MP #08

MITRE PRODUCT

Service Oriented Architecture (SOA) Performance Measures Expression in Performance-based Acquisition (PBA) Vehicles

Summary of FY 2008 Air Force/Army MOIE Findings

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Abstract

This final report summarizes the results of investigations that supported the joint FY 2008 Air Force (AF)/Army MOIE, entitled "Service-Oriented Architecture (SOA) Performance Measures Expression in Performance-Based Acquisition (PBA) Vehicles". The investigation was conducted by a multi-disciplinary team, consisting of staff with expertise in the areas of economic and decision analysis; portfolio and program management; and enterprise, systems, software and performance engineering.

SOA is an architectural style that guides all aspects of creating and using business processes -- packaged as services -- throughout their life-cycle, as well as defining and provisioning the Information Technology (IT) infrastructure (see Appendix A for definitions of terms applied in this report). The team focused on a critical challenge for instantiating SOA within the Federal Government: **on-going performance management**. The team determined: (1) realistic SOA outcomes and how to evaluate progress towards achieving them using Return-on-Investment (ROI) principles, (2) appropriate metrics and measurement techniques to gauge success in achieving outcomes, and (3) acquisition and contracting approaches to address uncertainties and complexity that have been associated with SOA implementations.

Although many Government sponsors are now adopting and implementing SOA solutions, there is limited steady-state performance history and cost, benefit, and risk data to support a determination of SOA progress and success. The team undertook this research to address this limitation and hypothesized that:

- Today's Systems and Performance Engineering techniques can identify and link mission, strategic objectives, and key performance measures together to build a useful performance management framework;
- SOA success determination can be achieved by comparing actual results to initial expectations over the lifecycle using economic and decision analysis approaches; and
- Properly constructed Performance-Based Acquisition (PBA) strategies, when appropriately applied, can support identification of progress toward achieving SOA promises and reduce the risk of contract modifications or terminations.

The research had three main thrusts: SOA performance management; metrics and monitoring; and acquisition and contracting considerations. An overarching theme of our discoveries, described below, is that confusion and potentially avoidable resource expenditure can be significantly reduced by **getting back to basics** (with program, investment, and risk management fundamentals) and **focusing on SOA-specific challenges**:

Performance Management

Fundamentally, managing performance of any investment should directly relate to the initial reasons why the investment was undertaken. Our research confirmed that, even in the absence of benchmarks, performance can be meaningfully managed by comparing actual to initial expectations and that ROI methods are appropriate for monitoring outcome achievement. The SOA- specific challenge is: (a) differentiating unrealistic expectations from what SOA can deliver and (b) focusing on deliberate implementations in light of what is reasonable with a broader perspective of performance (i.e., not just technology, but also process and people).

Metrics and Performance Monitoring

Fundamentally, outcome traceability and measurability are essential to effectively determining implementation progress. Identification and monitoring of both leading and lagging (i.e., outcome) indicators will, respectively, provide early warning and highlight the impact of significant performance problems experienced. SOA potentially increases reliance upon other entities/organizations to provide capability, and Service Level Agreements (SLAs) can be effective mechanisms to communicate performance commitments, status, and compensation (when relevant) between parties. What is specific to SOA metrics and monitoring is that achievement of the ultimate SOA outcomes—flexibility, agility, time and cost savings, and at a very mature stage, opportunities to innovate-- are not easily measured and are achieved incrementally over time.

Acquisition and Contracting Considerations

Effective SOA-related procurement (e.g., SOA development/maintenance and service provisioning/delivery) will require addressing pre-existing challenges faced by sponsors in selecting and effectively applying appropriate acquisition and contracting strategies, as well as following through with proactive contractor performance management. PBA[1] can support a greater focus on ultimate results for SOA and increased flexibility to evolve performance expectations over time, but they are not necessarily appropriate for all organizations and circumstances. Our recommendations focus on contracting strategy, including a diagnostic to determine PBA readiness, and effectively translating desired outcomes to contractor performance requirements. Stakeholders should acknowledge that there will likely be greater complexity introduced in reuse-focused SOA environments, which compels application of risk-hedging strategies (e.g., incremental and PBA contracts). Outsourcing vehicles, such as Software-as-a-Service (SaaS), may not be readily amenable to typical Government contracting situations.

Because SOA development, implementation, and operation may introduce many new and complex organizational and technological relationships and considerable uncertainty associated with future services, service demand, and performance needs, the research team recommends that a standardized process be developed and adopted by sponsors to explicitly manage performance of SOA. The team has assembled a set of methodologies, recommended decision support tools, lessons learned and advice to form a performance management framework. This framework can support sponsors in building a SOA lifecycle performance management program to help them more accurately assess progress in achieving desired SOA outcomes. Specifically, Portfolio and Program Managers, as well as Systems and Performance Engineers, can leverage the framework to a build performance management program based on: (1) a cohesive set of metrics, (2) a mutual understanding of the outcomes being pursued, (3) a widely understood expected ROI, and (4) a complement of acquisition and contracting strategies that appropriately support chosen outcomes. The framework will aid these managers and engineers in obtaining more timely indications of performance issues that could impact outcome realization if left unaddressed.

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[1] *According to the Federal Acquisition Regulation (FAR), Part 37.601, PBA describes outcomes expected, not the methods to perform work; uses measurable performance standards; provides for quality assurance surveillance plans; specifies procedures for reduction of fee or price; and includes performance incentives when appropriate.*

1.0 Research Overview

SOA is an architectural style that guides all aspects of creating and using business processes -- packaged as services -- throughout their life-cycle, as well as defining and provisioning the Information Technology (IT) infrastructure. The architecture allows different applications to exchange data and participate in business processes that are loosely coupled with the operating systems and programming languages underlying those applications.[2] As is illustrated in Figure 1-1, SOA is an architectural approach used to build solutions that contain a set of services, service consumers, service producers and service contracts.[3]

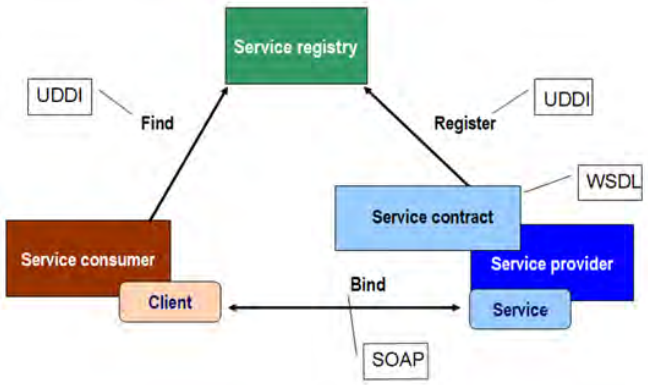

Figure 1-1. The SOA Construct

There is limited history associated with fully implemented SOA within the Federal Government. From a post-investment review standpoint, there are limited credible cost, benefit, scheduling, quality, and risk benchmarks to support Government sponsors in understanding the technical and related contractual performance that should be expected from SOA investment.

Multiple, ambiguous, and sometimes conflicting viewpoints have been expressed regarding what SOA-driven benefits can realistically be pursued. This is often the result of confusion in terms or differing stakeholder needs. For instance, a primary benefit expected from SOA is the ability to expose services for potential re-use by other Government entities, which is typically an enterprise viewpoint; however, an executing program viewpoint could realistically be that the expected benefit from SOA relates to garnering flexibility to quickly respond to a change in the environment. The need to address multiple viewpoints, while also meeting numerous stakeholder needs and addressing uncertainty associated with the nature of future services and associated demand can potentially increase complexity associated with acquiring necessary services and capability from other Government entities and commercial industry.

Methods that address these limitations, challenges, and pressures for more effective SOA lifecycle performance management have not been widely adopted within Government settings. Such methods are

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[2] *Understanding SOA with Web Services. by Newcomer, Eric; Lomow, Greg (2005). Addison Wesley. ISBN 0-321-18086-0.*
[3] *"The Seven Myths of SOA, Adrian Logan", ITWeb. 31July2008.*
http://www.itweb.co.za/sections/techforum/2008/0807310803.asp?S=Service%20Oriented%20Architecture&A=SOA&O=google

fundamental to determining whether both SOA business (e.g., cost savings through reuse) and technical (e.g., flexibility to meet operational needs) targets are being met in a mission needs context.

