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Correct requirements, a factor for success in major acquisition programs

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MBA PROFESSIONAL REPORT

Correct Requirements, A Factor for Success in Major Acquisition Programs

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June 2008

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13. ABSTRACT (maximum 200 words)

This MBA project investigates the importance of correctly deriving requirements from the capability gap and operational environment, and translating them into the processes of contracting, software and hardware design, system engineering, the acquisition cycle, and program management.

The research also examines inefficiencies in hardware and software development, acquisition management, and problems caused by organizational, systemic and stakeholder interferences. The primary goal is achieving the acquisition process to deliver the best quality system that is prompt, technically available, affordable, and meets the user's requirements.

The work addresses commonalities and differences of software and hardware development, inefficiencies, and a variety of influential factors for a new program from a more general perspective. The conclusions and recommendations illustrate the present difficulties of implementing constructive change. These recommendations are provide the reader with alternative approaches to consider.

Suggestions for further research are included at the end of this research.

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CORRECT REQUIREMENTS, A FACTOR FOR SUCCESS IN MAJOR ACQUISITION PROGRAMS

Holger Reich, Commander, German Navy

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requirements for the degree of

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This MBA project investigates the importance of correctly deriving requirements from the capability gap and operational environment, and translating them into the processes of contracting, software and hardware design, system engineering, the acquisition cycle, and program management.

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I. HARMONIZED CONSTRAINTS IN SOFTWARE ENGINEERING AND ACQUISITION PROCESS MANAGEMENT: REQUIREMENTS ARE THE KEY TO SUCCESSFULLY MEET FUTURE PERFORMANCE GOALS IN AN ENVIRONMENT OF SCARCE RESOURCES

A. INTRODUCTION

The acquisition community, Congress, companies, and taxpayers consider the Department of Defense (DoD) acquisition process to be a broken system. They are weary of endless program failures, cost overruns and delayed schedules for major acquisition programs. However, this is the only commonality of their judgements. Stakeholders do not enjoy being reminded of their own contribution to the mess and are more than willing to pass the blame to anyone else. They all have different opinions of what is wrong with the sophisticated system, which appears to be sensible when considering the process alone. Budgets will remain tight in the future because there are many other challenges, apart from the defense budget, appearing at the horizon. Everyone agrees that the system needs to be fixed quickly because of the scarce resources apparent in future budgets. Gathering a sufficient piece of the budget is essential to providing high quality weapons systems to the warfighters that are desperately needed to face upcoming threats and challenges.

Modernization and unexpected developments must be addressed as well. Considering the tight budget constraints, this is a difficult task. The need for a solid, fast and reliable solution to this inappropriate situation is urgent, and requires extensive analysis. The goal is to find the roots of the various problems in order to make the system work. Two of the most critical causes of acquisition problems are the development of sufficient system and software requirements. To understand this relationship, the facets of this complex and complicated system must be examined: important stakeholders, influential factors, and the challenges and opportunities ahead. Goals of the Project are illustrating common problem areas, developing new insights, addressing future needs, and offering recommendations for addressing some of the current weaknesses.

B. COMMONALITIES AND DIFFERENCES

To understand the role of software development and general requirements within the acquisition process, the commonalities and differences of these two segments will be examined.

1. Commonalities

Software and general requirements are derived from the same source: the goal[1] of closing a capability gap. The functional analysis, which is driven by the operational requirements needed to achieve this goal, leads to both preliminary and detailed design attributes.

2. Differences

The functional analysis step is where the two kinds of requirements deviate. General requirements investigate the design attributes needed for the physical characteristics of the new system. Software requirements identify the attributes and important functions that will be performed by software in the new system, not by hardware of the preliminary design[2]. Both address the interfaces, testing, and integration[3] necessary for the new system to work smoothly and reliably using different means. All these efforts take place during the design phases before the actual production process. What is evident from this is that the requirements must be generated in a completely different environment within the acquisition process. The further development of these requirements, beginning with the functional analysis, is completely different and often misunderstood.

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[1] See also Systems Engineering And Analysis, Fourth edition, Blanchard/Fabrycky, p. 99, Figure 4.3.

[2] See also Systems Engineering And Analysis, Fourth edition, Blanchard/Fabrycky, p. 100, Figure 4.4.

[3] See also Systems Engineering And Analysis, Fourth edition, Blanchard/Fabrycky, p. 100, Figure 4.4.

C. METHODOLOGIES AND MODELS

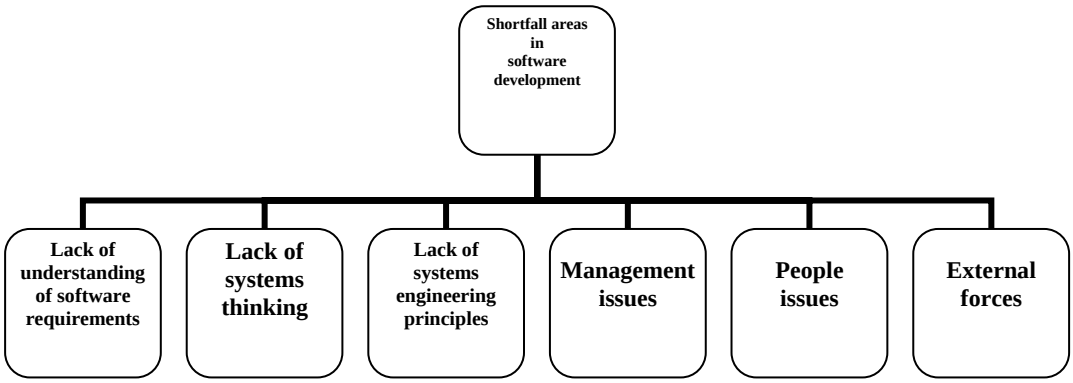
This research uses various analytical techniques referring to case studies and models to illustrate the roots of problems within the acquisition process. It also uses models, data and case studies to support the recommendations and conclusions.

D. SHORTFALLS IN THE INFLUENTIAL FACTORS AND THEIR IMPACT ON THE SUCCESS OF A MAJOR ACQUISITION PROGRAM

First, it is necessary to present the most common and important sources that lead to the frequently experienced shortcomings of cost and schedule overruns. The research investigates their general impact on major acquisition programs and focuses on six major sources for each segment. These sources are not exhaustive but address the most influential areas of the current weaknesses experienced within the different processes.

