Collaborative Achievement of Advanced Acquisition Environments

James W. Hollenbach
Simulation Strategies, Inc.
8615 Conover Place
Alexandria, VA 22308-2515
703-360-3902
jimh@simstrat.com

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ABSTRACT: *This paper describes the methodology being pursued by Department of Defense Acquisition Council and The Technical Cooperation Program (TTCP) to achieve advanced acquisition environments. Shared concepts have been identified by review of acquisition initiatives/strategies such as Simulation Based Acquisition (SBA); system of systems (SoS) development and testing; mission area management; and Integrated Digital Environments. From this concept set, a complete work breakdown structure (WBS) is being defined to support the realization of the required enablers. These enablers will allow programs to incrementally implement such acquisition environments. With the enabler WBS as a framework, various organizations - spanning government, industry, academia and commercial standards bodies, both national and international - can then collaborate to develop and share the enablers. A baseline WBS version is presented, some representative examples of in-hand and in-work enablers are identified, and the way ahead is described.*

1. Advanced Acquisition Environments

There are many initiatives, proposals and activities underway across government, industry and academia, within the U.S. and around the globe, that seek to improve the system acquisition (a.k.a., product development) process. To remain competitive in the marketplace, defense companies, like their commercial counterparts, are harnessing information technology (IT) to integrate geographically dispersed, multi-company teams for product definition, development, production, marketing and support. The Department of Defense is likewise interested in using advanced IT to take a whole-life, system of systems (SoS) view of new systems, extending into the operational employment phase. The use of modeling and simulation (M&S) has a prominent role in most of these efforts, being seen as a key tool for meeting aggressive goals for increasing quality, customer satisfaction and market share, and reducing risk, time to market and cost. The end states these efforts seek are here referred to collectively as "*advanced acquisition environments*."

A representative sampling of the initiatives, programs and activities in view follows:

- The U.S. Department of Defense (DoD) *Simulation Based Acquisition (SBA)* initiative, now established as key policy for effective management in the new capstone DoD acquisition directive [1]
- DoD's *Integrated Digital Environment (IDE)* initiative
- The United Kingdom's *Smart Procurement* and *Synthetic Environment Based Acquisition (SEBA)* initiatives.
- The U.S. Navy's *Distributed Engineering Plant (DEP)* and associated *Collaborative Engineering Environment (CEE).*
- The North Atlantic Treaty Organization (NATO) *Joint Computer-Aided Acquisition and Logistic Support (JCALS)* program
- The *Integrated Manufacturing Technology Initiative,* a consortium effort by the U.S. Government Departments of Commerce, Defense and Energy
- The National Aeronautics and Space Administration's *Intelligent Synthesis Environment (ISE)*
- Boeing's *Advanced Digital Enterprise Process and Tools* program
- Lockheed Martin's *Virtual Product Development Initiative*
- The Massachusetts Institute of Technology (MIT) Center for Innovative Product Development's *Distributed Object Modeling Environment (DOME).*U.S.

National Institute for Standards and Technology (NIST), "Knowledge-based Interoperability Project"

A more comprehensive, but still incomplete list of such efforts may be found in [2].

Since all of such efforts purport to improve the acquisition process, they engender both interest and confusion from the defense acquisition community. They likewise raise some interesting management challenges to government bodies that are stakeholders in this arena.

2. The Technical Cooperation Program Actions

The Technical Cooperation Program (TTCP) is a long-standing cooperative research and development (R&D) program among five English-speaking nations: Australia, Canada, New Zealand, the United Kingdom, and the United States. These nations collaborate in scientific research and technology development to enhance future defense capabilities. All participating nations contribute to research and technology development, and all have full access the fruits of the collaboration. The nations also conduct workshops and studies to pool and exchange information. In these ways, TTCP seeks to augment the national defense programs, avoid unnecessary duplication, and identify and close gaps in the defense technology base. Additional TTCP information is available at http://www.dtic.mil/intst/.