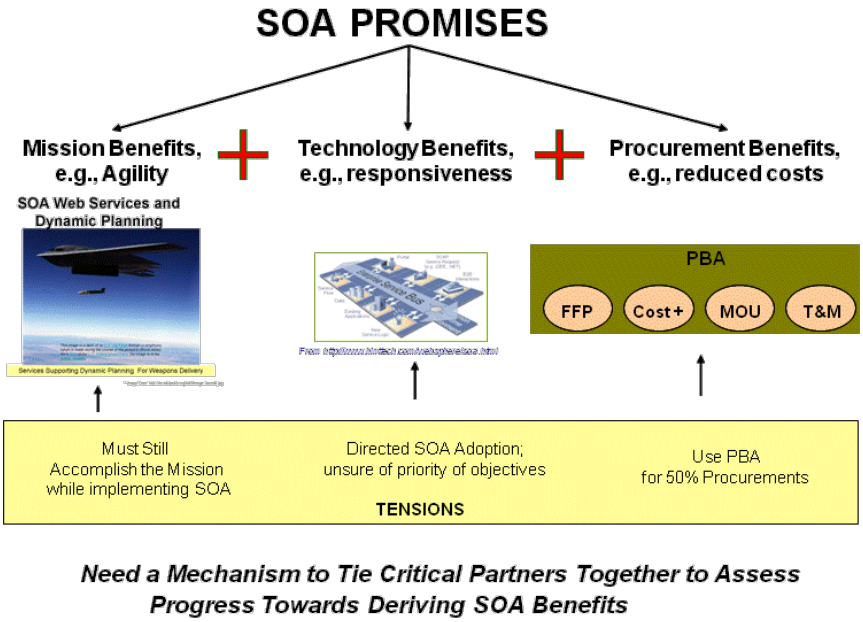

Figure 1-2. Incorporating SOA into a Government Setting

Three primary thrusts of this research included SOA performance management; metrics identification and monitoring; and acquisition /contracting considerations. A prevalent theme of our discoveries was that confusion and unnecessary resource expenditure can be reduced, or possibly avoided, by "getting back to basics" (i.e., program, investment, acquisition, and risk management fundamentals) and focusing on SOA-specific challenges.

1.1 SOA Performance Management

Managing performance of any investment should relate to the initial reasons why the investment was undertaken. Our research confirmed that, especially in the absence of benchmarks, performance can be meaningfully managed by comparing actual to initial expectations. We also discovered that ROI **analysis**, which is an extension of the more financially-oriented ROI **calculation** typically applied within commercial industry, can be an effective mechanism for monitoring Government outcome achievement. ROI analysis is more appropriate than ROI calculation for Government application because it includes objective evaluation of cost, benefit, and risk implications that are not readily monetized (i.e., described in units of currency). For example, an ROI analysis would accommodate consideration of the value of conformance to regulation. The SOA- specific challenge is: (a) differentiating unrealistic expectations from what SOA can deliver and (b) focusing on deliberate implementations in light of what is reasonable with a broader perspective of performance (i.e., not just technology, but also process and people).

1.2 Metrics Identification and Monitoring Performance

Fundamentally, outcome traceability and measurability are essential to understanding implementation progress. What is specific to SOA metrics and monitoring is that achievement of the ultimate SOA

outcomes—flexibility, agility, time and cost savings, and at a very mature stage, opportunities to innovate-- are not easily measured and are achieved incrementally over time. Furthermore, there are many other outcomes (e.g., promoting ease of reuse and promoting ease of re-composition) that contribute to those ultimate outcomes, and they are dependent on combinations of SOA characteristics or principles, which we identify as the outcome drivers. Because the drivers are more readily measured, SOA implementers should understand which drivers contribute to the outcomes that they expect/desire; identify metrics that effectively describe achievement of those drivers; and monitor these metrics over the lifecycle of the SOA. Identification and monitoring of both leading and lagging indicators of success/failure will, respectively, provide early warning and highlight the impact of significant performance problems experienced. SOA likely increases reliance upon other entities to provide capability, and SLAs can be effective mechanisms to communicate performance commitments, status, and compensation (when relevant) between parties. An SLA articulates agreements reached between the Government and service providers on the level of service to be provided. An SLA is a formal, negotiated, and legally binding agreement between customers and their service providers, and it records the common understanding about service features such as priorities, responsibilities, and guarantees.[4]

1.3 SOA Acquisition and Contracting Considerations

Effective SOA-related procurement (e.g., support to SOA development/maintenance and service provisioning/delivery) will require addressing pre-existing challenges faced by sponsors in selecting and effectively applying appropriate acquisition (e.g., Agile) and contracting (e.g., Firm-Fixed Price) strategies, as well as proactively managing contractor performance.

PBA, which is compulsory for 50% of Government contracting dollars, can support a greater focus on ultimate results for SOA and potentially create flexibility for making future contract performance modifications, but they are not necessarily appropriate for all organizations and circumstances.[5] The Federal Acquisition Regulation (FAR) defines PBA as:[6]

- Describing outcomes expected, not the methods to perform work
- Using measurable performance standards
- Provides for quality assurance surveillance plans
- Specifies procedures for reduction of fee or price (if a fixed-price contract) when services do not meet contract requirements
- Includes performance incentives when appropriate

Our recommendations focus on selecting the most appropriate contracting/acquisition approach and effectively translating desired outcomes to contractor performance requirements. PBA approaches can be applied with different acquisition strategies (e.g., agile or evolutionary acquisition) and contracting strategies (e.g., Firm-Fixed Price). Contracting strategies should align with expectations from selected contractors; the degree of understanding that the Government has regarding the most effective/efficient solutions; the latitude that should be provided to contractors to innovate; the level of oversight that the Government can reasonably apply to contract management; and the degree of risk that the Government is

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[4] *Applying SLAs for Performance-Based Service Acquisitions (PBSA), Kevin Buck etal., The MITRE Corporation. July, 2007.*
[5] *Per Office of Federal Procurement Policy (OFPP)*
[6] *FAR Part 37.601*

willing to accept. Sponsors should acknowledge that there will likely be greater complexity introduced in reuse-focused SOA environments, which would compel adoption of risk-hedging contracting strategies (e.g., incremental and PBA contracts). Outsourcing vehicles, such as Software-as-a-Service (SaaS) and Integrated/Managed Service Providers (I/MSP), may not be readily amenable to typical Government contracting methods.

2.0 Research Hypothesis

Our initial research hypothesis included:

- Success with SOA requires close coordination between engineering and business management, with a focus on achievement of mission and closing overarching capability gaps. By exploiting today's Systems Engineering and Performance Engineering techniques, sponsors can create a Command and Control (C2) capability for SOA implementations that links mission, SOA outcomes, and key technical and business performance measures and can be applied to manage SOA performance and implementation uncertainties;
- In the absence of credible and relevant performance benchmarks, effective performance management of SOA requires a comparison of actual results to initial expectations. The Government can determine actual vs. expected outcomes using economic and decision analysis approaches to address government unique environments; and
- Properly constructed PBA strategies, if applied when it is appropriate to do so, will support identification of progress towards achieving SOA promises and reduce the risk of contracts modifications or terminations.

3.0 Results, Findings, and Key Deliveries

The key research deliverable is a performance management framework shown in Figure 3-1. It ties together the analyses performed by the research team, reference materials collected, and recommendations formulated by the team and provides an aid to help readers navigate through our research activities/findings. Each area is linked to recommendations, readings, decision aids, or assessment tools to help focus the framework user to be more successful in monitoring, planning, assessing and executing a SOA performance management program. Some of these deliverables have been approved for public release and some are for sponsor or internal MITRE use only. Each key decision point (green diamond) addresses a key set of challenges identified during the investigation. Our findings to support these key decisions are discussed in more detail below.

