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Strategies for Competition Beyond Open Architecture (OA): Acquisition at the Edge of Chaos

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Panel 6. The Role of Competition in Contracting

Wednesday, May 14, 2014	
1:45 p.m. – 3:15 p.m.	**Chair: Elliott Branch,** Deputy Assistant Secretary of the Navy (Acquisition and Procurement) ***Gaining Leverage Over Vendor Lock to Improve Acquisition Performance and Cost Efficiencies*** Virginia Wydler, MITRE Corporation ***Open Systems Architecture License Rights: A New Era for the Public–Private Market-Place*** Nickolas Guertin, DASN RDT&E Howard Reichel, In-Depth Engineering Corporation ***Strategies for Competition Beyond Open Architecture (OA): Acquisition at the Edge of Chaos*** Niraj Srivastava, Raytheon Michael Rice, R2E, Inc.

Strategies for Competition Beyond Open Architecture (OA): Acquisition at the Edge of Chaos

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Abstract

Department of Defense (DoD) Open Systems Architecture (OSA) policies are supposed to enhance acquisition reform to ensure competition for better pricing as dictated by the Weapons Systems Acquisition Reform Act of 2009. However, the competition for better pricing using OSA does not necessarily drive innovation that addresses increasing system complexity. In the face of increasing system complexity, uncertain security profiles, and a challenging budget environment, the defense acquisition process and system engineering efforts need to work in concert to produce defense systems that reduce time to deployment and are more adaptable. We look to complex adaptive systems (CAS) and evolutionary theory for strategies for competition using methods from dynamical systems and population genetics. The key insight of evolutionary theory is that many behaviors involve the interaction of multiple entities in a population, and the success of any one of these entities depends on how its behavior interacts with that of others. Furthermore, we investigate the potential for bidirectional coupling between population density (market size) and the evolution of an emergent trait such as competition. We propose the Component Competition Readiness Level (CCRL) metrics that define and measure competition readiness to promote agility into the complex dynamics of the acquisition processes.

Introduction

> *If you want to build a ship, don't herd people together to collect wood and don't assign them tasks and work, but rather teach them to long for the endless immensity of the sea.*
>
> —Antoine de Saint-Exupery, Wisdom of the Sands

In the last couple of decades the nature of the threat faced by our nation has changed dramatically. A Booz Allen Hamilton report (Booz Allen Hamilton, 2010) points out that the United States is increasingly facing threats that are surmountable, but which are highly unpredictable. The unpredictable asymmetrical nature of the threats coupled with accelerated pace of change in the security landscape such as new and emerging foreign powers, non-state actors (Figure 1) with increasing destructive enabling technologies (DoD, 2010) are generating pressures on the way in which the DoD fields defense systems.

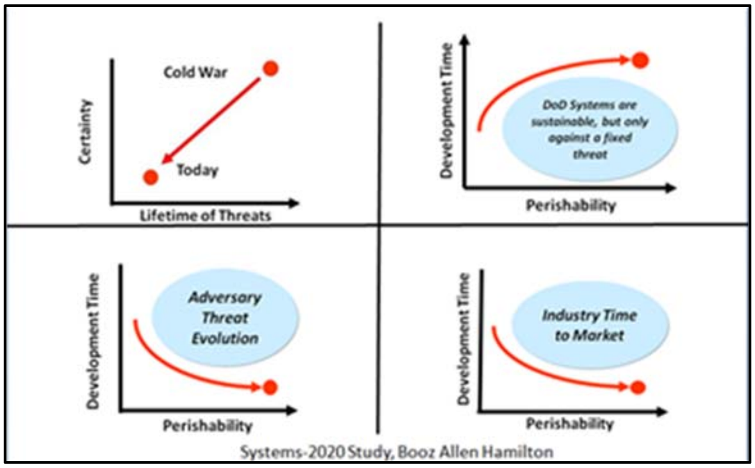


Figure 1. **Transformative Forces in the DoD Acquisition Landscape**
(Booz Allen Hamilton, 2010)

The DoD finds itself operating in a world that has become increasing more complex and unpredictable (Phister, 2010) while shifting "to a smaller, leaner force that is agile, flexible, and ready to deploy quickly" (DoD, 2014). The transformative forces have led the studies like System 2020 (Booz Allen Hamilton, 2010) initiative and NDIA's Report of the Model Based Engineering (MBE) (NDIA Systems Engineering Division, M&S Committee, 2011). The studies highlight the need for a system engineering transformation such that the DoD is able "to design and build an entirely new class of adaptive systems that allow the Department to operate with far greater speed and agility." (Booz Allen Hamilton, 2010) The same trends are highlighted in the context of information technology (Figure 2) that provides as much as 80% of weapon system functionality.

