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ACQUISITION STRATEGIES FOR DEALING WITH UNCERTAINTY

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Abstract[1]

The acquisition and engineering of large scale, complex information systems, particularly those that transcend organizational and functional boundaries, represent well-recognized challenges. The processes and procedures that evolved during the second half of the 20th century are best suited for the development of linear, well-bounded systems. These processes have proven difficult to adapt to situations in which stakeholders do not always agree, requirements evolve, and constraints keep changing. Different processes and procedures are needed to address the acquisition and engineering of information technology systems with evolving requirements and rapidly changing technologies.

This paper is based on the results of a multi-year research program that investigated how uncertainty-based acquisition methods can be used to improve the odds of successful IT acquisitions. The paper presents new concepts for managing uncertainty in acquisition programs: the uncertainty landscape, uncertainty-driven acquisition strategies (staged commitment, small bets), the Y model, and a three-step approach to implementation (i.e., diagnosis, strategy selection, and adaptive execution). More than 20 acquisition programs were studied, and pilot programs were initiated to test the frameworks and strategies suggested in the research.

I. Introduction

Traditional systems engineering and acquisition practices evolved during the second half of the 20th century primarily to deal with the particular challenges of developing large-scale weapon systems. These systems are expected to have long service lives, often measured in decades, and typically require development and harnessing of unique, breakthrough technologies. Because of these challenges, development occurs over a multi-year period before these systems enter production. Changes late in development or in production directly contribute to cost and schedule overruns. Consequently, once the design is completed, there is strong resistance to change, and rightfully so. The ideal situation for these types of programs is one in which requirements remain relatively stable and critical technologies mature over the course of the development period (Stevens, forthcoming). Related to this, there is growing Congressional emphasis on better up-front planning and governance practices that focus on controlling deviations from the plan (Levin & McCain, 2009).

Information technology (IT) systems, particularly those that provide user-facing applications, pose different challenges. These systems are often intended to operate in highly volatile environments and, thus, are subject to changing user needs and expectations. In the most volatile environments, the effective life of IT systems can be measured in weeks to months rather than years. Development and acquisition tempos have to be responsive to such urgent and short-lived needs. Further, these systems often leverage commercial technologies that are also rapidly evolving. Unlike weapons systems in which change is rightfully something to be controlled, for many information technology systems, change is inevitable and must be accommodated. For these systems, there is a risk that requirements are locked in too early and may not be responsive to legitimately changing user needs and that technologies become outdated while the system is still in development.

[1] MITRE Public Release: 09-1310

Traditional processes and procedures are best suited for the development of linear, well-bounded systems and have proven difficult to adapt to situations in which stakeholders do not always agree, requirements evolve, and constraints keep changing. Different processes and procedures are needed to address the acquisition and engineering of IT systems, particular those with evolving requirements and rapidly changing technologies.

Current systems engineering and acquisition practices that are optimized to deal with the unique challenges and risks in the development of weapon systems do not provide the flexibility and agility needed to deal with the uncertainties inherent in many IT systems acquisitions. A tailored approach to IT acquisition that explicitly acknowledges the inherent uncertainties and provides the necessary flexibility is required.

The challenge of developing and acquiring IT-based systems more rapidly and with greater agility complements and does not supplant the very real and widely recognized challenges of developing and acquiring weapon systems. In fact, Dr. Ashton Carter, recently confirmed Under Secretary of Defense for Acquisition, Technology and Logistics, in reply to advance questions from the Senate Armed Services Committee, pointed out these two challenges:

> A first major challenge is to ensure that AT&L is supporting the war effort through rapid acquisition of systems our soldiers, sailors, airmen, and Marines need in Iraq, Afghanistan, and in the war on terror …. A second major challenge is to get under control the many troubled acquisition programs that are supposed to be supporting our forces—both today and tomorrow. Too many of these programs are failing to meet their cost, schedule, and performance expectations, and some are failing even more fundamentally the test of whether they are needed for the future military challenges we are most likely to face. In addition to disciplining these programs, reform of the acquisition system is needed to ensure that we do not get ourselves in this position again in the future. (Carter, 2009)

This paper reports on research conducted by The MITRE Corporation to examine alternative acquisition strategies and practices for IT systems under varying conditions of uncertainty. Alternative strategies, tailored to an understanding of the nature and extent of uncertainty faced by the program, are proposed.

The paper is organized as follows:

- Section I introduces the need for new acquisition approaches for uncertainty.
- Section II discusses the regulations that permit flexible acquisition approaches.
- Section III describes the three phases of this research program.
- Section IV highlights the key research findings, including an uncertainty landscape and strategies for dealing with uncertainty.
- Section V describes a three-step approach for implementing the strategies.
- Section VI introduces a model to describe implementation drivers, enablers, and barriers. Section VII summarizes the acquisition and systems engineering implications of this research.

