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MITRE TECHNICAL REPORT

MITRE

Making Acquisition Measurable

FY 2010 NDAA Section 804 Principles

Kevin Buck and Diane Hanf
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1.0 Overview

This paper summarizes the results of preliminary investigations undertaken by MITRE's "Making Acquisition Measurable" (MAM) Capability Development Team to support Government programs in measuring the adoption and impact of four Information Technology (IT) acquisition principles. These principles are identified within Section 804 of the FY 2010 National Defense Authorization Act (NDAA) as critical to a new IT acquisition process that must be created by the Department of Defense (DoD). The four principles include:

- Early and continual involvement of the user;
- Multiple, rapidly executed increments or releases of capability;
- Early, successive prototyping to support an evolutionary approach; and
- A modular, open-systems approach.

The ultimate objective of our investigations was to establish a foundation for improving how acquisition performance is managed. The absence of a formalized and standard performance management methodology has been noted by the House Armed Services Committee Panel on Defense Acquisition Reform as a critical area of weakness. To create a foundation for improved performance management, the team needed to better understand how program managers can more effectively and efficiently:

- Account for the unique nature of IT in their performance measurement and program management;
- Apply performance metrics to determine whether desired outcomes from their programs and acquisitions will likely be achieved;
- Identify in a proactive manner whether course corrections are needed or expectations should be adjusted;
- Leverage best practices, lessons learned, and existing tools/analyses to improve data collection, performance measurement, acquisition monitoring, and acquisition execution decision-making; and
- Ensure that performance management efforts support improved performance (e.g., timely delivery of required capabilities, services, or products to the end-user).

"Information technology (IT) offers immense capability in terms of agility, flexibility, responsiveness, and effectiveness. It enables nearly all of our military combat capability and has become a necessary element of our most critical warfare systems. However, there is growing concern within Congress and among DOD leadership that the nation's military advantage may be eroding. The deliberate process through which weapon systems and information technology are acquired by DOD cannot keep pace with the speed at which new capabilities are being introduced in today's information age—and the speed with which potential adversaries can procure, adapt, and employ those same capabilities against the United States."

Report of the Defense Science Board (DSB) Task Force on DoD Policies and Procedures for the Acquisition of IT, March 2009

The project looked broadly across the four principles highlighted in NDAA Section 804 and subsequently focused on the challenges that program managers might face in measuring adoption and impact of the user engagement principle. We discovered that the principles are interrelated and that an understanding of how acquisition success will be measured is critical to understanding the principles' contribution to successful acquisition outcomes. Figure 1-1 illustrates key relationships among the four principles.

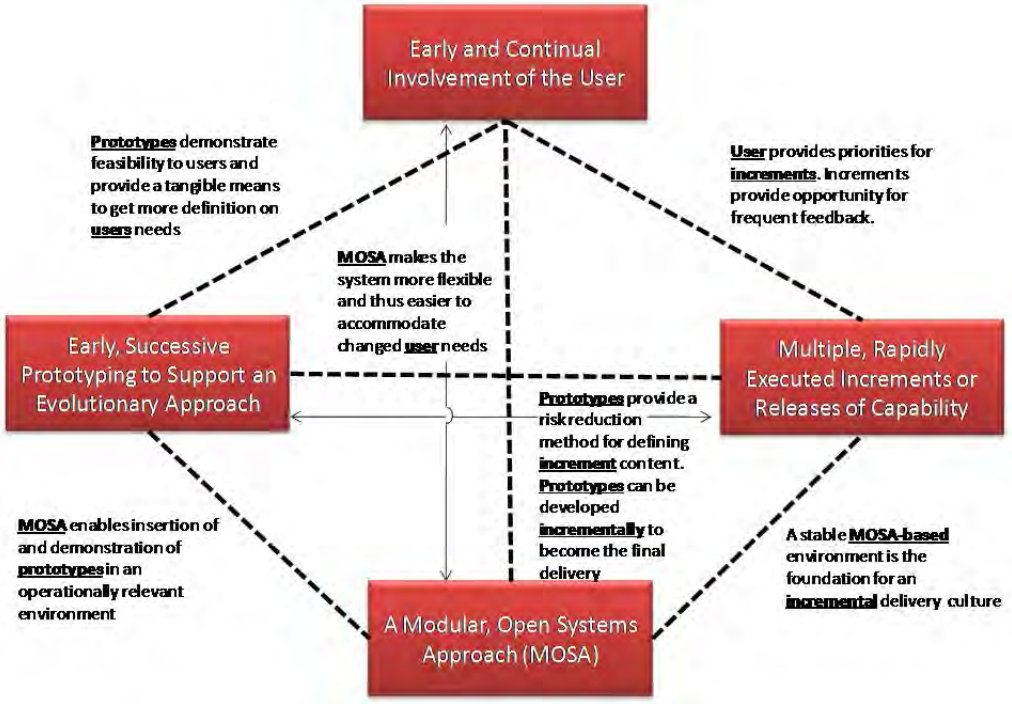

Figure 1-1. Relationship Among Section 804 Principles

Incremental deliveries and supporting underlying processes, for instance, should provide early opportunities to learn about the changing user environment. Designing user interfaces using MOSA principles should reduce user training needs and allow for more rapid deployment of components that have changed because of user needs. Applying prototypes should provide a tangible presentation of the evolving or proposed system, which should enrich user-developer interactions.

Our research focused most extensively on the challenges that Government program offices face in ensuring early and continual involvement of the user, measuring/monitoring user engagement in achieving program/system objectives, and determining the impact of user involvement. Based on direct interaction with users of Government systems and program capabilities, our research resulted in the identification of essential elements for an effective user engagement program, codification of key user types and characteristics, candidate high priority user engagement metrics, lessons learned in deriving metrics, relevance of performance management principles for measuring user engagement, and insights from users for improving how program offices can more effectively and efficiently engage users in the process of delivering required capabilities.

