecture.

Architecting is part of a strategy to task business processing that is used across the C4ISR enterprise. There are multiple ways of visualizing architecture. Using a home as an architectural example; the house can be viewed from the perspective of the components that make up the house; the walls, the plumbing, the electrical systems, etc. The house can also be looked at as a series of operations; how does food get cooked, stored, disposed, etc. Or one can view the house from a technological perspective, what is the component material in the walls, how does this material react to weather, what are the capabilities of the air conditioning etc. These views make up the architecture framework.

In the Popkin System Architecture these views are called the Operational View (OV), System View (SV) and Technical View (TV). The two charts following illustrate OV, SV, and TV system architecture.

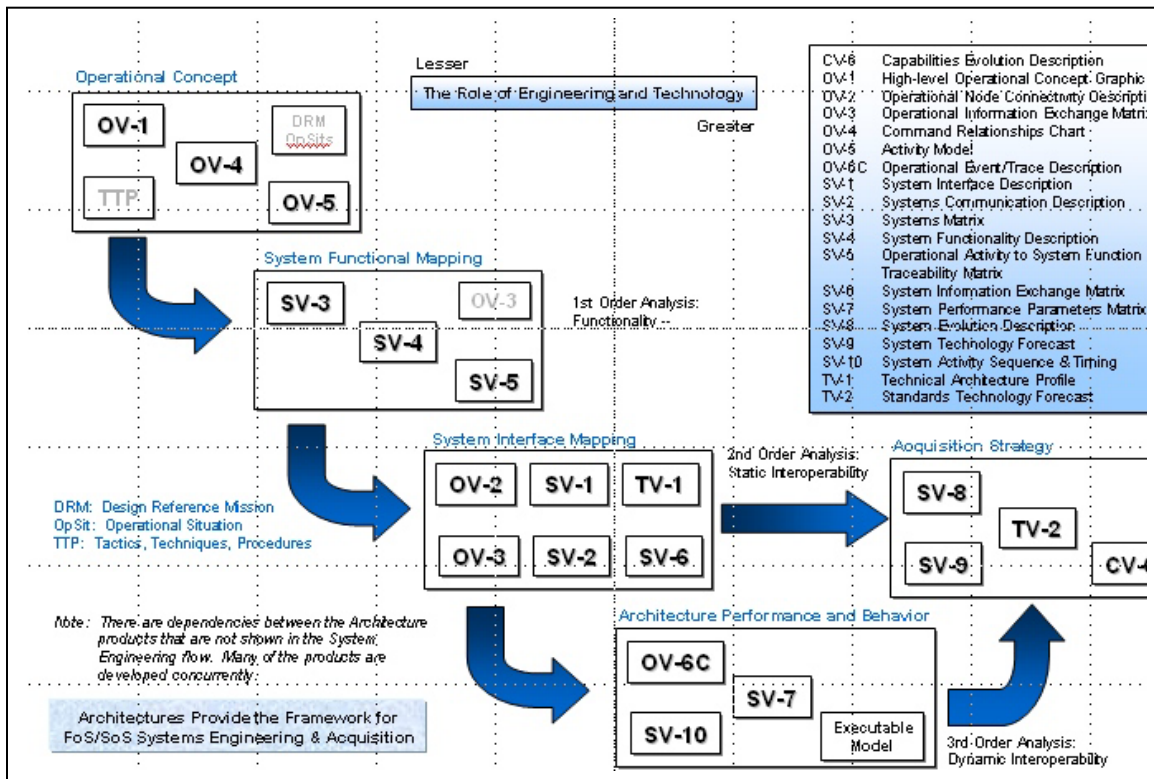


Figure 2.1 Fundamental Architectural Linkages (endnote 5)