There are currently ten technical groups within TTCP, one of which is the Joint Systems and Analysis (JSA) Group. The JSA Group has recently established a technical panel on "*Systems Engineering for Defence Modernisation*" (TP-4). This panel is chaired by Mr. Bahrat Phatel of the United Kingdom's Defence Evaluation and Research Activity (DERA). The JSA Group established TP-4 to examine the implication of procurement reform practices and processes, systems of systems methodologies, and whole life issues. It thus has a somewhat novel charter within TTCP, in that it is predominantly focused on exchanges of information regarding process rather than technology. Currently in its two-year start-up phase, TP-4 has been tasked to examine the topics of *Systems of Systems Acquisition (SoS), Simulation Based Acquisition (SBA)* and *Integrated Digital Environments (IDE).*

At its September 2000 meeting in Washington, DC, TP-4 made several important observations regarding these three initiatives [3]:

- Both the IDE and SBA initiatives aspire to improve defense system acquisition by providing advanced systems engineering environments
- Effective systems of systems management requires the capabilities envisioned by IDE and SBA.
- Together, these initiatives share many goals
- Just as these initiatives aspire to fulfill common goals, they often share common enabling components, whether technical, process, or cultural

Consequently, the Systems Engineering panel made the following recommendations:

- The initiatives should not be treated as stove-pipes; potential synergy should be harnessed, resulting in:
  - More effective use of talent
  - Better leveraging of investments
  - Reduction of redundant efforts
- Take a disciplined systems approach to building the envisioned system engineering capability

The panel went on to note that the relationship found between the explicit and implicit goals of SoS, IDE and SBA initiatives and the enablers they require is expected to be repeated in other focus areas.

3. DoD Acquisition Council Actions

SBA responsibility within the Office of the Secretary of Defense, along with chairmanship of the Acquisition Council, a component of the DoD Executive Council for Modeling and Simulation (EXCIMS), rests with the Director of Interoperability, Dr. V. Garber. Dr. Garber and other acquisition community leaders regard modeling and simulation as essential to the development and verification of interoperable defense systems. Another major motivation for pursuing SBA capabilities is the growing consensus among DoD leaders that the department must manage its acquisition activities on a SoS, vice individual weapon system, basis. [See reference 3 for additional information on the history of SBA within DoD.]

Under Dr. Garber's leadership, the Acquisition Council has been considering what corporate-level actions are appropriate and practical to promote the attainment of the capabilities envisioned by SBA. In November 2000 the council approved a set of goals for 2001. One of these goals builds on an approach originally advanced by the Navy Acquisition Reform Office [2], which is understand SBA in the context of the broader set of related efforts (referred to above) in order to establish a framework for collaboratively achieving the enabling policies, processes, technical capabilities, and cultural changes necessary to realize the goals that these efforts hold in common.

Recognizing the compatibility and potential synergy between its own goals and those of the TTCP systems Engineering panel, the DoD Acquisition Council has decided to serve as one of the coordination points with future TTCP activities.

4. Approach

The guiding rationale that determined the approach that has been adopted in principle by both the TTCP and the Acquisition Council may be summarized as follows:

- The objectives of most acquisition/product development improvement efforts have many similarities and they have embraced similar concepts to achieve their objectives. None has the resources it needs to reach its desired end state.
- The need for certain enabling abilities - enablers - is inherent in each of these concepts. (Note: The term "enabler" is defined as any ability that must be present to allow one or more of the cited concepts to be instantiated.) These abilities may be in the procedural, technical or cultural domains.
- Realization of these enablers can be accomplished most rapidly and cost-effectively if the various efforts collaborate. Such collaboration should span government, industry and academia, both nationally and internationally.

To identify the concepts shared among the various initiatives, and the enablers associated with each, and to eventually map all activities necessary to realize those enablers, the Acquisition Council and TTCP have decided to follow the process depicted in Figure 1.