II. Regulations Support Tailoring Acquisition Practices

Language in federal acquisition regulations specifically encourages the acquisition team to institute innovative practices tailored to the particular needs and circumstances of the program. In particular, the *Federal Acquisition Regulation (FAR)* Part 1.102: Statement of Guiding Principles for the Federal Acquisition System states:

> (d) The role of each member of the Acquisition Team is to exercise personal initiative and sound business judgment in providing the best value product or service to meet the customer's needs. In exercising initiative, Government members of the Acquisition Team may assume if a specific strategy, practice, policy or procedure is in the best interests of the Government and is not addressed in the *FAR*, nor prohibited by law (statute or case law), Executive order or other regulation, that the strategy, practice, policy or procedure is a permissible exercise of authority. (GSA, 2005)

Similarly, *DoD Instruction 5000.02* Section 1, Defense Acquisition Management System (USD (AT&L), 2008) states:

> b. Consistent with this Instruction and Reference (b), the Program Manager (PM) and the MDA shall exercise discretion and prudent business judgment to structure a tailored, responsive, and innovative program.

Despite regulations that allow flexible acquisition methods, there is little guidance on what these methods should be. This research was undertaken to identify particular methods.

III. Research Approach

The research explores strategies and methods for managing uncertainty and offers opportunities to address federal IT acquisition challenges. The objectives of the research are to determine: (1) how best commercial practices for dealing with uncertainty can be adapted to federal IT acquisition, (2) under what circumstances might they work and make a difference, and (3) what needs to change to make it happen. Research activities are organized into three phases as illustrated in Figure 1.

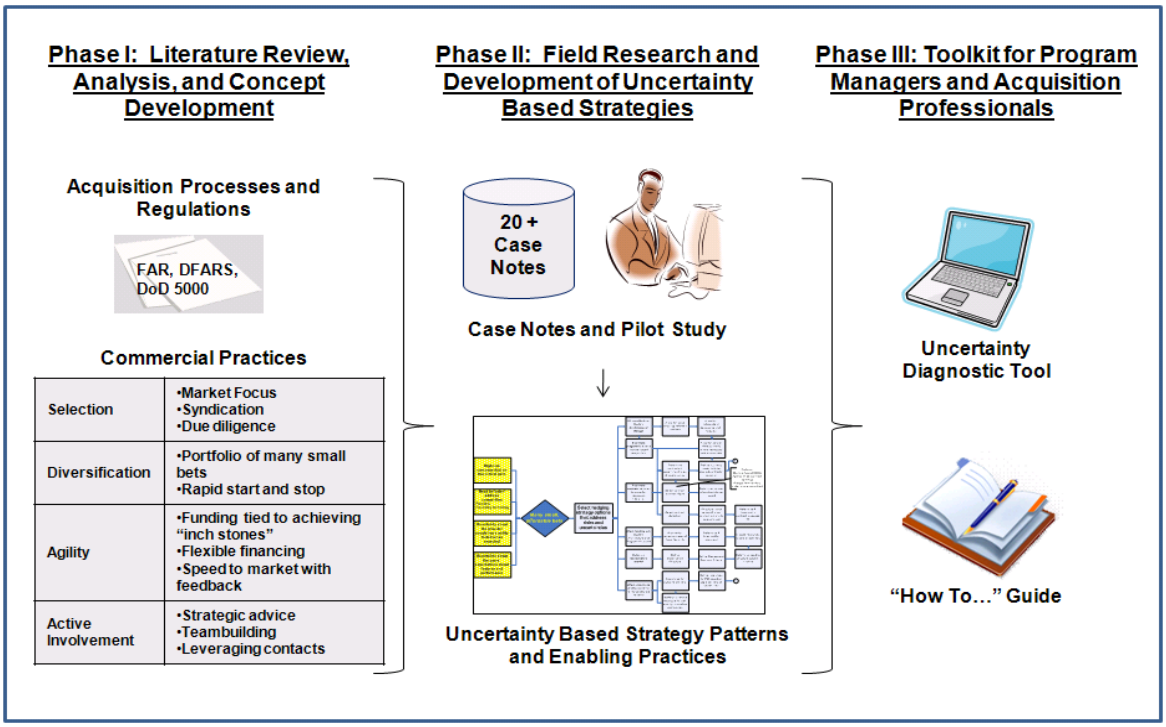

Figure 1. Three Research Phases

Phase I

Phase I of the research characterized and compared commercial entrepreneurial (McGrath & MacMillan, 2000) and federal acquisition environments and methods to develop a research framework to assess the nature and level of uncertainty within an acquisition program. The research was based on literature reviews and analyses of federal acquisition processes and regulations, as well as interviews with venture capitalists, entrepreneurs, government program and project managers, and acquisition, contract, and budget specialists. The concepts and frameworks were refined based on discussions with commercial entrepreneurs, government specialists, and academicians.

Phase II

Phase II developed and detailed alternative acquisition strategies for dealing with uncertainty and initiated field research. The field research was an embedded multiple-case study (Yin, 2002) and included data from more than 20 programs from 12 government agencies responsible for the acquisition of information intensive systems. Working from an interview protocol, the research team collected information on the programs' acquisition, development, contract, incentive, and governance strategies. The case notes provided input for identifying acquisition strategies for dealing with uncertainty and for exploring the motivators, enablers, and barriers to innovation in acquisition practice. A pilot study with an active acquisition program was initiated in Phase II to test and validate the strategies proposed in the research.

Phase III

Phase III focused on synthesizing, validating, and communicating the research. Research findings were captured in an interactive diagnostic tool and a "How to Guide" for

program and project managers and key members of the acquisition team. A model for assessing an organization's readiness to implement uncertainty-based strategies was then developed.