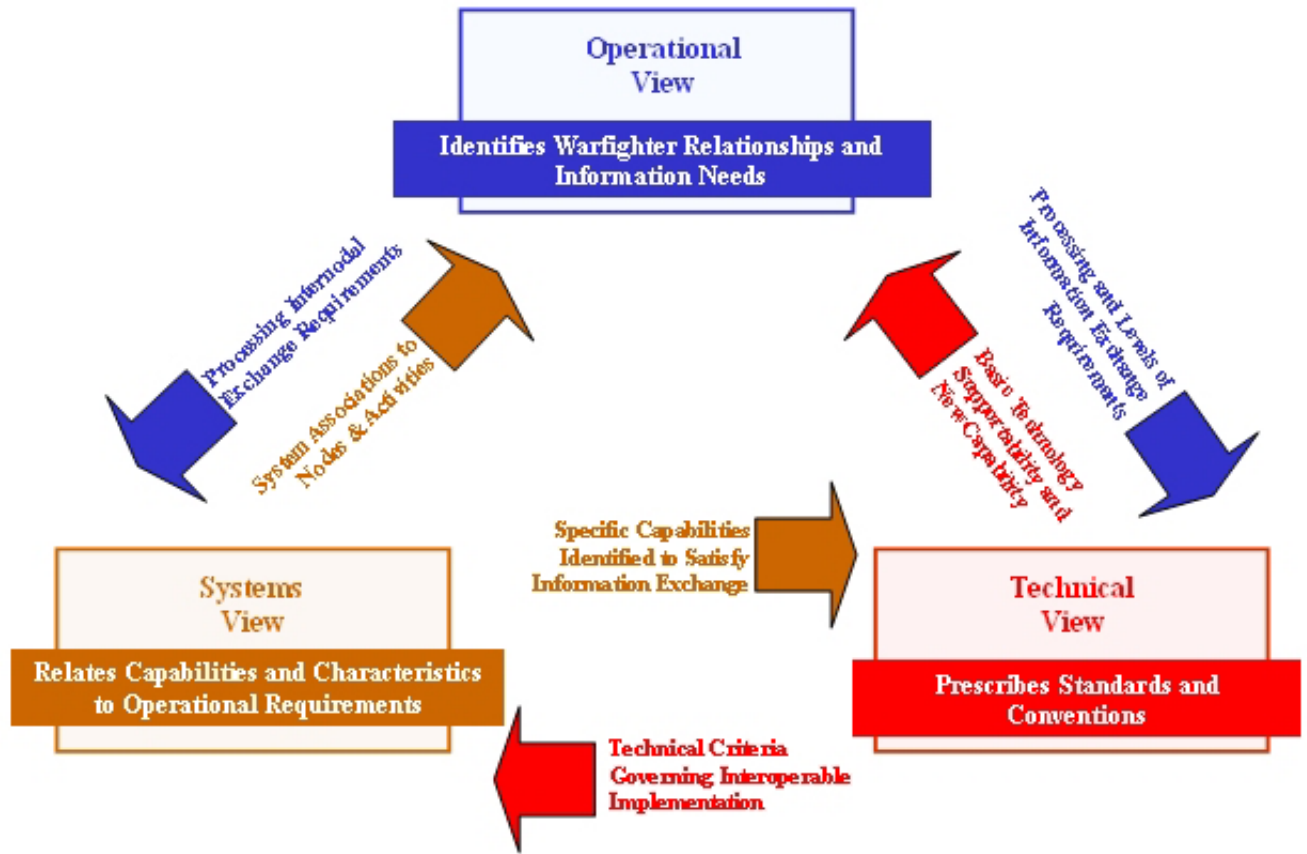


Figure 2.2 Architectural Information Flow

Architecture products have an implicit, built-in hierarchy. The top level is the Joint (DoD) view, and the Air Force Enterprise View. Top level architecture would include Global information Grid Architecture, Joint Technical Architecture, and products such as the JBMC2 Roadmap. The Mid Level architectures look at Domains, (Mission Area's) C2 Nodes (Product Focused) and Thread (Programming focus areas - ex. TCT). Mid level architectures include service architecture, C2 Constellation Architecture, and products such as the AF Task Force CONOPS. Bottom level architecture is the system program architecture (e.g. TBMCS). Each level serves a different business purpose, but all are equally valid and must be coordinated to accomplish netcentric vision tasking. There must be commonality, in lexicon, dimension, and perspectives.

There are three facets of architecting that need to be understood. Domain architecting is concerned with internodal connectivity. Domain architecting is primarily a long term focus, answering the larger questions of what new systems should be acquired, etc. Nodal architecting is concerned with the systems within a node and what internodal services they provide. Nodal architecting also looks at communication with systems outside of the node. It is a short to mid term focus, designed around system evolution. Thread architecting looks at a mission and understands how it is performed from cradle to grave. Mission examples include how the AF performs Time Critical Targeting (TCT), and

Joint Close Air Support (JCAS). In FY04 the Constellation will use a TCT thread as a focus for C2 Constellation validation efforts. TCT is a horizontal thread (passes through many nodes) which involves many systems and services. (*Footnote 1 TCT & TST)

The C2 Constellation can be realized as open systems architecture with enabling technologies and standards utilized to exploit network centric warfare. Services Oriented Architecture is an added layer on top of traditional architecture.

2.2 C2 Constellation Approach - Basic Precepts

Understanding Services Oriented Architectures (SOA)

SOA's examine how a stated capability is delivered. It is not dependent upon the node or program and in most cases would stretch across multiple programs. SOA's have several fundamental principles:

- Deliver components rather than systems
- Components are provided as information services
- Components can be arranged in any way to provide overall composite application
- Component design provides flexibility, higher re-use, and better manageability

Choosing the correct standards and technologies is crucial to meet the challenges of implementing service oriented architecture. SOA's support NCOW strategy through the mutual reliance on services vs. systems. In a netcentric operation, information users would query information distributors via secure web to collect only the information needed for their respective mission. Services would be implemented via Web services utilizing open commercial standards and precepts (i.e. XML).

Moving towards web services and utilizing SOA provides many benefits for the DoD. Web services allow for integrating legacy systems by "wrapping" around legacy system information and data regardless of the language that was used. Instead of replacing legacy systems in order for information to be exchanged, Commercial off the Shelf (COTS) developed products, such as the suite of XML related software, can be utilized to share data. By extending data transfer to common language formats, machine to machine information exchange can be undertaken. Figure 2.3 (following page) presents the SOA construct pictorially.

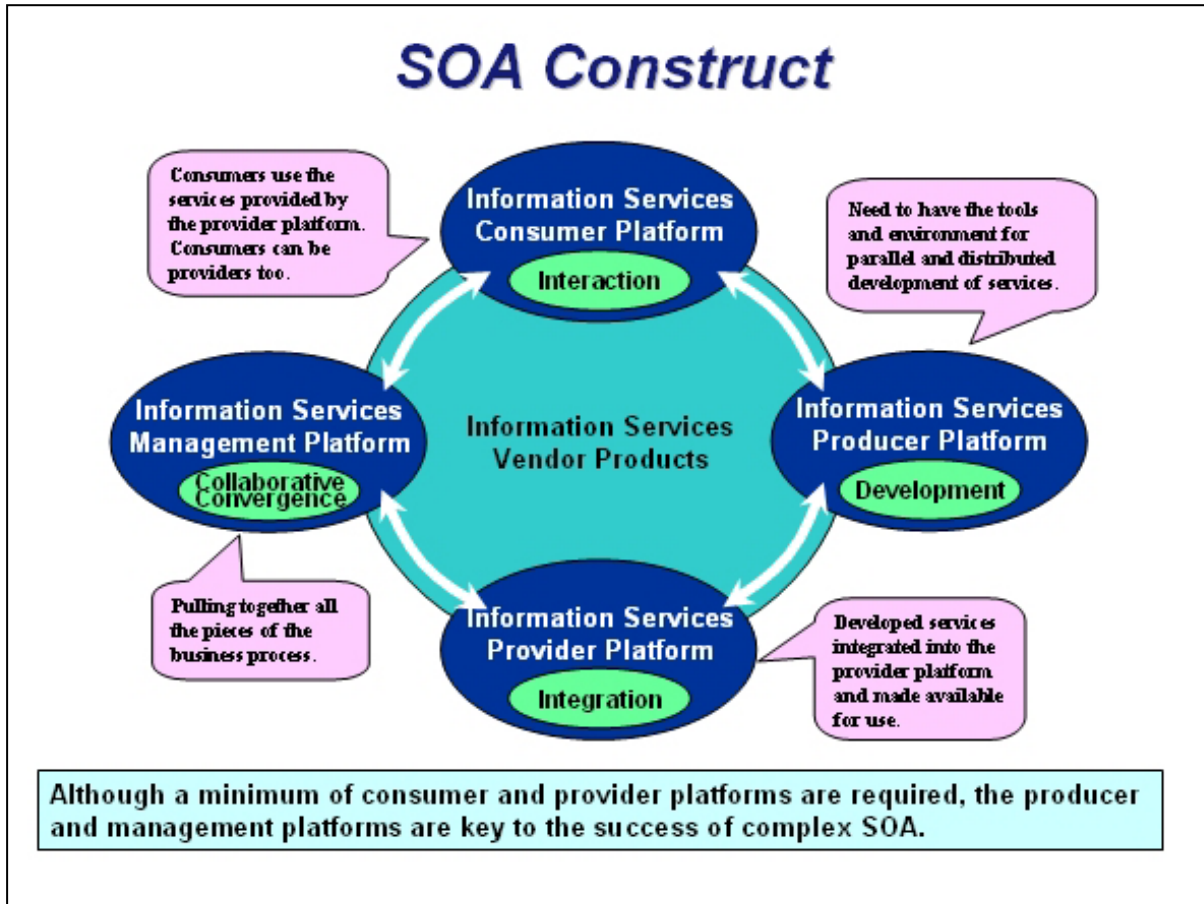


Figure 2.3 SOA Construct (Endnote 6)

In addition to facilitating data sharing, open standard web services can lower operating costs. Web services are cheaper than building individual M2M interfaces and can reduce footprint and operating cost by reducing manpower for translating data. Web services can reduce duplication throughout the force. Instead of services being replicated on different platforms, these services can be accessed through an enterprise web interface. Web services improve data exchange between users and customers and they can drastically reduce the cost of software development, code maintenance, increase re-use of software.