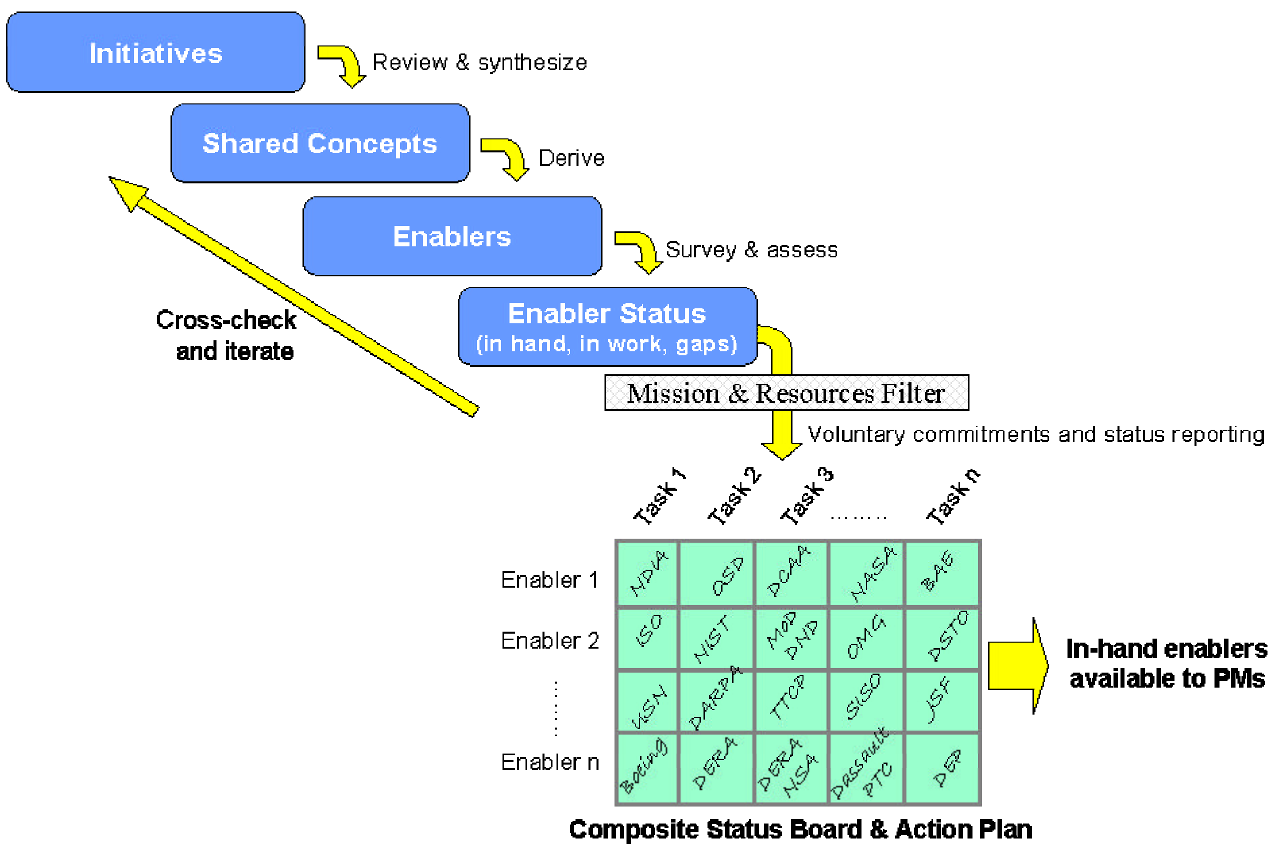

Figure 1. Process for Collaborative Identification and Realization of Enablers

5. Shared Concepts

As asserted previously, review and synthesis of the underlying concepts embraced by the Simulation Based Acquisition (SBA), Synthetic Environment Based Acquisition (SEBA), Integrated Digital Environments (IDE) and System of Systems (SoS) methodologies reveals many shared concepts. This commonality engenders additional confidence in the worth of these concepts, for it tells us that many different acquisition experts, working from their own perspectives, arrived at the same conclusions regarding how best to improve the acquisition process.

