Chapter 5

Bilateral Interoperability Through Enterprise Architecture

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The views expressed in this chapter are the opinions of the authors, and do not reflect the official opinions of any U.S. government agency.

5.1 INTRODUCTION

This chapter addresses the important role of architecture planning for ensuring system interoperability in a network-centric coalition environment. As US forces become more dependent upon coalition partners to support crises around the globe, systems interoperability becomes a major concern. This problem is more acute in the Pacific theater, where the US has no equivalent to NATO to address such issues. In the Pacific, the US has numerous bilateral agreements with allied nations and as such the degree of interoperability varies from country to country. A key to understanding interoperability shortfalls is documenting the "as is" architecture for each primary allied nation to facilitate identification of key information exchange requirements for critical command and control nodes.

The importance of enterprise architecture planning should not be downplayed. Enterprise architecture planning considers both the tactical and strategic need for information exchange in supporting the organization's mission [Spewak 92]. This is especially true with the plethora of C4ISR systems scattered throughout the US

Pacific Command (USPACOM) theater of operations where access to secure, quality data is vital to ongoing operations.

Headquarters (HQ) US Pacific Command (USPACOM) recognized the need for documenting baseline architectures with the publication of US Commander in Chief, Pacific (USCINCPAC) Instruction 2010-4 [USCINCPACINST 2010-4]. This instruction provided guidance to component commands on how to describe and construct systems and operational architectures. The Joint Forces Program Office was asked to assist with this effort at US Alaskan Command (ALCOM) in the fall of 1999. The ALCOM architecture study, using a prototype version of the Joint C4I Architecture Planning System (JCAPS), illustrated the utility of having a clearer picture of the enterprise architecture described in common lexicon. With this information, the CIO can make more informed decisions concerning resource requirements and contingency planning, to ensure information technology adequately supports Alaskan Command's mission threads.

Another result of the Alaskan Command study was the need to consolidate the numerous architectures that have been developed in recent years. During a survey at HQ USPACOM conducted by a CINC Interoperability / Joint Forces Program Office team approximately sixteen documented or ongoing architecture efforts were revealed across the J2, J3, and J6. Each effort was separate and distinct with no centralized data repository.

What are the implications of understanding the Enterprise Architecture for Joint/Coalition interoperability? Enterprise architecture provides a top-level model of how information flows across the organizations within the enterprise domain. It identifies the key nodes, potential constraints, and may identify duplication of efforts. It is a cornerstone to integrating or updating technologies and understanding what data is needed where and when [Spewak 92].

Next, this chapter will discuss the application of commercial best practices into the development of military C4ISR architectures and the effective consolidation of existing C4ISR architectures.

5.2 THE CHALLENGE

Since the end of the Cold War, there has been a significant reduction in the ranks of the US military. US presence overseas has also been greatly reduced. During the last decade, the operations tempo has increased with the US involved in numerous peacekeeping missions and humanitarian and regional conflicts. These joint operations have also included allies and coalition partners. In today's post 9/11 environment, with US forces stretched thin, any additional crisis will demand

US and Allied coalitions. Recent coalition operations have revealed interoperability shortfalls and lack of C4ISR and logistic systems synergies. These shortfalls impede the ability of joint US and coalition warriors to effectively and efficiently use all available information systems to perform the assigned missions, be they major regional conflicts, peacekeeping missions or humanitarian relief. Some suggest that the US work their own inter-service interoperability challenges first and foremost before engaging with its principle allies. This would be a serious mistake. Working US interoperability issues without addressing principal Allied force interoperability would only further exacerbate the capabilities gap. In order to understand the magnitude of the interoperability issues, consider viewing the C4ISR domain in terms of the enterprise architecture.

5.3 ENTERPRISE ARCHITECTURE

What is enterprise architecture? The DoD C4ISR Architecture Framework document describes architecture as a "mechanism for understanding and managing complexity [C4ISR 97]." David Sims of SharpAngle.Com, states, "Enterprise architecture provides the underlying framework, which defines and describes the platform required by the enterprise to attain its objectives and achieve its vision [Sims 00]." The enterprise architecture consists of four interrelated views: Information, Business, Application, and Technology.