2.0 Technical Approach

The House Armed Services Committee on Acquisition Reform published interim findings that highlight the importance of considering performance metrics in creating a new IT acquisition process: [1]

[1] *House Armed Services Committee Panel on Defense Acquisition Reform Interim Findings and Recommendations, DAR Interim Report. 4 March 2010, Page 18. Recommendation 1.1 was influenced by testimony delivered by Mr. Tim Harp, Dr. Paul Nielson, and Dr. Ron Kerber delivered at the Panel's July 9, 2009 hearing entitled, "Challenges to Effective Acquisition and Management of Information Technology Systems."*

"The alternative process must include from the start clear performance metrics for specific programs, as well as for comparison of programs at an enterprise level. As was pointed out to the Panel, 'the metrics we have been using have been the financial metrics and the acquisition process metrics [and] we have found they don't work very well in measuring IT success.' [2] Good metrics in this area have already been developed in the commercial and academic sectors. What is needed is a cultural change that emphasizes the capture and tracking of metrics integral to the IT acquisition process and additional tools and resources for this purpose."

The Armed Services Committee concluded that acquisition system successes, failures, strengths and weaknesses can be most effectively identified through the institutionalization of performance management processes. Figure 2-1 illustrates a performance measurement selection approach that, if applied to selecting IT acquisition metrics, would help ensure that selected metrics and performance levels provide meaningful and timely characterizations of progress in achieving desired outcomes.

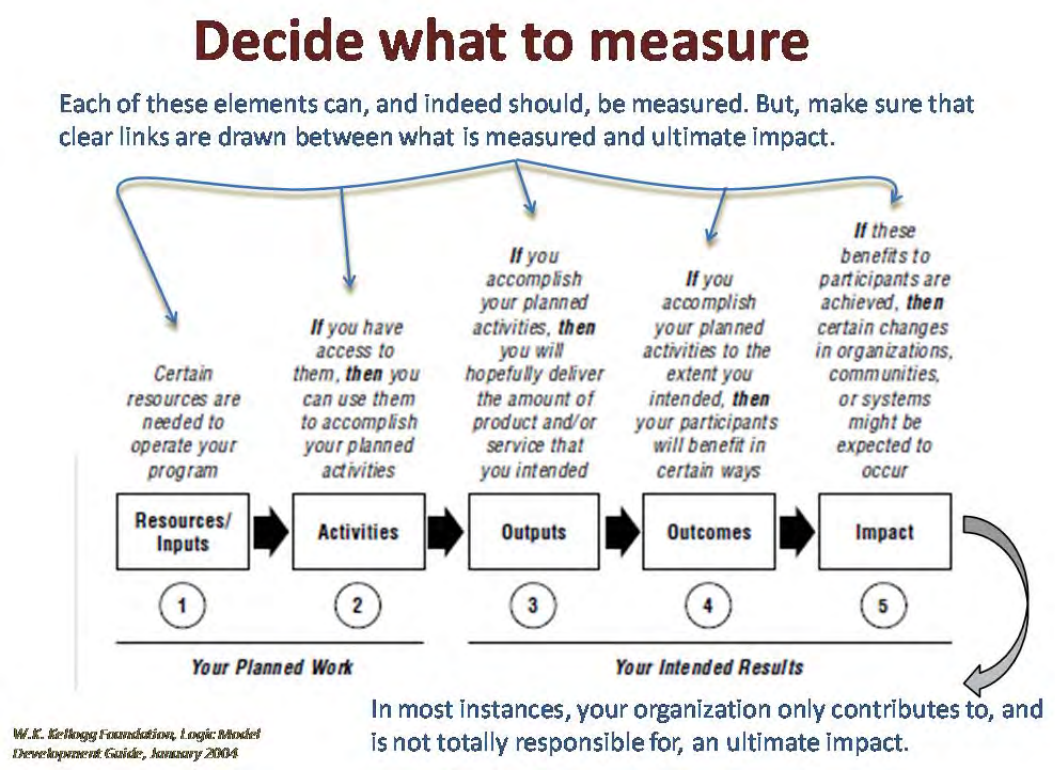

Figure 2-1. Identify What to Measure and What That Measurement Represents

Our team focused on performance measurement, and the overall approach involved:

- Defining the four principles and understanding how they relate to one another;
- Reviewing relevant policies and guidelines to understand why these principles are considered to be so critical and what outcomes are supported by adopting them;
- Understanding how these principles are, and should be, applied based on investigations of commercial industry and Government experiences, lessons learned, and best practices;
- Determining how principle adoption and impact is currently measured; and

[2] *Testimony of Mr. Tim Harp delivered at the Panel's July 9, 2009 hearing entitled, "Challenges to Effective Acquisition and Management of Information Technology Systems."*

- Exploring recommendations from academia, commercial industry, and Government as to how these principles should be measured;
- Identifying performance management best practices that will be critical to making informed performance metric selection decisions; and
- Determining next steps that will need to be undertaken so that program managers can select and effectively apply a suite of performance metrics that is tailored to specific program and acquisition circumstances.

3.0 Early and Continual User Involvement

The definition that we apply for Early and Continual User Involvement is illustrated in Figure 3-1.