The list that follows is a composite superset of the concepts shared by two or more of the limited number of initiatives considered thus far. Not every initiative embraces every concept and some initiatives may have additional, unique concepts. The acronyms in parentheses following each concept indicate the initiatives where that concept is found.

The shared concepts are:

a) Faster and better decisions/transactions among dispersed parties through digital information sharing and electronic interactions (IDE, SBA, SoS)

b) Early and continuing collaborative exploration of the largest possible trade space, including requirements, across the life cycle (SBA, SoS)

c) Conceiving, designing, testing and managing to optimize "system of systems" attributes (SBA, SoS)

d) M&S-based assessments earlier in the development cycle; system designed, built, tested and operated in the computer before critical decisions are locked-in and manufacturing begins (SBA, SoS)

e) Flexible, iterative mixing of simulations and hardware (SBA, SoS)

f) Reduction of activities more cost-effectively performed in M&S, such as drawings, mock-ups, prototypes and some live testing (SBA, SoS)

g) Maximum reuse of all acquisition resources: information, software, expertise, facilities, etc. (IDE, SBA, SoS)

As noted in the Figure 1 process, this conclusion can be verified by cross-checking this list of shared concepts against the official/accepted description of each initiative. For instance, in the case of SBA, the correctness of this list of shared concepts has been verified by comparison with the two-page definition of SBA approved by the DoD Acquisition Council and the SBA Industry Steering Group (SBA ISG), a component of both the National Defense Industrial Association (NDIA) Systems Engineering Committee and the Affordability Task Force of the National Center for Advanced Technologies (NCAT).

6. The Need for Collaboration

The high degree of commonality in the concepts underlying the various initiatives, projects and activities suggests some action be taken to ensure their aggregate cost-effectiveness. They should either be merged into a single program under a single manager or some other means be found to ensure make them coherent and synergistic.

Attempting to implement a new, all-encompassing, program to replace or compete with those already underway would be both impractical and unwise. Creating one big program, under a single manager, is impractical in almost all respects. No single organization has the resources or authority to develop a comprehensive solution, and many nations must be involved because they have legitimate interests. For instance, a reason for the TTCP panel's activity was to consider the implications of SBA, IDE and SoS for coalition defense and international collaborative acquisitions, leading to a conclusion that the associated issues needed to be dealt with in a collaborative manner.

Voluntary collaboration offers a better approach. It avoids the political problems associated with allocating power and resources. It fosters the participation of the broadest possible range of people with the requisite talent, experience and ideas. A collaborative approach is consistent with the very the way of developing complex systems promoted by SBA and other initiatives, and the acquisition environment sought is itself a complex system.

7. A Framework for Collaboration

As implied by the process in Fig. 1, a detailed enabler list, once developed, refined and agreed to, will allow mapping the ongoing, emerging and not-yet-started activities necessary to allow program managers to implement advanced acquisition environments. I.e., it provides a work breakdown structure (WBS) for implementing actions.

This is a sound systems engineering management practice: Taking a complex task and breaking it down into packages of smaller tasks that can be more readily understood and managed. By identifying each enabler, and the tasks necessary to produce it, we break the work down into discrete packages with defined products, at a level of detail that facilitates allocating resources (people, facilities, time, schedule, etc.).

Considering their own mission and resource availability, the various organizations interested in this work can volunteer to take on particular tasks and report back to the larger body of collaborating organizations regarding the status of their efforts. The greatest management challenge is establishing an effective process for gaining and maintaining the requisite cooperation among the parties, on an international scale.

8. Enabler Classes

Continuing with the Figure 1 process, careful analysis of the shared concepts (Section 5 above) soon yields some enabling capabilities – enablers – necessary to realize those concepts. However, to establish a comprehensive and detailed enabler WBS, it is first necessary to establish the correct taxonomy, or in objected-oriented terms, class structure. That serves as an organizing schema and also provides a useful framework for examining any resulting enabler set for completeness.