IV. Research Findings

Acquisition Uncertainty Landscape

IT acquisitions face both internal and external uncertainty. Within a typical acquisition, the team faces internal uncertainties in design, implementation, and performance. Even though the members of the team have had similar experiences, there are still many new aspects to address. The team can be uncertain about how to design the system, how to optimize the implementation, and how well the system will meet functional and performance requirements.

A typical acquisition also encounters even more challenging external uncertainties. These include changes in the:

- Operational environment, threat or mission,
- Business processes, governing policies and regulations,
- User requirements and expectations,
- Priorities,
- Competitors (including user-initiated efforts),
- Technologies, and
- Stakeholder actions and influence.

Internal and external factors translate into two critical dimensions of uncertainty: uncertainty about what to build and uncertainty about how to build it. Figure 2 describes an acquisition uncertainty landscape based on two key dimensions of uncertainty: evolving requirements and emerging technologies. In the lower left hand corner of the figure, requirements are relatively stable, and technologies are mature. This indicates less uncertainty and, therefore, more predictability in the execution and outcome of the program. Program/project managers know more clearly what needs to be built and the appropriate approach to building it. A traditional acquisition approach often works well in this predictable area of the landscape.

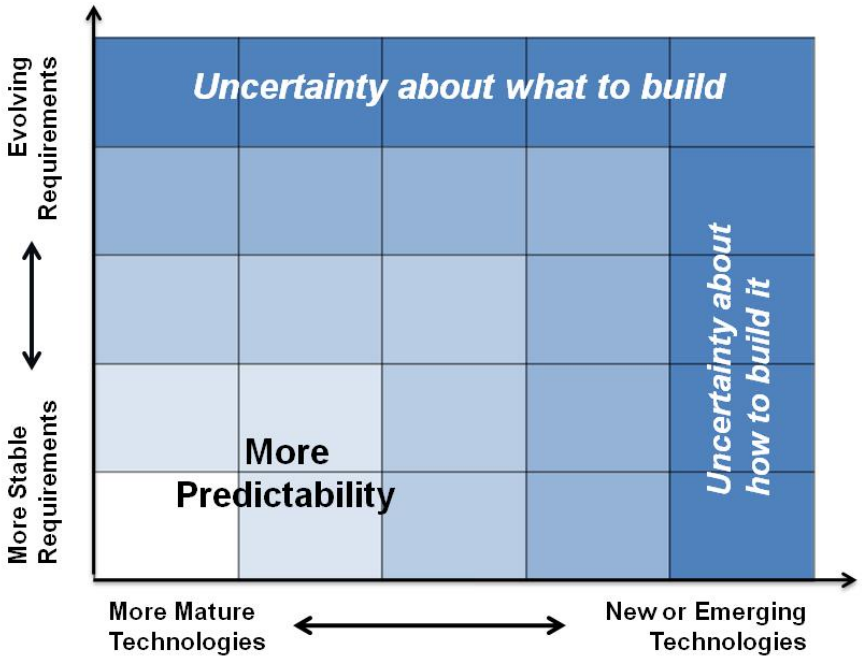

Figure 2. Acquisition Uncertainty Landscape

Farther away from the lower left hand corner, evolving requirements and emerging technologies introduce more uncertainty. The traditional approach of locking down requirements early and following a waterfall development effort do not work as well. Acquisition strategies must expect and accommodate change and build in the flexibility for dealing with uncertainty.

A basic premise of this research is that IT acquisition must take into account a program's position on the uncertainty landscape. Acquisition strategies should be selected depending on the nature and scope of the underlying uncertainties. In addition, not all parts of a program demonstrate the same type and degree of uncertainty. For example, development of the basic infrastructure may be more predictable and fall in the lower left hand quadrant of the landscape, while user facing services are often closer to the upper right hand quadrant due to changing user expectations and new technologies.

As shown in Figure 3, the various components ("chunks") of a program may belong in different locations on the uncertainty landscape. Therefore, not all parts of a program have the same need for flexibility. It is useful to envision the components of a program as constituting a portfolio. The core elements of the portfolio are those that are more predictable and can be managed using a classic approach, while the more uncertain components require a more flexible strategy.