1. Shortfalls in the Software Segment and Their Impact

Figure 1. Major shortfall areas in software development



a. Lack of Understanding Software Requirements

At the beginning of the acquisition process, detailed software requirements of the new system are always unknown because the overall amount of software required is determined by the functional needs that are elaborated early in the acquisition process. It is essential that the user requirements be correctly translated into software requirements

that address the system attributes derived from the functional architecture. It is particularly important to accurately estimate the amount of software development needed with as much realism as possible.

Another crucial factor is the software design, which will mirror only the functional requirements that are articulated in the requirement analysis. These requirements shape the framework and capabilities of the software designed. This relationship has a critical impact on even the smallest change that has to be made after this early stage of development, and is one of the most powerful factors of cost and schedule. Overly optimistic assumptions of the total amount of software needed leads to initial delays, as demonstrated by various programs such as the F22[4], FCS[5] and SBIRS[6] programs.

Software developers use a similar checklist[7] for developing hardware. It prepares for design reviews of the system to verify their compatibility and testability. The software development environment is not mature enough to allow for common development practices and compared to the hardware sector, has few verified and suitable tools. However, there has been significant progress since the early days of software development. Modern software languages allow more flexibility, focus on functional needs instead of lines of code, and increasingly support an open architecture that is advantageous for maintainability and sustainability of embedded software in major weapon systems[8].

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[4] F22 Raptor, first supersonic stealth fighter of the USAF.

[5] FCS, Future Combat System of the U.S. Army.

[6] SBIRS, Space Based Infrared System.

[7] A typical checklist for this purpose is illustrated as an example in Systems Engineering And Analysis, Fourth edition, Blanchard/Fabrycky, page 730, Figure B.2.

[8] See also Joint Strike Fighter Air Vehicle C++ Coding Standards For The System Development and Demonstration Program, December 2005 at http://www.jsf.mil/downloads/documents/JSF_AV_C%2B%2B_Coding_Standards_Rev_C.doc Last accessed February 2008.

b. Lack of System Thinking

The expression 'lack of system thinking' refers to two different major aspects: we try to make sense of reality applying filters and making assumptions. This is a helpful and vital tool for dealing with every-day life. However, these experience-based assumptions incorporate delays, biases, errors and other imperfections. It is necessary to be aware of this. To avoid those inherent mistakes, a vast amount of feedback possibilities must be implemented. Even then, there will be misperceptions of the feedback[9]. Unfortunately, false assumptions occur often when they rely on limited experience alone.

As researched by Scott Plous[10] in 1993, overconfidence is a common and catastrophic problem in decision making. His research indicates that judgements are rarely accurate. To gain confidence, assumptions must be corroborated by as much data as possible. However, data bases alone are not sufficient to avoid errors completely because they are limited and often allow ambiguous interpretations. Desire for change within a system might not become true simply because it cannot replicate the full dynamic complexity[11] of the system. This fact is a limiting factor to the success of any conclusions and recommendations made in this report. Nevertheless, if consequences are thoroughly investigated, the recommendations will be of some use to improve the existing difficulties if they are carefully applied.

[9] See also Business Dynamics, Systems Thinking and Modeling for a Complex World, Sterman John D., p. 27, Table 1-4 that shows numerous studies that have documented this observation.

[10] See also Business Dynamics, Systems Thinking and Modeling for a Complex World, Sterman John D., p. 272, Overcoming Overconfidence.

[11] See also Business Dynamics, Systems Thinking and Modeling for a Complex World, Sterman John D., p. 22, Table 1-3 that illustrates our difficulties to understand a system as a whole entity.

c. Lack of System Engineering Principles

As demonstrated in various acquisition programs[12], system engineering principles and models[13] are key tools for successfully developing a system. These principles however, need to be applied continuously, require strict oversight and good communication among the different stakeholders, and a chief system engineer who is experienced in the segment of the system that is to be developed. The steady and determined application of systems engineering principles and tight oversight is even more essential since the lack of software requirements and system thinking are common themes in failed projects[14]. One example of rushing into CDR and production is the SBIRS high program. According to a brief in class by a former student involved in the program, the program went into CDR with immature software (only about 50%) of the total amount of software produced and immature technology of subsystems still a problem at production start. System engineering principles are crucial in developing designs that accommodate current and future software and hardware attributes within a complex development environment for complicated system-of-systems architectures. On average, major weapon system programs software development tends to require almost twice the scheduled cost, and more than 220 percent of what was estimated at the start of the program[15]. The demand for cutting edge technology in almost every major program is one cause of this situation because of its associated uncertainties and risks.

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[12] For example SSGN Trident conversion program, Aircraft F18 E/F upgrade program, Link 16 program, Unmanned aerial vehicle Predator A MQ-1 / B MQ-9 program.

[13] See also Systems Engineering And Analysis, Fourth edition, Blanchard/Fabrycky, p. 131, Figure 5.6.

[14] See also Developing Software Requirements Supporting Open Architecture Performance Goals in Critical DoD System-of-Systems, Naegle Brad, p. 10.

[15] See also General Accounting Office, Defense Acquisitions: Stronger management practices are needed to provide DoD's software-intensive weapon acquisitions, Report to Committee on Armed Service, U.S. Senate, March 2004, publication no. GAO-04-393,7.

d. Management Issues

Management issues in the software development segment are often related to underestimations of the amount of work needed to accomplish the tasks. It is better to start with too many programmers and reduce the numbers later on because adding personnel late in the process is usually detrimental as different publications on this specific topic [16] show.

e. People Issues

Software development for complex weapon systems is different from software development for commercial businesses. The main defense contractors have typically employed people from one pool of programmers for their projects. This has two advantages: they are already familiar with the special demands of the Department of Defense environment and are also aware of special regulations and rules of the prime contractor. This means they can be easily integrated into the working environment. Other contractors discovered this phenomenon and have struggled with basic applications due to the lack of qualified software developers due to the competition for the same developer pool[17].

f. External Forces

Software development is a sensitive area, but crucial for the smooth functional performance and integration effort[18] of subsystems and their components. Disruptions in software development, like adding new requirements late in the

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[16] See also The Dynamics of Software Project Staffing: A System Dynamics Based Simulation Approach, Abdel.Hamid Tarek K., IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, Vol. 15, No.2, February 1989 and The Experience Trap, Sengupta/Abdel-Hamid/Van Wassenhove, Harvard Business Review, February 2008.

[17] As for example Northrop Grumman Ocean Systems had to learn when they allowed a subcontractor use an old software application to develop the Advanced Seal Delivery System, ASDS, a program that was cancelled due to multiple shortcomings later on.

