USAWC STRATEGY RESEARCH PROJECT

THE WAY AHEAD FOR JOINT TRANSFORMATION

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ABSTRACT

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Transformation is a central theme of current national security policy. Although OSD is firmly committed to change, the way ahead is unclear. Each Service is now pursuing its own version of transformation. Expected OSD guidance will cover transformation tenets, but will not provide the detailed approach required to determine which programs are indeed transformational and their impact to warfighting capability. What is needed is the newly approved JROC joint operational concept and detailed integrated architecture approach to provide a common framework for discussion and the ability to design an interoperable force structure meeting JV 2020 objectives. In addition, a method is needed to effectively describe and implement interfaces in U.S. and foreign information and weapon systems that do not exist today.

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> When our comprehensive review is complete, I will expect the military's budget priorities to match our strategic vision – not the particular visions of the Services, but a joint vision for change.
>
> —George W. Bush, Speech to the Citadel, September 23, 1999

Successful joint transformation requires a systematic approach utilizing common frameworks and interface implementations to describe, develop, and field joint operational concepts and interoperable capabilities. The stakes are very high, both in dollars and combat capability for now and in the future. This paper analyzes current Department of Defense transformation approaches, compares them to current Service efforts and describes several initiatives needed to develop a common transformation framework in order to more effectively field joint warfighting capabilities.

BACKGROUND

Transformation has been occurring throughout military history as nations have changed military equipment, organization, and employment concepts either to respond to defeats or exploit emerging opportunities. But unlike the past, where Services developed transformational capabilities such as helicopter air mobile-warfare, carrier aviation, and stealth aircraft armed with precision guided munitions, the United States is now attempting large-scale, multi-discipline transformation to develop truly joint warfighting capabilities superior to any threat that may emerge.

The term "transformation" first entered the current force structure debate in 1997. The 1997 Quadrennial Defense Review (QDR) committed the Department of Defense (DoD) to transforming to reflect the changing threat and funding realities. After the collapse of the Soviet Union, the U.S. no longer faced a superpower adversary; it no longer made sense in terms of budgets and missions to sustain the existing cold war force structure.[1]

Now that the U.S. does not face a peer competitor, the military is being re-designed to face future threats based on projected capabilities instead of a well-defined adversary. Hard choices need to be made concerning force structure, continuing legacy acquisition programs, and research required for new capabilities. Transformation poses radical questions regarding force structure and system development with considerable resources at stake. As part of the FY2003 budget, the President requested a significant increase in funding to support transformation. A $48B increase over FY2002 funding levels funded thirteen new transformational programs and accelerated funding for 22 existing programs.[2]

There are substantial concerns on how to balance force structure and transformation. On one hand, U.S. military forces need to meet current commitments and counter near term threats through 2010 including presumed anti-access strategies and weapons of mass destruction proliferation. We must also face the challenge of "reengineering for more capability for less cost."[3] On the other hand, there is the possibility that asymmetric technical breakthroughs available to adversaries post 2010 could render the current force structure vulnerable, if not obsolete, if the U.S. does not develop and field advanced capabilities and operating concepts. To successfully meet future asymmetric challenges, the U.S. needs to choose its near-term transformation investments wisely without closing out other potential efforts. With transformation now a central theme of current national security policy, it is time to examine the current Office of the Secretary of Defense (OSD) transformation approach and analyze its capability to successfully implement joint transformation.

CURRENT TRANSFORMATION APPROACHES

OFFICE OF THE SECRETARY OF DEFENSE

Following up with campaign themes, President Bush elevated transformation into a major section of the National Security Strategy (NSS).[4] Secretary of Defense Donald Rumsfeld laid out the current details of the DoD transformation policy in the September 30, 2001 QDR. Overall, OSD guidance states that:

> "Transformation results from the exploitation of new approaches to operational concepts and capabilities, the use of old and new technologies, and new forms of organization that more effectively anticipate new or still emerging strategic and operational challenges and opportunities and that render previous methods of conducting war obsolete or subordinate."[5]

In addition,

> "Transformation must therefore be focused on emerging strategic and operational challenges and the opportunities created by these challenges."[6]

Instead of providing a single joint direction, Secretary Rumsfeld tasked each of the Services to produce individual transformation roadmaps to develop the capabilities required to meet six critical operational goals:[7],[8]

- Protecting critical bases of operations (U.S. homeland, forces abroad, allies, and friends) and defeating CBRNE weapons and their means of delivery;

- Assuring information systems in the face of attack and conducting effective information operations;
- Projecting and sustaining U.S. forces in distant anti-access or area-denial environments and defeating anti-access and area-denial threats;
- Denying enemies sanctuary by providing persistent surveillance, tracking, and rapid engagement with high-volume precision strike, through a combination of complementary air and ground capabilities, against critical mobile and fixed targets at various ranges and in all weather and terrains;
- Enhancing the capability and survivability of space systems and supporting infrastructure; and
- Leveraging information technology and innovative concepts to develop an interoperable, joint C4ISR architecture and capability that includes a tailorable joint operational picture.

In addition to the six operational goals, the QDR adds that the DoD approach to transformation rests on four pillars:

- Strengthening joint operations through standing joint task force headquarters, improved joint command and control, joint training, and an expanded joint forces presence policy;
- Experimenting with new approaches to warfare, operational concepts and capabilities, and organizational constructs such as standing joint forces through wargaming, simulations and field exercises focused on emerging challenges and opportunities;
- Exploiting U.S. intelligence advantages through multiple intelligence collection assets, global surveillance and reconnaissance, and enhanced exploitation and dissemination; and
- Developing transformational capabilities through increased and wide-ranging science and technology, selective increases in procurement, and innovations in DoD processes."[9]

As the next step to guiding DoD transformation efforts, Secretary Rumsfeld tasked the OSD Office of Force Transformation to evaluate each of the Service's transformation plans and develop "Transformation Planning Guidance" for the next Planning, Programming, and Budgeting System (PPBS) cycle. Is this sufficient? Can it satisfy the Joint Vision? We will now look at how this guidance ties into the individual Service approaches.

SERVICE

Each Service defines transformation a little differently and delivers the combat capability it determines the combat commander requires. First, the Army is in the midst of tremendous transformation upheavals. The Army Transformation Campaign Plan defines transformation as:

> "…a continuous process that creates a culture of innovation, which in turn seeks to exploit and shape the changing conduct of military competition. The Army will explore new combinations of concepts, people, organizations, and technology in order to produce new or increased capabilities, and protect against asymmetric threats."[10]

This transformation process will change the Army "into a force capable of dominating at every point on the spectrum of operations." Following this approach, the Army is moving forward with an extensive effort to transform into a lighter, more lethal force resulting in a force structure very different from the one it currently owns.[11] Overall, the purpose of this future force does not vary with today's Army's overarching mission to fight and win America's wars.

The Air Force takes a different approach. The Air Force Transformation Flight Plan defines transformation as fundamental change involving three principal elements and their interactions with each other. Transformation is:

> "A process by which the military achieves and maintains asymmetric advantage through changes in operational concepts, organizational structure, and/or technologies that significantly improve warfighting capabilities or ability to meet the demands of a changing security environment."[12]

The Air Force defined its transformation path by expanding broad transformation goals in the overarching JV2020 guidance in the Air Force Vision 2020 and finally into specific details in the Air Force Transformation Flight Plan. Air Force Vision 2020 outlines the basis for "Task Force Concepts of Operation," which are used to focus planning, programming, budgeting, requirements, and acquisition efforts.[13] The Air Force will use results from these task forces to develop and field the transformational capabilities necessary to sustain its six core warfighting competencies shown in Table 1. Air Force doctrine defines core competencies as the areas of expertise or the specialties the Air Force brings to any activity across the spectrum of military operations.[14]

• Air and Space Superiority • Information Superiority • Global Attack • Precision Engagement • Rapid Global Mobility • Agile Combat Support

TABLE 1. AIR FORCE CORE COMPETENCIES

Advanced technologies enable new concepts of operation that produce order-of-magnitude increases in the ability to achieve desired military effects. Further, organizational changes such as the development of Aerial Expeditionary Forces enhance the Air Force ability to execute the national-security strategy.[15]

The Air Force has a balanced view of transformation that mirrors the OSD guidance.