The SOA approach assists the Air Force move to NCOW through several key functionalities. By establishing a range of services independent of programs, the AF moves from data integration to process integration. This will permit automation via workflow and business process management, and move from point to point connections to dynamic discovery connections (i.e. one stop shopping). Before detailing how the Constellation will utilize SOA's, architectures, and mature COTS technology, an overview of the basic C2 Constellation contractual vehicle is presented to outline the program's advantages and limitations.

2.3 C2 Constellation Approach - Basic Precepts *Understanding the C2 Constellation Contract Vehicle*

The nature of NCOW, Web Services, and Enterprise Integration all led C2 Constellation planners to understand that the commercial defense industry would play a vital role in any future success. The C2 Constellation needs the know-how of the program developer's Subject Matter Experts (SME) as well as the industry's technology forecast.

The Constellation developed a teaming arrangement in which many industry leaders interact together in a "badgeless environment", providing the Government a "best of breed" contracting core. The contract is named the Architectural Support and Engineering Analysis (AS&EA). AS&EA is a task order contract issued through AFWAY, with a high ceiling and room to grow. The contract has multi-service funds and has become a joint contract vehicle. The C2 Constellation established four Integrated Product Teams (IPTs) each with their own blend of Military (Army, Navy, Air Force), Contractors (AS&EA, Intrinsic, FFRDC) and Government participation. The four teams are the Architecture IPT (AR/IPT), Engineering Analysis IPT (EA/IPT), Knowledge Management IPT (KM/IPT), and Proof of Concept IPT (PoC/IPT). Some of the IPT work supports building the Constellation, and some support defining the Constellation.

The AR/IPT uses Time Sensitive Targeting (TST) as the initial mission construct. The AR/IPT leverages existing architecture products and identifies services associated with the architecture. For example weather services would be associated with mission planning architecture.

The KM/IPT develops the approach for capturing and developing Service Oriented Architecture (SOA). The KM/IPT also develops the web based tools and applications necessary to represent the SOA.

The EA/IPT identifies gaps and overlaps that may exist between the Services visions, capabilities and requirements. The EA IPT will assist in building the C2 Constellation by identifying potential COTS initiatives. The EA/IPT will also provide POM inputs to AF leadership which provide needed NCOW capabilities.

The PoC/IPT will build a demonstrated distributed services approach to TST. The POC/IPT will conduct a limited objective experiment based on C2 Constellation SOA.

The unique blend between various contractors, military, and government in the IPT structure has provided flexibility and reachback into the military systems. This contract allows the engineering design houses to tackle the immense challenge of interconnecting various military systems each with their own program management structure and contract support / technology development.

The following two sections of this essay will delve into the details of two-tiered C2 Constellation operations.

3.) Defining the C2 Constellation

This section will examine the C2 Constellation efforts in shaping the future of C4ISR capabilities. Defining the C2 Constellation is the top tier in the program management approach. The C2 Constellation will be utilizing top-level instructions (C4 Directives, Program Management Directives (PMDs,) and the C2 Enterprise Reference Architecture (C2ERA), establishing the common standards through Common Information Infrastructure (CII) and utilizing architecture products (Popkin System Arch. & Service Oriented Arch.) to help drive investment planning. The C2 Constellation will establish baseline criteria and Measures of Effectiveness/Measures of Performance (MOE/MOP).

How many man hours are spent collecting intelligence, surveillance and reconnaissance information, processing that information, and finally providing it to the combatant commander? It is a complex set of processes. The C2 Constellation has settled upon the use of architectures as our organizing framework. Usable architectures drive system design and development, and they facilitate integration and interoperability. The C2 Constellation is creating architectures utilizing spiral development concepts. The current version is therefore not a complete C4ISR picture but a small, bite size beginning.

The version 2.0 (current release) architecture details the C2 Constellation's core set of processes, information flows, operational and system nodes, systems and system functions directly supporting the Joint Forces Air Combat Commander (JFACC). The architecture does not document an operational node's internal processes, activities and associated information exchanges unless they have a direct bearing on JFACC operations.

3.1 Defining the C2 Constellation: *Version 2.0 Architecture*

Version 2.0 is constructed upon existing C4ISR architecture and the version 1.1 C2 Constellation architecture. Version 2.0 has three epochs; 2005, 2012, and a high level conceptual view based upon 2020 capabilities. Future phases of the architecture will provide further depth and extend the scope.

The Following Bullets Have been Drawn from the C2 Constellation Version 2.0 Architecture. For more information please contact the AF Chief Architects office. <https://cao.hanscom.af.mil>

Version 2.0 is intended to:

- Document a core set of processes, information flows, operational and system nodes, system functions, systems, networks, technology and standards for use by Air Force architectures and serve as a baseline for the Air Force Enterprise Architecture Reference Models.
- Support Program Objective Memorandum (POM) and Annual Planning and Programming Guidance (APPG)
- Support C2 Constellation definition and conceptual design
- Provide targets for C2ISR roadmaps planning and development

- Support requirements development and early milestone decision reviews
- Support CONOPS maturation, evolution and configuration management
- Validate C2 Constellation and related CONOPS as applied to theater operations
- Link ongoing Air Force and Joint architecture efforts to ensure alignment with the C2 Constellation
- Demonstrate Air Force architecture processes and infrastructure; assess tool capability and data management processes
- Facilitate Global Information Grid (GIG) architecture compliance
- Prototype uses of architecture specifically as a tool to align capital investments as required by the Clinger-Cohen Act
- Prototype the integration of other architecture models developed from different viewpoints, outlooks and assumptions
- Facilitate macro-level portfolio management to allocate resources across strategic areas
- Facilitate micro-level portfolio management to select and prioritize specific programs

(Endnote 7)

Highlights of the Version 2.0 C2 Constellation Architecture include complete System View (SV) connectivity for 10 nodes. These nodes are: AOC, AWACS, JSTARS, AF DCGS, Advanced Remote Ground Unattended Sensors (ARGUS), Air Support Operation Center (ASOC), and Forward Air Controller – Airborne (FAC(A), Control and Reporting Center (CRC), Wing Operations Center (WOC/EOC), and the Tactical Air Control (TACP). Version 2.0 collected data on 11 other nodes as they pertained to the primary version 2.0 structures, e.g. Rivet Joint, Predator, and Commando Solo.