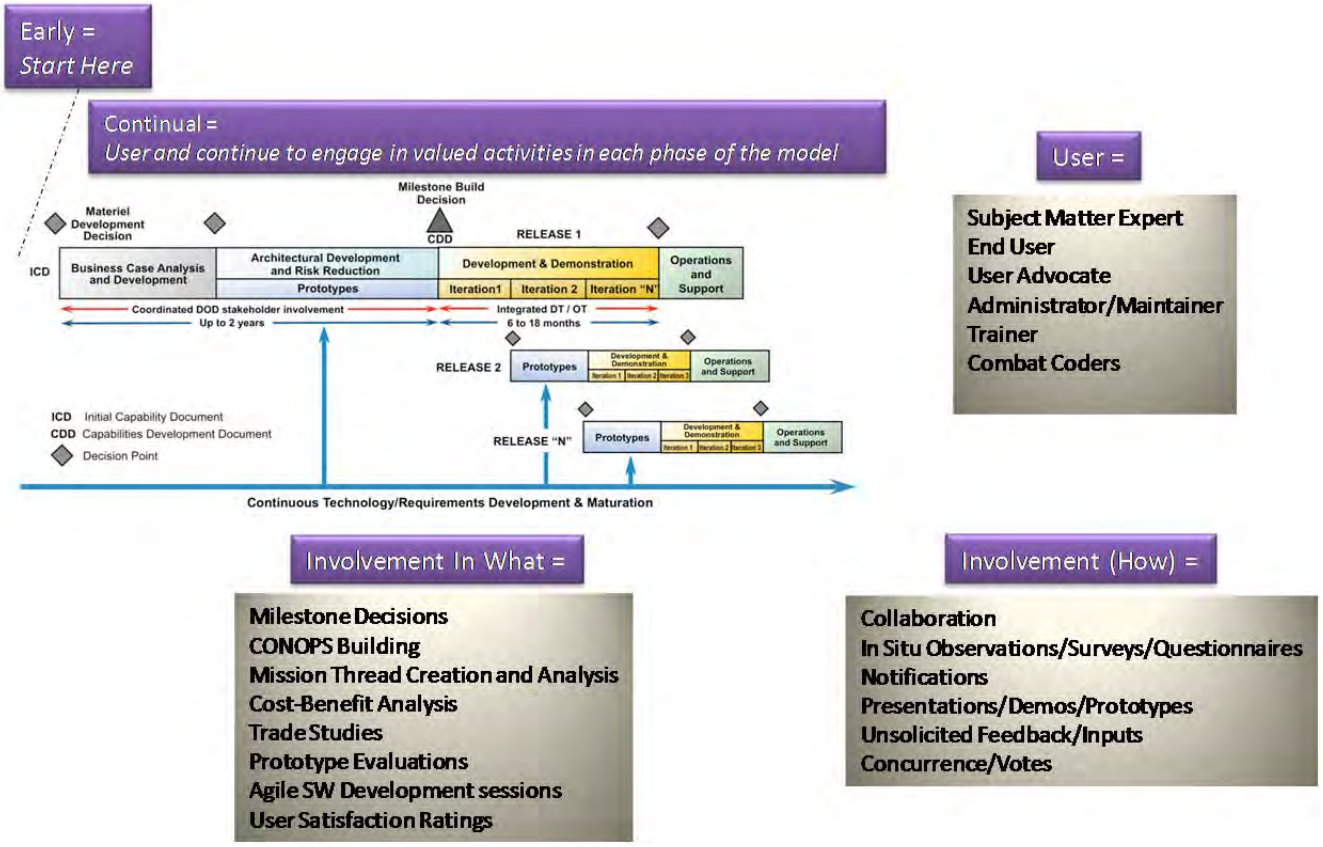

Figure 3-1. Early and Continual User Involvement: Definition in Context

The user is engaged before Interim Capability Description (ICD). *Continual* implies that the user and program continue to engage in valued activities throughout each phase of the model. These activities can be events (e.g., milestone/release/iteration decisions), collaborations on building mission threads; results of voting or surveys; or in situ observations of user behavior to gather information about what the user needs to perform his/her job and provide feedback on user satisfaction ratings.

3.1 CORE FINDINGS

Figure 3-2 illustrates key practices associated with Early and Continual Involvement of the User in relation to IT acquisition lifecycle milestones as proposed by the DSB (orange bubbles reflect practices that are relevant throughout the lifecycle, while blue bubbles reflect those practices that are relevant for specific milestones).

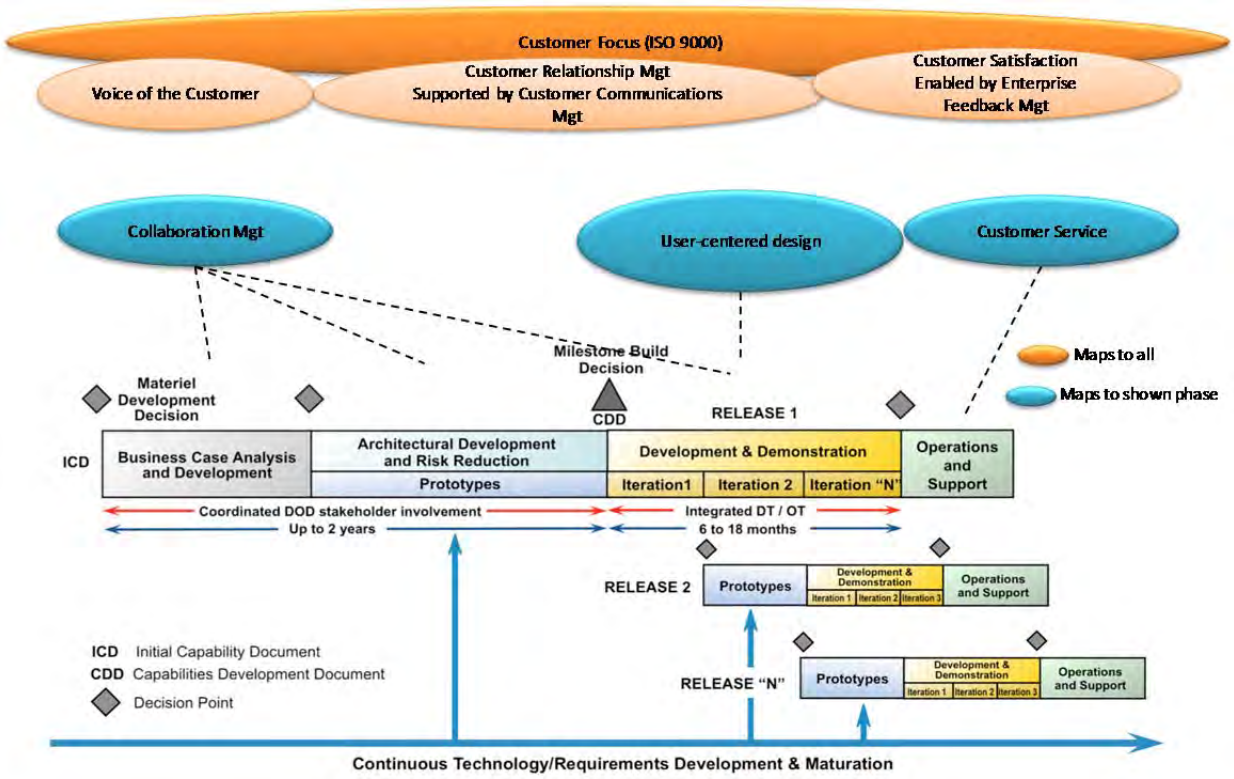

Figure 3-2. Early and Continual Involvement of the User – Mapped to IT Acquisition Lifecycle Milestones Proposed by the DSB