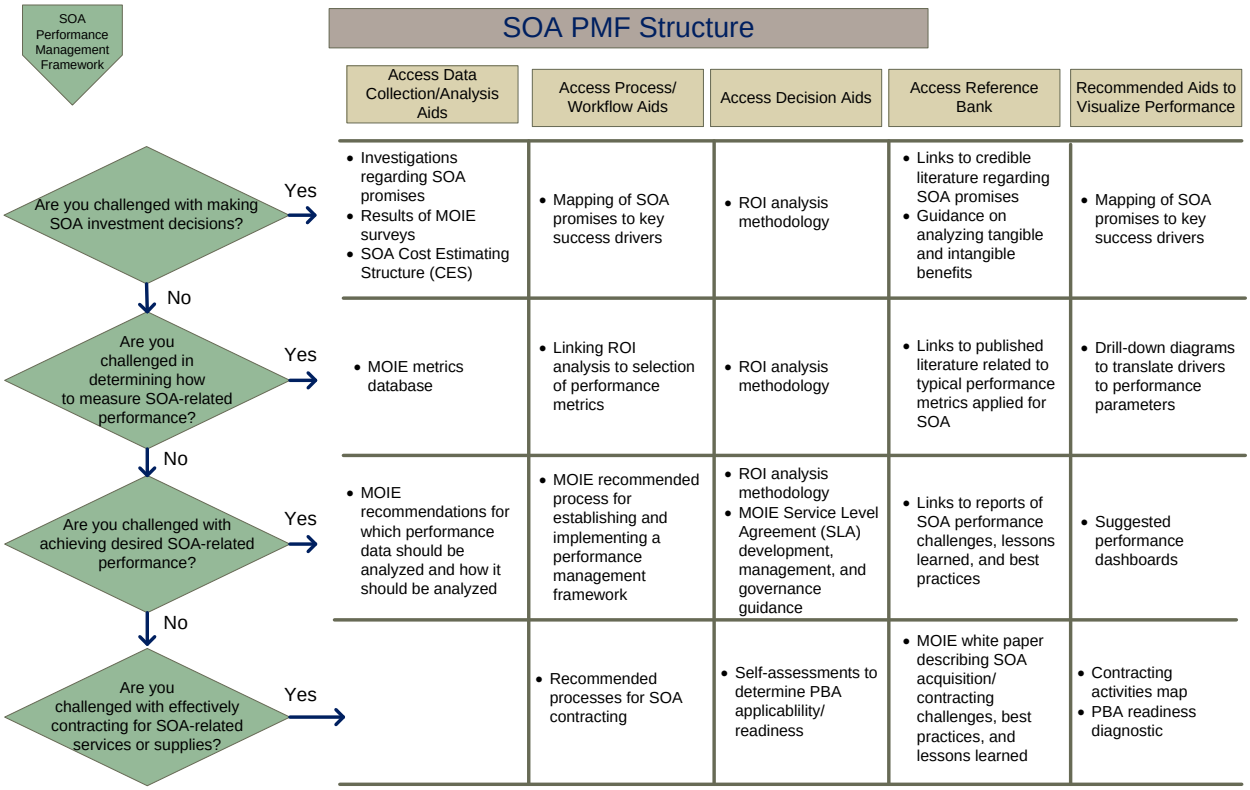

Figure 3-1. The SOA Performance Management Framework

3.1 Addressing SOA Investment Decision-Making Challenges

Managing performance of an investment should directly relate to the reasons why the investment was first undertaken. The research team investigated several methods that might support more effective performance management of SOA by Federal Government sponsors, including application of performance benchmarks from referent organizations to assess own progress . Currently, there are few credible and sufficiently granular SOA performance benchmarks that Government sponsors could effectively leverage as a comparison to own performance. The current lack of benchmarks is primarily a symptom that (a) many sponsors are still in the initial planning or development stages with SOA and do not have on-going, steady state results to share yet, and (2) those organizations that do have steady state performance results often consider the information to be proprietary, requiring close-hold. In the absence of meaningful benchmarks from referent organizations, alternative methods must be implemented by sponsors to evaluate performance of the potentially substantial investments in SOA that will be undertaken by numerous participants in SOA (e.g., SOA developers, service producers, and service consumers).

Our investigations in this area suggested that the application of ROI principles can be an effective means to support on-going[7] technical and contract performance management of SOA in Government settings. In developing recommendations for applying ROI analysis to support performance management, the research team conducted extensive commercial industry and Government literature investigations. The team also conducted a case observation with the Air Force (AF) Weather (WX) Systems Program Office (SPO), an organization that is currently in the SOA development planning stage. The research team also administered two internal MITRE surveys to (1) better understand sponsor expectations from development/implementing SOA, and (2) how sponsors are currently making investment decisions related to SOA. The majority of respondents indicated that on-going SOA implementation and operating decisions are not currently based on the economics because there is limited understanding of methods to evaluate the economic impact of SOA.

Our research confirms that SOA expected returns are not always fiscally driven (e.g., loss of life is more important in many cases or compliance with law and regulation), and the SOA construct seeks to align mission and IT investments that involve promoting a service-oriented culture. As a consequence, the research team proposes an expanded definition of ROI, to include return on the SOA investments required to close capability gaps and consideration of investment impacts that are not readily monetizable (i.e., stated in units of currency). An example of such impacts might include increased compliance with regulation, improved customer satisfaction, and avoidance of loss of life. This expanded definition is illustrated in Figure 3-2.

[7] *ROI is typically used as an initial investment or analysis of alternatives decision support tool*

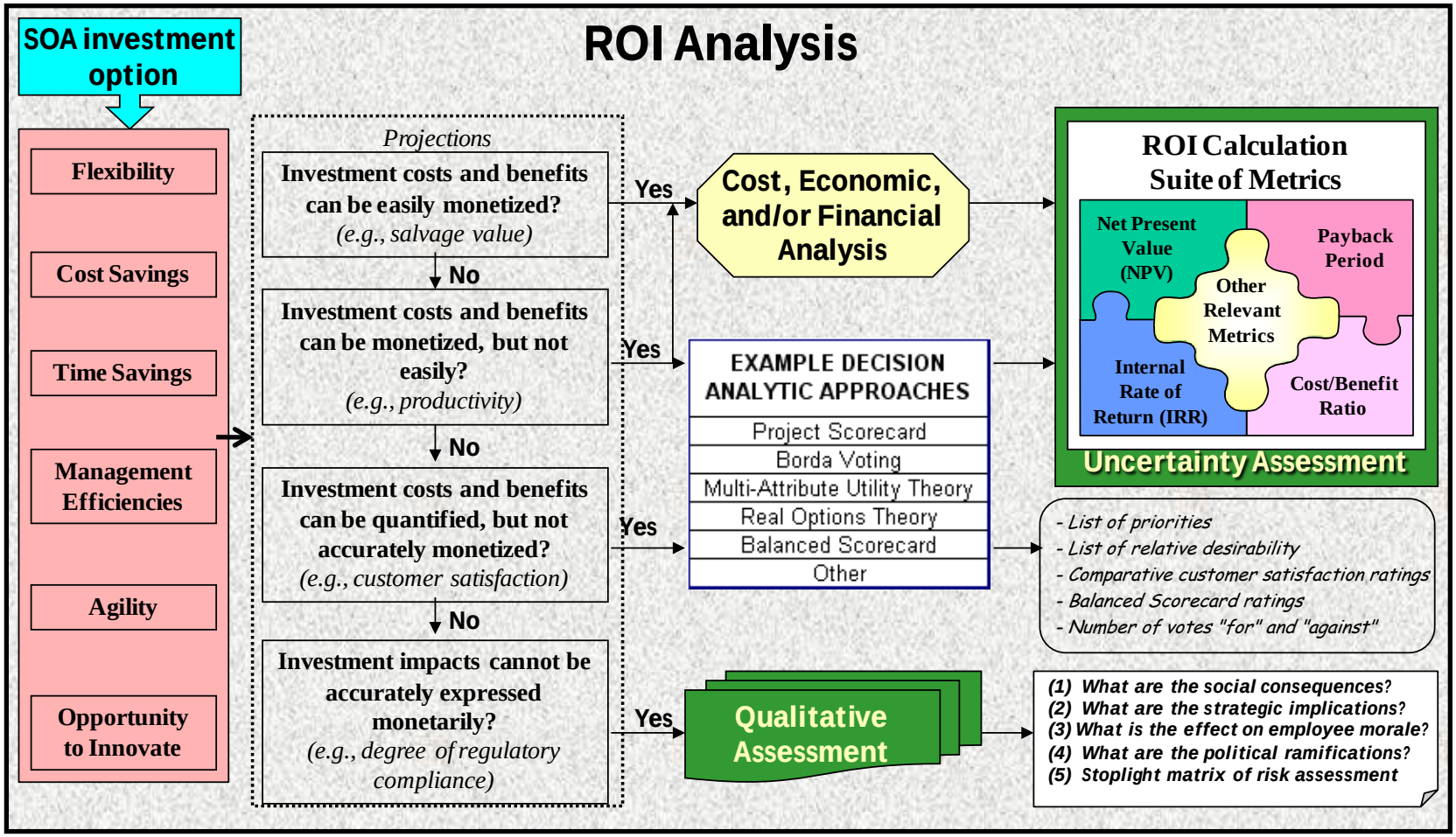

Figure 3-2 ROI Analysis Considerations for SOA

Application of the expanded ROI methods, in an on-going performance management program, involves comparison of actual tangible and intangible results realized from selected SOA investments to realistic, initial investment expectations. Initial expectations, in and of themselves, should reflect an incremental comparison of proposed SOA investment returns to those anticipated should current approaches be continued (i.e., the status quo, or "do nothing" case). Inherently, intangible results are difficult to measure, and our research results recommend decision analytic methods that can be applied to more objectively and, ideally, quantitatively evaluate these implications.

In general, many sponsors do not rigorously evaluate ROI. If sponsors do apply ROI techniques, the application is often limited to initial investment decisions and alternative selections. The techniques are rarely applied as the foundation for on-going performance management once investment decisions have been made. Our research results suggest that this application of ROI principles can be relatively resource-intensive, and the value of ROI analysis for an on-going performance management program must be balanced against the resources required to perform the analysis. The benefits to be derived from ROI analysis for performance depends on the ability of Government sponsors to effectively characterize initial expectations from SOA in measurable terms. According to ZapThink Research, "only by understanding the full range of SOA value propositions can companies begin to get a handle on calculating the ROI of SOA."[8]

Because of the resources likely required to analyze and apply ROI for on-going performance management, the research team has developed an approach to streamline the process (i.e., "ROI Lite"). This approach involves adoption of an Early Warning System that focuses on more frequent assessment of the "vital few" leading indicators of success/failure. Assessments take the form of variance analyses for key ROI variables (e.g., acquisition costs) and less frequent re-visiting of the overall ROI analysis itself (only required when variances are significant and suggest that either performance needs to be improved or re-baselining is necessary).