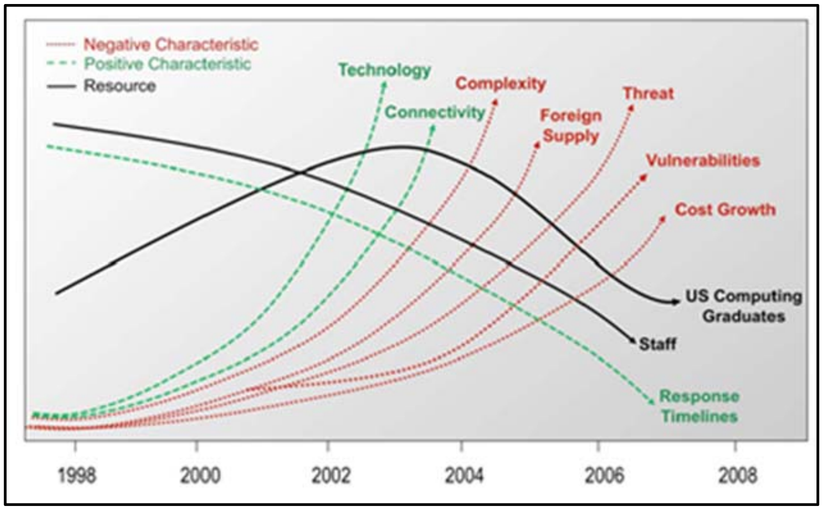


Figure 2. **The Perfect IT Storm—"Rate of technology change is increasing as is the interconnected nature of systems while timelines are shrinking."**
(Defense Science Board, 2009)

The current response to more complex and unpredictable world has been to field more complex defense systems. Many studies (Booz Allen Hamilton, 2010; Wade & Madni, 2010) have documented the increasing complexity of the defense systems (Figure 3). However, the increase in complexity has produced increased risk and development time such that time to field and cost of new systems are not acceptable. Traditional system engineering processes such as MIL-STD-499A are unable to deal with the Nm growth in system complexity where N represents components and m is the interactions between components. The traditional system integration approaches are unable to deal with power-law growth curve (Just imagine doing first order testing on N components with m connections not to mention second order effects).

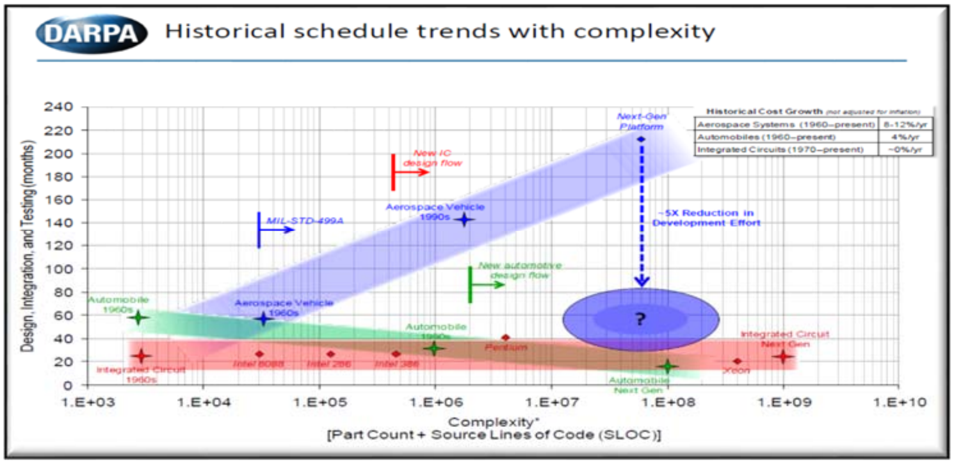


Figure 3. **Chart Showing Variability in the Way Different Industries Have Managed Growth in Complexity**
(TTO, DARPA, 2014)

The System 2020 study, mentioned earlier, has proposed many system engineering approaches such as Model Based Engineering (MBE), Platform Based Engineering (PBE) and Capability on Demand (COD) to modernize the discipline. The key insight is to leverage modularity and reuse to produce agility and adaptability.

The increasing complexity has also contributed to the cost of defense system acquisition. The legislature has forced Congress to use the only instrument available to them, United States Public Law 111-23. The Weapon Systems Acquisition Reform Act of 2009 dictates measures to ensure competition for better pricing. The drive for acquisition reform has led to DoD policies for better buying power through open architecture.

The purpose of this article is not to propose another system engineering approach. We derive insights based our understanding of complex systems and social networks for a marketplace driven by competition that can adapt to produce cost-effective defense systems and is able to evolve with new emerging threats.