[18] See also Systems Engineering And Analysis, Fourth edition, Blanchard/Fabrycky, p. 106, Figure 4.7.

development process, or software immaturity due to poorly defined requirements, will lead to major delays in schedule and massive cost overruns[19].

External forces are a permanent and serious challenge to the software development segment of acquisition programs. A lack of understanding of relationships within the process, requirement additions, funding changes, schedule pressures, and interference from political interest groups can have a very negative impact on acquisition programs, even if solid system engineering and acquisition management processes are in place. A major concern in the software development sector is a poor understanding of the processes that differ from the rest of the system's development. As an example, successful software development depends heavily on small incremental steps and a high demand for testing. This causes significant confusion and is often misunderstood[20]. Software is different in contrast to developing a new, cutting-edge hardware component or technology; non-software development is typically not the problem. Software depends basically on lines of code that are necessary to achieve the desired function, but systems are complex. It is rare that a complex system works as desired when first developed, and requires significant testing to ensure reliability and safety aspects expected from weapon systems. This also applies for programs that are costly and do not have any failure tolerance at all[21]. Political stakeholders are sometimes not aware of the additional risks[22] they impose with changes in schedule, funding, and requirements, or the related impact on the warfighters and the taxpayers in the long run.

[19] A good example is the SBIRS program that had to take 94 requirement changes after preliminary design and went into detailed design with less than 50 of the software accomplished.

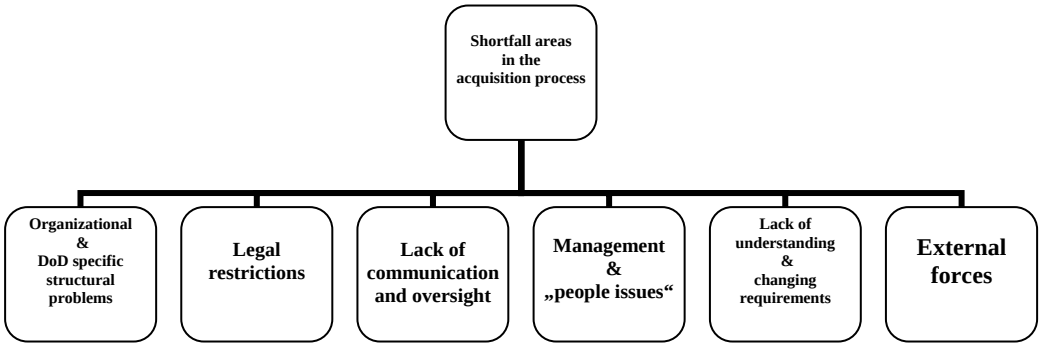
[20] See also Developing Software Requirements Supporting Open Architecture Performance Goals in Critical DoD System-of-Systems, Naegle Brad, pp. 11, 18.

[21] Good examples for such systems are satellite systems, space programs like the Space shuttle because any failure might result in complete loss of the mission or system.

[22] See also Systems Engineering And Analysis, Fourth edition, Blanchard/Fabrycky, p. 711, Figure 19.12.

2. Shortfalls in the Acquisition Process and Management Segment and Their Impact

Figure 2. Major shortfalls areas in the acquisition process



a. Organizational and DoD Specific Structural Problems

In this section, typical problems within the acquisition processes and acquisition environment are explored in more detail. The factors here are more numerous, but can have the same devastating effects on programs as those imposed during software development.

The structural and organizational framework of the DoD environment provides ample opportunity to implement changes, improve efficiencies, clarify responsibilities, and balance supervision and control. However, change is difficult to implement, especially in such a large and interdependent structural framework like the Department of Defense[23]. Therefore, any change will always face considerable resistance and require significant time before it is fully implemented and embraced.

The obligation to reduce personnel costs in the DoD environment has deteriorated the acquisition experience base as well as knowledge redundancy. Unfortunately, the loss of knowledge was far greater than the reduction of the workforce[24]. Two areas that were crippled by this effect were the general acquisition

[23] See Organizational Behavior, Mc Shane/von Glinow, Mc Graw-Hill/Irwin, New York 2007, chapter 14.

[24] As stated during MN3304 class, Yoder Cory.

workforce, and within this community, the contracting specialists. Experienced personnel were required or given incentive to leave; the professionals remaining had to deal with a large and increasing number of programs. Time is precious and there are not enough employees to properly analyze the programs in great detail. This leads to an increased danger of 'playing the system' and causing damage to the trust of the regulations in place[25].

In addition, frequent cost and schedule overruns of many programs did not result in a deeper investigation of their causes. Rather, it resulted in rapidly evolving new regulations and supplements to the Federal Acquisition Regulation (FAR) and other directives. For those trying to operate within the acquisition processes, this made work even harder. The regulatory additions addressed the symptoms of the problems instead of the cause. The envisioned workload reduction after the Cold War era was supposed to allow smaller Services and a reduced civilian workforce through a decline in transactions and smaller programs. Less need for oversight was also expected, but neither ever became reality. The increased number of regulations and the reduced number of surviving contractors capable of delivering the major weapon systems made more oversight mandatory. A flood of new regulations attempted to address the problem that an inexperienced workforce faced as schedule pressures and work overload increased, which triggered more compliance effort, that led to even more cost and schedule overruns.

Program Managers (PMs) willingly contribute, more or less, to the problems. Because their role is to successfully complete the program, they have no interest in revealing its actual performance, especially if that performance is not viewed favorably. Because they want to keep their program alive, they feel pressure from their service to bring their program to deployment so that the new system is not lost. However, the PMs cannot be primarily blamed for this effect; their behaviour is consistently rewarded and enforced. Even if this was not the case, the necessary and accurate information about real estimated costs of a program and its life cycle would be hard for them to accurately estimate. This is because the contractor is disincentivized in admitting

[25] See also Developing Software Requirements Supporting Open Architecture Performance Goals in Critical DoD System-of-Systems, Naegle Brad, p. 13.

the difficulties of accomplishing the program within the cost and timeframe. He will wait at least until production until he comes up with the full truth and more or less reliable cost of the program because before production he barely makes any money at all on state of the art weapon systems. He fears that otherwise, the program will be reduced considerably or even be terminated. This fear is understandable. An example using immature technology even in the production process was the Advanced Seal Delivery System associated with the SSGN conversion program. Immature technology for subsystems like the batteries led to a lot of delays, cost overruns and even more concerning to a fatal accident during testing. This fact caused a cancellation of the ASDS program and reduced the capabilities of the converted submarines.