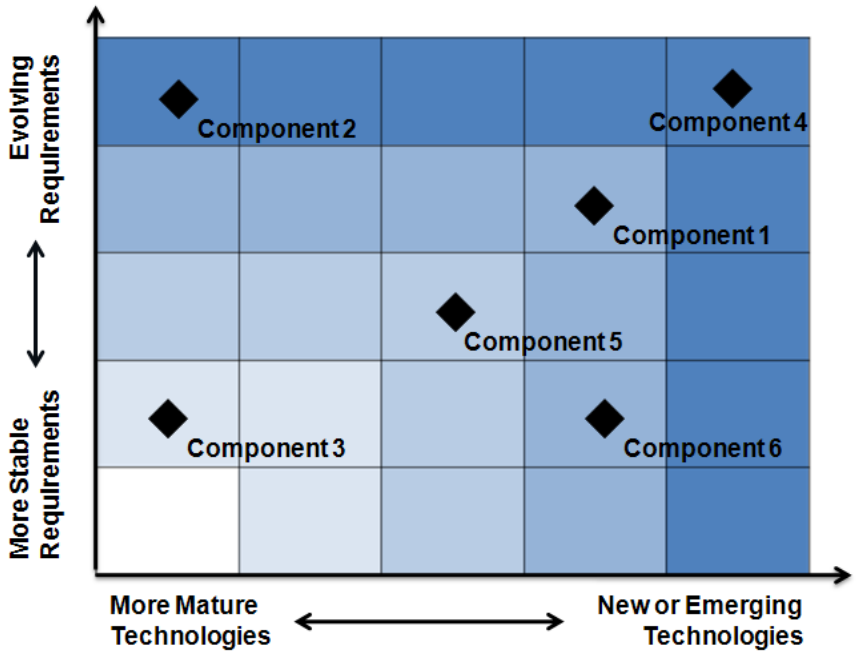

Figure 3. Mapping Program Components on the Acquisition Uncertainty Landscape

Strategies for Dealing with Uncertainty

This research found that different strategies are appropriate for different levels and types of uncertainty. A plan-driven strategy works best when requirements are primarily stable and technologies are mature. As illustrated in Figure 4, staged commitment and small bets strategies are more appropriate for components facing uncertainty about what to build and how to build it, respectively. These findings are consistent with earlier research in project management (Loch, DeMeyer & Pich, 2006), product development (Smith, 2007) and venture capital (Gompers & Lerner, 2001: Stevens, King & Halley, 2008).

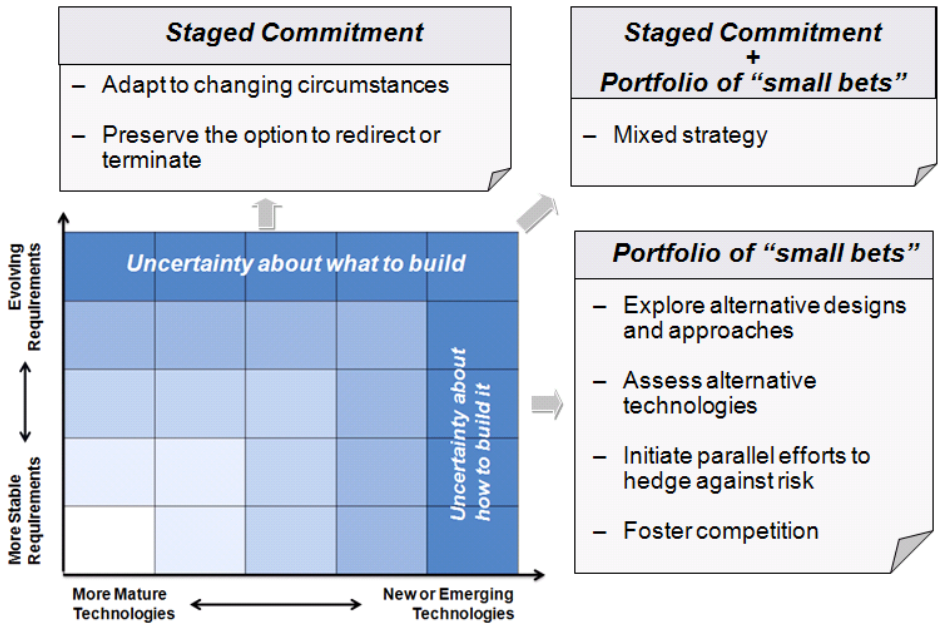

Figure 4. Strategies Used to Manage Uncertainty

The following paragraphs outline three strategies for different areas of the Uncertainty Landscape.

Strategy 1: Plan-driven

When there is little uncertainty in requirements and technology, a program/project manager can successfully use the traditional Plan-Driven Strategy. This traditional method consists of defining a set of requirements, design, cost, and schedule, and then carrying out the associated plan. Since there should be little need to change, progress is measured against the plan, and success is determined by how closely cost, schedule, and requirements goals are met. Project management techniques, such as Earned Value Management (EVM), have been developed to measure execution against the plan. This plan-driven method has been successfully used for years when there is little doubt about what is needed and how to satisfy it. Where risk is present, program/project managers use well-recognized risk management techniques. The idea is to "make a plan and execute to the plan."

Strategy 2: Staged Commitment

When there are rapidly evolving requirements and uncertainty about what to build, a program/project manager can follow an iterative, learning strategy and manage the project by staged commitment. In a staged commitment approach, the acquisition is structured so that funding and payment decisions are made based on small increments of demonstrable capability. Staged commitment enables the program/project manager to scan the environment, assess uncertainty at each stage, and adjust the direction appropriately. The approach preserves the option to re-baseline, re-direct, or terminate the effort if market conditions have changed, priorities have shifted, or the contractor is not delivering as expected.

A staged commitment strategy is warranted when there are uncertainties in the mission, business environment, or user expectations about particular features or performance. In addition, a staged commitment strategy is desirable when there are uncertainties about a provider's ability to achieve agreed-to objectives. Deliverables at each stage are concrete and can involve either early prototypes or small increments of delivered capability. They can be periodically evaluated using feedback from intended users and other critical stakeholders. From a contracting standpoint, staged commitment can be accomplished through such mechanisms as shorter duration contracts/task orders, with renewal options.