Background

Better Buying Power (http://bbp.dau.mil/) is part of the DoD's mandate to do more without more by implementing best practices in acquisition. The Under Secretary of Defense for Acquisition, Technology and Logistics, Honorable Frank Kendall, detailed in his memorandum of November 13, 2013, to acquisition professionals across the Department of Defense introducing Better Buying Power (BBP) 2.0. (DoD, 2013) That memorandum subsequently followed by another on April 24, 2013, which provided the implementation directive for BBP 2.0 (AT&L, 2013). The latest BBP direction comes nearly three years after the initial BBP 1.0, in both cases the intent, as expressed by USD A,T&L, is to obtain greater efficiency and productivity in defense spending by pursuing in the beginning with 1.0, a set of initiatives in five areas. With the issuance of the latest BBP 2.0 implementing directive, the number of initiative areas has grown by an additional two topics and several have undergone modification due to the results achieved with BBP 1.0. As part of the fifth of seven areas, the Open System Architecture has made its way into the priority scheme for implementing best practices to strengthen the Defense Department's buying power, improve industry productivity, and provide affordable, value-added military capability to the Warfighter.

OSA incorporation into area #5: "Promoting effective competition," represents a milestone unto the topic itself. Competition is considered by Defense leadership as the single most powerful tool available to the Department to drive productivity. For products, acquisition strategies must address how program managers will realize and maximize competition from program inception through sustainment.

OSA merges technical architecture with open business model. Technical Architecture defines open standards, published key interfaces, full design disclosure to produce modular, loosely coupled but highly cohesive systems. Recent efforts such as UAS Control Segment (UCS) Architecture, The Open Group Future Airborne Capability Environment (FACE™), and Acoustic Rapid COTS Insertion (ARCI) are all designed to support OSA. However, promoting effective competition also requires an Open Business Model.

Independent of BBP, the DoD Open Systems Architecture policies and governance, over the past several years, have significantly impacted the acquiring of weapon system products and processes. In reviewing past actions and accomplishments, the discussion must be viewed from both an Acquisition and post-IOC (deployment) context. From the Acquisition Systems Engineering perspective, based on the utilization of broad sweeping Modular Open Systems Architecture (MOSA)/Naval Open Architecture (NOA) principles, one could state that DoD stakeholders have achieved an excellent rating of "A+". However, from a post deployment context perspective, whereby the Government can fully receive fiscal relief due to competition, the rating at best is "fair/poor." So, why is the Government unable to receive high levels of return on investment (ROI) once a System is deployed? To address this complex subject, numerous factors must be addressed, some of which are listed as follows:

- Cultural behavior is a significant contributor. If a priority scheme was established to assess which MOSA-NOA principles are important, real-competition at the deployment phase would rank the lowest. Mission performance, acquisition cost and schedule are still the primary drivers that Acquisition Program Managers adhered to.
- Industry has implemented OSA initiatives primarily from a Corporate Enterprise commonality and productivity perspective such as build less, maximize reuse thru portability, and therefore sell more. OSA attributes can be used to gain market share locking-in such as corporate modularity; corporate selection of certain standards and corporate frameworks, and common product lines. These elements are all based on commercial COTS/open software products and processes. These attributes are often be used to drive down operating costs and provide competitive pricing at the major awards events.
- The DoD has difficulty aligning Data Rights strategy with Systems Engineering maturity model. The end result is that the Government limits their success by their inability to fully measure what/when they own, what rights they have, and how to release this information in a time based manner to

ensure that real competition at the component level will exist especially during the Operational and Support (O&S) phase.

- Lack of governance/measures for consistent and repeatable outcomes. Tools such as MOSA PART/OAAT are often ineffective since contractors always obtain passing grades due to the generic nature of OSA principles, and little to no emphasis is given to post IOC ROI.

The current tools sets do not consider the interaction of the technology with the environment in which they exist, namely the business environment. CCRL complements Technology Readiness Level (TRL), a metric to assess technology maturity, with component-level metrics relating to integration, interoperability and program readiness for Component Competition.

As stated within the general guidance for area 5, strategies to be considered include

> open systems architecture that enables competition for upgrades, acquisition of technical data packages, and competition aft the subsystems level. At the Component level, the prospect of a development program for a substitute or follow-on product can create indirect competitive pressure.

It is here within the realm of the “component” that the level of system/sub-system decomposition and the associated business and technical consideration must be more carefully and thoughtfully investigated. What implications and relations does the decomposition have to reasoned interests of competitors within the industrial base? In terms of components, what is competitively interesting (size, available industry competency, persistent life for follow-on contract, etc.) to the market place, and how can it be meaningfully defined and specified (architecture, interfaces, etc.), sized (capacity of bidders) and available / achievable (access to necessary specifications, tools and facilities, etc.) do present considerations and are possible obstacles for entry.

It is the intent of the proposed Component Competition Readiness Level to measure maturity levels of both the Open Business Model and the Technical architecture. The definitions of technical architecture have been well studied; however, metrics to define an open business model is more problematic. CCRL leverages concepts of social networks to answer or at least study open business model issues to measure the success of implementing open systems architecture as part of promoting effective competition.