The Services themselves are major sources of initial misinformation that feed this system. Quantities needed are exaggerated in expectation that these numbers will be cut by politicians or budget constraints. Contractors estimate cost and profit based on these numbers and are quick to rapidly accelerate unit costs as planned quantities are reduced by the Government. Members of Congress do not use the correct tools to terminate these unhealthy relationships. They cut funding and influence major programs for regional and political reasons. This behaviour and bias in favour of regional revenues and influence adds another level of inefficiency to the existing problems of the acquisition process.

Accountability for results is low among the services and PMs because turnover rates are high and people change positions every few years. Most of the time, they do not manage a program for even one complete phase of development. Accountability is even lower among politicians influencing the decisions and contractors taking advantage of this reality because it is hard to relate actions taken to the overall outcome of inadequate actions, and influence is hard to prove. The Joint Capabilities Integration and Development System[26] (JCIDS) introduced yet another source of inefficiency to the acquisition process. The goal was to achieve more ‘jointness’ to all programs, reduce redundancy among the services, and foster interoperability within the

[26] For a detailed historical background and discussion of the JCIDS process see U.S. military Program Management, Garret, Gregory A. / Rendon, Rene G., Chapter 2.

forces. JCIDS is a top down process, but the expertise that is really needed is strongly related to the experience of Combatant Commanders, who are not well versed in the JCIDS or acquisition processes.

Other important factors are organizational structures of the DoD and the acquisition workforce itself. They reflect the needs to handle the tasks in which they were designed. We can use organizational structure theories to investigate aspects of suitability, function, adaptability, and general fit. According to Mintzberg,[27] organizational structure can be related to the structures efficiency in dealing with uncertainty in an environment that is characterized by stability and complexity. There are two ways to produce undesirable outcomes. One is to use the wrong structure for the environment, and the other possibility is to use the wrong people or processes. Both observations can be made by examining the structures on different levels of the DoD environment and performing a stakeholder analysis of all the key players in the acquisition process. The results of this examination will make clear a few of the less obvious interdependencies and relations within the complex structure of the acquisition and DoD environment.

b. Legal Restrictions

The amount of legal restrictions[28] and regulations is a barrier to an efficient acquisition processes. The rules imposed provide guidance but current legal restrictions are so numerous that they actually hamper the flexibility needed in a changing acquisition environment. Because there are so many laws and regulations, some of the opportunities of the current legal framework are not fully understood or followed by the acquisition workforce. A costly example of this fact is the lack of understanding of the implications of subpart 13.5 within the FAR dealing with simplified acquisition procedures for commercial items up to a certain monetary threshold. This section was implemented to reduce transaction costs, ease acquisition processes and reduce

[27] Organizational Design: Fashion or Fit, Henry Mintzberg, Harward Business Review 1981.

[28] A small excerpt from all legally binding documents is presented in Table 3, 4 and 5.

acquisition time pressures[29]. Statuaries and regulations and continuous changes to the FAR are so enormous that the acquisition workforce has trouble keeping up with and correctly implementing them. In addition, many laws and regulations are designed to implement desired societal or democratic principles, not improve acquisition efficiencies. In addition to difficulty to keep up with the flood of laws, rules, regulations and directives these documents sometimes restrict competition among the few global contractors that are globally available to produce a major weapon system. This is unfortunately and partially contradicts the goals of the FAR as the FAR principles state that the amount of competition should be maximized whenever possible[30]. One example for legally restricting competition opportunities is the Buy American Act that hampers full use of globally available technology and contractors.

c. Lack of Communication and Oversight

Many acquisition programs suffer from a lack of communication and poor oversight. The fear of losing a program or admitting to an unexpected negative event has a negative influence on the communication of problems and solutions that make a program successful; errors that are easily resolved in their early stages accumulate until they become serious. In some cases, the program must be cancelled due to this accumulation. The schedule and costs needed in fixing these issues may become a major threat to the program.

d. Management and People Issues

Creating a new system requires significant management, coordination, and communication among many different people. This can become an issue if there are personal barriers that slow this process. Involved parties should be professional enough to overcome these issues, but this is not always the case.

[29] As stated during class MN3304, Yoder Cory.

[30] See also FAR, subpart 1.102 Statement of Guiding Principles for the Federal Acquisition System.

e. Lack of Understanding and Changing Requirements

A lack of understanding can be caused by poor translation or misunderstanding, and is a critical issue to the overall success of a program. Requirements that are wrong, unclear or misunderstood can be fatal to the success of a program. Requirements not defined clearly and agreed upon will inevitably lead to warfighter attributes that cannot be met by the system and will likely be considered inadequate. The relationship is well characterized by the following quote: "Why did we build the wrong thing? Because we could not get the requirements right."[31] The same underlying problem was articulated earlier with a different twist by Yogi Berra: "You got to be careful if you don't know where you going, because you might not get there!" This is unacceptable. Sometimes the missing function cannot be easily implemented, if at all, into the system if it is discovered too late in the acquisition process, such as during live-firing and testing. Faults during the first steps of the process will cause irreversible problems in scheduling, cost, and performance in the new system.

Stakeholders also contribute to this area of problems. During the different stages of the acquisition process, when the system is beginning to coalesce, stakeholders add or change system requirements. This practice is as bad as it is common. The operational requirements were formulated according to the initial need to close the capability gap. The requirement analysis should have addressed all requirements that are needed to achieve this goal Therefore, there should be no necessity to add new requirements unless specifically driven from unforeseen changes in the threat or to take advantage of a truly compelling opportunity.

The real need for requirement changes must be related to the change in the gap that has to be closed. This rarely happens. Most of the time, additional or augmented requirements have nothing to with the operational environment of the new system. These changes entail redundant capabilities, unnecessary items, and irrelevant opportunities. These are serious threats to the program because they consume development time, integration efforts, software development interfaces, testing needs, and other unplanned

[31] As stated during class MN3309, Naegle Brad.

activities. They reduce the available budget needed to fulfil the essential requirements. The additional requirements are especially damaging if the new system was designed for a specific gap and the mission suddenly expands well beyond the initial requirements.

f. External Forces

Changes in law and policies, general budget cuts, or funding for specific parts of a program are a major impact on the success and efficiency of an acquisition program. Some changes are not predictable, such as rapidly evolving crises or threats that must be solved by adapting capabilities, missions, and funding.

E. MORE DETAILED DISCUSSION OF IMPORTANT PROBLEM AREAS

This section analyzes why requirements and external forces are of special interest. The findings of this analysis will identify recurring patterns that must be avoided in the future. The solutions to these patterns will enhance the chances for successful system development.