Strategy 3: Small Bets

When there are new or emerging technologies, program/project managers can apply a small bets strategy. In a small bets strategy, parallel efforts are initiated to determine technical solutions and a way forward; the pharmaceutical industry makes particular use of this method (Eliasberg & Ding, 2002). Simultaneous, parallel mini-projects are initiated, each one with a different design approach. The projects are completed, and the design with the most successful outcome is adopted. In this way, many design alternatives can be assessed by field trial and experimentation.

"Small bets" strategies are used to:

- Explore alternative designs and approaches to implementation
- Assess alternative technologies
- Initiate one or more parallel activities for high-risk components on the critical path with the understanding that there will be a down-select decision2
- Foster competition
- Hedge against the risk of failure of one contractor/provider or solution

An IT program using small bets should be one that can be structured into small, concurrent increments that can each be developed and acquired independently and subsequently integrated. One critical method to enable a small bets approach is the creation of contract flexibility, which supports key decisions to modify the acquisition strategy efficiently and with controlled impact to cost and schedule**.**

Figure 5 illustrates sample strategies and compares the more traditional approaches of "one big bet" and "one bet with learning" with variants of "small bets." The small bets strategies included in Figure 5 are:

- Design fly-off: Multiple designs are initiated with a competition to select the best design. The winning design is then carried through to the end of the project.
- DARPA model: Multiple prototypes are carried forward in parallel through design, implementation, and field test. Only the winner is carried into operations.
- Two-button model: Multiple systems are presented to the user. The marketplace then decides which system best fits their needs, rather than the development team.

[2] This is often initiated during design or early prototyping but can also be used downstream if the program encounters design or contractor/solution issues.

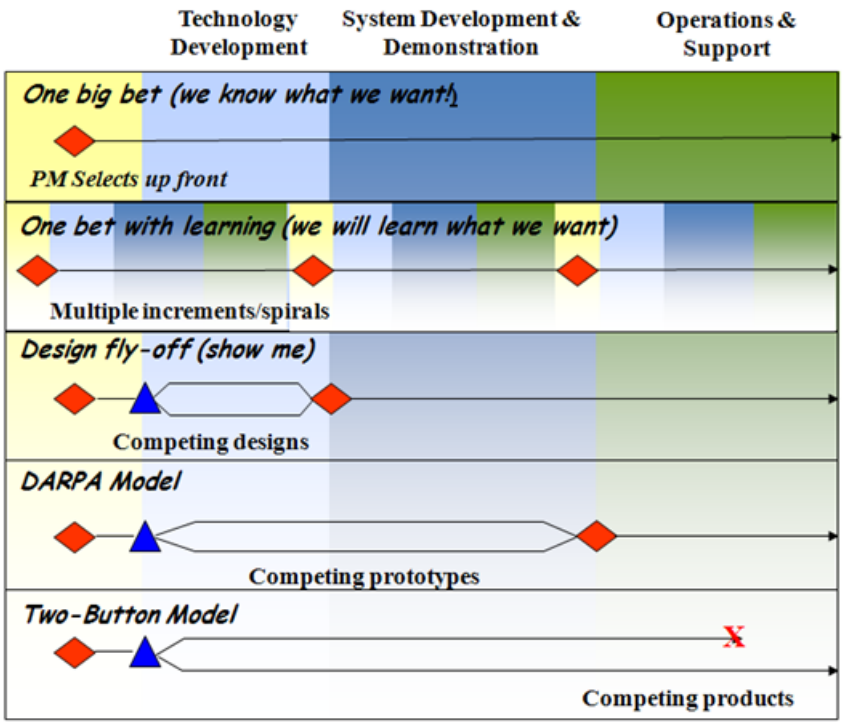

Figure 5. Variants of Small Bets

When both requirements and technology uncertainties exist, the program/project manager can use a combination of staged commitment and small bets strategies. Under these circumstances, the program/project manager could incrementally commit to requirements, and within each increment, initiate alternative designs to reduce technology risk.

V. Implementation: A Three-step Approach

Programs that are the most likely candidates for implementation of the alternative practices introduced above are those that:

- Are initiating a novel endeavor that demands a different approach,
- Have attempted to use traditional strategies, sometimes more than once, and found that they proved to be unsuccessful, and
- Anticipate considerable uncertainty and volatility either in terms of requirements and/or enabling technologies.

These circumstances provide the necessary motivation to try alternative strategies. In addition, the program/project manager must be willing to try these non-traditional practices, and the organization must be willing to support the effort. In effect, senior management must provide the necessary encouragement and "top cover." Finally, the program must lend itself to being structured into small increments that can be developed and acquired independently and subsequently integrated to yield the desired capability.

The implementation approach is organized into three steps (Figure 6).