After trying several other class structures, the Acquisition Council has settled on the following ten enabler classes as a baseline, expecting that this class structure may evolve as further collaboration occurs. The concepts requiring the cited enabler class are listed in parentheses.

1.Policy, law and organizational changes (Concepts a, c, d, f, g)

2. Process changes (a, b, c, d, e, f, g)

3.Standards for data interchange (a, b, c, d, e, g)

4.Standards for M&S software application interoperability (b, c, d, e, g)

5.Authoritative information sources (a, b, c, d, f, g)

6. Capable, reusable models and simulations (b, c, d, e, f, g)

7. Means to manage collaboration & multi-domain optimization (b, c, d)

8.Means to identify, protect & obtain reusable resources (a, b, c, d, e, f, g)

9. Business case evidence (a, b, c, d, e, f, g)

10. Education, motivation & evolution of work force (a, b, c, d, e, f, g)

A definition of each of these enabler classes, with examples, follows.

Policy, law and organizational changes remove structural barriers to, or provide missing management functions for, advanced acquisition environments. Examples of required policy changes may include providing industry the M&S tools used in source selection; issuing contractual guidance regarding the sharing of information, tools and processes; or establishing new norms for program funding profiles. Examples of changes to public law may address the optimization of solicitations, operational testing or live fire testing under these new concepts. Organizational changes may include changes to government/commercial organizational responsibilities or structures to provide management of widely-needed infrastructure elements, or to provide a more effective system of systems perspective throughout the acquisition process.

(Note: Where policies are intricately intertwined with another enabler class, they are addressed there.)

Process changes establish or evolve the processes used in various professional disciplines to optimize their effectiveness under advanced acquisition environment concepts. Examples may include the establishment of web-based electronic solicitation processes, modification of individual organizations' systems engineering processes to accommodate their use across an extended team of commercial and/or government organizations, or the modification of traditional test and evaluation procedures to more cost-effectively leverage M&S.

(Note: Where processes are intricately intertwined with another enabler class, they are addressed there.)

Standards for data interchange are required to minimize the inefficiency, miscommunication and incoherency (i.e., confusion) that can arise as information is shared among the diverse parties involved in an extended enterprise, a particular problem given the large and complex information sets typical of today's systems. These standards specify the semantics (meaning) and syntax (structure) of the exchanged information, in a machine-readable form. They are not meant to restrict the way in which information is maintained or manipulated within individual organizations, professional disciplines or software applications, but merely establish a common language (“*lingua franca”)* for information commerce among these entities. This enabler domain may include a taxonomy defining the requirements for such standards; various government or commercial data interchange standards (e.g., ISO's STEP, SEDRIS, XML DTDs); and their associated data engineering methods, information models and tagged data formats (e.g. XML, STEP Express).

Standards for M&S software application interoperability define the technical architecture(s), including associated application programming interfaces (APIs), rules and conventions, to allow the effective, coherent exchange of information among the software tools (e.g., models, simulations) used by various organizations and professional disciplines. These standards apply where such interaction is warranted, and may address either runtime interactions (e.g., linked executions across a federation of simulations) or non-runtime data transfer mechanisms (e.g., initialization or post-execution data collection).

Authoritative information sources provide the information/data needed to support advanced acquisition environments. This class of enablers includes a taxonomy for identifying information types; the identification of the authoritative source(s) for each type; and the information itself, in a logically-consistent (coherent) form. The information in view may pertain to (a) the natural environment; (b) man-made products/systems (e.g., U.S. weapon systems, threats); (c) the behaviors of units/organizations (e.g., strategy, doctrine, tactics), individual humans or other living creatures; or (d) the interactions of these entities (e.g., functional descriptions of a mission space, design reference missions). This information may be used directly or serve as raw material for other tasks such as building models, simulations or scenarios.