Version 2.0 of the C2 Constellation Architecture captured and categorized 834 system data exchanges. The following architecture views have been created for Version 2.0:

- AV-1, AV-2 (all views)
- OV-1, OV-2, OV-3, OV-5 (OV-6a for TCT) (operational)
- SV-1/2, SV-4, SV-5, SV-9 (system)
- TV-1/2 (technical)

The C2 Constellation 2.0 Architecture has been used as our program baseline; for AS&EA contract direction, initiative direction, and the overall planning data for the program. Version 2.0 is the C2 Constellation starting point for our services oriented architecture and our joint work with the Navy and Army.

3.2 Defining the C2 Constellation: *Cross Service Architecture*

The AR/IPT focuses on the cross service architecture efforts, and the SOA. The AR/IPT membership includes C2 Constellation architecture engineers, and all of the IPT's efforts are based upon the same foundation products.

The AR/IPT identified cross-service integration opportunities with Navy counterparts from the Space and Naval Warfare Systems Command (SPAWAR). The US Army Program Executive Office for Command, Control, Communications Tactical (PEO C3T) joined the Architecture IPT a few months later. The proposed joint integration architecture examined Navy FORCEnet architecture, C2 Constellation architecture, and the Army Enterprise architecture. The team developed architectural data based upon a joint TST thread. Cross service funding was applied to the AS&EA contract to further this integration effort.

This effort followed the guidelines established by JFCOM J89 documentation (Joint Forces Command organization in charge of systems engineering). The Joint Battle Management Command and Control (JBMC2) roadmap was one of the primary focus documents. The JFCOM J89 is based upon a large number of multi service platforms. The AS&EA cross service architecture is based upon fewer platforms, but with a more robust and in depth architectural engineering.

The AR/IPT conducted initial engineering analysis and produced a list of common interfaces. This analysis captured potential information services and prioritized areas for follow-on engineering analysis. One of the key outputs of this IPT is the touch point architecture product.

The touch point architecture is based upon a cross service TST use case analysis mapped to the C2 Constellation 2012 TST Operational architecture (OV5,6,3). The AF nodes examined are the AOC, JSTARS, and AWACS. The Navy architecture examines the Global Command and Control Systems (GCCS) Maritime, Air Combat Defense System (ACDS), and Aegis. The Army node currently being exploited is the Future Combat System (FCS). Touch point data is being collected on the following architecture views:

- AV-2 (Capture definitions of architecture entities)
- SV-1 (Allocate functions and info services to key platforms)
- SV-4 (Identify system functions relating to touch point)
- SV-5 (Map functions to 2012 TST Use Case)
- SV-5 (Service) (Map info services to functions to Use Case)
- SV-6 (Define information flow across info service interfaces)
- SV-8 (Roadmap from as-is to 2008 for key platforms)
- SV-10 (Describe info service and info service interfaces)

This cross service effort will be the first step in providing cross service capabilities by establishing opportunities, gaps, and connectivity for future investment. A schedule of

cross service (FY04) architectural product delivery is presented in figure 3.1.

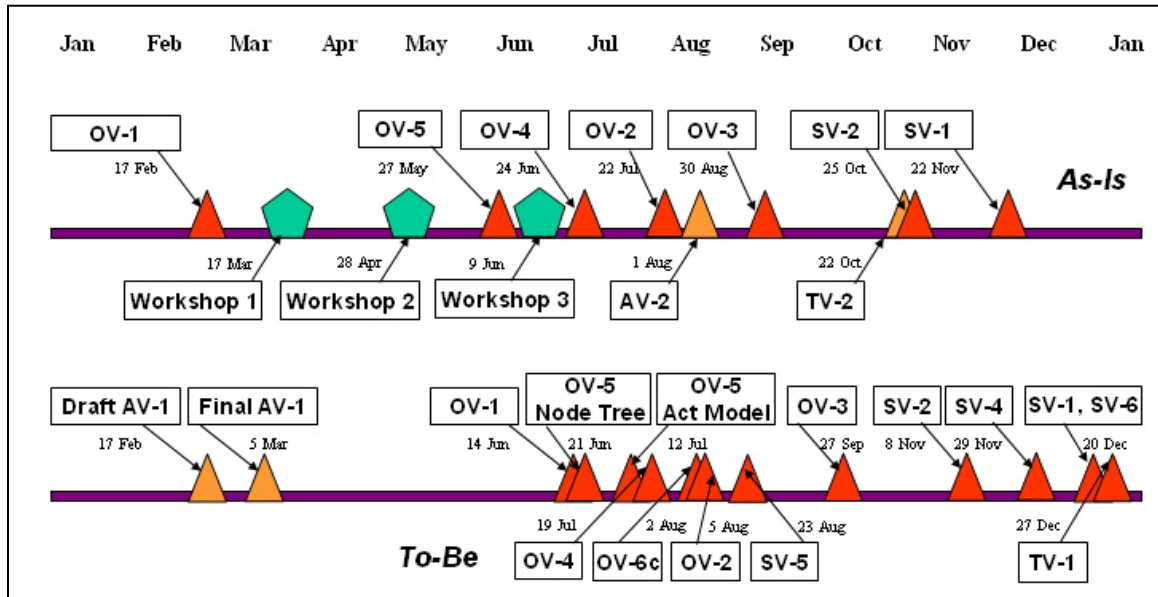


Figure 3.1 Cross Service Architecture Product Delivery Schedule

3.3 Defining the C2 Constellation: SOA

The SOA effort is being undertaken by all four of the IPTs. The AR/IPT has analyzed the TST thread and identified information service requirements. The next step in developing the SOA is cataloging and exposing available and planned information services. The KM/IPT identified 45 information services from two systems, TBMCS and Time Critical Targeting Functionality (TCTF) in an initial concept demonstration. The current data capture has identified 158 available and planned web services in the C2 Constellation.

The following step calls for the EA/IPT to map these services back to the TST thread and identify areas where TST can be reduced. The C2 Constellation program, assisted by the Block FY04 programs, will identify information service gaps/redundancies where cost saving investment strategies can be developed.

The PoC/IPT has created a web service scenario to test out the current SOA. The PoC operates at a secure testing facility in Hanscom AFB named the C4ISR Enterprise Integration Facility (CEIF). The demonstration that the PoC is building will be discussed in section 4.