1. Formulation of Requirements

a. Operational Requirements

Formulation of requirements applies to both hardware and software requirements. Both are generated from the operational requirements communicated by the user. This area needs special attention because every mistake in elaborating, formulating and translating those requirements into functional design will result in a function that is not represented correctly and further isolate functionality away from the user's need.

Why should the requirements be the first thing to start with if it is so difficult to get them correct? The answer is simple, but difficult to accomplish within the complex acquisition environment of the DoD: requirements are the boundaries of what is needed, and also describe all necessary functions that must be accomplished. From this starting point, the rest can be deduced.

An example might clarify this difficult point. Let us assume there is an island state and because of the proximity to an influential and powerful neighbour state this island feels threatened. The island state decides to develop a “protection system” to protect itself. Up to this point everything seems to be logical and easy to understand, however, this is typically where difficulties begin. The protection of the island state represents a capability gap that must be closed at the start of a major acquisition program. It is easy to go awry attempting to plan the ‘protection capability’ efficiently and affordably without unnecessary redundancies; there are many opinions about the “right” solution to this problem. Operational requirements are useful in deciding which way to proceed. They can help describe an optimal solution because they are free of biases. The requirements focus only on closing the capability gap according to the operational parameters of the state’s special situation. A parallel process that is needed for the successful creation of the new system has begun. It faces four basic challenges at this point:

1. The operational requirements must be correct. This requires significant communication, clarification, and feedback between the developer, customer, and the other stakeholders. Incorrect assumptions or requirements will produce additional and unneeded capabilities with negative impact on cost and schedule, or even worse, will not close the threat gap as a whole and leave the country vulnerable. This is anything but desirable.

2. The requirements then have to be clearly defined and stated. While simply stated, this is can be incredibly complicated process. There are likely many interpretations of the term ‘protection’ that need to be explored.

3. All stakeholders involved must understand the requirements. Precisely communicating a particular requirement with high confidence that the communication was well understood is not an easy task. Again, the requirements will likely be subject to interpretation despite all attempts to clearly communicate them.

4. Requirement changes and additions must be kept to a minimum. All necessary requirements should be fully identified, correctly stated, and implemented.

These four pitfalls must be overcome to enter the next step: translating the operational requirements into functional requirements.

b. Functional Requirements

The purpose of functional requirements is to identify functions that are needed to satisfy the operational requirements and create warfighting capability. In the aforementioned example, functional requirements would be ‘protection’ against air invasion, missile threat, amphibious landing etc., depending on the operational environment. Notice that the functional needs still focus on the need, or in other words, what must be done, not how this particular goal is achieved. The functional requirement analysis links every requirement to one or more functions that must be met to satisfy the need. This traceability is necessary to address all needed requirements and prevent redundant capabilities that are already accessible. This is essential to develop a system that fits the task and is efficient and economically reasonable. The functional analysis also investigates the best approaches, such as hardware, software, or manpower for completing functions; it identifies support and maintenance needs; and it gives the new system a rough skeleton consisting of requirements and structure.

2. Poorly Defined Requirements

Requirements that remain unclear invite interpretation, errors and rework once the mistake is discovered. Defining the requirements concretely is the key to enabling the right follow through of activities in the development process. Poorly defined requirements lead to deviations within the system, causing inefficiencies, frustration for customers and contractors, and endangerment of the required system performance. Unclear requirements are a major threat to the development of a good acquisition strategy; if assumptions are incorrect, they lead to wrong decisions and poorly defined objectives for a contractor’s legal obligations.

3. Late Changes in the Acquisition Process

Late changes and requirement creep are inevitable and endanger the success of a program. They occur frequently without being based on changes to the operational needs. Politicians, the services, and the users have to understand that adding a requirement means significant reengineering of the software component. Modern weapon systems are sophisticated; their physical design, software programs, multiple interfaces, and integration needs are not well suited for late changes because late changes can drive a drastically different design or solution causing significant reengineering and scrap of work already completed. Insisting on additional requirements often leads to integration problems, high costs, and poorer system performance. In the worst case, the system may be rendered complete uselessness[32], but unfortunately, understanding of the probable impacts of late changes is not widespread.

4. Differences in Testing Requirements

Testing is expensive. This valuable part of evaluation in the acquisition process is often underfunded because the benefits of adequate testing are not fully understood. Thorough testing is not a luxury of the program. It provides evidence that requirements have been met, the system works reliably and safely under all conditions. In addition to these aspects testing creates confidence, and gathers data that is essential to future capability technological advancements.

5. Lack of Mutual Understanding about Operational, Support and Maintenance Needs and Schedule

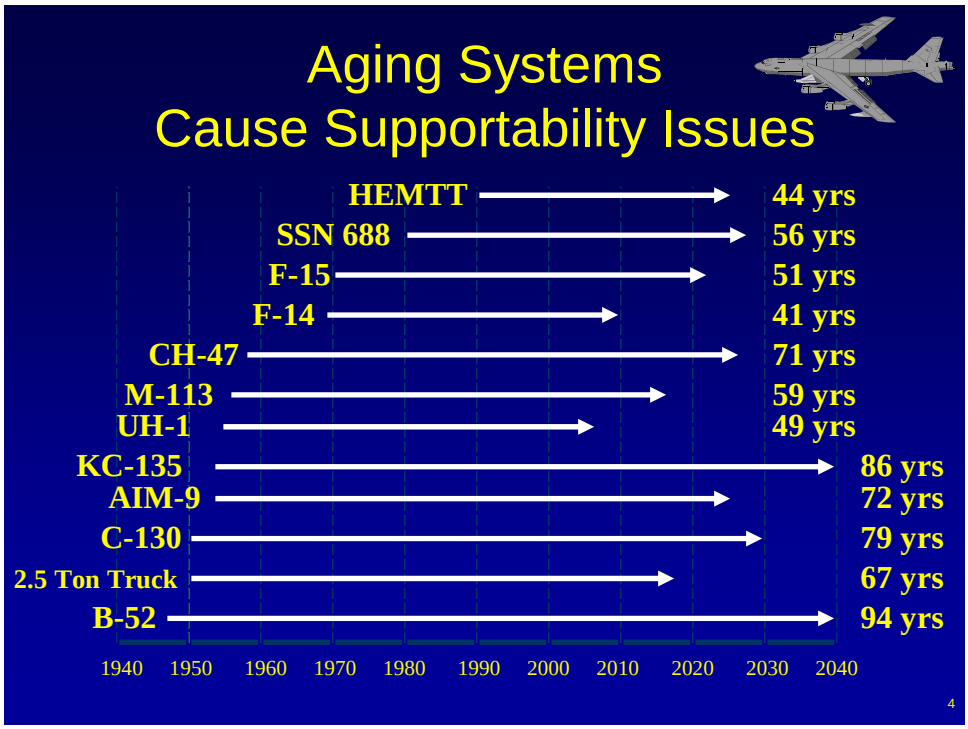
The government provides funding for new systems to close capability gaps and encounter threats to the country. It also expects a system to survive as long as it is needed for its task. System engineers plan for the system as long as a customer he intends to use it.