> "Transformation can be accomplished in various ways: by acquiring new technologies that perform new missions or significantly improving old systems or processes; using existing capabilities in new ways; changing how the military is organized, trained, and equipped; changing doctrine and/or tactics, techniques, and procedures that determine force employment; changing the way forces are led and leaders are prepared; improving how forces interact with each other to produce effects in battles or campaigns; and/or developing new operational concepts."

The Air Force understands that joint transformation will not occur in a vacuum and it expects to integrate its capabilities with the other Services. "Service-oriented transformational initiatives must ultimately become joint initiatives."[16] Until an OSD framework is established, the Air Force will use the 2001 QDR with its six operational goals and the Air Force core competencies for transformation guidance.

The Navy takes yet another slightly different approach. The Navy views transformation essentially as leveraging advanced technology along with evolving concepts of operation with new and legacy systems.[17]

> "True transformation is about seizing opportunities to create transformational capabilities by radically changing organizational relationships, implementing different concepts of warfighting, and inserting new technology to carry out operations in ways that profoundly improve current capabilities and develop desired future capabilities."[18]

The Naval Transformation Roadmap describes how naval forces will achieve nine transformational warfighting capabilities shown in Table 2. "Naval transformation will be captured by capitalizing on innovative concepts and technologies, and by employing processes to rapidly develop and integrate innovations into these forces."[19]

Sea Strike Transformational Capabilities
• Persistent ISR
• Time Sensitive Strike
• Information Operations
• Ship-to-Objective Maneuver
Sea Shield Transformational Capabilities
• Theater Air & Missile Defense
• Littoral Sea Control
• Homeland Defense
Sea Basing Transformational Capabilities
• Accelerated Deployment and Employment Time
• Enhanced Sea-borne Positioning of Joint Assets

TABLE 2. NAVAL TRANSFORMATIONAL WARFIGHTING CAPABILITIES

Transformational improvements in sea-based forces' precision, reach, connectivity, and decision speed will result in tightly integrated Navy-Marine Corps operations within the joint force. These enhanced naval capabilities developed through the Sea Strike, Sea Shield, and Sea Basing operational concepts will "produce and exploit a dispersed battlespace within which sovereign and sustainable naval, air, ground and space elements form a unified force that projects offensive power and defensive capability."[20]

JOINT TRANSFORMATION PROCESS ASSESSMENT

While each of the Services progress forward with some definition of transformation to meet the OSD QDR 2001 direction, significant questions remain as to how the DoD approach will accomplish joint transformation. Some of these issues are captured in Table 3 on the following page. Congress is concerned with the apparent lack of a clear transformation roadmap within the DoD budget. During the 2002 Senate Armed Service Committee hearings, Senator Levin posed the telling question: "How do we define transformation and identify it elements? How do we distinguish truly transformational programs, concepts and activities from those that are not?"[21]

- How do we define transformation and identify its elements?
- What is the joint roadmap for Service use to satisfy JV2020 requirements?
- How do we distinguish truly transformational programs, concepts and activities from those that are not?
- How do we determine progress?
- How do we know what to fix and prioritize?
- How do we balance existing force modernization and new system development and procurement within the current budget environment?
- What is the proper role of experimentation, including in helping decide what not to acquire?
- How do we share transformational innovations, concepts and programs with allies, particularly NATO allies, so as to preserve interoperability and strengthen alliances?
- How do we ensure Service capabilities and systems are interoperable?

TABLE 3. JOINT TRANSFORMATION ISSUES

At the end of 2002, transformation ends, ways, and means were not in balance. The current national policy did not deliver a clear roadmap required to develop truly integrated, joint operational capabilities. The QDR 2001 direction left many specific issues unresolved, including budgetary priorities for modernizing and transforming U.S. forces. From the joint perspective, there is no approved coherent top-level approach beyond the guidance to meet current threats as well as prepare for the future. Instead of delivering a focused OSD roadmap, Secretary Rumsfeld proceeded with the traditional approach with each Service developing and delivering the capability it believes the joint warfighter needs. With each Service pursuing its own transformation vision with differing definitions and concepts, the U.S is in danger of locking into expensive new weapon systems for the next 20 years that are still not interoperable or optimized for joint operations.[22]

The existing Chairman, Joint Chiefs of Staff (CJCS) Joint Vision 2020 speaks only in general terms of qualities the joint force must possess. For example, while Joint Vision 2020 sets the standard for interoperability as "the foundation of effective joint, multinational, and interagency operations,"[23] it does not provide guidance or concepts of operation necessary to build a future interoperable force structure. In reality, the in-depth joint vision and operational architecture cited by the CJCS in the National Military Strategy (NMS) does not yet exist but work is in progress.[24] While each of the Service transformation roadmaps stresses the need to meet joint warfighting requirements, none of them currently have a direct tie driving force structure design or operations from joint warfighting operational concepts or architectures. We run the very real risk of having to "stitch capabilities along the seams" instead of building truly integrated forces.

Because there currently are no published DoD joint operational concepts, integrated architectures, or common transformation definition, each of the individual Service transformation efforts, though well intentioned, concentrates more on major weapon system acquisition fitting the Service vision rather than satisfying a joint operational concept. For example, the Army objective force deployment timelines were not initially coordinated with Air Force future airlift asset planning. As a result, conflicts are bound to develop regarding the airlift capacity needed to meet Combatant Commander's requirements. Stryker Brigades are being fielded while a smaller number of C-17s are procured than required to meet even previously existing airlift requirements due to on-going budget pressures.

It is clear DoD needs a coherent strategy for transformation. One could argue for a standard transformation definition for all to embrace. But this approach is too simplistic. Due to the current complexity of the problem, a standard definition for transformation would probably be restricted to some kind of description of network centric warfare and miss the larger aspects of truly joint warfighting requirements. To fully meet the vision stated by President Bush, the transformation effort must be all encompassing. It must go beyond the C4I and network centric warfare arenas and tie into the core force structure development processes including the requirements generation system, system acquisition, and planning, programming, and budgeting system. Transformation must include a set of common definitions and products that can be used across the full spectrum of Service and OSD users. This process should provide feedback on transformational initiatives to the many stakeholders including the Services, Joint Staff, OSD, and Congress. Without a strategy or common reference framework it is impossible to determine the impacts of new operational concepts, doctrine, systems, and force structures. We need a process to facilitate key resource decisions, deciding which programs or activities are truly transformational and how they fit into the challenge of meeting the near to mid term threat or the emerging threat in the 2010 timeframe.[25]

TRANSFORMATION ENABLERS

There are several initiatives at work or under consideration that will provide the common frameworks and interface implementations so desperately needed to develop and field joint warfighting capabilities. In addition, the initiatives will be able to provide the insight necessary to make strategic transformation resourcing decisions. At this time, there are significant process changes in development affecting how the CJCS Joint Vision influences force development, DoD weapon system requirement planning, budgeting, and acquisition, as well as interoperability interface standards.