The goal in creating an SOA for the Proof of Concept is to link and formally capture the work that the Joint AR/IPT is doing with the scenario that the PoC team is running. Joint TST architectures, spiral iterations of the PoC, will continually verify larger and larger segments of the Joint TST architecture.

3.4 Defining the C2 Constellation: *Terminology, Definitions, and USAF Direction*

Common language, definitions, and the ability to share and disseminate information are core principles in NCOW. The C2 Constellation is facilitating this process by establishing common reference material and promoting Air Force directives that will establish NCOW guidance.

The C2 Constellation, Navy SPAWAR, and Army PEO C3T have joined efforts to create a common technical architecture. The first documents being analyzed are the C2 Enterprise Reference Architecture, the Navy RAPIDS and Army PASS. This effort is described as a multi-service development guidance which needs to be created, agreed upon, and implemented by the military services and agencies. Reference addendums with joint lexicons will be the output of this effort.

The Navy and Air Force collaboration has the aim of defining the application development standards to be followed, at a minimum, by Navy and Air Force C2/C4I programs. In addition, common contracting language is being written between the Navy FORCEnet contract and the C2 Constellation contract in order to facilitate future joint activities.

The C2 Constellation directives are a subset of the Global Information Grid (GIG), JBMC2, and Joint Command and Control Capabilities (JC2) that are providing the Services with the impetus to change. The C2 Constellation currently has C2 Constellation Concept of Operations (CONOPS) draft version 8, and the C2 ControlNet Addendum draft version 1.5 out for review by the corporate Air Force. This effort will further codify C2 Constellation core competencies and responsibilities, and define what is required from the C4ISR systems that make up the C2 Constellation.

Section four will outline the bottom tier of the C2 Constellation or how we build the Constellation today – to meet tomorrow’s NCO vision. Building today’s C2 Constellation includes Proofs of Concept (PoC) and Limited Objective Experiments (LOE) which will test potential integration solutions. Building also includes funding initiatives that solve immediate integration challenges that exist in today’s C2 Constellation nodes.

4.0 Building the Constellation

The C2 Constellation is responsible for building, sponsoring, and endorsing solutions to immediate integration challenges across the C2 Constellation nodes. This effort finds solutions which meet stated deficiency gaps in reaching NCOW. There are four components that will be discussed in this section.

- C2 Constellation PoC Modeling and Simulation efforts
- Task Force Paul Revere Test Bed (707 Aircraft)
- Horizontal Integration Initiatives (HII)
- Common Infrastructure Information (CII)

The Air Force has identified key capability gaps through a variety of processes including the Capabilities Review and Risk Assessment (CRRRA). Several priority capability gaps have been identified. The C2 Constellation has been organized in a structure to support these shortfalls. The gaps can be grouped together in three large technical groupings: Command and Control (C2), Communication and Computing (COM), and Intelligence, Surveillance, Reconnaissance (ISR). The C2 Constellation attempts to address these gaps and improve TST through Network Centric initiatives, testing, and modeling and simulation. In order to increase synergy, efficiency, and return on investment; Constellation building elements have been linked together wherever possible.

4.1 Building the Constellation: *C2 Constellation PoC*

The Proof of Concept activity involves experimentations utilizing a SOA approach for C2 system integration. The initial C2 systems being integrated encompass the Theater Battle Management Core System (TBMCS), Global Combat Support System (GCSS), ISR Warrior (ISRW), and Network Centric Collaborative Targeting (NCCT). The simulations to drive these nodes are the Air Warfare Simulation (AWSIM) and Joint Semi-automated Forces (JSAF). The AS&EA team is applying Web Sphere (web services) to implement the SOA environment.

The Proof of Concept will validate the adequacy and performance of key technical standards that are being developed. The common information services developed as CII initiatives (discussed in Section 4.4), will undergo an initial test and integration within the POC/IPT.

The POC/IPT will define improved TST and provide the user initial insight into new systems and support CONOPs development of effected systems. The POC/IPT will adopt the COTS Integration Competency Center (ICC) Model for their testing environment.

Three high level tasks have been defined for the PoC demonstration

- Migrate as many of the “harvestable” services from the selected platforms/nodes into the Core (Web Service Enabled) Enterprise Services.
- Construct other Web Service Enabled Enterprise Services within the present platforms/nodes (Managed Elements) where it is not feasible to migrate services into the set of Core Enterprise Services.
- Leverage software and hardware in the CEIF, and AS&EA contractor owned materials, that can be utilized as part of this task

A layout of the experiment is represented in figure 4.1

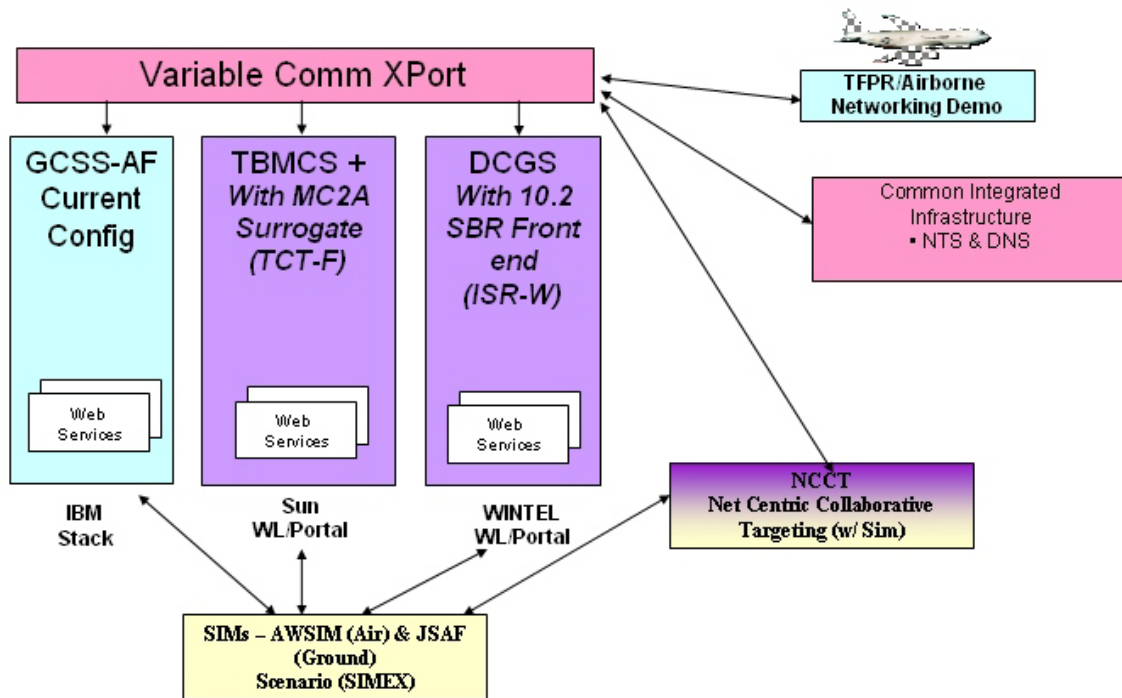


Figure 4.1 PoC Demonstration at CEIF

The POC/IPT outcome will demonstrate a single, consistent platform for performing integration experiments in a true SOA. This will provide an advanced capability for orchestrating services, including scripting with development-time visualization tools, integrated monitoring, QOS, scalability, a single point for applying security to advanced services, and an opportunity to introduce lifecycle management for these new integration points. The POC/IPT has been structured to support the three key technology groupings COMM (CII Services), C2 (TBMCS, GCSS) and ISR (DCGS, NCCT, ISR Warrior).