The information architecture consists of data models and databases that serve those within the domain. This suggests a universal common database exists that is the shared, distributed, accurate, and consistent data resource. The data providers of this repository ensure the quality of the information made available.

The business architecture represents the business processes. In a military vernacular, the business architecture describes the operational functions or what activities or tasks must be performed. Roger Founier of *Information Week* describes the application architecture as the core applications required to enable business process to successfully support the business enterprise [Sims 00]. The business architecture also assesses the health of current applications and forecasts new ones to satisfy future business needs.

The technology architecture describes the hardware platforms that connect the application, business and information architectures. The technology architecture is designed to provide interoperable systems that meet the needs of the users through out the business domain.

The META Group has projected that architecture enterprise planning and analysis is a growth industry. Their forecast in this discipline includes the following:

> *Through 2005, the primary business drivers for enterprise architecture will be: 1) right sourcing business components via disaggregation ...(i.e., corporate agility); 2) delivering customer intimacy and erecting exit barriers within a customer life-cycle management strategy; and 3) driving information value creation* [Meta 00].

5.4 RESULTS OF THE US ALASKAN COMMAND ARCHITECTURE EFFORT

When discussing enterprise architecture, it is instructive to consider what can be learned by actually constructing an architecture. In late 1999, the Joint Forces Program Office undertook the construction of a baseline, “as-is” architecture at US Alaskan Command (USALCOM). This project supported both USPACOM, as the first project to attempt execution of their new architecture generation instruction [USCINCPACINST 2010-4]; and US Joint Forces Command (USJFCOM), who was interested in the feasibility of theatre architecture development. Among other goals, the project provided a “live-fire test” for the then-current prototype of the Joint C4I Architecture Planning System (JCAPS) tool.

This effort was very carefully scoped, to include only the systems in the USALCOM headquarters – about 100 systems. Despite this limited scope, the effort took around 2100 staff-hours – more than a full staff year – to complete. A closer examination of how the time was spent will show some clear benefits to an enterprise architecture approach. The methodology that was followed is shown in Figure 1, with the number of staff-hours spent on each task in the lower right hand corner of each block.

First, the review of existing documentation and the data gathering took almost 750 staff-hours. This extremely laborious and time consuming process included collection and review of fragmented, uncorrelated, uncoordinated depictions of system connectivity for the system views, as well as interviews of operators about how they accomplished their missions for the operational views. Considering the large amount of time invested in this step, it is no wonder that architectures have been difficult to document.

An enterprise approach to architecture planning would help mitigate this level of effort. By integrating the collection and maintenance of architectural information into existing business processes, the experts’ knowledge can be captured in a way that is usable not just by them, but by others. Rather than having a specialized “architecture” group gather data from the experts, the experts themselves can maintain the data. By providing a uniform tool for this across the enterprise, experts can team and share knowledge more effectively. This might ultimately result in a reduction in effort across the organization by making key information more readily accessible – in contrast to the high cost of collection observed when the generation of the architecture was completely decoupled from the business process.