FORCE DEVELOPMENT AND REQUIREMENTS TRANSFORMATION

In 2002, the CJCS recognized that the Decision Support System (DSS) consisting of the Requirements Generation System (RGS); Planning Programming and Budgeting System (PPBS); and the Acquisition Management System (AMS) needed significant changes to integrate joint warfighting requirements and interoperability. The JCS white paper "An Enterprise Architecture for Joint Warfighting: Reforming the Joint Requirements Process" described these significant changes to the Service combat capability development process. Up to this point, warfighting requirements were often developed and approved as "stand alone" solutions to counter specific threats. In addition, Service acquisition decisions were not fully coordinated or integrated with the other Services. This was due to the fact that there was no structured method or framework to evaluate joint warfighting capabilities of competing systems, often leading to sub-optimal decisions and significant duplication.

The CJCS decided that transformation could only be achieved through a top-down approach and the logical vehicle to use was the Joint Requirement Oversight Council (JROC) process.[26] The CJCS directed the JROC to strengthen the DoD's ability to use the JROC process as a strategic management and integration tool and provide a method to integrate joint warfighting requirements and interoperability.[27] In parallel with this, the Joint Chiefs of Staff (JCS) established a process to link the overarching national military strategy and Joint Vision to acquisition process changes by tying together joint operational concepts, operating and function concepts, and integrated architectures to improve joint warfighting.

This is in marked difference to the "bottom up" requirements generation system the JROC has used since its inception to provide joint capabilities and reduce redundant system acquisitions. The two requirement generation approaches are contrasted in Figure 1. Historically, the Services have sponsored very specific stand alone requirements for joint validation leading to the acquisition of weapon systems designed to counter a specific threat. However, the previous approach did not have any structured methodology to evaluate how competing systems across the Services would contribute to joint warfighting.[28]The left side of the diagram shows the previous requirements generation process and highlights the fact that the Combatant Commander faced the difficult task of coordinating force employment concepts well after the legacy combatant capabilities were acquired. The right side emphasizes the shift in the requirements development process to accommodate Combatant Commander influence prior to acquiring any capability. One can argue that the previous process allowed Combatant Commanders the opportunity to influence Service requirements as they are being generated and as part of the JROC approval process. However, this requirements generating process did not address how we fight from an overarching system-of-systems perspective or operating concept. The new requirements generation system will start with a top down approach. It will be comprised of various joint combat commanders' operational concepts providing concise visualizations or mental pictures addressing strategic requirements and the scenarios to be used to defeat the adversary.

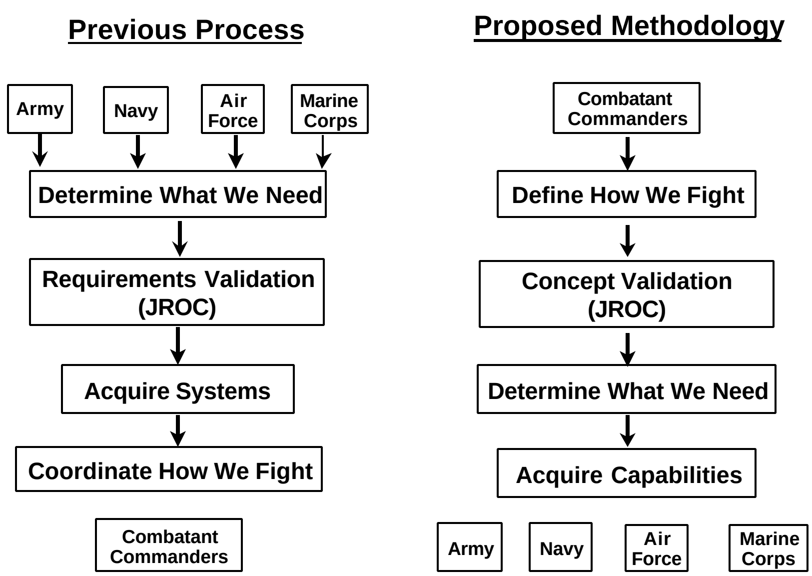


FIGURE 1. TRANSFORMING REQUIREMENTS AND ACQUISITION

Figure 2 shows how the DoD will integrate this top down approach into the overall Joint Vision and Decision Support System process. Once developed, the new overarching process will provide the framework required to adequately manage and assess DoD transformation.

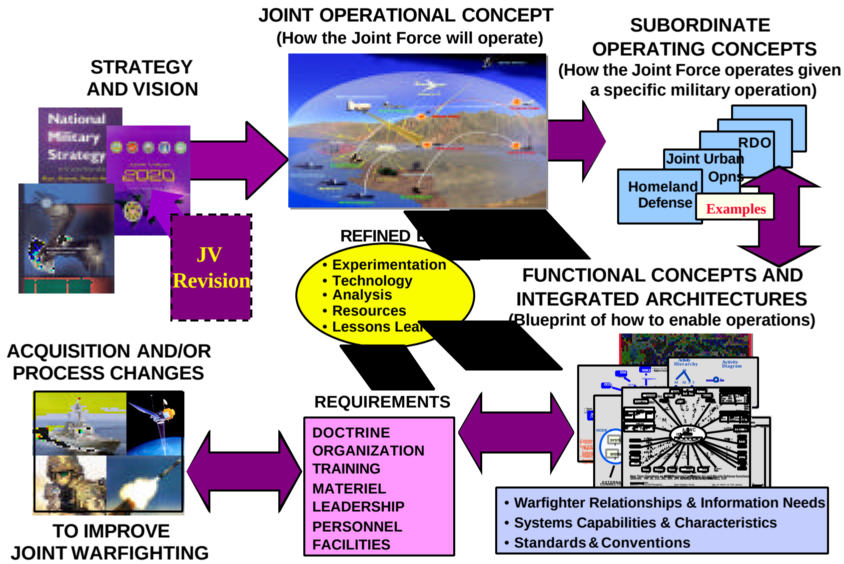


FIGURE 2. THE LINK: JOINT VISION TO WARFIGHTING CAPABILITY[29]

The new DSS provides the important capability to "address interoperability in terms of warfare capabilities versus the ex post facto integration of Service programs."[30] It is worthwhile to take a detailed look at the DSS process and its associated products to understand the extremely significant changes they will bring to the process of developing weapon systems and force structure. It begins by adding several products that describe how the Combatant Commander will fight including the joint operation concept, the operational concept and the functional concept. The approach then fills out the details and ensures interoperability through the use of an integrated architecture,

The joint operational concept provides the first level of resolution below the Joint Vision by amplifying the Joint Vision's key ideas to provide a more detailed foundation for follow-on experimentation and assessment. The joint operational concept is currently in development and will focus on joint forces employment in missions across the range of military operations. Once complete, the joint operational concept establishes the framework necessary to describe the relationships and integration of subordinate operational concepts, functional concepts and architectures.

Subordinate Joint Operating Concepts (JOC) provide more focused detail in key areas. JOCs integrate Service and component concepts in an operational-level perspective for detailed development and experimentation. They describe how a Joint Force Commander will plan, prepare, deploy, employ and sustain a joint force along a specified range of military operations.[31] JOCs will focus on forces and functions instead of specific weapon systems. Examples of JOCs include Rapid Decisive Operations, Homeland Defense, Combating Terrorism, Joint Urban Operations, and National Missile Defense.