[32] A program that suffered from the last three segments was the A12 A Avenger II. The program was cancelled after only three years. At that point the aircraft was already two years behind schedule, 1,3 Billion dollars over cost and had 8000 pounds overweight.

Sometimes, these life-cycles are not aligned at their beginning. This causes cost problems in the use, reduced availability and life-cycle of the system. Operational requirements or conflict may cause a system to be used more than expected, which causes accelerated wear and tear, higher maintenance support efforts, and operational costs during wartime. These circumstances cannot be planned for, but cost expectations for prolonged life-cycles and excessive use can be calculated and predicted. The government and services often have goals for intended economic useful life spans, but do not communicate them to the contractor. This may be unintentional; they forget to update the information before the program starts. It may also be intentional; they know that longer life-cycles go hand-in-hand with higher system-costs. As already stated, system and life cycle costs can determine whether a program is initiated, as well as the total planned number of systems to acquire. This view is short sighted; the contractor should be provided the expected system life-cycle, especially if it might be considerably longer[33]. The following depiction shows that this is not rare. Most systems are designed for an average life-cycle of about 25 to 30 years.

[33] This basically applies to all aircrafts and many other systems in use, see examples on table 1 below.

Table 1. Aging Systems Cause Supportability Issues



Source: MN3331 lecture slide, Professor Rene G. Rendon, NPS

The point is, if a new system stays in service considerably longer than it was designed for, there is a major impact, especially on the Operations and Support (O & S) life-cycle costs (LCC) and supportability[34] expenditures. If the contractor is aware of planned system economic useful life, the system design and design for supportability will likely be properly architected. In the long run, this will lead to a more robust design that allows for further upgrades. This can be an essential factor for controlling the costs of program upgrades, which can be planned for technical refreshment, mid-life conversion, or other life cycle considerations. Communicating requirements and expectations for extended life-cycles can save significant operational and support funding over the extended life cycle.

[34] See also Systems Engineering And Analysis, Fourth edition, Blanchard/Fabrycky, p. 542, Figure 15.10.

6. Funding of Programs

a. Budgeting/Funding

Funding for acquisition programs is a complex process, burdened with numerous laws, policies, and other guidance documents. It is also vital to the program's survival.

Budgeting and the acquisition process are not aligned, and are driven by several factors. The cyclical budgeting process schedule is fixed, as required by law. Contrary to this, the schedule of an acquisition process is closely related to ongoing developments. These different methods do not mesh well.

This problem is addressed, in part, by multiple years of identified funding. However, to determine how much money is available for a program, several numbers must be considered and calculated: the amounts that are available from the different years of funding, how much has already been spent, and how much is actually needed for successful completion. This system works well for accounting and control purposes, but is not good for program flexibility and overall performance of the acquisition programs. When there is no funding available, and the PM cannot secure additional funding, a program remains idle when it could otherwise be progressing towards completion. Another problem arises when money that is available has been specified for a specific purpose, known as the "colors of money,"[35] and those specified purposes are different than the needs of the program. This leads to an insufficient amount of funding to continue development because of the use restrictions. Navigating the myriad of funding laws and directives requires a significant amount of management, reducing the amount of time PMs have to manage the system's development.

This legal background causes another challenge. The preparations for the beginning of an acquisition program must be finished early enough to fit into the fixed cycle of the budgeting process. Pressure from the services to get programs started and

[35] The expression "colors of money" refers to the fact that any funding by law is determined by purpose, time and amount. The purpose is the related appropriation, often referred to as color of money and has its origin in Title 31, USC, which is also sometimes referred to as the "Colors of Money" law.

underestimated preparation time, for things such as requirement analysis, sometime result in a program that is rushed. The haste to begin a program is the result of significant pressure: either the program starts immediately or never. The perception that deficits can be fixed at later times is almost always wrong; life-cycle costs that are overoptimistically low improve chances of initial funding for programs. Over time, the needs and practices described in the paragraph above have resulted in interesting and malicious side-effects. Two common side-effects are burden shifting[36] processes and the implementation of a misleading reward system[37]. Both have a negative impact on the overall accuracy and trust of the acquisition process.

F. ESSENTIALS OF SOFTWARE ENGINEERING AND ACQUISITION PROCESS MANAGEMENT REQUIREMENTS

1. Software Engineering Requirements

The crucial needs of software development are often misunderstood. Clear and well stated requirements are an absolute must for the success of any major program involving software. This applies to the overwhelming majority of modern systems as they are increasingly software-intensive. Service software has become an elementary part of virtually every program. The need for clearly communicated and addressed requirements covering all functional, interface, and all current and envisioned interoperability needs are vital to effective and efficient software development.

Directly related to this need is a stable developmental environment that allows the identification and establishment of a framework that the software and system can operate within. As systems become more sophisticated and complex, systems within systems become more important. These factors are major schedule and cost drivers and dependent on software engineering. The keys to success therefore, include significant early work in

[36] See also Systems Archetypes Basics, Kim Daniel H. and Anderson Virginia, Pegasus Communications, p. 25.

[37] See also On the folly of rewarding A, while hoping for B, Academy of Management Executive 1995 Vol. 9 No. 1.

requirements analysis, software development, and effective management to minimize changes to functional requirements and framework aspects.

One pitfall is inadequate predictions of the amount of software that will be needed during early system development. Coding of the software itself is rarely a problem, but late requirement and operational framework changes are time consuming, costly, and risk not being incorporated during later stages of development. Software development is very expensive during the early stages of development (up to 60% of the overall software development cost or more), and can be compromised by rework resulting from poor requirements analysis, resulting in significant cost growth and schedule slips.

2. Capability Requirements

Capability requirements are an important factor of system design and are essential for a sound system engineering process. Capability requirements are increasingly expressed in terms of performance characteristics and metrics. Together with functional requirements and operational needs, they shape the preliminary and final design of a new system during trade-offs within the system engineering process. Identification, formulation and correct prioritization of these requirements are key in developing the overall abilities, optimizing strengths, and limiting weaknesses of a new system. Weighing, examining, and balancing tradeoffs in the system engineering process is part of the analysis of alternatives.