Customer satisfaction is a recurring theme within published literature from multiple aspects, including the system as it is operating as a whole, the system as it is operating at the time of a new release, and relationship management. The literature, however, focuses on methods to select measures, rather than providing recommended metrics. Best practices that emerged from our investigations include:

- Researching and understanding customer needs and expectations
- Ensuring that the objectives of the organization are linked to customer needs and expectations
- Communicating customer needs and expectations throughout the organization
- Measuring customer satisfaction and acting on the results
- Systematically managing customer relationships
- Applying user-centered design approaches
- Ensuring customer support experiences are positive
- Ensuring a balanced approach between satisfying customers and other interested parties (such as owners, employees, suppliers, financiers, local communities and society as a whole)[3].

Although there are a number of approaches available to focus on user engagement, these approaches are applied inconsistently. A standard approach for knitting the best practices together with an objective of improving IT acquisition results have not emerged. Although techniques for measuring user satisfaction have been developed, our investigations did not uncover recommended approaches for how to measure the success of engaging with the user; assess cost, benefit, and risk tradeoffs regarding how users should be engaged; and make informed IT acquisition decisions based on the results of measurement.

[3] *From ISO Quality Management Principles*

3.2 MEASUREMENT AREAS

We administered a survey and facilitated focus group discussions and face-to-face interviews with users across a spectrum of Government organizations to understand their experiences and opinions regarding user engagement with program offices. We wanted to better understand how well program offices currently engage with users, how significantly user engagement can contribute to program success, and user perspectives on what program offices should measure to determine how effectively they are engaging users to achieve overall program objectives. The results of the survey supported an identification of metrics that program offices should consider applying to monitor the effectiveness of their user engagement practices and the contribution of user engagement to overall program success. The types of users we targeted through our data collection are illustrated in Figure3-3.

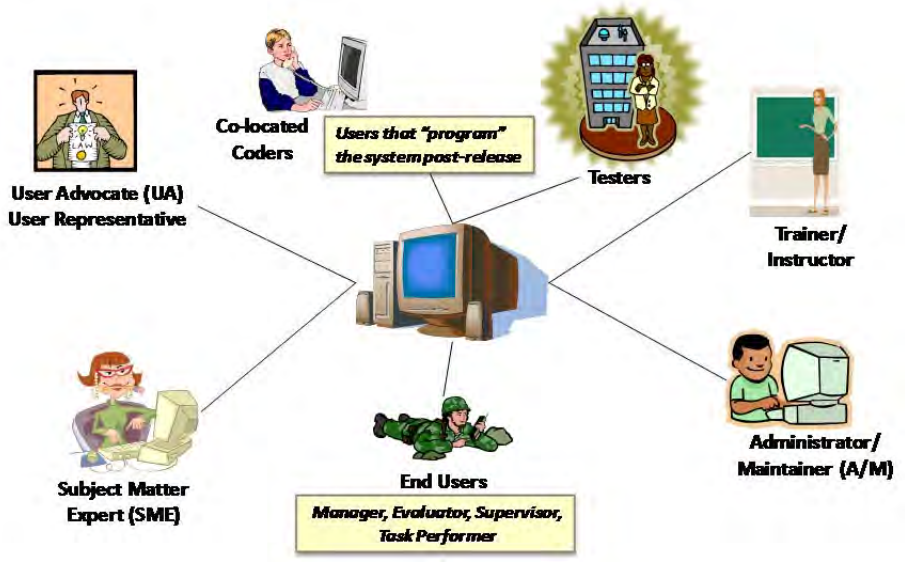

Figure 3-3. User Types Encountered

Some key lessons learned from our interactions with users regarding their experiences with systems and capabilities offered through program offices include:

- Programs are not all that reluctant for objective observers to engage with their users
- Users don't just complain; they typically provide constructive input
- Users aren't shy about sharing the good, bad, and ugly
- Users understand and are interested in the user engagement process

Here are some highlights of what we heard from users:

- "We liked it when they came to us, showed us a new capability and then returned with changes that we had suggested"
- "The program office should come out and see the pain that we experience using the system; they would understand the requirement better"
- "The program office is only an hour away… really?"
- "User representatives in the program office should come from the users' organization"
- "Consistency in interactions on a cadence that is predictable is important to obtaining desired capabilities"

Key conclusions that we drew from our engagements with users included:

- Provide additional venues for users to communicate with procurement professionals (acquirers and developers)
- Investigate the feasibility of having a lightweight education pamphlet (message at system start up) that lets people know where their system program office is and how to provide good ideas to them
- Establish a user involvement regime that coincides with program increment planning and accommodates in situ capability development sessions at a variety of locations
- When many systems deploy to a location, a system environment study should be conducted to determine the total system impact on end user productivity
- Formulate an alliance with operating agencies to help alleviate non-performance of systems when deployed

Based on these conclusions, essential elements of a user engagement program should include those illustrated in Figure 3-4. Recommended engagement program elements are illustrated on the right side of the diagram, and recommendations for metrics that answer important questions about effective and efficient user engagement are illustrated on the left side of the diagram.