Operational concepts may be developed by any organization including the Services, Joint Staff, Combatant Commanders, or Supporting Commanders. The development process should include representation and review by each Service and combatant command having any potential involvement in the joint operation described by the concept. Each of these concepts will be evaluated for joint warfighting potential within the Joint Vision and then, if applicable, be designated by the JROC as a joint concept for integration into the Joint Operational Concept. If a concept is not designated "joint," the sponsor can still use the concept for its designed purpose. For example, a new anti-submarine warfare concept that may not be designated joint will still be used by the Navy as a Service specific concept.

Functional concepts complement the Joint Operating Concepts. They amplify a particular function or describe how to employ a system or conduct a task across the full range of military operations. An example is precision engagement performed by all of the Services. Functional concepts rely on Joint Operating Concepts for context. A functional concept may be specific to a particular operating concept or it may apply more broadly to multiple concepts. They also provide the detail for experiments and establish benchmarks used to measure improvement.[32]

Once an operating concept is approved, an integrated architecture is developed to describe its relationship within the Joint Operational Concept. Operational concepts and architectures are the frameworks used to identify the fundamental improvements in the way we want to fight. Linking concepts and architectures will better enable joint transformation by identifying capability gaps and overlaps, identifying solution possibilities, and eliminating redundant programs. [33]

A detailed discussion of architectures and their products is important to understand their use and potential. The draft DoD Architecture Framework, Version 1.0 defines an architecture as "the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time." Simply put, an architecture description is a representation of a defined domain, at any given point in time, in terms of its component parts, what those parts do, how the parts relate to each other, and the rules and constraints under which the parts function.[34] The domains can be at any level, from DoD down to an individual system such as a computer workstation as a component in an infantry-fighting vehicle.

The groundbreaking aspect of the DoD Architecture Framework is that it provides a common methodology for all that ensures that architecture descriptions can be compared and related across organizational boundaries, including Joint and multinational boundaries.[35] We now have the capability to satisfy joint warfighting requirements and synchronize Title 10 Service modernization efforts as depicted in Figure 3.

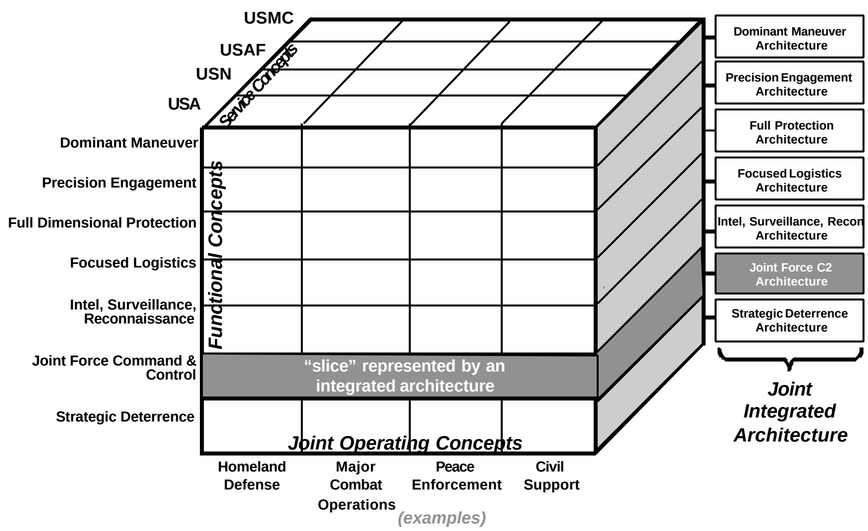


FIGURE 3. JOINT INTEGRATED ARCHITECTURE CONTSTRUCT

Architectures describe the operating concept in detail using three views: an operational view focusing on the functional perspective; a systems view focusing on the physical perspective; and the technical view focusing on standards and protocols.[36] Each of these views has a set of predefined products and data formats that can be readily shared across organizational boundaries. More importantly, mandating the use of these predefined products eliminates confusion and misunderstanding between the different organizations.

The individual architecture products are not standalone items. They represent depictions of different sets of information describing various aspects of an integrated architecture.[37] The relationships between various products are shown in figure 4. This paper will address several products that answer transformation related questions concerning capability gaps or overlaps and interoperability requirements.

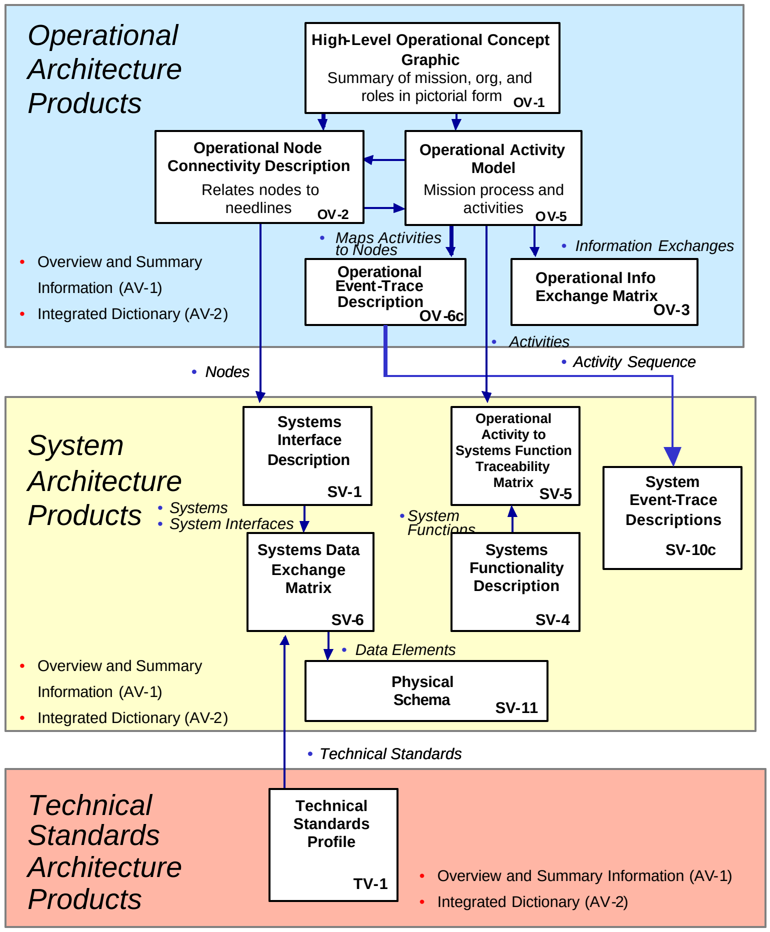
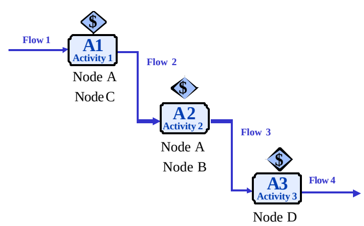


FIGURE 4. ARCHITECTURE PRODUCT RELATIONSHIPS

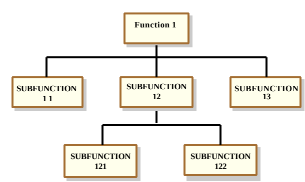
The High Level Graphic (OV-1) is the initial architecture product and presents the operational concept in one or two charts describing the overall operational objective. It also provides a very quick graphic representation of what the system is supposed to do and how it will do it. Its primary purpose is to provide information to high-level decision makers in an easily understood format. Figure 5 on the following page shows an OV-1 example depicting the Navy Notional Operational Concept for Strike.[38]