3.2 Addressing SOA Performance Measurement Challenges

Fundamental to selecting and effectively monitoring appropriate metrics that clearly describe progress in achieving SOA outcomes are:

- Creating traceability to outcomes throughout the implementation disciplines; such as, engineering, program and contract management, contractor performance;
- Identification of a set of coherent metrics for all the disciplines involved in the SOA implementation that effectively describe achievement of those outcomes;
- Delineating both leading and lagging indicators of success/failure; and
- Applying transactional and relational SLAs to communicate performance needs and delivery among producers and consumers.

What is specific to SOA metrics and monitoring is that achievement of ultimate SOA outcomes—flexibility, agility, time and cost savings, and at a very mature stage, opportunities to innovate-- is not easily measured and is realized incrementally over time. Furthermore, there are many other

[8] *The ROI of SOA, R. Schmelzer, 27Jan2005, Document ID: ZAPFLASH-20050127 | Document*

intermediate/interim outcomes (e.g., promoting ease of reuse and promoting ease of re-composition) that contribute to those ultimate outcomes; in turn, these interim outcomes are dependent on combinations of SOA characteristics or principles, which we identify as the outcome drivers. Because the drivers (the SOA characteristics or principles) are more readily measured, SOA implementers need to understand which drivers contribute to desired outcomes; identify those metrics for their performance management program; and monitor those over the lifecycle of the SOA. The multiple dimensions associated with outcomes traceability are illustrated in Figure 3-3.

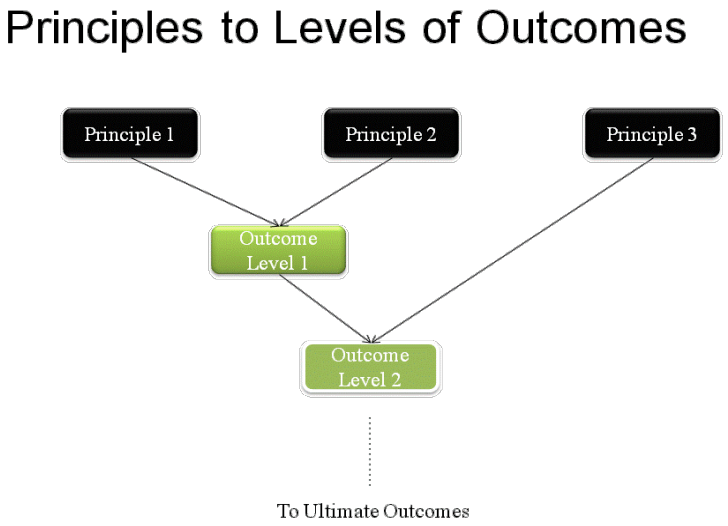

Figure 3-3. Notional Figure of Principles to Outcomes Traceability

The research team constructed a mapping that can be applied to trace dependencies and identify which SOA principles must be emphasized to be successful in achieving particular outcomes. This mapping has become a key product in tying together the inputs that establish ROI value and the technical, process and people metrics that would need to be monitored to ensure success.
The team also constructed a metrics database which synthesized viewpoints from early adopter commercial practitioners[9] ; Defense Information Systems Agency (DISA) guidelines for the Netcentric Enterprise Services Performance Measurement Plan (PMP)[10]; and the Association for Enterprise Integration's for what would boost Industry's confidence in shared services[11] and other sources. The team then derived the actual metrics expressions against outcome drivers and identified metrics categories recommend as relevant for Government sponsors' SOA implementations.

The metrics database maps metrics to SOA principles/characteristics. It also maps characteristics to outcomes so that a program or portfolio manager can start with an outcome and quickly get to the set of metrics that should be monitored to support that outcome. The database further tags these metrics as to

[9] *Such as Marks and Well, Service Oriented Architecture, A Planning and Implementation Guide for Business and Technology and CBDi*
[10] *Nov 10 2005*
[11] *DoD Performance Metrics to Support Industry Confidence in Shared Services, October 12, 2006*

which are leading and which are lagging indicators of performance and who should be interested in them so that a program or portfolio manager, systems or performance engineer can know where to focus monitoring against the outcomes expected. As shown in Figure 3-4, each metric also has context information to help sponsors understand the significance of that metric and how to measure it. Using this database, a case observation was conducted to produce metrics that would apply for our advocating sponsor, the Joint Mission Planning Systems and the Air Force Weather Systems program office.

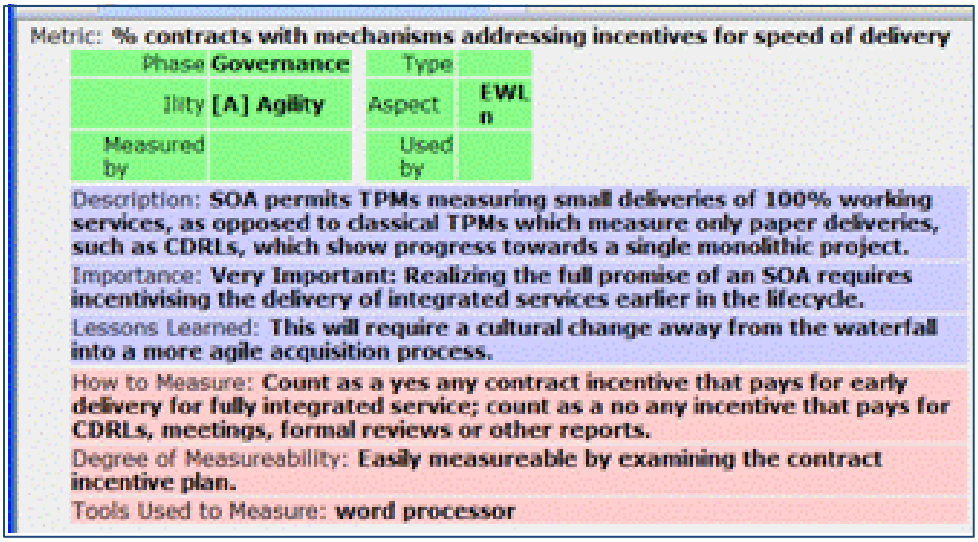

Figure 3-4. SOA Metric Database Excerpt

To address the practicality of measuring performance, a publish- and-subscribe-based capability, called a SOA-in-a-box, was developed, which comprises several Representational State Transfer (REST)-based services and demonstrates a mission-oriented mission thread executing in a service-based environment. The thread sequence, illustrated in Figure 3-5, involves a notional base defense commander in a forward operating location who has a base environment with valuable assets to defend. The services in the SOA implementation provide weather updates, access to decision support tools and images, and the opportunity for participants to send or subscribe to "canned" notifications and commands. The capability provides a measurement function so that each service's performance can be monitored for reliability and speed. It performs Client (external), server (redirection), and invasive (requires changing the Service) measurements. It also has a stopwatch capability, which is a user activated feature used to time how long the entire thread takes to execute. All collected data is stored in the accompanying database, which also contains the outcome-keyed metrics described above to provide a link to what outcomes you are measuring against. This capability addresses the challenges of understanding a "lean" SOA environment by providing an implementation that engineers can peruse (the code is included) to help understand and baseline performance in their circumstances. It also addresses the challenge of setting up a simple measurement functionality that provides quick feedback on progress towards meeting outcome goals and determining how a service actually performed against its respective SLAs over its lifecycle.