Capable, reusable models and simulations are key software tools required to support advanced acquisition environments. This class of enablers includes the requirements for such tools; the models (including CAD systems), simulations, and simulation federations themselves, along with the software components thereof (e.g., Digital System Models); the procedures and tools required to develop or use these tools; and their associated descriptors (e.g., conceptual models, simulation and federation object models (SOMs/FOMs), VV&A histories). The procedures in view include model/simulation development and use procedures, and verification, validation and accreditation (VV&A) procedures to incrementally review, analyze, evaluate and test them to gauge their credibility and guide their use. The M&S software applications in view include those required to represent the full range of system characteristics, (e.g., performance, reliability, supportability, costs) across a system's life cycle (requirements definition, concept development, design, manufacturing, test, employment and disposal). Supporting tools in this class include M&S execution monitoring/management tools, data collection tools, etc.

Means to manage collaboration and multi-domain optimization facilitate mastering the complexity inherent in such tasks. Included in this enabler class are (1) distributed team interaction means (e.g., e-mail, VTC, virtual presence, software application sharing) and strategies for their efficient use; and (2) management methods and tools to support workflow planning, and tracking. Also included are (3) methods and tools to relate, deliberate and weigh among the viewpoints/measures of merit provided by various members of the enterprise (e.g., prioritization and/or weighting algorithms, groupware, visualization) and (4) means to capture decision rationale.

Means to identify, protect and obtain reusable resources (e.g., information/data, software applications, software components, analysis results) make advanced acquisition environments economically feasible by avoiding the costly duplicative development/procurement of such resources. Identification means may include distributed resource repository systems such as commercial Product Data Management tools and DOD's M&S Resource Repository system; electronic bulletin boards; and help desks. Protection means may include and (a) access control and encryption policies, standards, applications and devices, (b) standard templates to describe appropriate and inappropriate uses for each resource; and (c) methods to prevent misuse/abuse. Means by which qualified users can obtain resources will include request, release/delivery and adjudication/appeal procedures. This area also includes effective incentives (e.g., monetary compensation) for resource developers to make their products suitable for reuse, bear the burdens of assisting new users, and expose their products to potential criticism. Finally, it includes population of the repositories and bulleting boards.

Business case evidence supports decisions regarding commitments to establish and use advanced acquisition environments. This evidence may be based on parameters such as product quality/performance, risk avoidance, time to market/field, market share, profit, and cost savings or cost-avoidance. Enablers in this class may include: (1) cost-benefit assessment methods and metrics; (2) analyses or anecdotal evidence; (3) arguments from market trends in commercial industry; and (4) methods to extrapolate results from today's product development environment to the full achievement of advanced acquisition environment concepts.

Education, motivation and evolution of work force enablers allow the development of the human skills and behaviors needed in advanced acquisition environments. These include educational source material, education delivery means (e.g., publications, conferences, workshops, classroom training, distance learning, help desks, assist visits) and education opportunity awareness. Motivation enablers include financial and non-financial incentives and human resource management policies.

9. The Emerging WBS

With this class structure as a foundation, an initial WBS has been drafted. Because of its wide availability and user familiarity, Microsoft EXCEL was chosen as the software application to develop, manipulate and configuration manage the WBS.

The WBS lists the individual enablers that are required to achieve advanced acquisition environments. It also attempts to provide a crude assessment ("stoplight chart") of the status of those enablers. The right portion of the WBS lists information about the products that serve as those enablers, or the activities that are attempting to develop products that will satisfy those enabler needs.

An example of the WBS is provided in Table 1. This is offered to help the reader understand the expected structure of the WBS. The details of individual elements of it are of course open to debate. There will be many frequent changes to the WBS. The left side of the sheet – the enabler class structure – should remain fairly stable, but as we move right among the columns, the changes will likely be increasingly frequent.