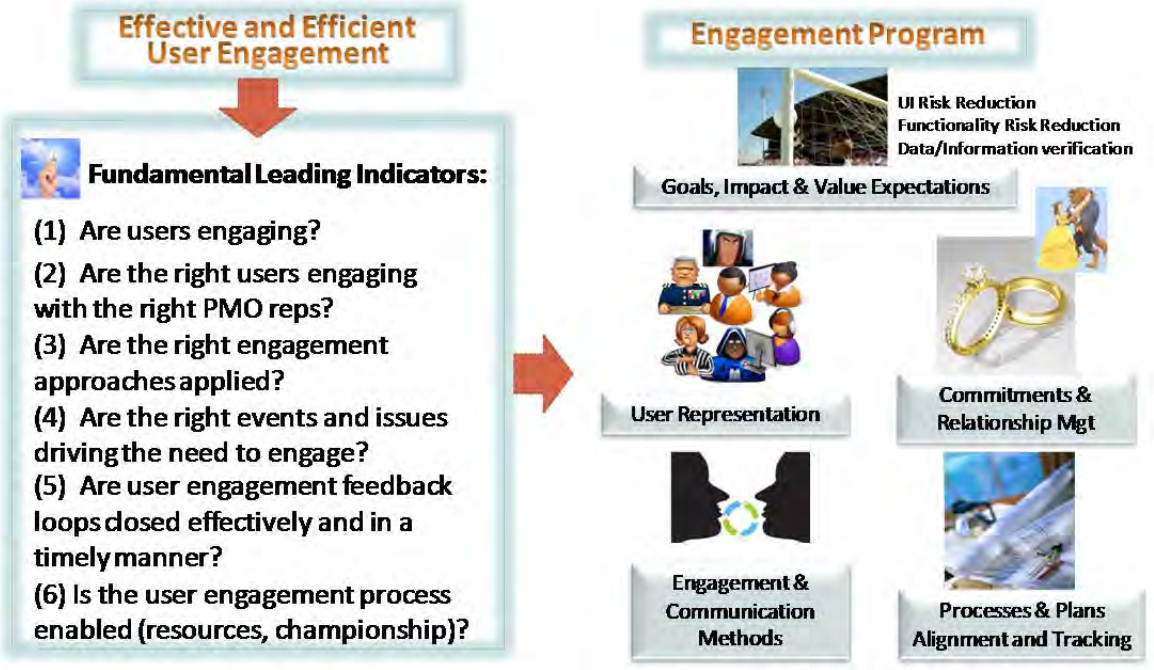

Figure 3-4. Essential Elements of a User Engagement Program

As Figure3-5 illustrates, several categories of recommended metrics emerged based on our engagement with users. These categories relate to monitoring whether the organization and program circumstances enable meaningful and efficient engagement with users, program execution health, and the ability of the program office to collect and apply feedback.

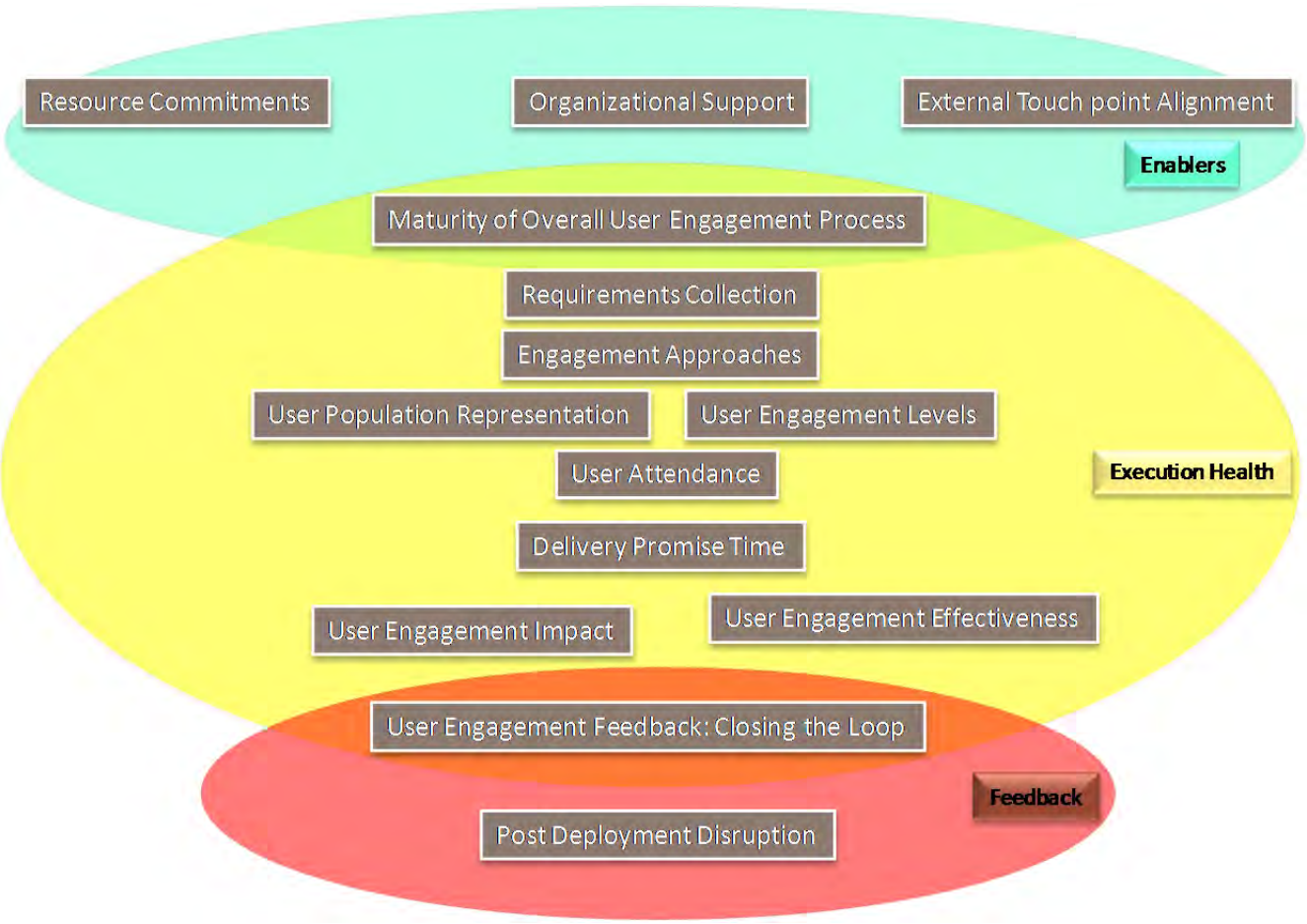

Figure 3-5. Program Office Enablers, Execution Health, and Feedback Metrics Categories