Complex Adaptive Systems

Insight to systems that consist of many interacting components and hierarchies lies in understanding complexity theory. System engineering approaches are necessary but not sufficient to deal be the complexity of modern weapon systems and respond to the changing needs of the warfighters. Over the last couple of decades, a body of work based on mathematics has led to the discipline of non-linear dynamics and study of complex adaptive systems. Complex adaptive systems is a new approach to science that studies how relationships between parts give rise to the collective behaviors of a system and how the system interacts and forms relationships with its environment. (Wikipedia, 2012) The term complex system formally refers to a system of many parts which are coupled in a nonlinear fashion. Natural complex systems are modeled using the mathematical techniques of dynamical systems, which include differential equations, difference equations and maps. (Srivastava, Kaufman, & Muller, Hamiltonian Chaos, 1990) The insight is that behavior of the complex system is influenced by

- interconnectedness with the environment and itself
- non-linearity of coupling
- applicability of the principle of superposition not valid
- emergence of system properties and behaviors

The system behavior is said to be emergent when it cannot be understood simply as the sum of its constituent parts. Emergent behavior involves interactions between individual components that yield distinct patterns at the system level. Emergent systems have group level outcomes that cannot be understood simply as the superposition of their constituent parts; instead emergent group behavior is nonlinearly related to individual interactions. Moreover, just as individual actions affect group outcomes, group outcomes feedback to affect individual actions. This coupling between the microscopic individual level and the macroscopic group level makes the model of emergent behavior useful for understanding a dynamic market place driven by competition that leads to the emergence of innovation and productivity for DoD acquisition.

A key insight of complex adaptive systems has been an appreciation of the mechanism of emergence. Models of self-origination show how systems can locally adapt to a critical region in which the global properties of the system take on regular behavior, such as a power-law distribution of event sizes. Such ideas are likely to serve as fodder for explaining various social scaling laws, like the success and failure of open source software (OSS) project (Axtell, 1999).

In a complex system, it is not possible to reduce the overall behavior of the system to a set of properties characterizing the individual components. Furthermore, interactions produce properties at the collective level that are simply not present when the components are considered individually. However, the evolutionary models to study emergent behavior provide fascinating insight into observed behavior in emergent social phenomena from the perspective of evolution by natural selection. A simple model for the analysis of behavior dominance in social networks where replication is akin to imitation of individuals subscribed to successful behaviors in a population, and mutation is akin to random error in behavior selection. Much of the analysis of the dynamics is focused on stable equilibria and their bifurcations. Random (stochastic) effects play a crucial role in the vicinity of bifurcation points in a decision tree. In complexity theory, bifurcation of new branches of solution following the instability of current state caused by nonlinearities and interaction with the human system generates a source of innovation and diversification. This endows the system with new solutions.

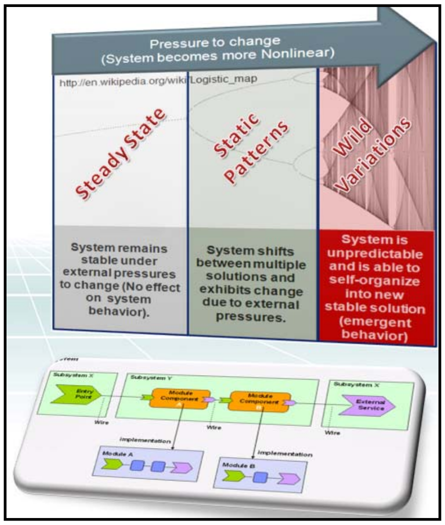


Figure 4. **Bifurcation Generates New Decision Points and Leads to Complexity but Also Can Serve as Source of Innovation**

The CAS approach considers landscapes (of possible solution) in which the various elements interact in nonlinear ways, resulting in a solution space with many peaks and valley where each peak represents a solution branch on the bifurcation curve (Figure 4). Contribution of complex adaptive social systems has been recognized for the nonlinearities and interactions that lead to a search across these peaks and valleys for a collective decision-making dynamics (Srivastava, Pietryka, Horne, & Theroff, 2005).

Social Network and Evolutionary Dynamics

A suitable language to relate emergence in CAS to dynamic DoD acquisition and procurement marketplace is found in the science evolutionary dynamics of behavior in social networks. (Olfati-Saber, 2007) The main thesis is that institutions such as the DoD serve to build a network of actors, with individual actions, into a marketplace with desired emergent behavior. The notion of institutionalization can be a set of rules, conventions or mechanisms that produce a pattern of aggregate behavior.

The description of the marketplace is thus reduced to a network, and a network is any collections of entities in which some pairs are connect by links as shown in Figure 5.