The Activity Model (OV-5) describes the process the Combatant Commander will use to achieve his or her desired effects. It is used to clearly define the lines of responsibility and uncover redundant or unnecessary operational activity. The Systems Functionality Description (SV-4) is a counterpart to the Activity Model (OV-5), and describes the functions each system performs and the data or information flow between the systems. The Systems Matrix (SV-3)

FIGURE 5. HIGH LEVEL OPERATIONAL CONCEPT GRAPHIC (OV-1)



Activity Model (OV-5)



Systems Functionality Description (SV-4)

	SYSTEM 1	SYSTEM 2	SYSTEM 3	SYSTEM 4	SYSTEM 5	SYSTEM 6	SYSTEM 7	SYSTEM 8	SYSTEM 9	SYSTEM 10
SYSTEM 1		•								
SYSTEM 2	•		•	•	•	•				
SYSTEM 3		•		•	•	•				
SYSTEM 4		•	•		•	•				
SYSTEM 5		•	•	•		•				
SYSTEM 6	•	•	•	•	•		•	•	•	•
SYSTEM 7						•				
SYSTEM 8						•				
SYSTEM 9						•				
SYSTEM 10						•				

Systems Matrix (SV-3)

FIGURE 6. ARCHITECTURE PRODUCTS

takes the family of systems and evaluates the system-to-system relationships, emphasizing the interoperability of systems pairs. This matrix makes possible a rapid assessment of commonalities or redundancies. Once the SV-3 and SV-4 views are complete, the Operational Activity to Systems Functional Matrix (SV-5) can map the functions needed from the Activity Model (OV-5) to systems that can perform those functions from the Systems Functionality Description (SV-4). This provides a capability to identify how to correct an operational shortfall by either updating a fielded system or acquiring a new capability. Figure 7 shows how this planner-level matrix allows decision makers to quickly identify stovepiped and redundant systems, as well as capability gaps. It is also particularly useful in identifying possible future investment strategies within the architecture time horizon. [39] This framework will be a central part of making critical joint transformation capability and resource decisions.

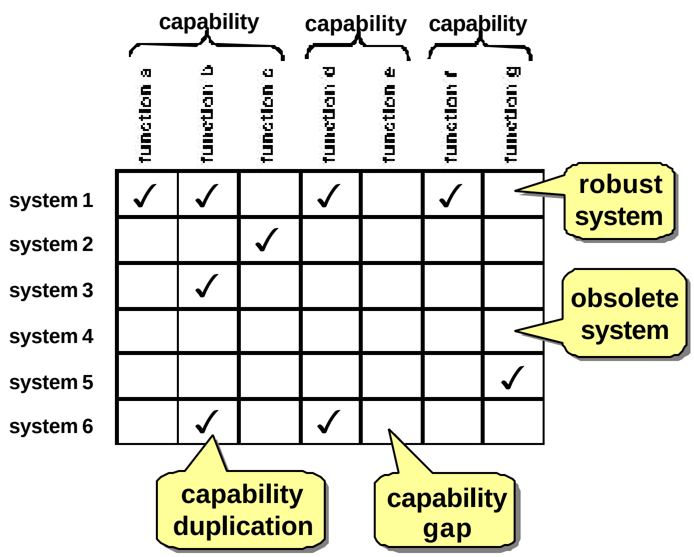


FIGURE 7. SYSTEMS FUNCTION MATRIX (SV-5)[40]

Other architecture products group systems and functions into functional or capability nodes that form the basis needed to describe interoperability requirements. The Operational Node Connectivity Description (OV-2) and its related Systems Interface Description (SV-1) depict these. While these products address connectivity between nodes, the Systems Communication Description (SV-2) describes the specific systems that connect with other systems within nodes. The OV-2 shows which nodes must be interoperable, while SV-2 displays which systems must interface with others inside the nodes for the network to operate effectively.[41]

By grouping functions by nodes in the Operational Node Description (OV-2), and grouping systems into related nodes in the Systems Communication Description (SV-2) the user may then analyze interoperability aspects. The resulting "need lines" shown in Figure 8 highlight dependencies needed to successfully connect these nodes. Not only can this process describe information exchange needs, but it can also describe other related warfighting or sustainment requirements such as fuel or ammunition. This may even be expanded to determine airlift requirements in a larger system of systems, as is the case with the Army Future Combat System.

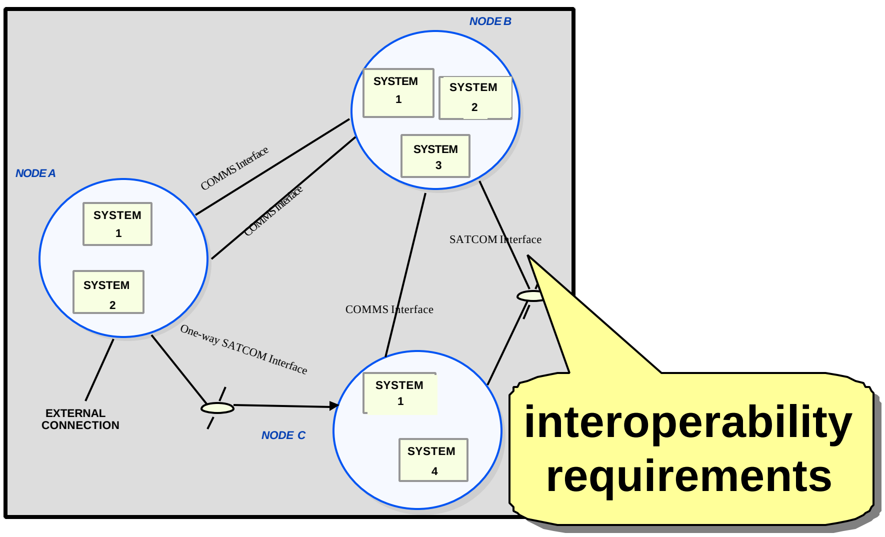


FIGURE 8. NODAL ANALYSIS

Finally, the last product covered in this paper is the Systems Information Exchange Matrix (SV-6). This describes, in tabular format, the information exchanges between systems within a node and between systems in differing nodes.[42] Although very detailed, this series of products are critical to identifying the key interface points that define boundaries between organizations, technologies, networks, and layers in architectures. These offer concept and architecture developers and maintainers a small number of interface specifications to manage effectively.[43] This directly impacts the degree and ease to which we can be interoperable.

All of these architecture framework tools and products described above are used to facilitate coordination between requirements developers, system acquirers, and interoperability enforcers. They can be used to help clarify roles, boundaries, and interfaces between components of a larger system of systems. More importantly for joint transformation, architectures are the primary tool for enterprise level systems integration.[44] Figure 9 shows how architectures are used in a requirements and interoperability analysis process beginning with overall operational requirements and ending with a dynamic interoperability assessment. The Information derived from architectures can be used in a systems analysis approach that is repeatable, systematic, and contributes to efficient acquisition of cost effective and interoperable military capabilities.[45]