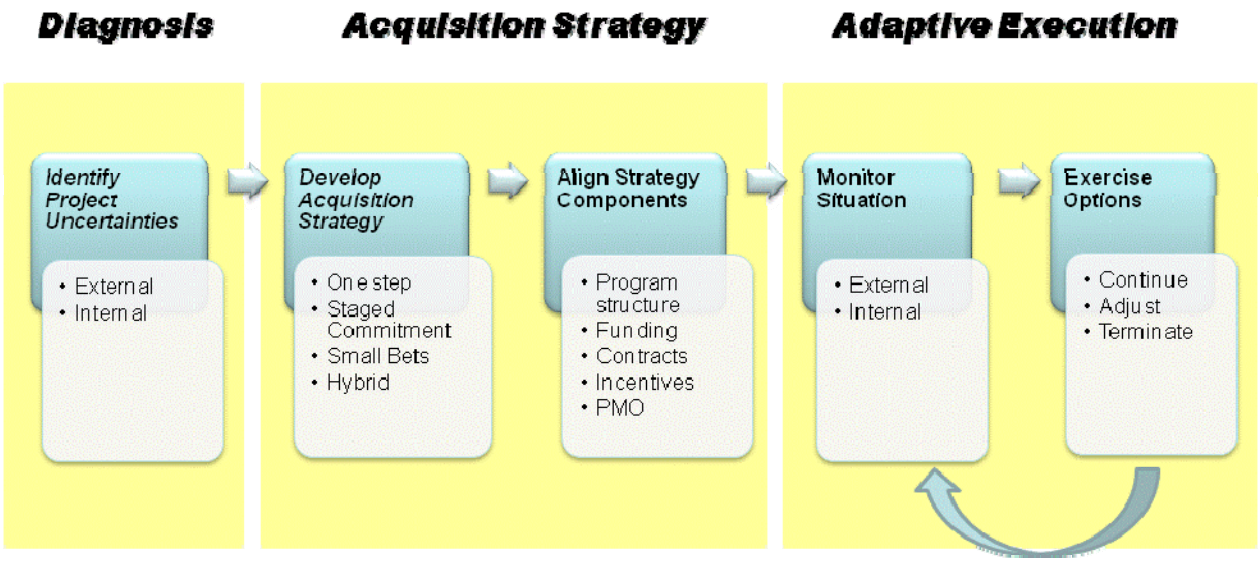

Figure 6. Three-step Approach to Implementation

Step 1: Diagnosis

The diagnosis step is used to determine which parts of the program are subject to uncertainty, as well as the nature and magnitude of the uncertainty. The underlying premise is that uncertainty is not distributed evenly. Different parts of the program face different sources and levels of uncertainty. Examples of uncertainties that may be faced include:

- Changes in the mission environment or underlying business process that result in changing user needs and/or expectations,
- Uncertainties about user expectations and user acceptance of particular features and/or levels of performance,
- The pace of change of the enabling technologies,
- Uncertainties about the ability of providers to achieve agreed-to objectives within the time and resource constraints,
- Items that are on the critical path for which risk-hedging strategies are warranted, and
- Desire to foster competition of ideas, approaches and/or technologies.

The diagnosis step maps each of the relevant project components onto the uncertainty landscape and suggests strategies that may be suitable based on the nature and degree of uncertainty. The research effort has developed an interactive tool to assist in conducting the diagnosis. Figure 7 provides an example output of the diagnosis step for one of the case studies in this research. (Note: the project name is disguised for anonymity).

Figure 7. Example Diagnostic Output

Step 2: Select and Implement the Acquisition Strategy

In this step, the program/project manager plans for and implements the selected strategies to provide a set of options that can be exercised as situations warrant. In order to preserve the flexibility to respond to potential uncertainties, conditions have to be built in early in the planning phases of the project. These conditions address program structure, funding, contracting, and contract/contractor performance. In both the staged commitment and the small bets strategies, the project uses a modular system design and lends itself to modular development. An overarching architecture is critical to defining the components, their relationships, and interactions enabling their integration.

The enabling conditions for the staged commitment strategy include:

- **Development approach**: Adopt an agile or spiral development approach to delivery of capability.
- **Funding**: Align funding with the system architecture and project structure. Arrange for payments to be made based on achieving user needs in increments of capability.
- **Contracting**: Structure contract vehicles to allow for incremental periods of performance (modular contracting), including the options for rapid termination, if and when needed.
- **Contract/contractor performance**: Emphasize outcomes (capability delivered).
- **Incentives**: Structure contractor award to delivery of capability—reflecting user feedback.

The enabling conditions for the small bets strategy include:

- **Development approach**: Adopt a modular-based acquisition strategy.
- **Funding**: Provide fiscal flexibility to support establishments of parallel activities as needed.
- **Contracting**: Structure contract vehicles to allow for competitive parallel developments.
- **Contract/contractor performance**: Define business model to foster desired contractor behavior.
- **Incentives**: Structure contractor award to delivery of capability—reflecting user feedback.

These strategies place greater emphasis on initial and recurring trade-space assessment that address not only cost, schedule and performance but also affordability, responsiveness to changing needs, capability delivered, and interoperability with other internal components and external systems. For such strategies to be effective, and not overly costly, there is a need to:

- Limit documentation to what is necessary,
- Find more cost efficient ways to evaluate working prototypes and early capability increments,
- Implement a "light-weight" governance process for small increments and a more traditional governance process for major milestones, and
- Encourage competition to get better products, sooner, at lower cost.

Step 3. Adaptive Execution

The program/project manager who must operate in the today's uncertain environment requires a degree of flexibility to make informed decisions and to adapt to changing circumstances. Laying the groundwork in the acquisition strategy is critical. So, too, is the ability to continuously monitor the situation to identify changes in demand, priorities, the delivery of products, and the "fit" between the product delivered and user expectations. If the program/project manager views and manages the program as a portfolio of interconnecting components, he or she is prepared to rebalance the portfolio as warranted. This includes redirecting, accelerating, slowing, or terminating future increments and initiating risk-hedging initiatives.