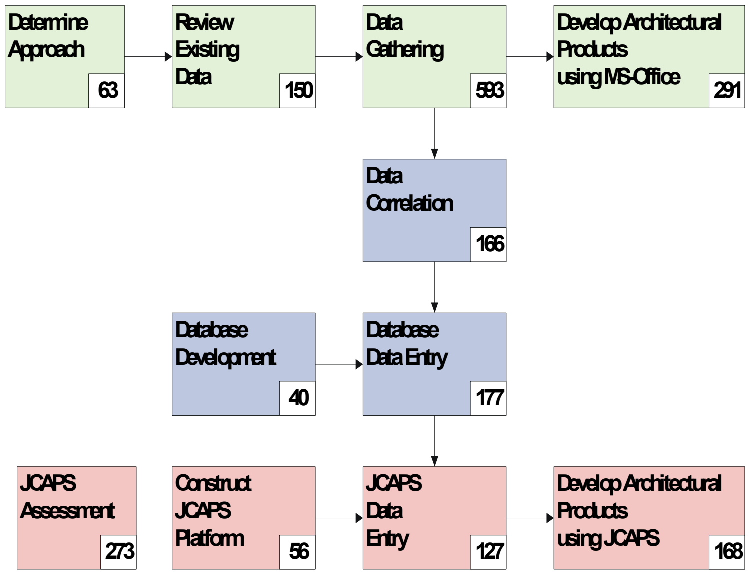

Figure 5-1 *ALCOM Architecture Methodology and Levels of Effort.*

Another key indicator in terms of level-of-effort was the amount of time required to perform data correlation. Multiple data sources had to be reconciled and fused in order to produce a coherent, consistent set of architectural data. This process, including the development of a lightweight tool to support it, took nearly 400 staff hours. There were several systemic issues that lead to such a high cost in man-hours. The existence of overlapping and uncoordinated data sources was only aggravated by the absence of common terms of reference and means of representation. Not only were there multiple sources of data (which did not necessarily agree on *what* they said), but the sources each said the same things in different ways. Even when they were in agreement, the data would often have to be repackaged into a form that would be consistent across the enterprise.

We can examine how an enterprise approach to architecture might have reduced some of this cost. Rather than generating several sets of node connectivity diagrams in several different applications for different purposes, all node connectivity data would be captured in the same data source. By understanding how the organization would use this sort of data – the elusive “so what?” of architecture – the right data can be captured. An agreement across the organization can be reached that will allow data compiled by different users to be used together to make decisions, without having to go through the time-consuming and complex cost of comparing data that is represented differently. Thus, the investment in standardization at the enterprise level pays off by allowing the organization to leverage the data embedded throughout the organization.

Finally, we can consider the amount of time constructing products. As summarized in Table 1, two sets of products were generated in this effort – one in JCAPS and another in PowerPoint. A significant amount of time was spent in constructing architecture products after the data had been entered. It took nearly 300 staff-hours to generate the PowerPoint products, while the time required to generate the JCAPS products from the data was less, about 170 staff-hours. The generation of these products was eased by the presence of the first data set.

Table 5-1 Architecture products for Framework 2.0 supported by JCAPS Version 2.0 R14

Applicable Arch. Product	*Product Ref.*	*Architecture Product*	*Essential or Supporting*	*General Nature*
Operational	OV-1	High-level Operational Concept Graphic	Essential	High-level graphical description of operational concept (high-level organizations, missions, geographic configuration, connectivity, etc.)
Operational	OV-2	Operational Node Connectivity Diagram	ESSENTIAL	Operational nodes, activities performed at each node, connectivities & information flow between nodes
Operational	OV-3	Operational Information Exchange Matrix	ESSENTIAL	Information exchanged between nodes and the relevant attributes of that exchange such as media, quality, quantity and the level of interoperability required
Operational	OV-4	Command Relationships Chart	Supporting	Command, control, coordination relationships among organizations
Systems	SV-1	System Interface Description	ESSENTIAL	Identification of systems and system components and their interfaces, within and between nodes
Systems	SV-2	Systems Communication Description	Supporting	Physical nodes and their related communications laydowns

Again, however, we see a clear advantage to employing an enterprise architecture strategy. This effort was geared toward producing the *products* specified in the USCINCPAC instruction, rather than contributing to a shared, dynamic enterprise architecture. By embedding the *data* and the use of that data into the business processes of the organization, the demand for (static) products is reduced, if not eliminated.

Ultimately, the investment in architecture development must yield returns if it is to be continued throughout the enterprise. Looking through the perfect lens of hindsight at the architecture developed for USALCOM, we see that its utility is directly related to a set of well-defined goals or objectives for the use of the architecture. Perhaps the most important lesson learned from the ALCOM effort was that these goals must come first and be used to drive what data is collected. A clear understanding of the need for and uses of architecture is required in order to ensure a favorable return on investment. In a nutshell, this is the purpose of the enterprise architecture strategy.

5.5 ARCHITECTURE CONSOLIDATION:

During the ALCOM Architecture outbrief to the USPACOM J6, it was suggested that all of HQ USPACOM's architecture data should reside in one repository (the "Holy Grail" as then-USPACOM-J6 BG James D. Byran described it) in order that the data can be readily accessed, centrally managed, updated and reused. In order to determine the organization's "as-is" architecture baseline, one should consider collecting, de-conflicting, and normalizing all existing architecture data that has been accomplished previously.