Enabler Class	*Enabler*	*Task*	*Sub-task*	*Status*	*Satisfying Product or Activity*	*Responsible Organization*
5. Authoritative information sources				yellow		
	5.1 Information taxonomy			red		
	5.2 Identification of the responsible organization for each information type			yellow	Authoritative Data Sources project	DMSO lead, Services
	5.3 Coherent information available within each responsible organization			yellow		
					SBA Distributed Product Description (DPD) concept	
6. Capable, reusable models and simulations						
	6.1 Functional descriptions of the mission space (FDMSs)					
		6.1.1 Define required domains (SoS and functional area partitions)		red		
		6.1.2 Define reference missions for each domain		red		
		6.1.3 Define required levels of granularity		red		
		6.1.3 Define entities, attributes and interactions for each domain-resolution pair		red		
	6.2 Best practices for model and simulation development			yellow		
	6.3 Verification, Validation and Accreditation (VV&A) procedures			yellow		
		6.3.1 Define responsibilities		yellow	DoD 5000.61	DoD EXCIMS
		6.3.2 Define VV&A Best Practices		yellow	VV&A Recommended Practices Guide 2000	DoD DMSO
		6.3.3 Establish VV&A documentation templates				
		6.3.4 Establish enforcement means		red		
	6.4 Current and projected model and simulation inventory	6.4.1 Map existing applications against FDMSs and other requirements (e.g., user constraints)		red		
		6.4.2 Prioritize needs		red		
		6.4.3 Divide responsibilities to meet remaining needs		red		
		6.4.4 Select std application development frameworks (e.g. JMASS) where appropriate		yellow		
		6.4.5 Develop models & simulations, including associated DSMs where applicable		yellow		
		6.4.6 Document application capabilities and weaknesses per VV&A procedures in 6.3		yellow	(long list)	
		6.4.7 Maintain M&S applications		red		
	6.5 Persistent federations of simulations	6.5.1 Develop federation object models (FOMs)		yellow	RPR FOM	
					Naval Training MetaFOM	
					RDEC FOM	
					others tbd	
		6.5.2 Develop & document federations		yellow		

Table 1. Example of Enabler WBS (draft)

10. The Way Ahead

The great management challenge to the successful implementation of this collaborative approach is establishing an effective process for gaining and maintaining the requisite cooperation among the parties, on an international scale. A successful process will have these characteristics:

- Be familiar to, and understood by, all the stakeholder communities: Acquisition management, systems engineering, test and evaluation, standards development, M&S, etc.
- Provide an effective, responsive way for interested parties to have a voice in the evolution of the WBS and the associated mapping of associated activities.
- Be regarded as reinforcing, vice threatening, their individual efforts, by better explaining how they contribute to a larger cause.
- Be expandable in scope to include more related initiatives and their activities (perhaps yet undiscovered).

Thus this proposal for the collaborative achievement of advanced acquisition environments, and the emerging WBS and status assessments, is being presented to this body and others associated with the professional disciplines noted above. Likewise, the leadership of other advanced acquisition environment-related activities will be consulted and invited to participate.

After an initial round of comments, the viability of this approach and the enabler class structure examined to see if they remain viable. Adjustments will be made as deemed appropriate. However, it is certain that a distributed, collaborative approach will be the best path to achieve distributed, collaborative advanced acquisition environments.

The configuration management process for evolution of the WBS will be determined. Consideration will also be given to replacing the stoplight judgments with a quantitative method for assessing enabler status. This is seen as also offering other potential benefits, such as aiding an overall assessment of progress in implementing advanced acquisition environments.

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Author Biography

JAMES W. HOLLENBACH, Captain, USN (Ret.), holds a BS in Mechanical Engineering and an MS in Aeronautical Systems. A Naval Aviator, former EA-6B squadron commander and DoD Acquisition Professional, he has devoted much of his professional life to analyzing, defeating, developing or managing complex information systems. During his career he has managed over $250M in projects addressing standards, services, software and infrastructure in the areas of C3I and M&S. As Director of the Defense Modeling and Simulation Office from 1994 to 1998, he led development of the DoD and NATO M&S Master Plans and key initiatives such as the High Level Architecture, Conceptual Models of the Mission Space, and Synthetic Environment Data Representation and Interchange Specification. His company, Simulation Strategies, Inc., provides modeling, simulation and enterprise integration expert