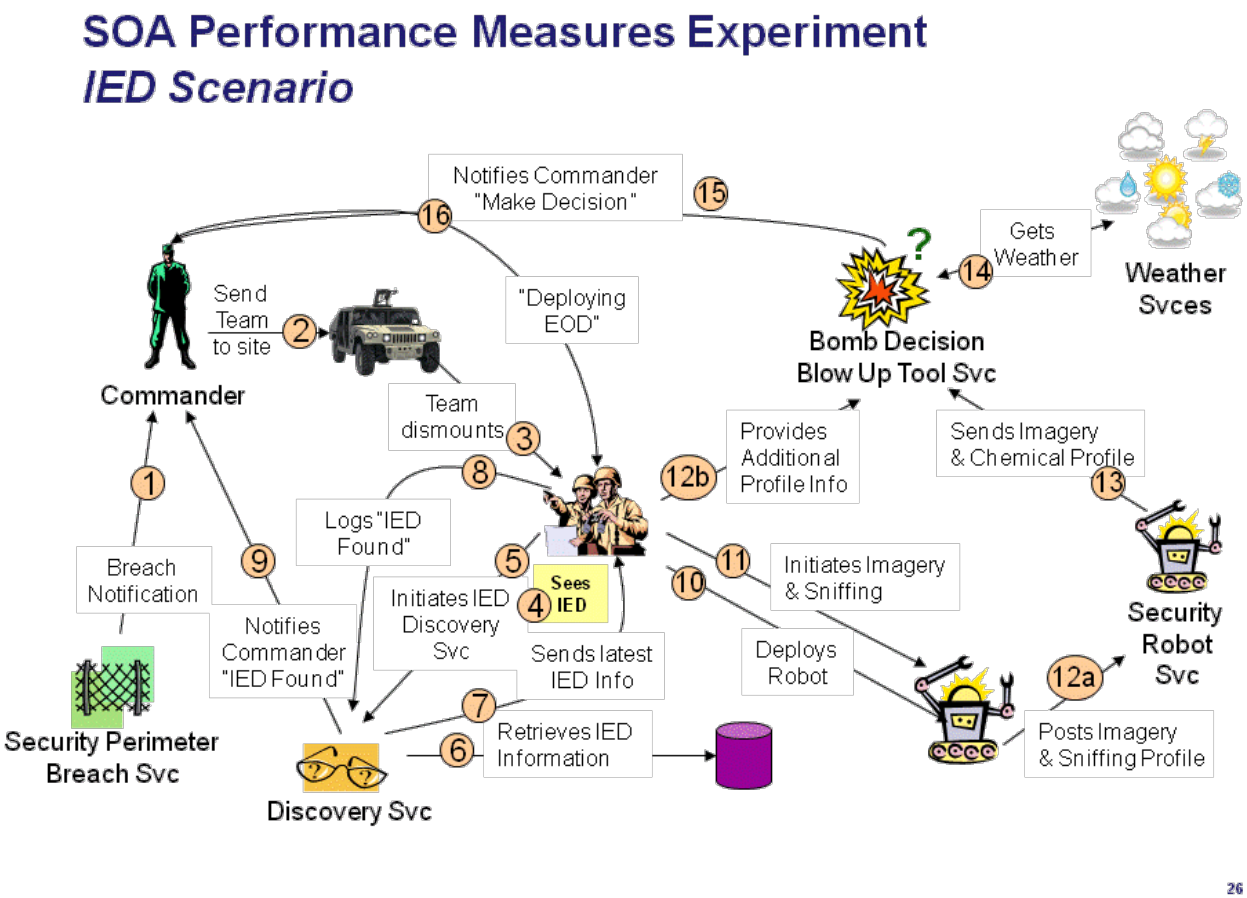

Figure 3-5. SOA Performance Measures Experiment - IED Scenario

Identification and monitoring of both leading and lagging indicators of success/failure will, respectively, provide early warning of potential problem areas and highlight the impact of significant performance problems experienced. SOA likely increases reliance upon other entities to provide capability, and SLAs can be effective mechanisms to communicate performance, commitments, status, and compensation considerations (when relevant) between parties. There are three critical aspects of SLAs:

- Relational aspect: describing the performance agreement between parties, including performance expectations, escalation procedures, methods to be applied for measuring performance, and considerations for how performance results impact compensation or the overall agreement.
- Transactional aspect: the methods/mechanisms applied to communicate performance and resulting actions
- Governance aspect: managing SLAs as an ultimate and cohesive expression of expected outcomes

We focused on the relational and governance aspects of SLAs and produced two white papers that discuss these aspects in greater detail (see Section 5.0).

3.3 Addressing On-Going SOA Performance Management Challenges

The end result of a SOA performance management effort should be that desired performance is achieved on time, within budget, and in the most efficient manner possible. Research investigations confirm that sponsors are challenged to achieve this end result because of lack of clear vision as to what should be expected from SOA; when expectations should be achieved; how to discern whether current performance demonstrates that ultimate expectations will be realized; and how to effectively address current or projected shortfalls to ensure that the effort expeditiously gets back on track. Overall, identified challenges associated with SOA performance management can be addressed by:

- Establishing and documenting a standardized performance management process;
- Clearly assigning performance management roles and responsibilities;
- Developing clear traceability between expected outcomes and desired performance (e.g., Technical Performance Measures);
- Adopting a methodology to determine what current performance means in terms of realizing ultimate outcomes on time and within budget;
- Recognizing resource limitations and adopting approaches to streamline assessments that determine whether performance is on track, is unrealistic, or must be improved to ensure outcome achievement;
- Tightly coupling contractor performance with technical requirements, outcome drivers, and expected outcomes.

In addition to identifying recommended technical and contractor performance metrics, the research team developed a suite of recommended metrics that monitor the effectiveness and efficiency of performance management. Based on our investigations, those within the enterprise that should be held accountable for these metrics include Governance and program and performance managers.

The performance management framework, supporting methodologies and recommended metrics, enforce a lifecycle perspective to SOA performance. Sponsor experiences and lessons learned, as reported by oversight and audit authorities, have been analyzed to determine root causes of problems encountered in managing lifecycle performance. The framework also acknowledges that there are many different participants in SOA (e.g., producer, service provider, and service consumer) whom likely have different SOA expectations and resulting performance needs.

3.4 Addressing SOA Acquisition/Contracting Challenges

Development, implementation, and operation of SOA will likely increase complexity of contractual relationships across Government and commercial industry boundaries. For example, many sponsors are sharing (both funding and management) in the development and maintenance of the SOA itself. In addition, the exposure of services for potential re-use increases the likelihood that existing or proposed contract mechanisms will need to consider the possibility of future increased demand from sources external to the organization that originally contracted for support. Also, there are likely more agreements to be reached between Government organizations as they share in SOA development and maintenance and assist one another in exposing/re-using services with other Government organizations. In the current Federal procurement environment, Government agencies and components are under considerable pressure to apply PBA, which is compulsory for 50% of Government contracting dollars. Although PBA

can support a greater focus on ultimate results for SOA and potentially create flexibility for making future contract performance modifications, it is not necessarily appropriate for all organizations and circumstances.[12] To identify and address acquisition and contracting challenges, the research team:

- Conducted extensive commercial industry and Government literature reviews;
- Administered an internal MITRE survey to identify critical procurement problems experienced by sponsors when significant uncertainty exists regarding future performance needs, methods to incentivize contractors, and the nature and magnitude of future service demand; and
- Conducted direct-funded observations and analyses to support SOA solicitations (Navy/Marine Corps Intranet [NMCI] NGen) and adoptions of SLAs for performance management (US Central Command [CENTCOM]).

As illustrated in Figure 3-6, the team identified and evaluated numerous procurement scenarios to support an analysis of potential challenges associated with application of PBA (used relatively interchangeably, in the literature, with the term "Performance-Based Service Acquisition [PBSA]).