The problem of network aggregation/deaggregation is one that parallels the military need for rapidly changing command organizations that can add or subtract command levels based on the current situation. For a detailed discussion of the aggregation/deaggregation problem, see [Hamilton, Nash and Pooch 97].

Various architectures already exist to some extent--having been produced by J2, J3, J6 and other supporting organizations. These independent, non-collaborative efforts have resulted in information resources that often are of little use and are consequently shelfware. A cursory review during the 1 Mar 2000 visit to HQ USPACOM by the CINC Interoperability / Joint Program Office team revealed approximately 16 documented or ongoing architecture efforts across the J2, J3, and J6. Each effort is separate and distinct. No centralized data repository exists for the data collected. A relational architecture database that can be easily updated, maintained and reused would reduce repeated duplication of efforts and multiple data requests and improve resource planning and allocations. A proposed methodology for executing architecture consolidation in the JCAPS relational database is shown in Figure 2.

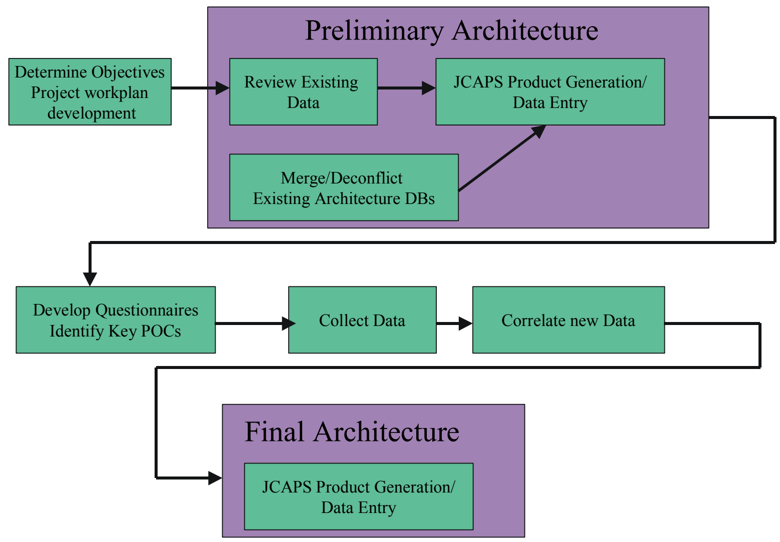

Figure 5-2 *Proposed Methodology for Executing Architecture Consolidation in JCAPS*

In addition, by consolidating existing architecture data, a clearly defined enterprise architecture advances C2 capability through enhanced integration of C4ISR architectures. This in turn promotes alignment of Joint and Service force modernization initiatives with concept of operations and joint war fighting doctrine. Consolidating existing architectures also provides a vehicle to highlight potential interoperability shortfalls within the enterprise domain.
Developing the enterprise architecture is no small task. Ample resources should be made available for such an undertaking, as well as strong management support [Spewak 92]. Consolidation of existing architecture data is the cornerstone to developing the enterprise architecture. Consolidation and integration of existing and ongoing C4ISR architecture efforts into a single reusable and maintainable data repository can be accomplished in three steps. First, decompose existing architectural threads into constituent objects. Then, de-conflict instances of objects within each class, predicated upon a configuration management and confliction resolution process. This is the most tedious part of the consolidation activity, as it requires much analysis and is database-query-intensive. Third,

reconstruct the architectural thread using normalized objects. This is the result of the de-confliction process as shown in Figure 3. A configuration control and maintenance process is required to ensure data integrity upon completion of consolidation efforts. This task may be delegated based on the data owner, type, location, organization or any combination thereof [Manley 00].