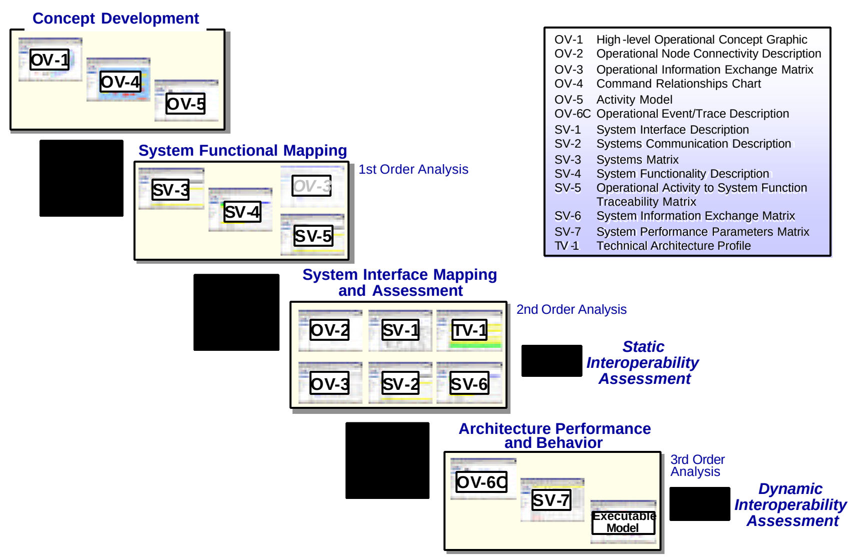


FIGURE 9. USING ARCHITECTURES IN SYSTEMS ENGINEERING

INTEROPERABILITY

Interoperability is the foundation of the architecture development process described above. It is also key to all future transformation efforts. Current DoD policy (DoDI 4630.5, Procedures for Interoperability and Supportability of Information Technology and National Security Systems) provided the direction to develop architectures for process reengineering and interoperability. Its impact has already spread as a tool to redefine the requirements generation process. However, merely identifying the required interfaces is not sufficient to ensure interoperability within the U.S. military and with our allies and coalition partners. What is needed is a method to effectively describe and implement interfaces in U.S. and foreign information and weapon systems that do not exist today.

Current interoperability standards, including U.S. military standards and international standardization agreements, evolved as a collection of diverse user requirements. They were not a product of a disciplined system engineering process needed to deliver a system of systems. As in the case of LINK-16 airborne data links, the standards grew out of a concept of "interoperability through non-interference" as each weapon system contractor or nation implemented the data link a little differently in order to satisfy unique weapon systems requirements. As a result, we have marginal data link interoperability and no globally agreed upon implementation strategy or timeline. Another complication comes from the acquisition streamlining effort. In order to reduce cost and acquisition overhead, Service acquisition executives have waived mandatory implementation of many military standards. Now what is often the case, is that each weapon system will implement a tailored application of a particular standard based on its specific need or funding timeline. In the international arena, it is often the case that NATO will agree to changes to the standards, but the member nations are not bound to implement these changes on their information or weapon systems. What is obvious is that the link or interface is not managed as a weapon system.

Two LINK-16 examples will illustrate the point. One is fairly trivial, the other less so, but both have significant interoperability impacts. The first problem centers on identification taxonomy (ID) or the ability to determine the different classification of an object reported over the data link. All Services Combat Identification Evaluation Team (ASCIET) 00 test analysis conducted by the Joint Integrated Air Defense System Interoperability Working Group (JIADS IWG) determined that “the JIADS lost the benefit of LINK-16 expanded ID taxonomy” due to the fact that not all participants displayed the full range of LINK-16 ID classifications of PENDING, UNKNOWN, ASSUMED FRIEND, FRIEND, NEUTRAL, SUSPECT, and HOSTILE (ASCIET 2000 Evaluation Report, Sep 2000). In some cases there was inconsistent mapping of incoming tracks having non-implemented categories by the Link-16 participating units. For example, one system that did not implement the Neutral value would map a Link-16 neutral track to an identification of Unknown, while another system that hadn’t implemented the identification of Neutral would map it to Assumed Friend. This violated the Single Integrated Air Picture (SIAP) principle of consistency among all participants.

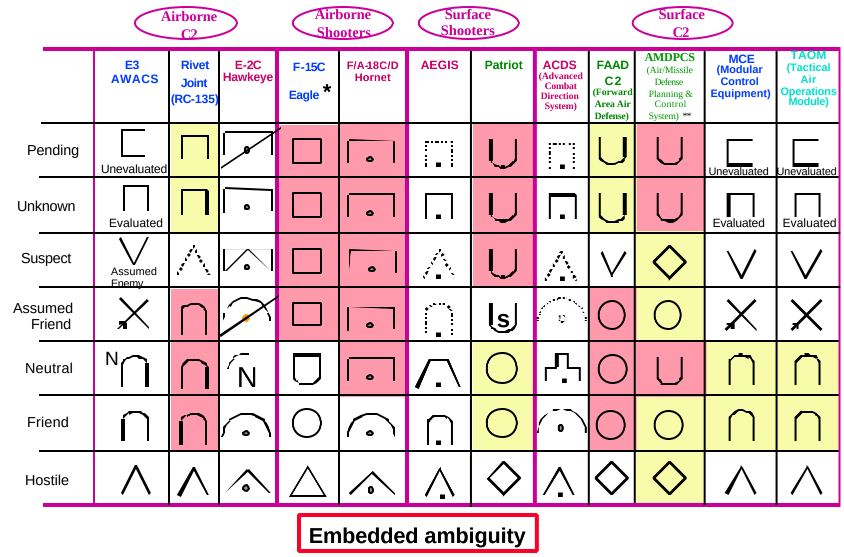


FIGURE 10. INCONSISTENT ID TAXONOMY

One problem hampering the solution to this problem was that no military standard directed display of all seven taxonomy classifications in fighter aircraft. MIL-STD-6016A TACTICAL DIGITAL INFORMATION LINK (TADIL) J MESSAGE STANDARD required each participating Link-16 unit to process seven classes of ID (PENDING, UNKNOWN, ASSUMED FRIEND, FRIEND, NEUTRAL, SUSPECT, and HOSTILE) (MIL-STD-6016A, ICP TJ00-004 Ch3, Table A.7-J3.2). However, MIL-STD-6016A did not mandate cockpit display. MIL-STD-2525B COMMON WARFIGHTING SYMBOLOGY defined symbology for all seven ID classifications, but did not directly apply to fighter cockpit design. Another standard, MIL-STD-1787C AIRCRAFT DISPLAY SYMBOLOGY, defined approved cockpit symbology for only four of seven ID taxonomy classifications (UNKNOWN, FRIEND, NEUTRAL, and HOSTILE). However, compliance was voluntary and each fighter system implemented the LINK-16 symbology based on unique requirements from particular weapon system operators. Until this problem is corrected, this interoperability shortfall must be resolved by implementing tactics, techniques, and procedures that have already been shown to be deficient and may result in friendly or neutral aircraft losses in the future.

The second example is more involved because it deals with how particular weapon systems manipulated data received over the data link and serves as an excellent example of current interoperability challenges. The phenomenon of multiple tracks on a single object is referred to as "dual designation" or simply "dualing." A single sensor erroneously creating more than one track on a single object can cause dualing, but is more commonly observed when multiple sensors participate in a network such as a TADIL.