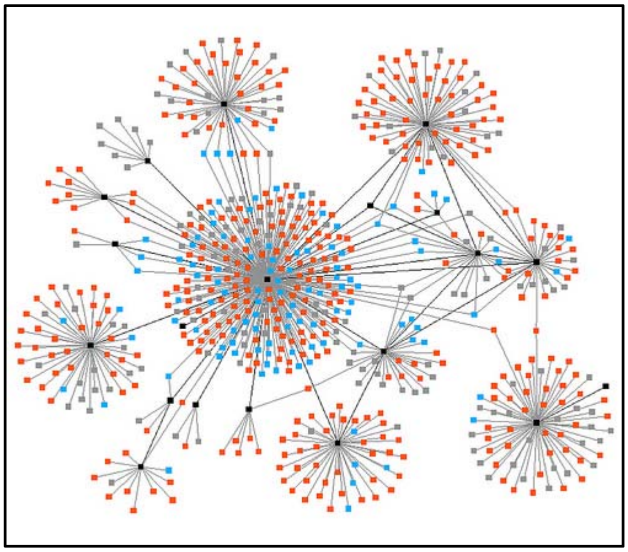


Figure 5. **A graph Is Formed by Vertices and Edges Connecting the Vertices; Connectedness Can Lead to Very Complex Networks**

Study of these networks provide key insight for institutional deign to produce self-regulating marketplace with desired results. Depending on the properties of the network such as total number of links connected to a node, a network can exhibit range of behavior from a very rigid or static network to a chaotic network where changing a node or a link completely alters future dynamics of the network. However, some networks also settle into relatively few patterns of behavior. Such ordered yet flexible systems are said to be “on the edge of Chaos.” These systems are also adaptive such that a change in the environment causes perturbations to the system; however, the systems reorganize themselves with most of the previous characteristics. A networks behavior is dependent on the network topology. The following properties are generally used to characterize networks:

- Degree distribution—the degree of a node, k, is the total number of links connected to this node and degree distribution is the relative frequency of each value of k in a network.
- Diameter—maximum number of links traversed for communication to flow from one node to another
- Cluster—set of all nodes connected by some path
- Clustering coefficient—of a node is the ratio of the number of links to the total number of possible links. Clustering coefficient of a network is the average of all clustering coefficient of the nodes.

Studies show network structures with high cluster coefficient and a small network diameter are found in a wide range of natural, social or collaborative networks. (Hinds, 2013) These networks are called scale-free networks. The degree distributions for these networks follow a power law, as in complexity theory. The robustness properties of free-scale network are important for BBP marketplace (open business model) because information and resources can easily and quickly diffuse through the network even as nodes continuously join and leave the network (under contract/out of contract). In addition, free-scale networks are robust against node failures and preserve its structure.

A look at social networks provides us with insight for deriving the CCRL metrics for open business models to supplement existing measures of technical architecture.

Open Source Software (OSS) Development Community

Multiple case studies have looked at OSS development projects and network structure of the open source community (Hinds, 2013). Conventional wisdom is that open source development produces more bug-free code, faster and is more innovative and responsive to the user needs. OSS projects are self-organized and employ rapid code evolution, massive peer code review and rapid releases of prototype code (Hinds, 2013). self-organizing process.

OSA should look to replicate the positive aspects of OSS by moving to an open system architecture paradigm. However, modular software architecture, common standards and tools are necessary but not sufficient to explain the success of OSS. OSS communities also exhibit scale-free networks features and have power law distributions since communities are self-organizing due to sequential growth and preferential attachment (business ties, preferred supplier relation, etc.). OSS networks tend to have small diameter and high clustering coefficient. The small distances result from the fact member can participate in multiple communities; furthermore, large numbers of members participate on one project clustered around a thought leader.

A competitive DoD marketplace that’s self-organizing, adaptive and agile needs more than just open systems architecture, but must also be engineered to support a dynamic open business model.

Component Competition Readiness Level (CCRL)

A dynamic ecosystem that encourages component competition requires establishing a framework that depicts the confluence of business and technical drivers. Part of establishing a business ecosystem or a network that encourages component competition is to foster the proper dynamics between the business (network architecture) and the technical framework. CCRL is thus concerned with documentation and dissemination program roadmaps to drive an open acquisition process, to provide the infrastructure and organization for system integration. Mil-HDBK-881 Work Breakdown Structure (WBS) was used to provide a guide for defining the top three levels as shown in Figure 6. The levels are as follows:

- Level 0: Goal
    - Reduce total ownership cost through agility and adaptability
- Level 1: Drivers
    - Technical drivers were addressed through Open Infrastructure and Roadmaps.
    - Business drivers were addressed through Open Acquisition and Organization.
- Level 2: Measurable Objectives
    - Inter-relationship of objectives that generate a complex dynamic behavior resulting in competition