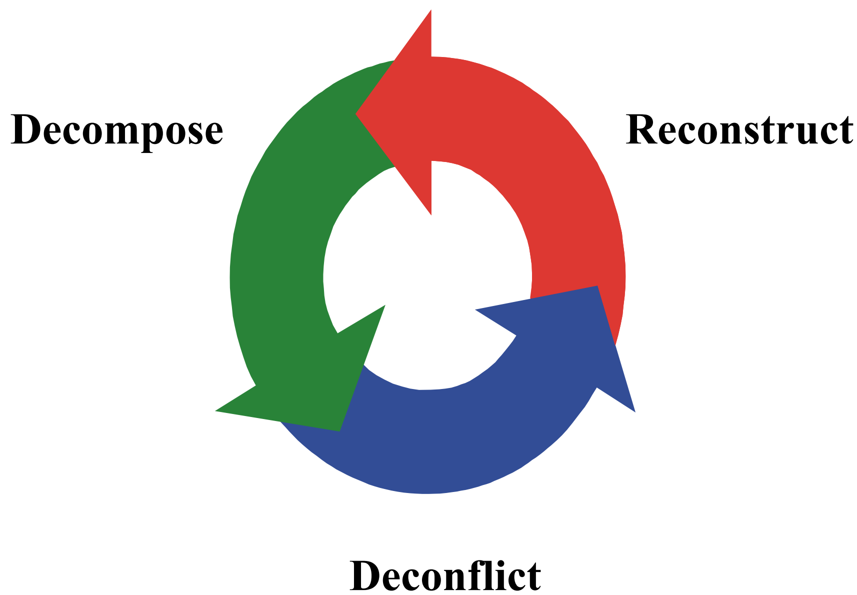

Figure 5-3 *Architecture Consolidation Methodology*

By consolidating the existing architecture data, a collective understanding of what is "built to date" is established. This will illuminate areas that require further development within the enterprise domain and provide a launching point for assessing baseline requirements through gap analysis. The organization, then, can prioritize follow-on efforts to fill in the architecture gaps. The impact in a joint coalition environment is profound. Understanding the enterprise architecture is vital to coalition forces ability to effectively operate in a plug and play environment.

5.6 IMPLICATIONS FOR COALITION INTEROPERABILITY

C4ISR architecture development and implementation is complicated when the systems belong to different services and nations. Combined interoperability – that is, interoperability between different services from different nations – is challenging. Sustained interoperability cuts across two dimensions: laterally between countries and horizontally over time. The essential starting point for combined C4 planners is the existing communications architecture. Common architecture formats greatly expedite combined C4 planning. This is particularly obvious in operational architecture planning for US Forces, and there is no reason to think that resolving differing architecture formats would be any easier in a combined operation.

5.7 AN OUTLINE FOR AN AUSTRALIAN DEFENSE FORCE/ US PACIFIC COMMAND ARCHITECTURE EXPERIMENT

According to the Director, Defense Information Environment Architectures Office, Headquarters, Australian, Defense Forces (ADF), the ADF is keenly interested in the usefulness of architecture development as it relates to mission planning and resource management [Burns 2000]. In October 2000, during the Command and Control Research and Technology Conference, a collaborative architecture project was further explored and proposed.

The key to the success of the proposed collaborative venture between the US and AS is the operational relevance of the selected architectures. This is especially challenging in light of the balance required between the objectives of the participants and stakeholders from both sides.

From the Australian perspective, pursuing the concept of an ‘architectural’ approach has now generally been accepted as a reasonable response to resolving key concerns with the problems with the AS Defense Information Environment (DIE), there was and remains uncertainty on how it is to be achieved, the risks and costs and where the high pay-off areas are. There is a healthy degree of skepticism that this is just another IT industry fad with the real cost of implementation being high and the value of the outcome too low to justify it. This skepticism is consistent with reports from the US Unified Commands. While the Australian interest is directly related to the construction and use of architectural products, the various US participants view architecture as a means to a set of distinct ends. The SPAWAR perspective that the work be tied closely to mission planning is indicative of widespread concerns expressed about architecture in the US, particularly the often-expressed viewpoint that architecture has no relevance to the operator.

Previous US experience with architecture (notably the USALCOM experiment) has tended to indicate that neither the operational nor the system views of architecture, by themselves, provide utility to the operator. Without operational context, it is difficult, if not impossible, to evaluate the meaning of system views.

Conversely, without understanding how the systems support the operational requirements, it is difficult to make use of the operational information in addressing interoperability (which often relies on the abilities of systems to exchange information). The relationship between the operational and systems architecture is symbiotic.