We identified numerous metrics within each of these three categories and subsequently identified a recommended suite of high priority metrics to assess user engagement effectiveness, efficiency, and impact. These metrics, as illustrated in Figure 3-6, include both lagging indicators (e.g., outcome-oriented) as well as leading indicators (process-oriented, financially-oriented, as well as activity-oriented). While lagging indicators will communicate if overall outcomes were realized, leading indicators provide a warning that results are being under- or over-achieved in sufficient time for corrective actions to be undertaken.

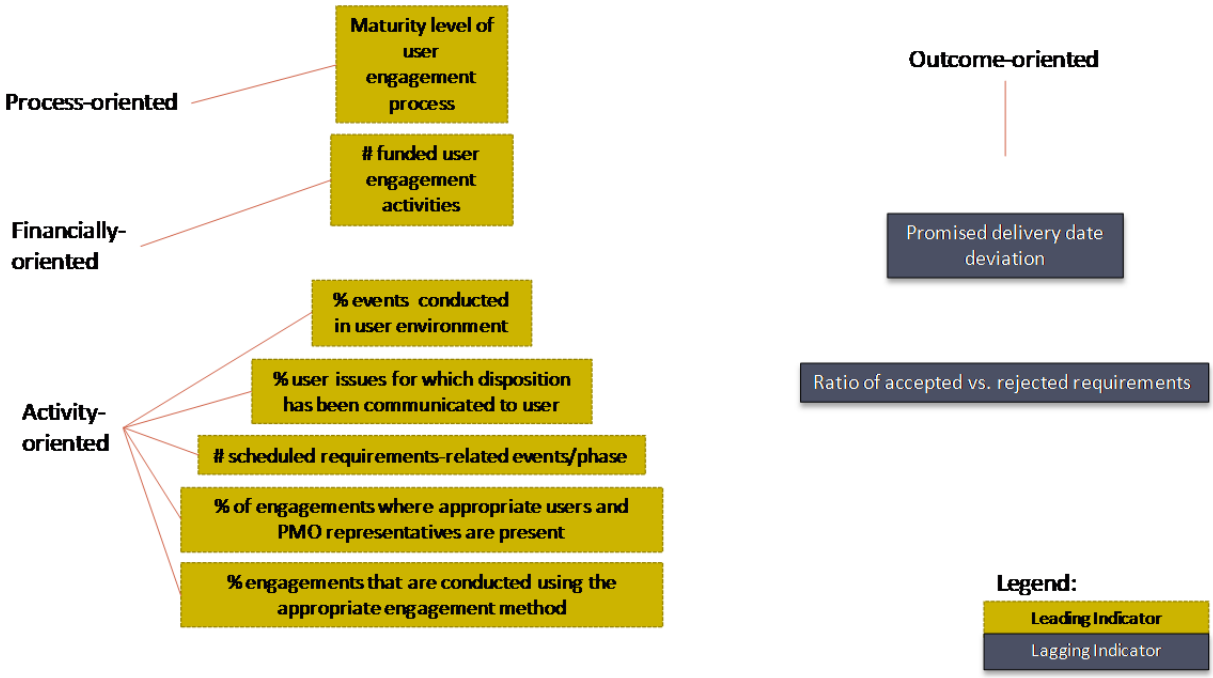

Figure 3-6. High Priority User Engagement Metrics

Program circumstances should ultimately dictate which particular metrics should be applied, but our research suggests that many of the high priority user engagement metrics illustrated in Figure 3-6 will likely be very relevant for managing user engagement across many program offices.

3.3 RELATIONSHIP WITH THE PRINCIPLE OF MULTIPLE, RAPIDLY EXECUTED INCREMENTS OR RELEASES OF CAPABILITY

The March 2009 DSB report states that multiple, rapidly executed increments/releases of capability involves:

- *Well defined objectives but not over defined requirements for the initial increment*
- *Evolving requirements for subsequent increments/releases*
- *Mature technologies (often with short half-life that require periodic refresh)*

This implies that the overall capability is released incrementally; there are specific objectives for the increment itself; the process must accommodate learning that is applied to future increments; and mature technology insertions must be accommodated where appropriate.[4]

> *Multiple, rapidly executed releases of capability allow requirements to be prioritized based on need and technical readiness, allow early operational release of capability, and offer the ability to adapt and accommodate changes driven by field experience.*

The DSB further discusses the integration of this principle into the fabric of program execution:

- Program reviews initially quarterly but then linked to program's subsequent iterations/releases
- Early, successive prototyping to support an evolutionary approach

[4] *Report of the Defense Science Board Task Force on Department of Defense Policies and Procedures for the Acquisition of Information Technology, Executive Summary, 2009*

- Early operational release of capability from within an increment
- Modular, open-systems approach—designed for ease of updates (NDAA endorsed process success criteria discussed later in this paper)
- Available full funding of initial increment(s); solid funding stream for next overlapping upgrade increment(s)

Incremental deliveries and supporting underlying processes promote more frequent engagement with the user, learning about changing end-user environments, and iterative developer learning. The practice of time-boxing increments helps to reduce opportunity to "grow" requirements and provides heightened user awareness of delivery constraints. Increments also provide an opportunity to more realistically update cost estimates as more is discovered and learned, which reduces cost surprise. An incremental approach with early releases provides opportunities to more frequently interact with the users of the system which, when folded in to future releases, contributes positively towards user satisfaction.