VI. Drivers, Enablers, and Barriers to Adopting Uncertainty-based Strategies

Although the strategies proposed in this paper for addressing uncertainties in IT acquisition are supported and encouraged by statute and regulations, in some instances these strategies may be viewed as non-traditional and meet with resistance. To assess an organization's readiness to implement uncertainty-based strategies, the diagnostic tool includes a framework for program/project managers and acquisition professionals to assess whether there is "fertile ground" for implementing the proposed strategies. Will the strategies be successfully adopted or challenged by long-standing practices and culture?

Throughout the field research, the team observed several motivators, enablers, and barriers to trying a new acquisition approach. The findings in the case notes and the extensive literature on innovation provide the basis for a model of innovation readiness. The "Y" Model (named because of its shape) is illustrated in Figure 8.

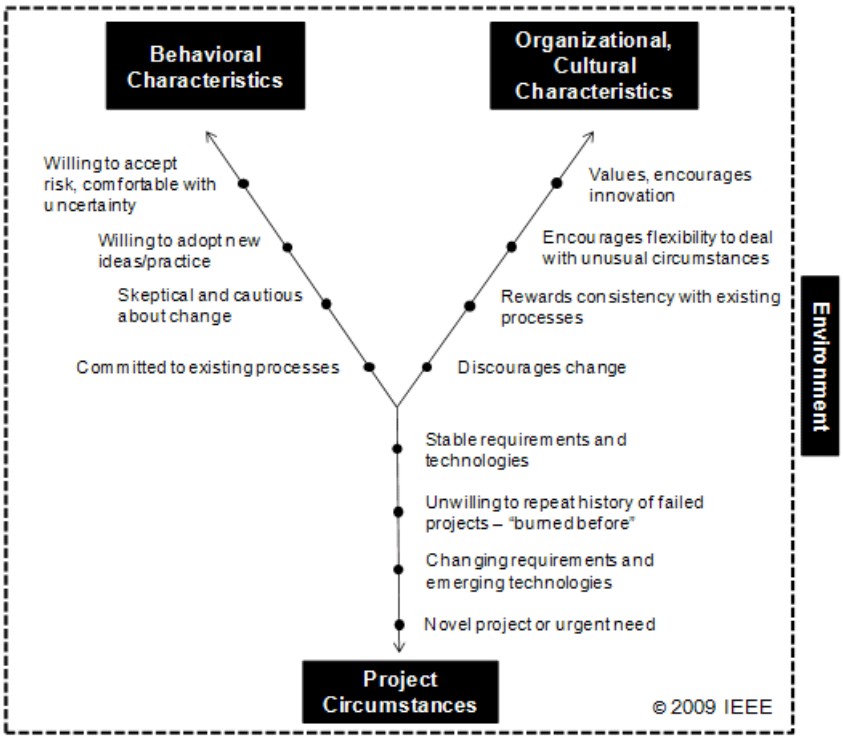

Figure 8. "Y" Model of Innovation Readiness
(Stevens, King, Beard & Halley, 2009)

The three dimensions of the "Y" model portray a range of individual behavioral characteristics, organizational/cultural characteristics, and project circumstances. A program is plotted on the model, and the resulting triangular shape suggests the degree of alignment between the need to implement alternative practices and the ability and willingness of the organization to do so.

The project circumstances dimension of the model was developed primarily from information gathered from the case notes research. The project circumstances are often the motivation for trying an innovative acquisition approach. Project circumstances that may serve as drivers for innovation include:

- The program is trying something novel that necessitates an innovative acquisition strategy.
- The program is responding to a critical or urgent need.
- The program is dealing with rapidly changing circumstances or threats.
- The program has run into difficulties before (in some cases, two or three times) and wants to try a different approach.

The behavioral characteristics and organizational/cultural characteristics dimensions of the model were developed primarily from the literature on innovation (Rogers, 2003) and organizational change (Kotter, 2007; Schein, 2004; Holt, Armenakis, Harris & Field, 2007). The individual behavior and organizational dimensions of the model form the upper arms of the Y. Points that are farther out on the vectors represent a greater willingness to accept innovative acquisition approaches.

A mapping of the programs studied in the field research on the "Y" model highlights some interesting patterns. Figure 9 illustrates a project that maps to the outer points on each vector. In this instance, the project was developing a novel capability—the project leader was comfortable with uncertainty and willing to accept risk, and the senior leadership of the organization was supportive and willing to provide "top cover." This is an example of an aligned project.