Another issue that has arisen from earlier CIPO/JFPO experience in Alaska, and the experiences of other architects throughout the US DoD, is that capturing a complete operational architecture, and validating that architecture, is a potentially intractable problem. Including a number of allied nations in the scenario would only aggravate the difficulty of accurately modeling an operational architecture. This observation tends to suggest that a careful definition of the effort should occur in order to ensure that results can be obtained within the available level-of-effort.

By focusing on the specific goals of this effort – the use of architecture to address coalition interoperability – we can immediately suggest a substantial simplification in terms of operational architecture. If we focus our efforts on the requirements to exchange information that cross national boundaries, we will address only the parts of the operational architecture that are truly "coalition" in nature. This set of operational requirements can be further limited by addressing only one operational thread (i.e., logistics, coalition common operational picture, etc.).

If we can identify these key operational requirements from the exercise plan, or show that these requirements are not adequately addressed by this plan, we will have made a contribution toward understanding the relationship between architecture and operational planning. We may, for example, be able to propose the use of architectural methodology as an adjunct to or a new method of operational planning.

5.8 BILATERAL INTEROPERABILITY OVER THE COWAN

Once these requirements have been identified, we can identify the systems that will be involved in conveying the information between the appropriate endpoints. As the primary connection between coalition partners, the Combined Operations Wide Area Network (COWAN) will almost surely be captured as a result of this analysis. (In fact, we can ensure that this is the case through appropriate choice of operational thread in the first step.) It is important to note, however, that the COWAN will not be the only system captured in this analysis. We must also capture other connections between the nations that will support the required exchange of information (for example, secure voice circuits), and we must capture the parts of the national systems that will be involved in the information exchange.

For example, we may find that a US Marine unit needs to send a request for fire support to the RAAF as shown in Figure 4. This request may be sent from a Marine system to a (US) Navy system, from where it might be moved by an operator onto the COWAN, where it might be sent to the RAN, where it might then be moved by an operator onto an AS system where it will eventually be communicated to the RAAF. All of the steps on this path are required to exchange the information between the US Marines and the RAAF, in this scenario; they should all be captured by the system architecture that describes how the operational requirements are met.

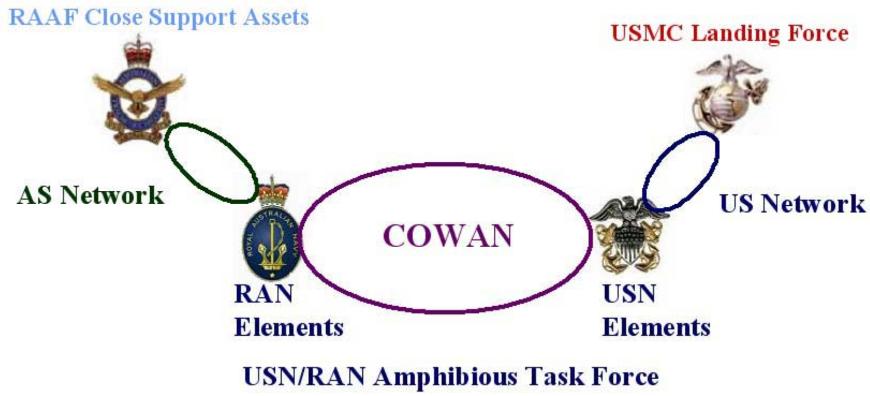

Figure 5-4 *COWAN in support of coalition operations*

Using this basic methodology, there are still a number of key issues that must be addressed. Issues of primary interest to the operator are maintainability and utility of the architecture. As part of the effort, we must address ways in which the architecture can be maintained and used by the operator as an ongoing part of coalition exercises and future operations. At the same time, we must ensure that the architecture has utility to this community – that it helps plan for system requirements, predict interoperability problems, and help identify work-arounds. As a part of this question of utility, it may be useful to explore whether enough information is captured to enable the effective use of modeling and simulation. This is especially significant since most previous efforts with architecture have concluded that completed architectures do not generally capture enough information to move directly to the construction of a model or simulation.