3.4 RELATIONSHIP WITH THE PRINCIPLE OF EARLY, SUCCESSIVE PROTOTYPING TO SUPPORT AN EVOLUTIONARY APPROACH

As it relates to IT and software intensive programs, prototypes are:[5]

- A preliminary type, form, or instance of a system that serves as a model for later stages or for the final, complete version of the system. A prototype may be a usable product.
- A model or preliminary implementation of a piece of software suitable for the evaluation of system design, performance or production potential, or for the better understanding of the software requirements.
- A hardware and software development technique in which a preliminary version of part or all of the hardware or software is developed to permit user feedback, determine feasibility, or investigate timing or other issues in support of the development process [IEEE STD 610.12-1990].

The March 2009 DSB report view is that prototyping should begin during the technology development phase, and should be inserted whenever useful during the development process. In the life cycle schedule, prototypes are usually inserted at the beginning of each major milestone. However, the DSB report calls for insertion "whenever useful", which is more adaptive to the individual program needs. Multiple iterations of prototypes are used to progressively refine the design of the technology or system. It is common to design, test, evaluate, and modify the design based on analysis of a prototype. Prototypes are commonly used to demonstrate design possibilities, limitations, and capabilities; demonstrate and measure technology maturity; and impact technology adoption rate.

Since prototypes provide more definition of the functional requirements, or demonstrate the feasibility of new technology for the program, user prototype evaluations provide opportunities for feedback regarding more concrete aspects of a system. This enables more actionable direction during the requirements refinement, testing, and evaluation phases of a program when prototyping is used. Several users that we interviewed felt that their concerns were "heard" if they were initially shown prototypes and the developer subsequently returned with prototypes that incorporated their suggested updates.

[5] http://www.totalmetrics.com/resources/software-metrics-glossary/software-metrics-glossary-p-part-2

3.5 RELATIONSHIP WITH THE PRINCIPLE OF A MODULAR, OPEN SYSTEMS APPROACH

The Office of the Secretary of Defense Open Systems Joint Task Force states that:

> *"An integrated business and technical strategy that employs a modular design and, where appropriate, defines key interfaces using widely supported, consensus-based standards that are published and maintained by a recognized industry standards organization."*[6]

The DSB report, Chapter 6, quotes on open systems approach:

> *modular, open-systems approach—designed for ease of updates*

A system built using a MOSA approach has the potential of being more agile in the face of changing user needs.

4.0 KEY PERFORMANCE OBSERVATIONS AND OVERALL CONCLUSIONS

Our investigations of the four NDAA Section 804 principles revealed that:

- Example metrics could be identified that may be meaningful for certain programs in measuring principle adoption and impact. However, much further investigation would be needed before specific metrics could be strongly recommended;
- There are likely no one-size-fits-all approaches for adopting or measuring the principles. Adoption and measurement recommendations must be tailored to the specific circumstances surrounding a program and supporting acquisitions;
- The four principles are not necessarily the only important principles that have been identified by the DSB and other studies. And, all four principles are not equally important for all types of program circumstances; and
- Selection of performance metrics is only one aspect of performance management; good performance management involves ensuring that the metrics support intended desired outcomes.

Although example metrics that may be important for determining progress and impact associated with adopting the four IT acquisition principles identified in this report, selection of the most appropriate metrics requires an understanding of program-specific circumstances, as well as how these principles support achievement of desired outcomes. Although the MAM Capability Development Team agrees with the importance of overarching principles that likely drive success for many programs, a performance management process should be developed and implemented that links these principles to desired outcomes and program circumstances. The March 2009 IT acquisition recommendations formulated by the DSB, as well as the requirements of FY 2010 NDAA Section 804 must be evaluated from the following perspectives:

- What are the outcomes and ultimate impact desired from adoption of these principles?
- How do these principles relate to one another?
- How important are these principles to outcomes and impact?
- How do program circumstances influence how these principles should be adopted and measured?
- What are the performance metrics that should be applied to assess, on a timely basis, adoption and impact of these principles? Will the metrics, measurement methodology, and monitoring approaches vary according to specific program circumstances?

[6] http://www.acq.osd.mil/osjtf/mosadef.html

- How should programs apply the results of principle adoption and impact measurement to make decisions in moving forward?
- What data is required to effectively measure and monitor principle adoption and impact? What data already exists to support this measurement and monitoring?

Many of these perspectives can be more readily addressed by the adoption of a robust and standardized approach for performance management. There are a number of approaches that can be applied, and Figure 4-1 illustrates a process that has been successfully developed for a large Intelligence Community enterprise.