The problem is poor communication among the services regarding the functional and operational requirements. They do not focus enough on tradeoffs and their consequences on the system design. Instead, the responsibility lies in the contractor's system engineering process, whose results depend on the interaction between IPTs[38].

[38] See also Developing Software Requirements Supporting Open Architecture Performance Goals in Critical DoD System-of-Systems, Naegle Brad, pp. 13-16.

3. Safety Requirements

Safety requirements of new systems repeatedly represent a common pitfall for the acquisition process. Sometimes, safety requirements are forgotten, poorly communicated, or assumed to be a software engineering environment.

Unfortunately there are a lot of programs that tell a different story. A system is safely handled when data transfer is secure and is robust against electronic countermeasures, hacking, and spoofing. These needs must be satisfied in an environment where equipment used by ground forces has a high risk falling into the hands of the enemy[39].

4. Interoperability and Interface Requirements

The operational framework is the most influential factor in determining the nature, complexity, and number of interfaces and interoperability needs. The operational environment in modern warfare is very complex and inhibits joint aspects, at least at the national Services level and below. More often, another level of complexity like interoperability with allied forces, is created by the net-centric nature of command and control systems and data processing systems, which aid the decision making of Combat Commanders and political leaders. The recipe for sound interoperability and reliable, robust interfaces is the selection of a correct work sequence. The easiest way to achieve this goal is to begin laying out the operating framework of the new system. The goal of the framework is sometimes not completely communicated, verified or accurately examined, which leads to problems in integration, interface suitability, and causes time consuming and costly design changes late in the acquisition process. Once the complete requirements framework is established, the design of individual components, subsystems and systems-of-systems within this framework becomes easier and less risky. Interoperability aspects and interfaces become more transparent and obvious; the amount of misinterpretations and unidentified needs are considerably reduced. The numbers of systems or system-of-systems that must interface in the depicted operational environment

[39] See also Developing Software Requirements Supporting Open Architecture Performance Goals in Critical DoD System-of-Systems, Naegle Brad, p. 24

and network sometimes face the challenge of incorporating legacy systems and equipment that was not designed for upgradeability or interoperability within the operational framework of modern warfare. Although most of the newer systems use an open-system-architecture to allow future changes, as conceivable in a significant time horizon, some of the legacy systems are difficult to integrate at all, or need significant, expensive redesigns in order to adapt to current standards. This is evident for every system incorporating only a small amount of software consisting of obsolete or unsupportable program languages, or simply did not allowing for extensions of relatively simple features like more throughput and memory.

5. Upgrade Requirements

There are tools and processes available that help to identify and determine various needs for software development. The Modular Open Systems Approach[40] helps to identify required interfaces. System engineers define areas where software support is needed to achieve system performance that can not or should not be represented by hardware. Modelling and simulation tools and software developing programs help to illustrate the complexity, total amount of software needed and how it might look like. This allows Program Managers and contractors to evaluate how suitable the software will be for the requirements stated and the amount and size of upgrades that might be needed over the life-cycle of the new system. The Modular Open Systems Approach (MOSA), consequent use of system engineering processes and a great variety of available software programs help to define how complex the new system will be. This allows system engineers, Program Managers, contractors also how complex the software package will be that is needed to satisfy the needs for interoperability, interfaces and upgradeability for the new system. The standards and metrics for software development do not match those of hardware. However, compared to the 80s and 90s, there is a better understanding of software development's needs and underlying processes. Examples of this are the older metrics of software lines of code (SLOC), which become increasingly replaced by

[40] See also "Using a Modular Open Systems Approach in Defense Acquisitions", Dr. Rene Rendon, pp. 17-19.

metrics of functional points that are more meaningful. Quality of software development has become vital to the interaction of information and first-move abilities on the battleground.

6. Life-Cycle Requirements

Software development and requirements have an important impact a system's life-cycle. Software requirements are likely to change over the life-cycle of the system. If a good software developmental process is in place, this should not be an issue, but their consequences can become one if not considered at the start of a program.

The military often uses their systems over an extended life-cycle. This is different from the commercial world, where special and operational availability needs lead to expensive systems.

Software development does not end with the delivery of a new system. There is always the need to adapt to new operational aspects, lessons learned by the users after testing, suggestions for improvement, new technology, and changes in interoperability. A second set of common challenges for software requirements relate to the supportability and maintainability of the software. The software language used, proprietary rights of the software to develop the new system, and costs of maintaining the complete life-cycle are sometimes not given enough consideration. This leads to repercussions for the overall life-cycle expenses, security needs of the software, updated availability, restrictions for full and open competition, and other factors. Long term access to the development codes for new software, proprietary rights, and security aspects must therefore be a mandatory consideration of all programs that use embedded software or software intensive applications.

G. ACQUISITION PROCESS & MANAGEMENT REQUIREMENTS

1. Capability Requirements

Capability requirements are not only of crucial importance for software as already described earlier. All requirements that try to describe the capabilities of the new system

are extremely sensitive for the overall achievements and operational success of the new system. These requirements should be performance based to allow a maximum of contractor creativity. They also should be related to metrics that can be easily evaluated and verified during developmental, operational and life-firing testing as the program moves towards fielding. If stated and prioritized correctly these requirements define the suitability and effectiveness of the new system and will contribute largely to its overall performance. Necessary trade offs have to represent the priorities of the customer and should be verified as decisions are necessary to shape the design and best solution to close the detected capability gap. All design changes with the exception of safety needs should be made prior the critical design review as late changes have a huge negative impact on cost and schedule.

There are two decisive aspects that will have a major impact on the overall cost, performance and suitability of the new system. First, all requirements must be directly traceable to functional or operational needs. Second, the user must be aware of how different prioritization of those two sets of requirements interacts with the system engineering process during the design tradeoffs, influencing cost, performance, and suitability of the system as a whole. Chain of Command, users, technical, operational experts, logistical experts, contractors and IPTs must agree before developing a new system that addresses all requirements and delivers the best economical solution possible to the warfighter. The overall suitability and performance of the system are compromised by too many opinions on the importance of single requirements. This can also lead to unnecessary costs.

The method of current requirement generation gives more weight to this argument. The top-down Joint Capabilities Integration & Development System (JCIDS) and Joint Requirements Oversight Council (JROC) do not include enough input from the Combatant Commanders regarding functional and operational needs for a new program. These inputs are not included in the acquisition process until too late, when they lead to requirement, software, and design changes. This process is inefficient, expensive, and adds an early and unnecessary risk in cost growth and schedule slips. Starting with

correct requirements and a relevant set of metrics for all functional and performance aspects of aligned system requirements is necessary for effective and efficient use of the available budget.