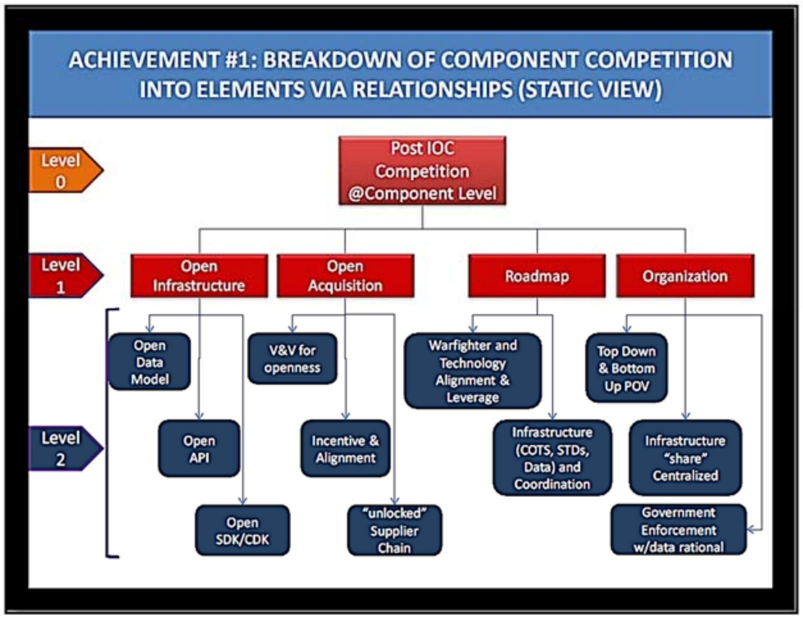


Figure 6. **Achieving Competition at Component Level Requires a Balanced Interplay of Business and Technology**

Level 1: Open Infrastructure Composition

Open infrastructure requires numerous stakeholder involvements that drive the development Interface Technology Requirements via three measurable objectives:

- Common Data Models
- Open Application Programming Interface (API)
- Open Software AND Component Development Kits (SDK/CDK)

Together Level 2 defines and codifies Interface Technology Requirements that includes all components (the application layer, transport layer, network layer, data layer, and the physical layer), provide for a Protocol Requirements and Performance Requirements. Included in the Interface Technology Requirements are the open infrastructure tasks for promoting a component competition ecosystem is periodic third party evaluations and assessment to judge the openness of the infrastructure. In this technical framework infrastructure, openness is not as much a determination of whether the technology is an industry standard, de facto standard, etc., but it is more weather or not the technology is available to all of the organizations that want to compete and contribute modules to the Program system.

Along with the SDK/CDK and its associated middleware, key components and their key interfaces should be identified. These components and interfaces are the ones that implement the feature/functionality upgrades in the aforementioned system capabilities roadmap. By designating these components and interfaces as key, they require more extensive documentation and stewardship throughout the Program execution. The key components, standards and interfaces should be identified during the system architecture design phase and maintained for the remainder of the program execution.

Relying on all of the organizations contributing to a program to integrate their modules into the greater system without a designated Program test bed is a management headache. Therefore, it is important for the Program to have an integration test bed with which all contributing teams integrate their components. Otherwise, integration efforts will be too disjointed to be effective.

Finally, a third party assessment team should review the technical framework infrastructure periodically to fulfill verification and validation (V&V) phase. An assessment should provide greater confidence that the systems' open architecture is on the right track with regard to promoting a component competition ecosystem.

Level 1: Open Acquisition Composition

The approach to acquire a DoD system that is built ground up for component competition, from a life cycle perspective, is considered essential. There are three (3) primary business drivers enablers, considered Level 2 items: a) V&V for transparency, b) Proper strategy to provide adequate incentives and alignment to promote good behavior of the willing and able, and c) Assurance that after system deployment, certain suppliers are not locked-in for the life of a program

The acquisition strategy should be aligned with modular product family design. The common functions (modules) for a given product platform have the governance to promote reuse across derivative products. Within a product family, a collaboration, communication, and continuous delivery mechanism is established to promote a robust network. Finally, a third party assessment team should review and assess the health of the ecosystem using metrics defined for free-scale networks.

Timing of events demands the alignment of Data Right Strategy (DRS) with that of the open architecture Component Competition strategy. Getting Government Purpose Rights (GPR), Unlimited Right or knowing what sub-elements have restricted rights must be transparent to all interested parties before major contract awards. If components are labeled incorrectly, the Government must take appropriate and timely steps to challenges such stated rights to ensure proper handling and markings.

In the open acquisition process, all efforts should be made to isolate all vendor specific IP and technology in specific modules/components for a derivative product. The lock-in of suppliers from a long term perspective often prohibits the Government and prime to select components from 3rd party solutions. The prime/LSI must address such issues before the MS-A award. They must recognize this challenge and state upfront how they plan to ensure this will not become so-called “business-as-usual.” Upon entering TD phase, the challenges will be understanding what and what-not to open and compete. An item that has a great deal of agility (rapid number of changes having high cost) is best suited for competition.