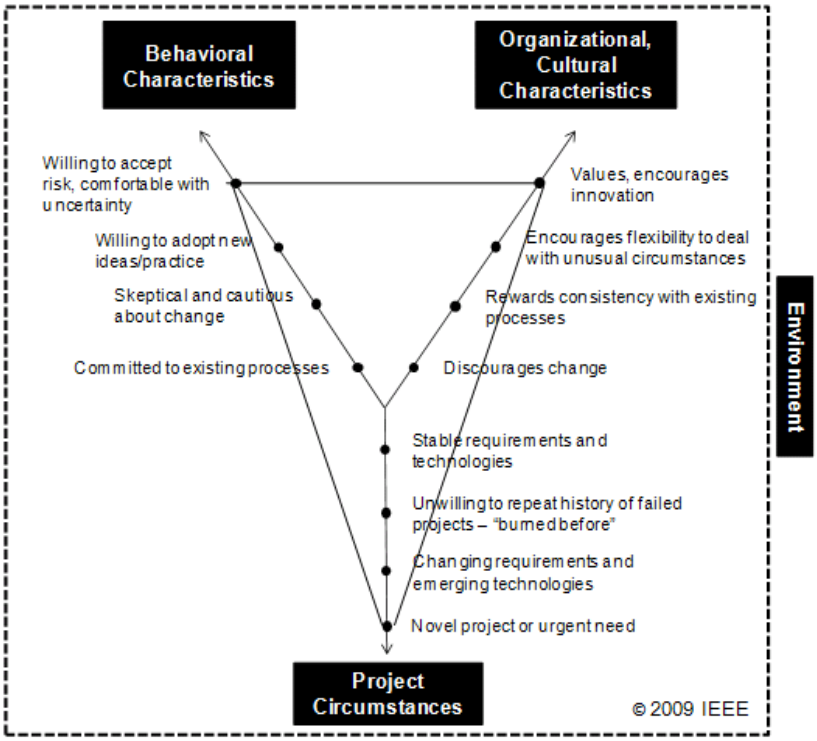

Figure 9. Examples of Aligned Project
(Stevens, King, Beard & Halley, 2009)

Figure 10 provides an example of a misaligned project. In this case, the project was developing a capability that was fundamentally new to that agency, and the project leader was interested in implementing acquisition strategies that were considered to be innovative in that environment. However, higher-level management in that agency actively discouraged change.

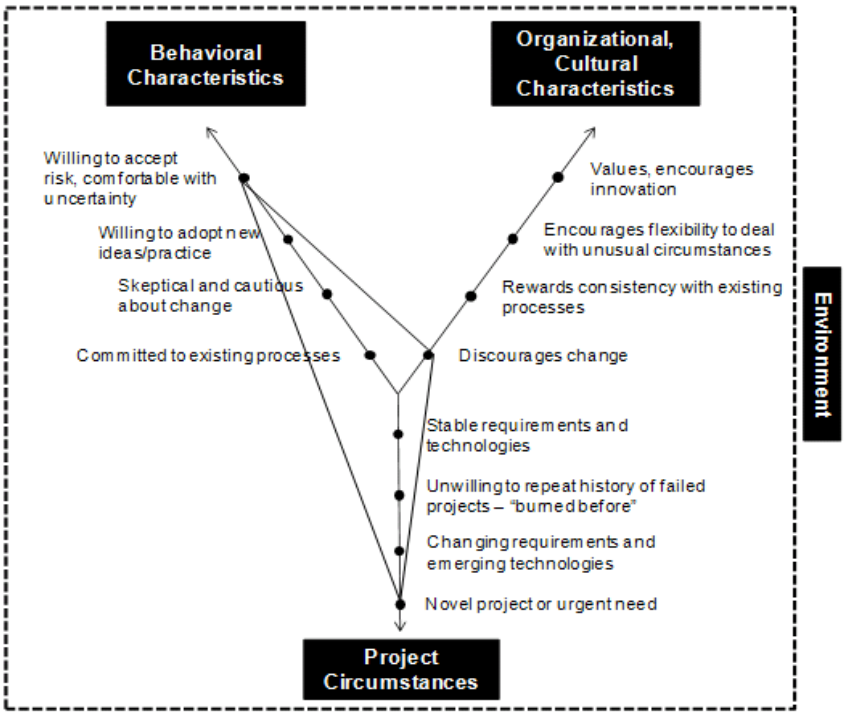

Figure 10. Example of a Misaligned Project

Plotting the overall program and components of the program on the "Y" model can provide an early visual indicator of potential roadblocks to uncertainty-based strategies. A misaligned mapping helps focus attention on the areas that need to be addressed up front when implementing innovative strategies. The areas of concern can become part of a risk-mitigation plan.

A word of caution is warranted. While this model arose from field research observations and is supported by a rich body of literature (Holt et al., 2007), it is still a work in progress. Much of the literature focuses on the commercial and education sectors, not on acquisition practices in the federal government. Follow-on research will be required to refine and validate the model and extend its granularity.

VII. Conclusion

The research effort is an ongoing study of acquisition strategies suitable for dealing with uncertainty, particularly as it applies to IT acquisitions in the federal government. The primary products of the research are an interactive diagnostic tool as well as a *How to Guide* that provides actionable recommendations for program and project managers and acquisition professionals that wish to implement these strategies.

Key to the successful implementation of these strategies is a perspective that allows the program/project manager to:

- Understand that different parts of the program face different types and degrees of uncertainty and urgency,

- Be prepared to tailor acquisition strategies, picking a staged commitment strategy in which there are uncertain or ambiguous requirements and a small bets strategy to hedge against risk or foster competition,
- Balance the need for agility and discipline, applying discipline in executing the current increment while being agile and adaptive in adjusting subsequent increments to changing needs, priorities and evolving technologies,
- Recognize that while statute and regulations encourage flexibility and innovation, non-traditional acquisition approaches are often challenged by long-standing practice and culture,
- Seek an active partnership with the end user and "top cover" within the organization, and
- Strive to implement a culture that emphasized outcomes, "time to value" and responsiveness.

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