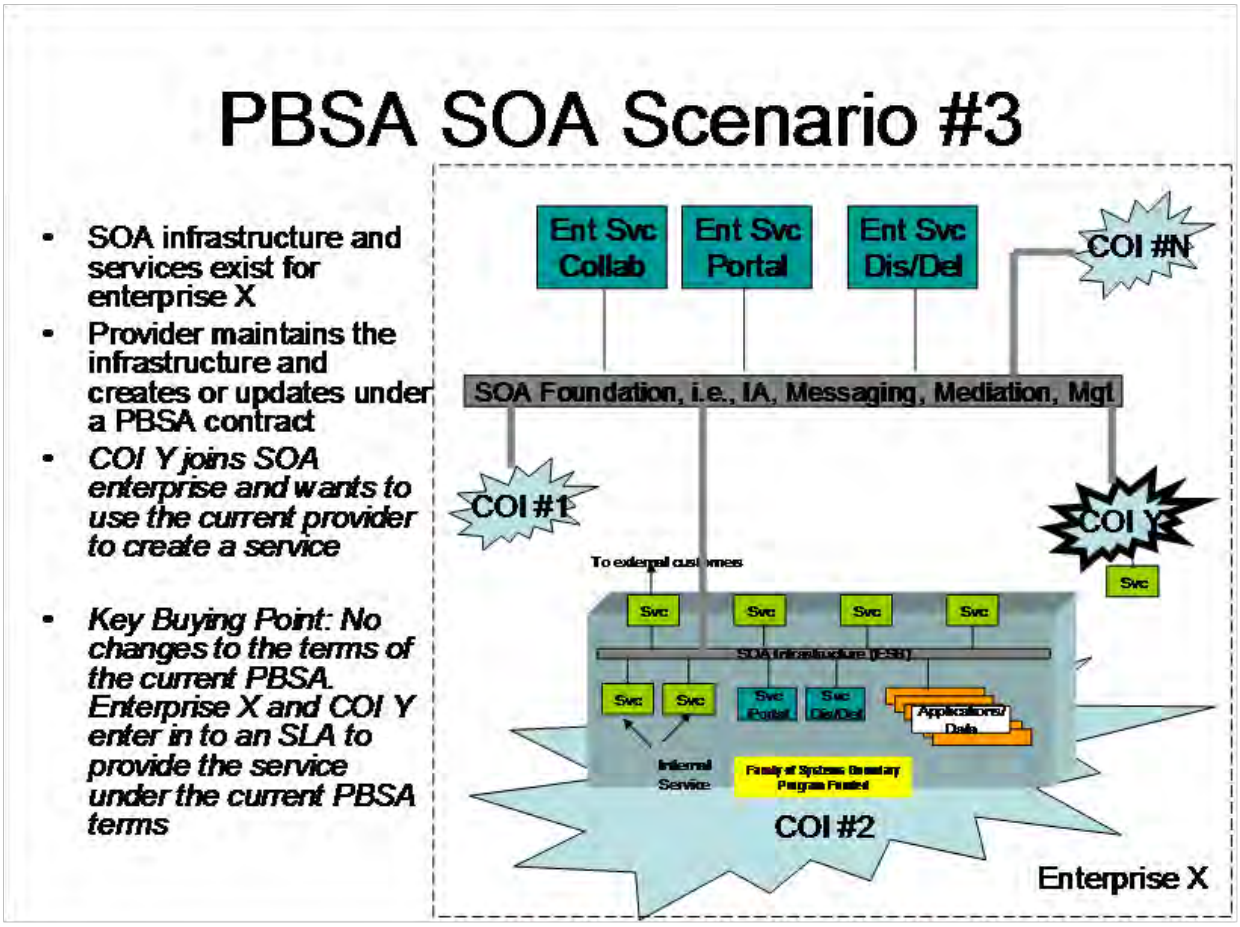

Figure 3-6. Sample SOA Procurement Scenario Examined

[12] *Per Office of Federal Procurement Policy (OFPP)*

The research team explored the complexities identified above; reviewed how Government organizations are currently, or are planning, to address these complexities; and offered acquisition/procurement recommendations based on investigation of best practices, lessons learned, and current procurement trends.

Our research investigations confirm that performance-based methodologies can be effectively applied to any number of overarching acquisition strategies (e.g., agile acquisition) and specific contract vehicles (e.g., Firm-Fixed Price). Benefits of these methodologies include a focus on achievement of ultimate outcomes and creation of significant flexibility to evolve technical and contract performance standards over time. Our research also confirms, however, that application of performance-based methods cannot be effectively and efficiently applied to achieve desired outcomes unless certain circumstances and foundational understanding/advocacy of PBA exists within the sponsor environment. We recommend a specific approach that sponsors (and supporting MITRE staff) can apply to diagnose PBA readiness and determine areas for improvement that research investigations confirm can hinder the ability of the Federal Government to maximize benefit from application of performance-based methods. As illustrated in Figure 3-7, effective application of performance-based methods requires that PBA "fundamentals" be in place (e.g., a clear understanding of ultimate outcomes, plans for achievement of these outcomes); an enabling culture that encourages follow-through with developing/managing PBAs; sufficient resources to prepare for, and manage on an on-going basis, PBA; and the likelihood of creating a trusted partnership with the candidate contractor population.

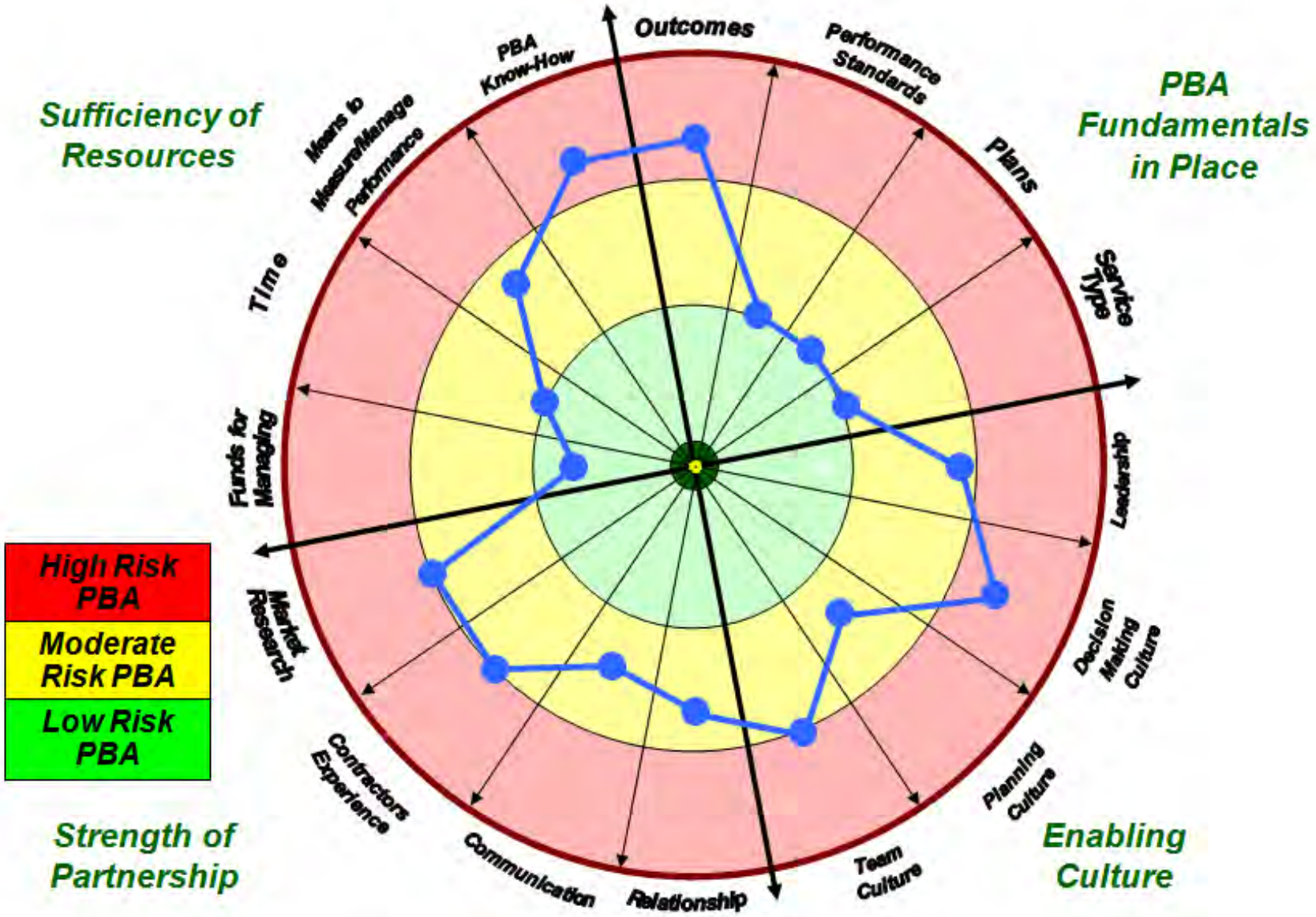

Figure 3-7. PBA Readiness Diagnostic

In reviewing Government experiences with PBA, an emerging challenge identified is clearly translating expected outcomes into contractor performance requirements. To address this challenge, the research team focused on the specific sequence of activities that must be performed and the supporting contracting artifacts that must be prepared when applying PBA methods. Process recommendations (see Figure 3-8), as well as recommendations for how to effectively communicate desired outcomes were formulated.

Figure 3-8. A Process for Translating Outcomes to Contracted Performance Requirements

The research team also developed recommendations for managing, and governing, contractual SLAs to ensure that SLA administration does not hinder delivery of required performance and achievement of ultimate SOA outcomes. Research investigations confirm that a key risk associated with application of SLAs to support contractor performance management is "losing the forest for the trees" by focusing too much on the administration of SLAs and focusing too little on whether the SLAs are actually measuring something meaningful for achievement of desired outcomes. To address this challenge, the research team has formulated recommendations for SLA governance (see Figure 3-9).