As the issues identified above are addressed and the project takes a more concrete form, issues of implementation will need to be addressed. These issues must be addressed early, but not too early – these decisions should not be made before an understanding of the data to be collected, the products to be produced, and the desired use of the data and products is understood. Key implementation issues include the data representation, tool selection, and collaboration mechanisms between US and AS members of the project team.

5.9 A PRESCRIPTION FOR COALITION ARCHITECTURE

With the development of the USPACOM Information Capabilities Framework (described later in Chapter 7), emphasis has been placed on having a clear understanding of the systems capabilities as they relate to mission requirements. This strategic plan encompasses and is built around Joint Mission Areas that includes improving coalition combined operations. Additionally, a portion of the USPACOM CIO's Systems Information Modernization Plan is focused on improving the International Information Networking Capabilities.

5.9.1 Organizational Goals to be Supported

- Supports the consolidation of initiatives in support of combat C2 under a Combined Operations Wide Area Network, or COWAN, effort.
- Promotes Joint/Coalition and Service force modernization initiatives alignment with concept of operations and joint war fighting doctrine
- Provides vehicle to highlight potential interoperability shortfalls
- Provides a baseline database that eases the stand-up of future Coalition/Joint Task or Mission Force
- Exports JFPO/CIPO architecture methodology as it relates to implementation of the DoD architecture framework

5.9.2 Objectives

- Show utility of architectures in support of operational planning
    - Predict interoperability from existing systems
    - Understand interoperability requirements
    - Identify interoperability shortfalls
    - Identify potential solutions
    - Assess predicted shortfalls versus actual shortfalls
- Assess business case for architecture planning
    - Validate using real-world experiences
    - Assess benefit obtained
    - Provide real data on costs
- Improve understanding of architectures, architecture frameworks and related issues (such as relationship of architecture to standard operational planning)
- Synergize, if practicable, with ongoing ASD(C3I) study efforts to: (1) Identify requirements for a standing secure Pacific Coalition Wide Area

Network and (2) coordinate/develop standardized Pacific coalition C4 operations, technical and systems architectures.

5.10 PROPOSING A WAY AHEAD

Military command and control architecture development requires active participation by the commands involved. Simply forming a team, launching to a remote headquarters and documenting an architecture is not enough for command and control use. Recall that there can be many intended uses for an architecture, in this case we are focused on operational use of architecture by a J6/G6 staff.

Experimentation to develop useful, scalable coalition C2 architectures is needed. Successful experimentation will require a bilateral team and common objectives between two equivalent headquarters. For example, an AS/US experiment could be run between HQ, Australian Theater and HQ US Pacific Command. The architecture team would be composed of both Australian and American military communications and software engineers. It should be stressed that the team composition requires personnel with strong technical skills as well as thorough understanding of the staff procedures of both countries.

A proposed procedure is illustrated in Figure 5. In advance of a combined exercise, the architecture team would focus on an agreed to operational thread such as logistics or fire support. Modeling the thread is required to identify systems, their uses, their required connectivity and finally their required interoperability.

A successful architecture team must determine the systems that both countries will be used and what the required (and allowable) interoperability between the two systems is required. This should be used to perform a useful gap analysis. To illustrate gap analysis, we go back to the example of a US Marine ground element requesting a close air support mission from a Royal Australian Air Force element. First the desired path of such a request must be traced. Available systems are then mapped to that mission thread and gaps are identified.

Much of what is called experimentation in Defense is really not experimentation in the scientific sense at all. An exercise is not necessarily an experiment. To make a combined architecture project a useful experiment requires an evaluation of predicted versus actual results. This can be accomplished by development of the C2 architecture before the combined exercise and evaluating the predictive value of the architecture from an interoperability standpoint.