Level 1: Roadmaps Composition

Most program managers are familiar with the technology roadmap(s) that are important to every Program. Technology roadmap(s) are also important to maintaining component competition in Programs. Program managers and lead engineers must maintain cognizance of the technology trends in industry and be able to explain how those trends will impact the Program. The technology roadmap should be addressed soon after passing milestone-A and should be kept up-to-date with periodic updates well past IOC.

Along with the technology roadmaps, a system capabilities roadmap activity is equally important. Many technology-driven Programs require that the system to be deployed not only have certain features at initial operational capability (IOC), but also have subsequent upgrades to the IOC system to address evolving threats. It is the roadmap of the IOC features and feature upgrades that is critical to managing the openness of the system and the solution platform as a whole. The system capabilities roadmap should be developed, documented and product platform identified.

CCRL Implementation via an Acquisition-Systems Engineering Process

CCRL defines a process consisting of both a business and a technical framework strategy. As a business strategy the process evaluates the appropriateness and feasibility of applying free-scale networks to successfully permit component competition and third-party involvement. The CCRL process for development programs concentrates on life cycle affordability and managing change as part of the overarching business strategy by decomposing products into functions, grouping common functional modules into a common product platform, and choosing standards for interfaces to facilitate addition, removal, and substitution of modules. Also prioritizing and identifying the subsystems / modules that change most often and therefore have the greatest impact on program cost over its life cycle. Using the Key Open Sub System (KOSS) the program can determine the subsystems/components: relative rate of change over the life cycle; cost of change; and relative value to the Warfighter. The CCRL process provides guidance for the program to document the hardware and software open system architecture design requirements for the entire program development effort including the TM, TD and EMD Phases.

The CCRL process is the vehicle for interfacing component competition into the Systems Engineering (SE) acquisition process, whereby CCRL activities are identified and enhance the development of component competition. The CCRL process goals will ensure that a way of measuring the “openness” of a system is how readily a system component can be replaced with one developed by a different vendor, with no loss in overall system effectiveness. The CCRL process adheres to the principles of MOSA-NOA. The program achievement of these five principles will allow qualified third parties to add, modify, replace, remove, or provide support for a component, based on open standards and published interfaces. Key CCRL criteria can be specified for each of the System Engineering phases leading up to a major program Milestone, and it is important to establish these criteria across the full lifecycle in order to build component competition into the system.

Materiel Solution Analysis (MS-A) Phase

During the Milestone A (MS-A) phase, most of the CCRL related activities, criteria, and results can be mapped to content of the MS-A Program Open System Management Plan (OSMP). Associated MS-A engineering analyses engineering analysis, which includes the following:

- Establish OSA Training Workforce
- Establish OSA Policy & Guidance
- Establish a Strategy for Unlocking Vendors at a Component Level
- Establish a Data Rights Strategy
- Perform Initial Key Open Sub Systems (KOSS) assessment, the process which defines subsystems/components that have the potential to yield the greatest benefit to life cycle affordability by applying MOSA principles.
- Achieve a Component Competition Readiness Level (CCRL) of 2 by Milestone A.
- Identify product platform ecosystem and establish node connection to the ecosystem network

The MS-A Phase provides a business and technical approach for Modular Open Systems Architecture to enable competition.

Technology Development (TD) Phase

During the Technology Development (TD) phase, most of the CCRL related activities, criteria, and results can be mapped to content of the Milestone-B Open System Management Plan (OSMP). Associated Technology Development (TD) engineering analyses and OSMP content include the following:

- Systems requirements and technology development
- System architecture and technology demonstration
- Establishment of a Long-Range Volatility Capabilities Roadmap
- Performance of a KOSS Assessment to identify components for competition
- Identification of Key Interfaces to enable Competition
- Alignment of a Unified Data Model Strategy, Tools, and Process
- Open Systems Architecture with Component Competition Roadmap
- Achieve a Component Competition Readiness Level (CCRL) of 6 by Milestone B.