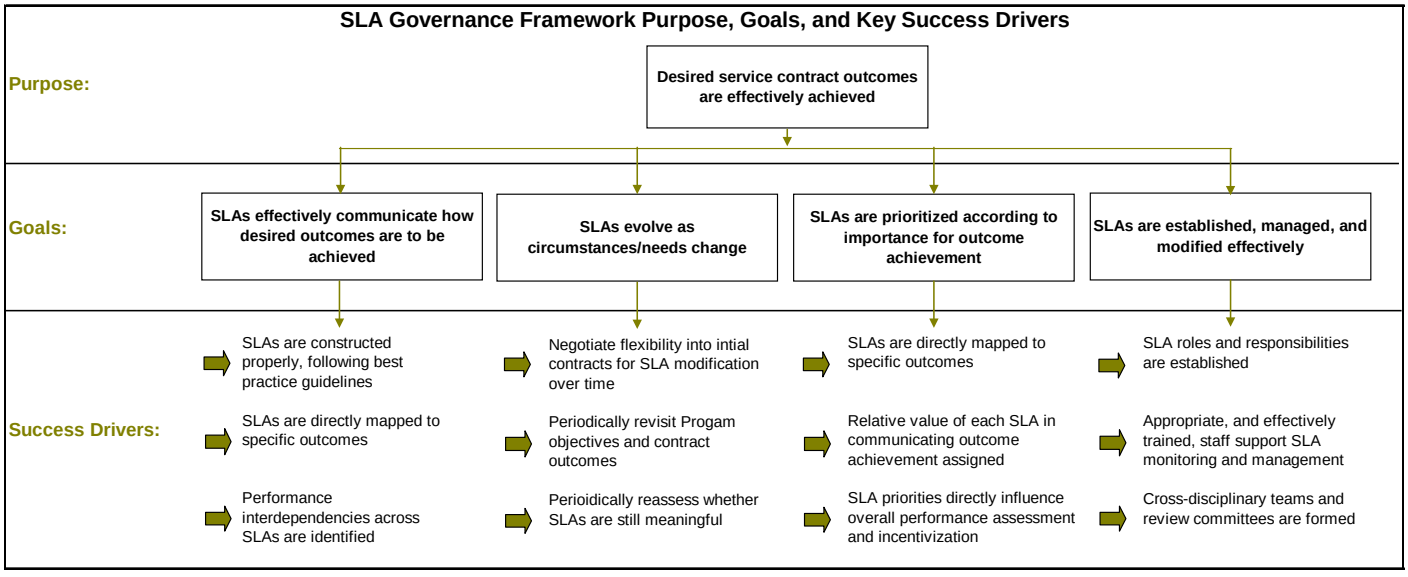

Figure 3-9. SLA Governance Objectives and Key Success Drivers

4.0 Products and Transitions

The research resulted in many products that the team or sponsors thought would be most useful for individual circumstances or the community as a whole. The products are briefly described below:

1. SOA Promises Basics Brief – Provides an overview of the promises of SOA and identifies which are credibly supported
2. ROI Analysis Paper - Provides a roadmap for applying ROI Analysis for SOA
3. ROI Analysis Storyboard* – Provides an example of how ROI Analysis would be applied for a specific flexibility outcome
4. SOA Security ROI Paper and Brief* – Identifies differences to be considered when constructing an ROI process for SOA Security investments
5. SOA Survey Results brief – Results of two surveys administered to determine
6. SOA-in-a-box – Actual publish/subscribe SOA implementation with a measurement capability and supporting database
7. SOA Metrics Determination Tool - Engine that allows SPO personnel to derive metrics relevant to outcomes that they are trying to achieve
8. SLA Governance Paper – Process recommendations for establishing SLA governance policies
9. Relational SLA Paper – Recommendations developing and managing SLAs based on investigations of government best practices and lessons learned
10. PBA Readiness Diagnostic Tool - Helps sponsors determine whether or not PBA is appropriate for their circumstances
11. SOA Acquisition and Contracting Considerations Paper - Identifies appropriate actions to be taken to construct SOA acquisition and contracting strategies
12. SOA Outsourcing Trends Brief- Identifies commercial trends used in SOA implementations and assesses them in light of government settings
13. Key Findings Brief* – Key findings of the research
14. SOA PBA Research BOK – SharePoint site or CD which contains MOIE research deliverables, papers, articles and book lists gathered by and used by the research team
15. Research Results Final Report* – Summarizes the final results and provides overall orchestration for the products above

* = *Denotes publicly released information.*

Several individual products of this work transitioned to many sponsors, each with different interests over the year. Summarily, sponsors were either more interested in the technical aspects or the business aspects. The MOIE's advocating sponsors receive all products at the end of the reporting period. Some sponsors provided funded activities to have the team tailor findings to their circumstances during the year resulting in transitions occurring before the end of the reporting period. Figure 4-1 identifies the transitions that would have occurred by the end of the reporting period.

Transitions	Key Deliverables Transitioned														
	SOA Performance Management					SOA Metrics/Monitoring				SOA Acquisition/Contracting			Overall		
	SOA Promises Basics Brief	ROI Analysis Paper	ROI Analysis Storyboard	SOA Security ROI Paper and Brief	SOA Surveys Results Brief	SOA-in-a-box Demo	SOA Metrics Tool	SLA Governance Paper	Relational SLA Paper	PBA Readiness Diagnostic Tool	SOA Acquisition and Contracting Strategy Paper	SOA Outsourcing Trends Brief	Key Findings Briefs	SOA PBA Research BOK	Research Results Executive Summary
DIRECT SPONSOR TRANSITIONS															
AF Mission Planning SPO	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Army Test and Evalaution Center	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Global Weather SPO		X	X			X	X								
NMCI NexGen Source Selection			X								X	X			X
USCENTCOM Source Selection											X	X			
Pentagon Information Technology Agency													X		
DIA Source Selection													X		
STRATCOM	X												X		
INDIRECT TRANSITION TO SPONSORS (via MITRE liaisons)															
Corporate SOA Initiative													X	X	X
Army Enterprise Lab						X									
MITRE Corporate ISIS			X				X						X		X
CEE						X									
Business Investment Analysis Tech Team	X	X	X	X	X			X	X	X	X	X	X	X	X
Acquisition and Program Mgt Tech Team	X	X	X	X	X			X	X	X	X	X	X	X	X
COMMERCIAL INDUSTRY/ACADEMIA TRANSITIONS															
IEEE			X	X									X		
AFCEA			X	X									X		

Key:
Direct Sponsor
Indirect Sponsor
Commercial/Academia

Figure 4-1. Key Deliverables and Transitions

5.0 Conclusion

In conclusion, this investigation, sponsored jointly by the Army and Air Force research programs, resulted in identifying that confusion about SOA can largely be addressed by pursuing the fundamentals with an eye towards identifying SOA-specific challenges, such as, expanding performance management focus beyond technology to people and process; understanding which key drivers or SOA characteristics are responsible for your needed outcome(s); and using risk-hedging acquisition approaches such as incremental strategies and PBA. The research has produced a performance management framework-- a set of tools, recommended decision aids and guidance-- to help sponsors construct a performance management program so that they can determine SOA success. Key aspects to this framework include using an ROI analysis method to construct an assessment of whether sponsors are meeting desired SOA outcomes, determining the metrics relevant to the outcomes that are desired with perspectives on measuring them, understanding how to construct an effective and efficient performance management program and choosing appropriate acquisition and contracting strategies to support SOA implementations.

Appendix A: Key Definitions

Adaptability[13] characterizes a system's capability to adapt itself towards changing environments to deliver necessary functionality, where that functionality may be a variant of the functionality for which the systems was originally developed.

Agility[14] represents the property of a system to implement necessary changes rapidly in order to respond to changing needs. There are several different types of agility that are referenced:

- ***Business agility***[15], in the context of SOA, is the ability to add new functionality, expose functionality to new channels, and vary functionality based on context (e.g., customer, partner, entry point).
- ***Acquisition agility***[16] means an organization is able to use change to define a program rather than letting change disrupt a program. Ability of the program office to shorten its decision-making loop and rapidly respond to changes in the environment.

Benchmarking[17] is a process used within many disciplines, including technical evaluations. When it is applied for strategic management purposes, organizations evaluate various aspects of their processes in relation to best practice, usually within their own sector. This then allows organizations to develop plans on how to adopt such best practice, usually with the aim of increasing some aspect of performance. Benchmarking may be a one-off event, but is often treated as a continuous process in which organizations continually seek to challenge their practices.

Flexibility[18] represents the property of a system to be changed easily and without undesired effects. Flexibility is a prerequisite to achieve agility.

Governance[19] specifies the decision-making authority and accountability to encourage desirable behaviors, providing a framework in which the decisions are made and aligned with the overall business strategy and culture of the enterprise. Governance develops and manages consistent, cohesive policies, processes and decision-rights for a given area of responsibility. For example, managing at an enterprise level might involve evolving policies on privacy, on internal investment, and on the use of data.

Legacy System[20]***:*** An existing system, usually a computer system, which must be accommodated in building new systems.