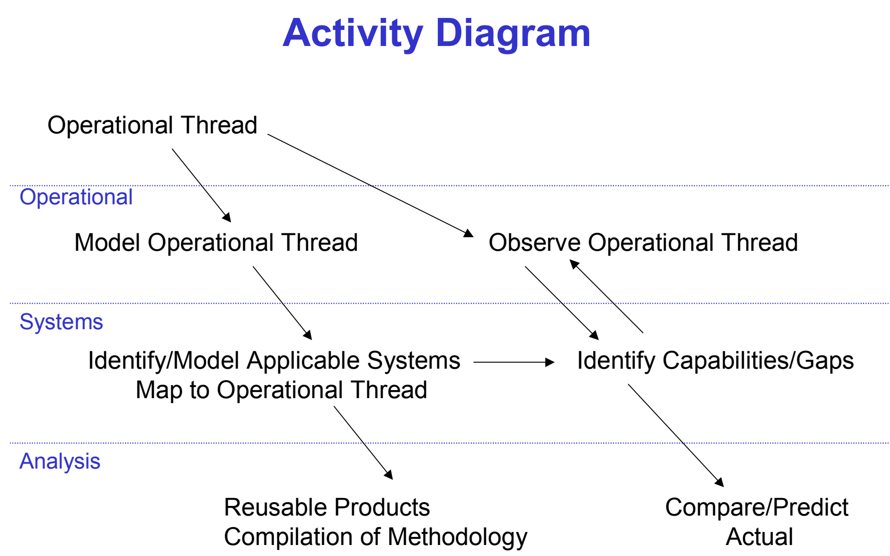

Figure 5-5 *Coalition architecture activity diagram*

5.10.1 A potential combined interoperability experiment

Document an as-is combined command and control architecture related to a specific mission thread and illustrate transition to the objective architecture from the CJTF perspective. In doing so, achieve the following:

- Analyze interoperability requirements & capabilities
- Predict shortfalls/suggest work-arounds
- Test analysis against targeted exercise

The architecture must be sustainable, maintainable and re-useable. The process and methodologies used must be repeatable and *scaleable*. The architecture must capture information about the following as shown in Figure 6.

- Information flows and processes
- Interfaces to AS and US national systems
- Nature and scope of COWAN
  - Infrastructure
  - Usage
  - Traffic management
- Information semantics

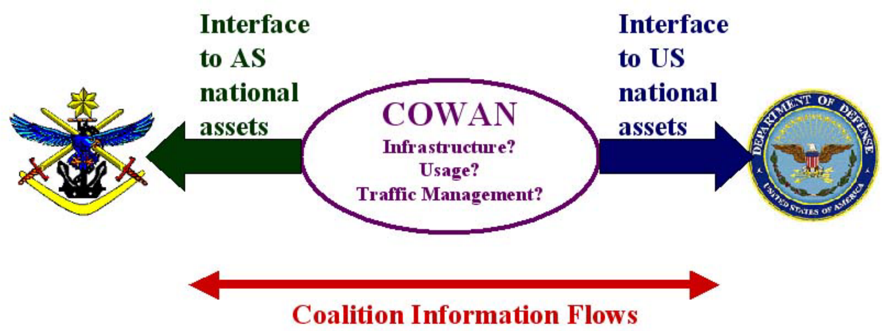

Figure 5-6 *Objectives of a coalition architecture experiement*

5.11 PRODUCTS

The DoD Architecture Framework document or its successor provides an excellent starting point for determining what should be produced. Because enterprise-level architectures have scalability issues, it is easy to get focused on various "tools." But tools must follow process, not the other way around. For a bilateral or multilateral architecture effort, any tools used must be readily available to all participants. An outline of what should be expected from a combined experiment in C2 architecture is outlined below:

- Technical Report describing baseline architecture
    - Operational architecture graphics
    - System architecture graphics
- Configuration management of the architecture data elements
- Maintenance process of reusable products
- Cost Benefit Analysis/Business Case
- Predicted versus actual interoperability requirements assessment
- Comments on usefulness and completeness of products as outlined in the framework

5.12 CONCLUSIONS

In this chapter, the authors have outlined a practical strategy for consolidating existing C4ISR architectures. Using our practical architectural success in the US Alaskan Command, we suggest that this methodology can be applied across large, combined, theaters of operation. Our recommendation is to evaluate this premise by implementing an enterprise architecture with a coalition partner. Such a development would provide practical coalition C4 architecture planning benchmarks.

Combined architecture efforts should be operationally relevant. The focus of such efforts should be to benefit the military and naval communications planners, the prediction of potential C2 interoperability issues and to proactively identify solutions to C2 interoperability problems.

5.13 REFERENCES

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