The Paul Revere test bed aircraft support the POC/IPT in analyzing potential C4ISR solutions. The Paul Revere, configured to support COMM, C2 and ISR technologies, will be discussed next.

4.2 Building the Constellation: *Task Force Paul Revere*

Task Force Paul Revere (TFPR) is a C4ISR experimental test bed 707, sustained by Lincoln Laboratories in Bedford Mass, and operating under the Air Force auspices. The C2 Constellation supports TFPR with funding in order to promote C2 integration. The TFPR is used for C2 Constellation experimentations, concept demonstration, integration & assessment.

TFPR is an experimentation enabler for airborne components of the constellation. TFPR is focused on demonstrating Battle Management Command and Control (BMC2), horizontal integration, and wideband Line of Site (LOS) and Beyond the Line of Site (BLOS) communications. In FY04 the TFPR will demonstrate Communication Transport services via an Airborne Networking demonstration linked to the CEIF. This test is a critical piece of the CII initiative. The TFPR cross cut view is provided in figure 4.2.

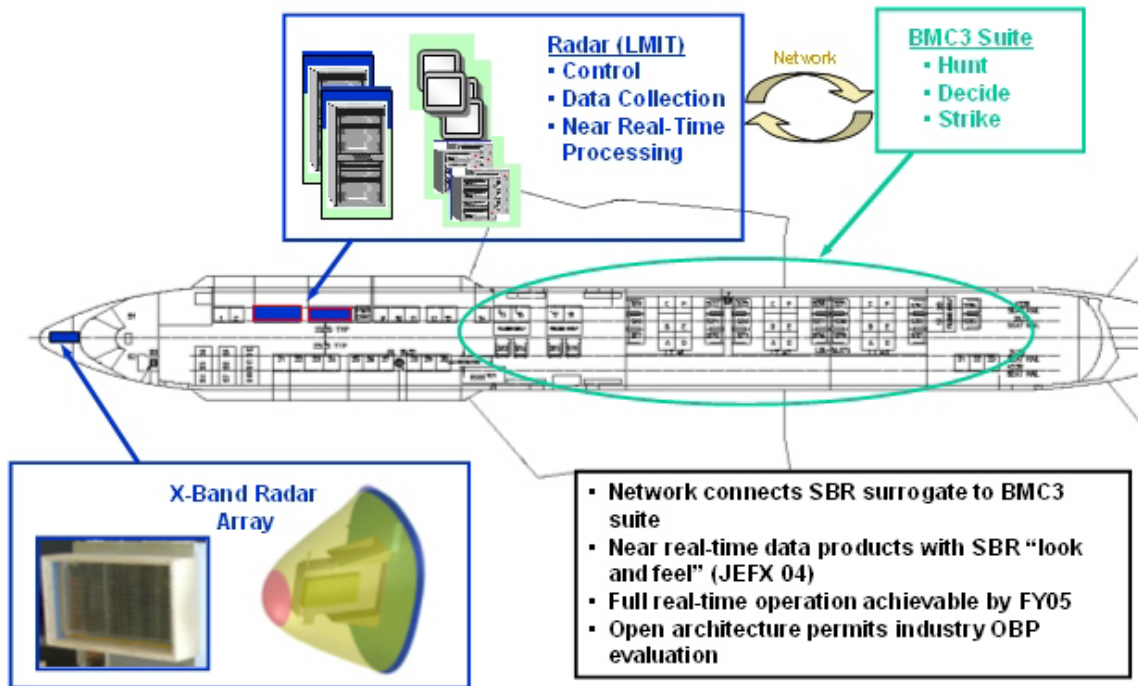


Figure 4.2 Task Force Paul Revere (endnote 8)

The POC/IPT and TFPR both support testing near to mid term C4ISR solutions grouped through the COMM/C2/ISR structure. In the next sections we will outline initiatives which are funded to provide COMM/C2/ISR delivered capabilities to the warfighter.

4.3 Building the Constellation: *Horizontal Integration Initiatives*

Horizontal Integration Initiatives (HII) solves immediate integration challenges across the C2 Constellation nodes. HII's employ mature, network-centric technology, focused on transition-ready capability, tracked to the C2 Constellation delivery plan (COMM/C2/ISR). The HII's employ technologies that are transitioned to the force with execution year funding. Benefits of the HII's include:

- 1) Optimal use of constrained resources
 - a. Flexibility
 - b. Adaptability
 - c. Scalability
- 2) Improved Situational Awareness
 - a. Track Targeting
 - b. Combat Identification
 - c. Improved Detection
- 3) Enhance Time Critical Targeting
 - a. Shorter Response Time
 - b. More Effective Response
- 4) Reduce Theater Footprint and Operator Risk

Solutions focus on technology drivers that have an enterprise wide effect. The material solution must already be well into development, but lack the enterprise focus. The C2 Constellation will promote integration by providing seed funding for potential re-engineering, reworking CONOPs etc. The key factor is that the HIIs are utilized to promote C4ISR integration for realizing NCOW goals within the C2 Constellation focus areas.

The COMM/C2/ISR focus areas have been further deconstructed into several subcategories which have been mapped to Air Force (e.g. CRRA Master Capabilities List) and Joint documentation (e.g. JBMC2 roadmap) as capability shortfalls. These areas have also been linked to the C2 Constellation architecture, particularly the architecture products which document the technology forecast. The areas for investigation are then delineated over the Fiscal Year Defense Plan (FYDP) time schedule. The following chart shows the FY04/FY05 breakout.

FY04 / FY05 Initiative Roadmap

FY04 COMM:	FY05 COMM:
Airborne Networking	Airborne Networking
Communication Transport	Communication Transport
Information Services	Information Services
FY04 C2:	FY05 C2:
M2M integration	Situational Awareness
Multilevel Security (MLS)	MLS
Data sharing / Situational Awareness	Data Visualization

FY04 ISR:	Predictive Battlespace Awareness
Data fusion	FY05 ISR:
NCCT integration	Sensor Integration
Sensor Integration	Data Fusion
Engagement (AMSTE) integration	Advanced SIGINT

An HII example: The C2 Constellation has funded an effort in partnership with a National Satellite Office, to provide the capability to link together various sensors so they might improve clarity and resolution of the target picture. The project is developing an interface between NCCT (Network Centric Collaborative Targeting) and the (National Satellite) process, to allow Tip and Report exchanges between NCCT and XXXX via Guardrail.