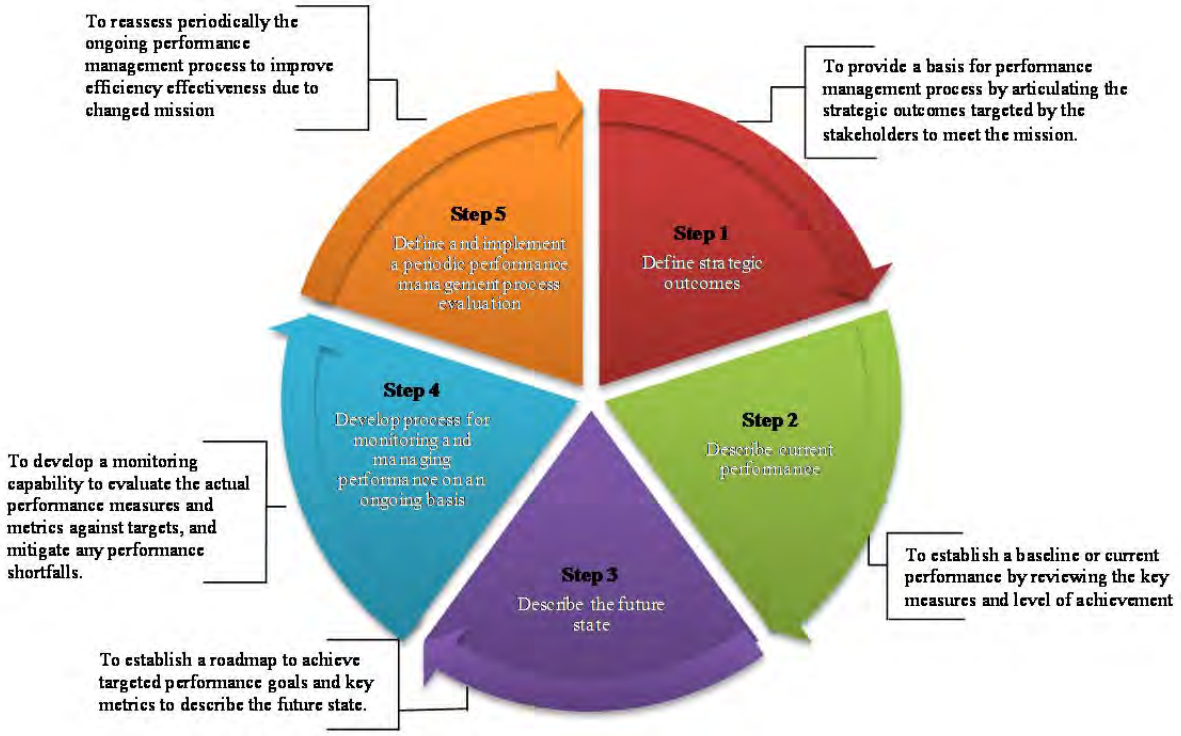

Figure 4-1. Key Performance Management Process Steps

5.0 NEXT STEPS

5.1 CREATING A DIAGNOSTIC CAPABILITY TO TAILOR ACQUISITION MEASUREMENT APPROACHES

A longer term objective should be to create a decision framework that Federal government organizations can apply to formulate prioritized and more tailored improvement plans. This requires an understanding of what flexibilities may exist for programs to tailor the process. The framework must ensure the acquisition process accounts for different program types at different stages of the lifecycle and contract types (e.g., managed services, commodity purchases, breakthrough technologies). To be successful, the decision framework must enable contingency planning; improve situational awareness and understanding of organization/environment constraints and enablers; accommodate assessment of realistic scenarios and options; and support an identification of recommended course corrections as circumstances evolve over time.

5.2 CREATING AN ACQUISITION GAMING ENVIRONMENT TO SUPPORT USER ENGAGEMENT

Based on the discoveries during the MAM investigations, a MITRE research project is taking the approach to building a new IT Acquisition process for Composable Capabilities on Demand (CCOD) by creating a serious games environment to promote early and continual stakeholder interaction with the research team during study.

The CCOD construct assumes that conventional and non-conventional information feeds are available and can be combined to form situational awareness capabilities by techno-savvy users and/or operators rather than a traditional developer. The traditional acquirer could make the feeds available in the form of services and vendors or open sources can offer tools or widgets that can be used to combine the services into a situational awareness system. In the construct, the complexities of the underlying system are masked and the interface used to compose the system is intuitive. A key feature of the CCOD construct is that the capability-building environment is highly flexible and can accommodate a range of time sensitive needs. CCOD appears to be a good match for capabilities that cannot be entirely anticipated and can then only be assembled when the true need is known. Situations that occur in counter-insurgency operations, Homeland Defense and Disaster relief type scenarios are examples of where CCOD could apply because of unanticipated, newly emerging information needs.

The gaming environment emulates a set of acquisition tactics and then gets users of the proposed acquisition process to interact with the game while the gaming framework collects records of the participants' actions (sequences of tactics). The observations of play help determine which tactics yield better results in the game; such as buying components, using certain procurement mechanisms, that were a good match for mission needs, buying components at best costs and completing acquisition processes in the least time possible while still satisfying the user requirements. Such an approach is being used with MITRE research for deriving a set of acquisition tactics that would support a rapidly evolving Web 2.0-based systems development construct.

MITRE researchers are using a modular, extensible gaming environment to construct the game-based decision support environment. It allows users to:

- Play through lightweight CCOD acquisition exercises
- Evaluate CCOD acquisition processes through game play measurement
- Convey to players the concepts of CCOD and CCOD acquisition, both broad and nuanced
- Stimulate players' creative thoughts on how to do CCOD acquisitions

We are currently exploring the application of serious games as a decision support mechanism, an environment for accelerating the learning curve for a new IT acquisition process, a means to increase interaction between program offices and users, and a tool to explore acquisition program performance measurement approaches.

Appendix A: Acronyms

CCOD	Composable Capabilities on Demand
CDD	Capabilities Development Document
DOD	Department of Defense
DSB	Defense Science Board
ICD	Interim Capability Description
IEEE	Institute of Electrical and Electronics Engineers
IID	Iterative and Incremental Delivery
IOC	Initial Operational Capability
ISO	International Organization for Standardization
IT	Information Technology
ITIL	IT Infrastructure Library
JCIDS	Joint Capabilities Integration and Development System
JCTD	Joint Capability Technology Demonstration
MAM	Making Acquisition Measurable
MOSA	Modular and Open Systems Approach
NDAA	National Defense Authorization Act
NDI	Non-Developmental Item
PMO	Program Management Office
SME	Subject Matter Expert
SW	Software
TD	Technology Development
UA	User Advocate

Appendix B: About the Authors

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As a Principal Economics and Business Analyst within the Center for Acquisition and Systems Analysis (CASA), Kevin provides investment, portfolio, and performance analyses and management solutions for Defense, Intelligence, and Civilian Agency sponsors. He is a Principal Investigator for a MITRE research project related to Streamlining transparency, accountability, and performance management Improvement. Kevin has a Bachelors of Science in Marine Transportation from the U.S. Merchant Marine Academy, and a Masters of Science in Industrial Administration from Carnegie-Mellon University. Kevin has served in the US Navy (enlisted and officer).

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Diane Hanf conducts multi-discipline, systems/software engineering and acquisition investigations on various technology assets, such as Web 2.0-based services and applications. She is currently conducting research on the use of gaming to investigate acquisition changes needed to support rapidly changing component-based systems. Diane has bachelor's degrees in Electrical Engineering (Oklahoma State), Wire Communications Technology, Business Administration (Wayland Baptist) and a Master of Science Degree in Systems Engineering from Johns Hopkins University.