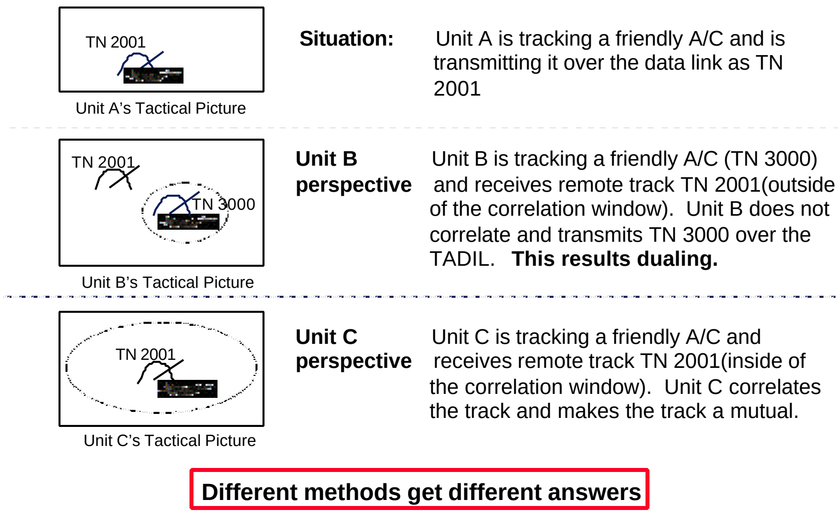


FIGURE 11. LINK-16 CORRELATION / DECORRELATION ISSUE

In the network case, participating units having sensors with overlapping coverage areas may detect the same object and report an associated track over the network. This results in multiple tracks displayed for a single object at all participating units on the network. Analyses from the ASCIET evaluations link failure to prevent and/or resolve such duals to:

- Warfighter confusion about the number of actual aircraft,
- Failure to provide combat identification (CID) to unknown tracks, and
- Increased risk of cross-correlation of tracks between groups of adversary and friendly aircraft.

These observations had critical operational impacts including:

- Misallocation of limited resources,
- Fratricide - commonly caused by self-defense shots at tracks with unknown ID, and
- Leakers - enemy aircraft gaining access to defended air space because tracks had unknown (or even friend) ID.

Dual designations for LINK-16 objects reported over the data link have been a continuing problem since a 1977 test confirmed the problem, and are the most severe interoperability problem experienced in current interface operations. Existing correlation/decorrelation processes and rules contained within the TADIL standards were inadequate to meet JROC-validated requirements. Different weapon systems were implementing the standards inconsistently resulting in an unacceptably high number of dual/multiple designations and miscorrelations. These anomalies severely degraded the ability of the Joint Integrated Air Defense System (JIADS) to maintain a SIAP to effectively fight the air battle. ASCIET analysis showed approximately 25- 40% of air vehicles were dual reported, and a like number were miscorrelated. A series of improvements have been proposed, and many rejected, to MILSTD-6016. MILSTD-6016, STANAG 5516, and STANAG 5522 contained correlation criteria which had no equivalent in Link 11/11B, and the Link-11/11B STANAGs contained a mandatory correlation message which was optional in MIL-STD-6016 and different from the message in STANAG 5511. All of this complicated interoperability.

These two examples highlight interface interoperability difficulties that need to be addressed in order for the U.S., its allies, and coalition partners to be able to realize Joint Vision 2020's seamless interoperability. The commercial software community faces similar problems as technology drives software and hardware development, often out-pacing standards. As a result, standards have not kept pace with technology resulting in significant costs to update software to run on new technology machines and operate on increasingly complex networks. The National Institute of Standards and Technology is pursuing an innovative solution to move away from a standards architecture to model a model driven architecture in which the model itself specifies all of the desired, function, and behavior of the system. In its simplest sense, the model driven architecture separates functionality from implementation. This approach provides design stability as implementation technologies evolve and improve into the future.[46]

This approach offers unique advantages. "Standards can be protected against premature obsolescence, and the cost of maintaining interoperability in the face of software technology change can be reduced."[47] In the case of the two LINK-16 examples above, a model-driven architecture would provide a common information processing approach, eliminate ambiguity, and present the same operational picture to all users on the network. If the standards organization provided a reference model that precisely specified the interface and how the information would be processed and displayed, the implementing contractor would not have to engineer a unique implementation based on vendor hardware or proprietary software, saving considerable time and money. The analogy is very similar to today's internet protocol incorporated by all computer and software vendors. None of the personal computer hardware builders write unique code to interface with other systems on the internet. Figure 12 shows a DoD example where the model driven architecture approach is being used to solve SIAP interoperability problems such as described above. The benefits to the U.S., its allies, and coalition partners are phenomenal. Standards ambiguity would be eliminated and updates could be quickly implemented among various platforms providing interoperability.

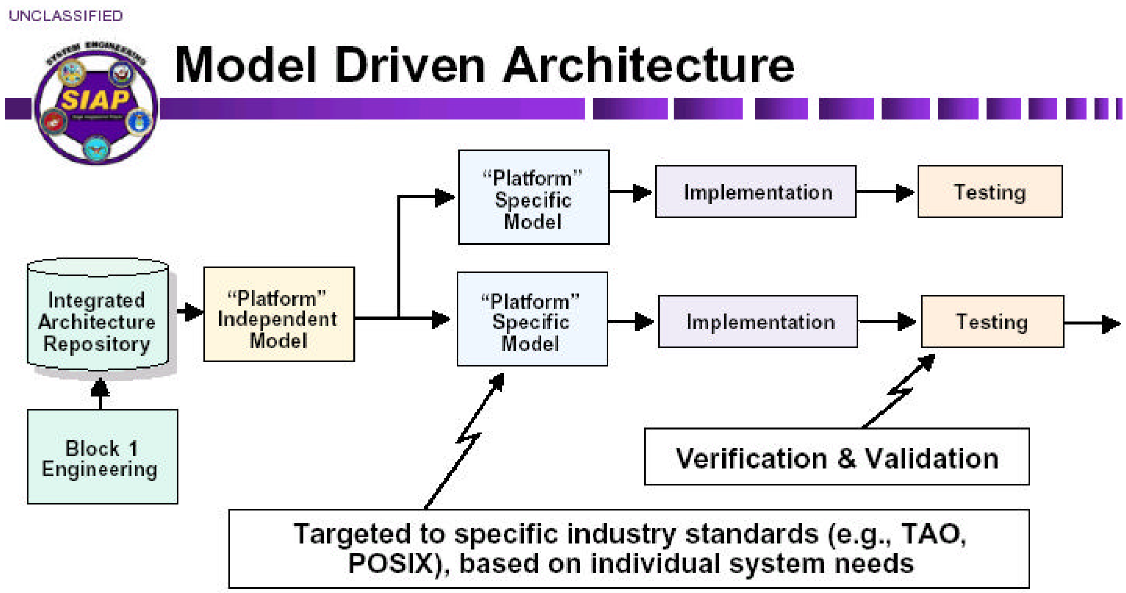


FIGURE 12. SINGLE INTEGRATED AIR PICTURE MODEL DRIVEN ARCHITECTURE

CONCLUSION

Joint operational concepts and their associated integrated architectures will become key products in the proposed DSS by framing discussion and providing a systematic, analytical approach to address very difficult joint decisions. As shown in figure 13 on the following page, the framework can be used to identify capability gaps by developing and then analyzing architecture products. Desired functions not supported by DOTMLPF at this point will form the basis of mission needs. These needs, in turn will be addressed in a capabilities roadmap as part of the PPBS.

The JROC will be able to drive requirements at the front end of the process through validation and approval of Combatant Commander's operational concepts and architectures. It will also ensure that requirements are capability based rather than threat based as in the past. In addition, the DSS process will greatly improve interoperability as new capabilities will be "born joint." The interface requirements as defined in the architecture products will significantly reduce expensive redesigns late in the weapons system development cycle and fielding of non-interoperable capabilities.