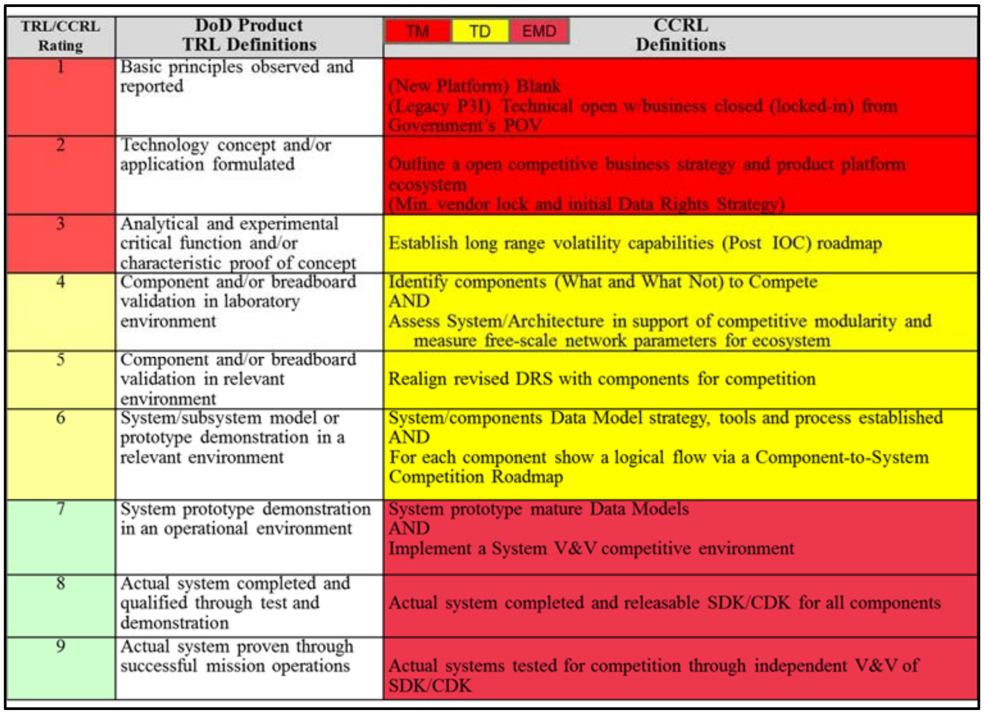
Engineering and Manufacturing Development (EMD) Phase

During the Engineering and Manufacturing Development (EMD) phase, most of the CCRL related activities, criteria, and results can be mapped to the content of the Milestone-C Program OSMP. Associated Engineering and Manufacturing Development (EMD) engineering analyses content include the following:

- Provides data model/processes
- Addresses testing for OSA components
- Open Systems Architecture with Component Competition Roadmap
- Achieve a Component Competition Readiness Level (CCRL) of 9 by Milestone C.

CCRL Governance Verification Process

CCRL processes have to be designed to produce verifiable artifacts that can to use to certify compliance as shown in Figure 7.



TRL/CCRL Rating	DoD Product TRL Definitions	TM TD EMD CCRL Definitions
1	Basic principles observed and reported	(New Platform) Blank (Legacy P3I) Technical open w/business closed (locked-in) from Government's POV
2	Technology concept and/or application formulated	Outline a open competitive business strategy and product platform ecosystem (Min. vendor lock and initial Data Rights Strategy)
3	Analytical and experimental critical function and/or characteristic proof of concept	Establish long range volatility capabilities (Post IOC) roadmap
4	Component and/or breadboard validation in laboratory environment	Identify components (What and What Not) to Compete AND Assess System/Architecture in support of competitive modularity and measure free-scale network parameters for ecosystem
5	Component and/or breadboard validation in relevant environment	Realign revised DRS with components for competition
6	System/subsystem model or prototype demonstration in a relevant environment	System/components Data Model strategy, tools and process established AND For each component show a logical flow via a Component-to-System Competition Roadmap
7	System prototype demonstration in an operational environment	System prototype mature Data Models AND Implement a System V&V competitive environment
8	Actual system completed and qualified through test and demonstration	Actual system completed and releasable SDK/CDK for all components
9	Actual system proven through successful mission operations	Actual systems tested for competition through independent V&V of SDK/CDK

Figure 7. **Representative CCRL Definition and Alignment With TRL**

Acquisition at the Edge of Chaos

System engineering practices has become stagnant. They were designed to perform tasks accurately, predictably and repeatedly, but not to continually modify their behavior in reaction to a dynamic environment and to solve a range of problems. In the language of complexity theory, the current system engineering and the supporting acquisition model has developed to support a steady state system of the cold war world. A complementary system engineering and acquisition model is needed for the world faced with a dynamic and asymmetric warfare that is based on complex adaptive systems.

The Component Competition Readiness Level (CCRL) defines and measures competition readiness at the component-level to promote agility into the complex dynamics of the acquisition processes. CCRL is a set of specific OSA and ecosystem health related tasks. Tasks are applied to the time-driven Acquisition maturity model (DoD5000).

According to a new University of British Columbia study published by the Proceedings of the Royal Academy, social connectedness is crucial for the development of more sophisticated technologies. A Stanford University study has also suggested that social networks may be contributing to increased intelligence among the young (Ray, 2013).

As shown by OSS, DoD acquisition model needs the power of the network by creating ecosystems around product platforms and eliminating closed-source development teams in favor of communities consisting of developers, co-developers and active users. Co-developers and active users are generally not part of a closed development team but are required for product innovation process.

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