How this affects NCOW: Joint Stars, Rivet Joint, AWACS, Army Guardrail, and the Natl. office can communicate back and forth almost instantaneously (M2M) so that the various sensors will act together as one ELINT source, allowing the warfighter to “focus” in on the target in an expedient and accurate way. The new capability will allow for near real- time (NRT) exchange and correlation of sensor data to reduce the false alarm rate and improve target location and ID.

The end result: The development of network-centric techniques to horizontally integrate multiple ISR assets, providing M2M interaction of multi-INT sensors to create actionable information on Time Sensitive Targets (TSTs). The newly developed tools and processes will be demonstrated with NCCT at the Joint Expeditionary Experimentation (JEFX 04) in July of 2004.

An example where the C2 Constellation is providing a situational awareness benefit today is the FY03 HII; Combat Air Forces / Mobility Air Forces (CAF/MAF) integration. In today’s air operations, disruptions are often encountered and have to be dealt with in real time without advance notification – Air Traffic Controllers flow control-induced re-routing, diversion around a cumulus buildup, etc. Without the benefit of time to think about the situation, the aircrews operate in a reactive mode.

New technologies allow the Air Force to share information about disruptions, permitting replanning cycles prior to the time a decision must be made. The ability to replan and communicate information among C2 system helps ensure mission synchronization, and maintains the timeline for the operational mission. Improved information flow and planning also enhances the ability to retask the assets for improved mission effectiveness.

The CAF/MAF Integration will demonstrate the ability and benefits of; sharing real-time information between MAF (global) and CAF (multi-AOR centric) C2 planning and execution systems, and flying assets via Machine-to-Machine XML data exchange. Principal focus is the enroute phase of the overall Global Strike mission prior to entering the AOR. These efforts will ensure GSTF-GMTF mission synchronization and enhance mission effectiveness and efficiency. The CAF/MAF will also improve MAF asset allocation, management and effectiveness.

Future HII's include continued data fusion between NRO data and JFACC mission planners. The final component of the C2 Constellation is the Common Information Infrastructure support (Section 4.4). This support is in the form of Common Information Initiatives (CII) which follows the same structure as the HIIs.

4.4 Building the Constellation: *Common Information Initiatives*

A vast array of defense contractors and commercial products are being utilized as the backbone of the many communication systems, radars, data links, and operational command centers within the Air Force. An equal number of software and hardware packages make these systems run. The interfaces between these systems must be engineered so that they can "talk" to each other. Differing levels of security (Multi Level Security) between various users, differing use of terms, throughput limitations, system flexibility and responsiveness, and integration of legacy systems are all part of the problem confronting enterprise integration for the C2 Constellation.

A primary emphasis of this effort is the development and application of a web based common information infrastructure that will greatly improve the exchange of information across the C2C nodes. The goal is to improve joint operational support between the Services and implement Defense Information Services Agency (DISA) CII services, and extend these services and information exchanges to the civil world as well through the Group Decision Support Services (GDSS) interface. The output will be a series of well structured information services that can be extended to other nodes throughout the constellation and support the implementation of web-based intelligent software agents (ISAs) and related technologies as they mature, as well as a set of service ontologies. The result of this effort will be a powerful integrated infrastructure and set of web based capabilities that will start to automate the "kill chain".

The C2 Constellation performs CII tasks in partnership with the Air Force, ESC/NI System Program Office. The C2 Constellation will be looking at three primary CII tasks during FY04.

- Demonstrate/evaluate value of operating C2 apps over airborne networking capabilities using a test aircraft
- Demonstrate web service broker capability to support web service discovery among C2 Constellation nodes
- Deploy Network Time and Domain Name Services

CII examples include the Airborne Networking (AirNET) CII. AirNET will work with Paul Revere to define demonstration objectives and design. In conjunction with the C2 Constellation POC/IPT demonstration, the CII will determine C2ISR applications and services to be used to demonstrate AirNET.

The CII will begin with an emulated AirNET demonstrated in the CEIF. In the next phase the AirNET will transition to live fly demonstrations with the TFPR. The Airborne Networking will engineer and implement necessary aircraft and surface infrastructure modifications.

Another CII example is a focused on information services. These initiatives will Deploy Network Time Service (NTS) and Domain Name Service (DNS) capabilities for C2 Constellation Block 04 nodes. Activities include:

- Complete NTS and DNS service definition and deployment planning
- Seek service definition approval by IAC and i-TRM acceptance
- Identify and coordinate with programs that will be NTS and DNS enterprise service providers
- Define and execute actions to have TDC and CITS programs be initial NTS and DNS enterprise service providers
- Standup NTS and DNS capabilities in CEIF to support C2 Constellation POC demonstration

The C2 Constellation is developing technologies, processes and protocols that will allow a common information infrastructure to operate. In this environment different users and developers must design their products to the defined standards. The CII services build and deliver capabilities tied to FY04 C2 Constellation Block nodes and the technology (COMM/C2/ISR) groupings.

This final component completes the divisions of work within the C2 Constellation. The following section will outline the C2 Constellation, restate the mission statement, and close with a portion of a speech given to the US Congress on the C2 Constellation

5.0 Conclusion

All the services and the joint world are pursuing enterprise integration. At the heart of enterprise integration is the vision of network centric operations. The Air Force as well as all DoD components will be providing seamless services to one common goal. Whether that service is placing a bomb on target, or cross cueing ISR data, it will be part of a common operating picture. The difficulty is not getting support for the concept; it's how that concept is actualized. The C2 Constellation was created to begin implementation of NCOW.

The saying around Hanscom AFB is "Everyone loves integration as long as you integrate with me." From the C2 Constellation perspective it became obvious that several underlying themes bound integration efforts.

- Sometimes four pieces of information are worse than one
- Knowing it's coming doesn't help if it's a Tsunami
- What's a pound of Command and Control or ISR worth?
- How much does it cost?

The C2 Constellation is taking these difficult issues on through a two-tiered approach. In the top tier we will define the C2 Constellation. Architectures, and the program roadmaps that must support these efforts, are some of the tools needed for successful definition.

In the bottom tier we will build today's Constellation by employing mature, network centric technology, and conducting modeling and simulation exercises. These efforts will identify near term solutions and transition capabilities.