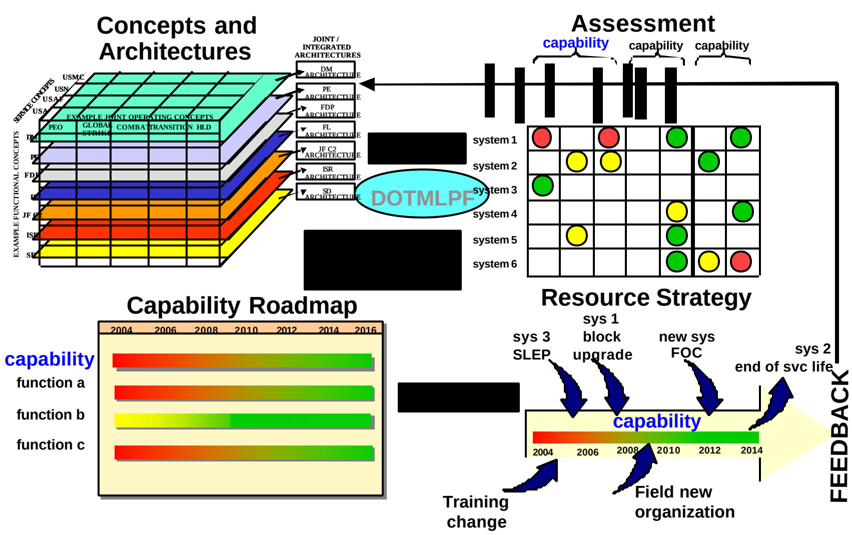


FIGURE 13. PROPOSED METHODOLOGY

The transformational enablers this approach offers allows us to answer the many global questions posed by senior decision makers. The Joint Staff will have an effective process able to evaluate Service programs using integrated joint architectures and use this evaluation as the basis for the Chairman's Program Assessment (CPA). The OSD will also be able to use this information to fund truly transformational capabilities and interoperability by altering Service budget submissions during the Program Decision Memorandum (PDM) and Program Budget Decision (PBD) process prior to submitting the President's defense budget to Congress. Finally, both the Services and OSD will be able to defend the budget submission to congress throughout the committee review and mark-up process. With this new process, we will be able to definitively answer the senate questions as to “How do we define transformation and identify its elements?" and "How do we distinguish truly transformational programs, concepts and activities from those that are not?"

It will not be easy, but implementing this systematic approach utilizing common frameworks and interface implementations to describe, develop, and field joint operational concepts and interoperable capabilities will allow us to successfully transform to meet current and future warfighting challenges. The stakes are too high for us to continue business as usual.

Word Count = 6,564.

ENDNOTES

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[2] United States Department of Defense, “Testimony Delivered On Military Transformation.” 9 April 02. Available from http://www.defenselink.mil/speeches/2002/s20020409-depsecdef1.html. Accessed 23 September 2002. The budget included $53.9B for research and development, a $5.5B increase, and $68.7B for procurement, a $7.6B increase. Also included in the budget were $9.3B in budget savings from terminating programs including Peacekeeper, DD-21, Navy Area Missile Defense, and 18 Army legacy programs. It also accelerated the retirement of the F-14 and 1000 Vietnam era helicopters. Overall, transformation programs accounted for 17 percent of investment funding and would rise to 22 percent over the next five years.

[3] Paul K. Davis, et al, “Transforming the Force – Suggestions for DoD Strategy.” Available from http://www.rand.org/publications/IP/IP179/. Internet; Accessed 25 September 2002. p3.

[4] George W. Bush, The National Security Strategy of the United States of America Washington, D.C.: The White House, September 2002, p29.

[5] Rumsfeld, Quadrennial Defense Review Report, 29.

[6] Rumsfeld, Quadrennial Defense Review Report, 30.

[7] Ibid.

[8] FY 03-07 Defense Planning Guidance: “Each Military Department will prepare and update annually for review by the Secretary of Defense a transformation roadmap…. The roadmap will specify timelines to develop Service-unique capabilities necessary to meet the critical operational goals… The written transformation roadmaps will address resource requirements to fully fund transformation through the FYDP (Future Years Defense Program).”

[9] Rumsfeld, Quadrennial Defense Review Report, 32.

[10] Thomas White and General Eric. K. Shinseki, The Army Transformation Roadmap. (Washington D.C., 2002) 1.

[11] Gen Eric K. Shinseki, “The Army Vision: A Status Report.” Army Magazine, 2001.

[12] James Roche and General John Jumper, The USAF Transformational Flight Plan, FY03-07 (Washington, D.C., 2002) V.

[13] James Roche and General John Jumper, 42.

[14] Department of the Air Force, Air Force Basic Doctrine. Air Force Doctrine Document 1. (Maxwell AFB, AL: U.S. Department of the Air Force, September 1997), 80.

[15] Major General David A. Deptula, “Air Force Transformation – Past, Present, and Future.” Aerospace Power Journal – Fall 2001. Available from http://www.airpower.maxwell.af.mil/airchronicles/apj/apjo1/fal01/phifal01.html. Internet; Accessed 17 September 2002.

[16] James Roche and General John Jumper, 44.

[17] Gordon England, Admiral Vern Clark, and General James L. Jones, Naval Transformation Roadmap (Washington, D.C., 2002), 45.

[18] Ibid, 5.

[19] Ibid, 1.

[20] Ibid, 2.

[21] United States Department of Defense, “Testimony Delivered On Military Transformation.” 9 April 02. Available from http://www.defenselink.mil/speeches/2002/s20020409-depsecdef1.html. Accessed 23 September 2002. Senator Levin was also concerned with interoperability with allies: “How do we share transformational innovations, concepts and programs with allies, particularly NATO allies, so as to preserve interoperability and strengthen alliances?”

[22] Hans Binnendijk and Richard Kugler, “Sound Vision, Unfinished Business: The Quadrennial Defense Review Report 2001.” The Fletcher Forum of World Affairs, Vol. 26, No.1 (Winter/Spring 2002): pp.123-139., 11.

[23] General Henry H. Shelton, Joint Vision 2020. (Washington, D.C., June 2000),15.

[24] Andrew F. Krepinevich, “Defense Transformation – Testimony to United States Senate Committee on Armed Services.” 9 April 2002. Available from http://www.csbaonline.org. Accessed 24 September 2002, p8.

[25] Ibid.

[26] Ibid.

[27] Directorate for Force Structure, Resources and Assessment, the Joint Staff, An Enterprise Architecture for Joint Warfighting: Reforming the Joint Requirements Process, Draft. (Washington D.C.,11 December 2002), 6.

[28] Directorate for Force Structure, Resources and Assessment, the Joint Staff, 2.

[29] Colonel William Gildner, "Implementing Joint Vision: Strategy to Capabilities Through Concept Development." lecture, Carlisle Barracks, PA, US Army War College, 21 October 2002.

[30] Directorate for Force Structure, Resources and Assessment, the Joint Staff, 5.

[31] Colonel William Gildner.

[32] Ibid.

[33] Directorate for Force Structure, Resources and Assessment, the Joint Staff, 6.

[34] DoD Architecture Working Group, Architecture Framework Version 1.0, Final Draft (Washington D.C., 15 January 2003), 1-3.

[35] DoD Architecture Working Group, ES-1.

[36] Ibid, 7.

[37] DoD Architecture Working Group, 4-3.

[38] DoD Architecture Working Group, Vol 2, 4-3.

[39] DoD Architecture Working Group, 5-33.

[40] Directorate for Force Structure, Resources and Assessment, the Joint Staff, 4.

[41] Ibid,19.

[42] Ibid,15.

[43] Ibid.

[44] Ibid, 4.

[45] Ibid.

[46] Rear Admiral Mike Mathis, Col Harry Dutchyshyn, and Captain Jeffrey Wilson, "Integrated Architecture Development," 6 February 2003.

[47] David Flatter, Impact of Model Driven Standards (National Institute of Standards and Technology, Gathersburg, MD, 2001), 2.

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