Operational Analysis[21] is the system to measure the performance and cost of an operational asset against the baseline established in the Planning Phase. This information will allow agency resource managers to

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[13] *Incorporating Flexibility, Agility, Robustness, and Adaptability within The Design of Integrated Systems – Keys to Success?, Armin P. Schulz, Ernst Fricke 0-7803-5749-3/1999. IEEE.*
[14] *Ibid*
[15] *"Service-Oriented World Cheat Sheet": http://enterpriseleadership.org/content.php?cid=1395*
[16] *"Net-Centric Warfare and its impact on system-of-systems", S. Zenishek and D. Usechak, DAU Review Journal, Page 217.*
[17] *Wikipedia*
[18] *Incorporating Flexibility, Agility, Robustness, and Adaptability within The Design of Integrated Systems – Keys to Success?, Armin P. Schulz, Ernst Fricke 0-7803-5749-3/1999. IEEE.*
[19] *Wikipedia*
[20] *www.cs.cornell.edu/wya/DigLib/MS1999/glossary.html*
[21] *MITRE Business and Investment Analysis (BIA) Tech Team Glossary of Terms*

optimize the performance of capital assets. Additionally, operational analysis may indicate the need for the acquisition of a new capital asset. The system established should have the capability to provide simple, easy to understand information that can be used by managers to make sound management decisions.

Performance-Based Service Acquisition (PBA):[22]

a) Describes outcomes expected, not the methods to perform work
- Apply a Statement of Objectives (SOO), or
- Apply a Performance Work Statement (PWS)

(b) Uses measurable performance standards
- Standards may be objective or subjective, but shall reflect the level of service required by the Government to meet mission objectives
- Standards shall enable assessment of contractor performance to determine whether contract results and objectives are being met

(c) Provides for quality assurance surveillance plans

(d) Specifies procedures for reduction of fee or price (if a fixed-price contract) when services do not meet contract requirements

(e) Includes performance incentives where appropriate
- PBA contracts may include incentives to promote contractor achievement of the results or objectives articulated in the contract

Incentives may be of any type, including positive, negative, monetary, or non-monetary

Return-on-Investment (ROI) Calculation and Analysis[23] **-** An ROI calculation is typically performed to quantitatively assess more traditional financial measures of investment attractiveness. An ROI analysis, on the other hand, typically incorporates quantitative and qualitative characterizations of investment impact. In other words, an ROI analysis includes an ROI calculation, but it also includes many other things. An ROI calculation is a mathematical formulation of the future benefits of a project, relative to the initial and future costs. "Benefits" can refer to all positive impacts of an investment option, including directly realizable monetary gains (including cost avoidance) and less easily quantified advantages (e.g., greater compliance with regulation, mission effectiveness). When ROI is defined strictly as a numerical calculation, it is most often referred to as the ratio of benefits to costs (profitability index)[24], the NPV, or the IRR. Another variation appropriate to accounting is the Book Rate of Return, or "generally, book income as a proportion of book assets[25]." A benefit/cost ratio can be calculated even when benefits are non-financial, but in this case the ratio will have dimensions consistent with the units of the performance measure, or performance units/cost. An ROI analysis, on the other hand, typically includes an ROI calculation, plus a discussion (in quantitative or qualitative terms) of uncertainty associated with projected costs and benefits, strategic (e.g., political, regulatory) implications of an investment option, and impact of investment on mission effectiveness. The definitions applied to ROI calculation and analysis are critical to effective government investment decision-making. ROI analysis should be an integral part of performance measurement during all investment management phases, including mission analysis, select,

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[22] *Federal Acquisition Regulation (FAR), Part 37.601*
[23] *MITRE Business and Investment Analysis (BIA) Tech Team Glossary of Terms*
[24] *GAO Glossary of IT Investment Terms. http://www.gao.gov/policy/itguide/glossary.htm. Extracted 11/27/2000.*
[25] *Brealey, Richard A., and Myers, Stewart C. Principles of Corporate Finance (6th edition). McGraw Hill, 2000.*

control, and evaluate. ROI analysis should combine both quantitative and qualitative assessments of investment cost and value.

Reusability[26] the degree to which a resource, e.g. a software module or other work product, can be used in the development of other solutions, such as use in more than one computing program or software system.

Robustness[27] characterizes systems, which will continue to provide their intended functionality when faced with changing operational environments. Robust systems may exhibit degradation of their functionality, but the degradation will be graceful and predictable. Robustness is a prerequisite to achieve adaptability

Scalability[28] is the property of a system which enables and supports adjustments of the system's capacity to its usage by adding resources during exploitation (a) without modifying the systems fundamental Architecture, (b) without sacrificing other qualities and (c) at a reasonable price, in a reasonable time and with reasonable effort.

Service[29]

- *A **business service** is the functionality invoked in using a capability designed and implemented to address certain needs (i.e. the solution to a business problem). It implies actions. The real world effects of using a business service are changes to the public aspects and/or the user's private aspects of the world in a way that has some positive impact on those needs. The user may not be aware of private impacts on others.*
- *A **SOA service** is an IT artifact (i.e. a thing) that makes possible the efficient connectivity between consumer needs and provider capabilities. It provides a mechanism to access the capability of a business service and to realize some subset of the real world effects gained by interacting with the SOA service to access the business service. As implied, the SOA service is not required to enable access to all of the underlying capability's potential real world effects. In operational use, the SOA service is the entity that must conform to such things as quality of service (QoS) metrics and the thing to be fixed if these metrics are not met.*

Service Level Agreement (SLA)[30]***:*** An SLA articulates agreements reached between the Government and a service provider on the level of service to be provided. An SLA is a formal, negotiated, and legally binding agreement between customers and their service providers, and it records the common understanding about service features such as priorities, responsibilities, and guarantees.

Service-Oriented Architecture (SOA)[31] is a design paradigm (i.e., a way for thinking about the solution space) for building flexible, adaptable distributed-computing environments. Service-oriented design is fundamentally about accessing distributed capabilities across ownership boundaries. Service-oriented design focuses on the following best practices:

- Design application and system functionality as accessible and reusable services

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[26] *IEEE 90*
[27] *Incorporating Flexibility, Agility, Robustness, and Adaptability within The Design of Integrated Systems – Keys to Success?, Armin P. Schulz, Ernst Fricke 0-7803-5749-3/1999. IEEE.*
[28] *From Scalability, Towards a discipline?, presented by Erik Groeneveld, SERC, Seminar Software Quality, 20 February 2001; http://serc.nl/resources/producten/seminars/sk/Groeneveld.pdf*
[29] *From MITRE SOA Foundations Course*
[30] *"Applying SLAs for Performance-Based Service Acquisitions (PBSA), MP #070143, The MITRE Corporation, K. Buck etal., July 2007.*
[31] *Excerpt from MITREpedia*

- Expose service functionality through programmatic interfaces
- Describe service interfaces using standard metadata
- Visibility key but not require registries
- Communicate with services using standard protocols

A SOA is an approach of distributed systems architecture that is typically characterized by the following properties:

- Message orientation: The service is formally defined in terms of the messages exchanged between provider agents and requester agents, and not the properties of the agents themselves.
- Description orientation: A service is described by machine-processable metadata. The description supports the public nature of the SOA: only those details that are exposed to the public and important for the use of the service should be included in the description. The semantics of a service should be documented, either directly or indirectly, by its description.
- Network orientation: Services tend to be oriented toward use over a network, though this is not an absolute requirement.
- Platform neutral: Messages are sent in a platform-neutral, standardized format delivered through the interfaces. EXtensible Markup Language (XML) is the most obvious format that meets this constraint."[32]

***Test and Evaluation*[33] -** Testing is the means by which objective judgments are made regarding the extent to which the system meets, exceeds, or fails to meet stated objectives. The purpose of evaluation is to review, analyze, and assess data obtained from testing and other means to aid in making systematic decisions.

[32] *From MITREpedia*

[33] *Systems Engineering Fundamentals, Supplementary Text**, DAU,** Jan 2001,*

Appendix B: Acronyms

AFCEA	Armed Forces Communications and Electronics Association
EI	Association for Enterprise Integration
C2	Command and Control
CEE	Collaborative Experimentation Environment
CENTCOM	Central Command
COI	Community of Interest
DIA	Defense Intelligence Agency
DISA	Defense Information Systems Agency
DoD	Department of Defense
DoDI	DoD Instruction
EOD	Explosive Ordinance Disposal
FAR	Federal Acquisition Regulation
FFP	Firm-Fixed Price
IEEE	Institute of Electrical and Electronics Engineers
IED	Improvised Explosive Device
ISIS	Information Systems, Infrastructure and Services
ISP	Integrated Service Provider
IT	Information Technology
MOIE	Mission-Oriented Investigation and Experimentation
MSP	Managed Service Provider
NCES	Net-Centric Enterprise Services
NMCI	Navy/Marine Corps Intranet
NGen	Next Generation
OFPP	Office of Federal Procurement Policy

OMB	Office of Management and Budget
PBA	Performance Based Acquisition
PBSA	Performance-Based Service Acquisition
PMP	Performance Measurement Plan
QoS	Quality of Service
REST	Representational State Transfer
ROI	Return on Investment
SaaS	Software as a Service
SLA	Service Level Agreement
SOA	Service-Oriented Architecture
SOAP	Simple Object Access Protocol
SPO	System Program Office
STRATCOM	Strategic Command
UDDI	Universal Description Discovery and Integration
WSDL	Web Services Definition Language
WX	Weather