A quick summary of the C2 Constellation can be provided through our Mission Statement: ***The C2 Constellation will achieve horizontal integration through: (1) development of a network centric architecture, (2) use of rapidly maturing modeling and simulation techniques, (3) detailed analysis and experimentation, and (4) application of rapid reaction, high leverage technology initiatives.***

The importance of this task has been highlighted with this testimony to Congress: "A quick after-action review for Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF) found that our Soldiers, Sailors, Airmen and Marines were more powerful and effective than ever before. This effectiveness was seen in increased precision, speed and lethality. As we become more effective, our adversaries have become keenly aware of the reaction time for our operators to obtain information and disseminate it to the shooters. At times they are able to exploit any delay and adapt tactics to improve their survivability. Just a few years ago, reaction time for time-critical targets was nominally measured in hours. Although reaction time was compressed to double-digit minutes during OIF, it's clear that future operations will require reaction times in the single digits." David Tillotson, SES—Statement House Armed Services Committee (endnote 9).

The C2 Constellation is at the heart of netcentric operations and enterprise integration. We stand at the cross roads, bringing the architecture products and the netcentric technologies together in a shared vision for the future.

Appendix A – Endnotes

- **Endnote 1:** Quote from Gen Jumper: (Air Force Brief, OAL Kosovo Lessons Learned, Gen Jumper, Lt Col Dutch Masters – Jan 2000)
- **Endnote 2:** Network Centric Warfare: Developing and Leveraging Information Superiority, David Alberts, John Gartska, CCRP, July 2002
- **Endnote 3:** Joint Vision 2020, America's Military Preparing for Tomorrow
- **Endnote 4:** STATEMENT BY DAVID TILLOTSON, BEFORE THE COMMITTEE ON ARMED SERVICES SUBCOMMITTEE ON TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES, UNITED STATES HOUSE OF REPRESENTATIVES, FEBRUARY 11, 2004
- **Endnote 5:** Constellation Architecture, 2001, Mitre
- **Endnote 6:** C2 Tech Vision Briefing, Chis Kaprielian, Paul Kim Mitre 2004
- **Endnote 7:** Command and Control (C2) Constellation Architecture, (*Draft*), Version 2.0, 17 Oct 2003
- **Endnote 8:** C2 Constellation PMR, Dec 2003, ESC/CXP
- **Endnote 9:** STATEMENT BY DAVID TILLOTSON, BEFORE THE COMMITTEE ON ARMED SERVICES SUBCOMMITTEE ON TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES, UNITED STATES HOUSE OF REPRESENTATIVES, FEBRUARY 11, 2004

Appendix B – Reference Material

DoD Documents

- Joint Vision 2020, America's Military Preparing for Tomorrow
- Global Information Grid Capstone Requirements Document, (GIG CRD), 28 August 2001
- Global Enterprise Services Initial Capabilities Document (GES ICD), (*Draft*), version 1.1, 10 June 2003
- Department of Defense Net-Centric Data Strategy, 7 May 2003
- Transformational Communications Study CONOPS, 10 May 2002
- Transformational Communications Architecture CONOPS, 28 February 2003
- Joint Battle Management Command and Control (JBMC2) Roadmap (Preliminary Version, 30 October 2003)
- Net-Centric Operations and Warfare Reference Model (NCOW RM), Version 1.0, 30 Sep 2003

Air Force Documents

- Nuclear Response Task Force CONOPS, Version 7.0, 20 December 2002
- Global Mobility Task Force CONOPS, Version 2.01, 15 October 2002
- Global Response Task Force CONOPS, Version 3.0, 25 September 2002
- Global Strike Task Force CONOPS, Version 2.0, 26 July 2002
- Homeland Security Task Force CONOPS, 16 September 2002
- Space and C4ISR Capabilities CONOPS, Version 8.1, 29 September 2003
- Air Force Vision 2020, Global Vigilance, Reach and Power
- Command and Control Constellation CONOPS, Version 8 (*Draft*), 1 October 2003
- Command and Control (C2) Constellation Architecture, (*Draft*), Version 2.0, 17 Oct 2003
- Air Force NetOps CONOPS, Version 4.0 (*Draft*), 10 October 2003
- Air Force Forces (AFFOR) CONOPS, 22 Jul 2002
- Network Centric Collaborative Targeting CONOPS, Version 5.3, 6 April 2001
- Airborne Network Architecture Design and Performance Operational Drivers Template, Version 1.0, 9 June 2003
- Air Force Command and Control Technical Reference Architecture, Version 3.0, 1 December 2002
- Air Force Basic Doctrine, AFDD-1, September 1997
- Air Force Policy Directive 10-28, CONOPS Development, 15 September 2003
- CSAF's "The Edge--Air Force Transformation," 31 July 2003
- Multi-Platform Battle Management Command, Control, Communication, Computer Intelligence, Surveillance, Reconnaissance (BMC4ISR) Wideband Network, Version 2.0 (*Draft*), 5 June 2003

Commercial References

- **Network Centric Warfare: Developing and Leveraging Information Superiority**, David Alberts, John Gartska, CCRP, July 2002
- **Networks + Study Guide**, Ben Bergensen, Tim Catura, Sybex, 1999
- **Understanding Information Age Warfare**, David Alberts, John Garstaka, Richard Hayes, CCRP, 2001
- **Web Services**, Stephen Potts, Mike Kopack, SAMs, 2003
- **Executive's Guide to Web Services**, Eric Marks, Mark Werrel, John Wiley and Sons, 2003

Electronic System Center Briefs

- C2 Constellation Overview Brief, Version XX, March 31, 2004
- C2 Tech Vision Briefing, Chis Kaprielian, Paul Kim Mitre 2004
- C2 Constellation PMR, Dec 2003
- C2 Constellation and FORCEnet Convergence Update, Feb 2004
- C2 Constellation SOA Outline, AS&EA Team, Jan 2004
- Constellation Architecture, 2001, Mitre
- C2 Constellation and FORCEnet Convergence Update
- OAL Kosovo Lessons Learned, Gen Jumper, Lt Col Dutch Masters

OTHER

- STATEMENT BY DAVID TILLOTSON III, SES
DIRECTOR FOR C4ISR ARCHITECTURE AND ASSESSMENT, HEADQUARTERS
UNITED STATES AIR FORCE -- BEFORE THE COMMITTEE ON ARMED
SERVICES SUBCOMMITTEE ON TERRORISM, UNCONVENTIONAL THREATS
AND CAPABILITIES, UNITED STATES HOUSE OF REPRESENTATIVES,
FEBRUARY 11, 2004

Appendix C Footnotes

Footnote 1 Please note that the Air Force refers to the TCT thread, (Time Critical Targeting), while the other services refer to a TST, or Time Sensitive Targeting thread. The agreed terminology for the joint IPTs is TST.