2. Cost Control and Transparency

Cost control and transparency are necessary for proper planning of the acquisition process and adequate stewardship of taxpayer. Congress, major defense contractors, Services, user communities, program managers and contracting experts agree that control and transparency of cost is necessary.

There is a lack of enforcement procedures, proper group and individual accountability, and rewards for cost-conscience behaviour. As a consequence, regulations and tools are in place for a lot of partial processes attempting to maintain close cost control and visibility, but these are sometimes are not well-understood nor strictly followed. Unwittingly, these measures are neglected and at times, purposely circumvented to reach individual goals.

3. Program Documentation Requirements

The documentation for a major program has become a large burden in the acquisition process. Proper documentation is clearly beneficial and necessary, but it does hinder the acquisition process and contribute to higher program costs. This was especially true from the late eighties until the beginning of the 21st century, before documentation efforts shifted towards electronic media, which is easier to change and does not incur high costs from reprints. Too much pressure on acquisition programs often leads to slips in proper documentation and any delay in documentation deliveries is usually a sign of a an over-worked staff struggling to keep up with the documentation requirements while managing the development of complex systems.

4. Legal Requirements

The flood of legal statuaries, regulations, and guidelines has become a definite challenge to the acquisition workforce. Program Managers must understand the variety,

and impact, of legal restrictions that apply to their program. They must work closely together with a diminished and less experienced contracting workforce to make sure the contract for the new acquisition conforms to all regulations and legal restrictions. The requirements have been developed by the IPTs to meet acquisition process goals, so that troops receive the best, affordable technical solutions as soon as possible. Now these requirements have to be transformed into a binding legal contract that is free of arbitrary formulations, contains all information needed by the contractor and incorporates all performance based metrics that are essential for the program. This is a challenging task and a decisive phase of the acquisition process.

Especially when requirements or important performance parameters are not met by contractors, a contract can be the only leverage available to the government, so it needs to be clear. Developing necessary requirements and articulating them clearly to different stakeholders is very difficult, even if this process was well planned and successfully implemented into the request for proposal (RFP). A sufficient level of work breakdown structure (WBS) in the solicitation and contracting documents is just as important. Both processes need a sufficient schedule to support development success during the rest of procurement.

Environments for the acquisition process are different. They span from stable, well planned system replacements, to contingency contracts. These environments can incorporate the need for complex systems, a research effort to make new cutting edge technologies mature enough to use for defense needs. Those environments include unstable and rapidly changing environments like unconventional warfare, terrorism and other new global challenges. . This is the reason why the legal framework must allow several approaches for acquisition procedures & processes, and several levels of competition and contracting methodologies to accommodate different situations.

This does not only apply to current legal restrictions, but also to basic regulations and laws that hamper full and open competition. Analysis of alternatives (AoA) is one step that benefits from the system engineering process. This powerful tool for competition should not be compromised by legal restrictions if there are other options for addressing security and national interests.

5. Operational and Performance Requirements

Realistic and measurable formulation of operational and performance requirements is vital to the acquisition process. Late design changes, bad trade-off decisions, delays, and cost and schedule overruns are almost inevitable if requirements are not fully formulated. For the purpose, there is no difference between traditional development, commercial off the shelf (COTS), or non developmental items (NDI). A wrong classification of COTS or NDI due to poorly defined or lack of requirements will have tremendous impact on the cost, schedule, and performance of the envisioned system acquisition. There were expensive and painful experiences during the aircraft T-45 and A 12 procurement.[41][42]

Realistic and measurable operational and performance requirements formulation is vital part of the acquisition process. Without enough effort on this basic early step, changes, late design changes, bad tradeoffs, delays cost and schedule overruns are almost inevitable and just a matter of time to occur within the program. There is no difference for this section whether we talk about traditional development or commercial off the shelf (COTS) or non developmental items (NDI). A wrong classification of a system as COTS or NDI due to poorly defined requirements or lack of requirements analysis will have a tremendous impact on cost schedule and performance of the envisioned acquisition of a system.

6. Maintenance and Supportability Requirements

The reality of acquisition reveals that if a program comes under funding pressure, whether due to cost or schedule overruns, there are usually two reactions. What is likely to happen first is a reduction of the program's unit numbers[43].

[41] See „The T45 T/S A Case Study", GB 4450/MN4470.

[42] As stated in a brief on system engineering lessons learned from different programs during SI4011 class, May 2007.

[43] See as an example change in production numbers for the F 35 JSF.

Table 2. Changes in JSF Program Purchase Quantities and Costs

November 1996(program start)	October 2001(system development start)	December 2003[a] (rebaseline)	December 2005[a](latest available data)	
Expected Quantities				
Development quantities	10	14	14	15
Procurement quantities (U.S. only)	2,978	2,852	2,443	2,443
Total Quantities	**2,988**	**2,866**	**2,457**	**2,458**
Cost Estimates (Then Year $ in billions)				
Development	$24.8	$34.4	$44.8	$44.5
Procurement	Not available	196.6	199.8	231.7
Other	Not available	2.0	0.2	0.2
Total Program Acquisition	**Not available**	**$233.0**	**$244.8**	**$276.5[b]**
Unit Cost Estimates (Then Year $ in millions)				
Program acquisition	Not available	$81	$100	$112
Average procurement	Not available	69	82	95
Estimated Delivery Dates				
First operational aircraft delivery	2007	2008	2009	2009
Initial operational capability	2010	2010-2012	2012-2013	2012-2015[c]

Source: GAO Report 07-360, p. 5

This strategy leads to less cost savings than anticipated due its negative impact on This is partially caused by spreading the fixed cost on fewer units but also by changing stress levels on material and increased times of operation for those units. This can lead to increased life-cycle cost and is unfortunately not given enough thought. Programs experiencing a substantial cut in production numbers typically lead to unit costs that were higher than originally envisioned[44]. This should never happen for short term savings. Cuts in procurement numbers are very common and can be an indicator of an incomprehensive and short-sighted view of these cuts' effects on the acquisition costs because they have a major impact on the costs of long term lifecycles. Operational availability of the system will be lower as the flight hours on single units will be higher and result in more failures than envisioned. As there are fewer units used over a longer period as planned, maintenance turn-around time will be longer as higher stress is placed on the material. An insufficient level of spare parts might even be an additional consequence of an increased burden on the material. A significant cut in numbers combined with a false estimated reliability between failures can even lead to a temporary

[44] See Joint Strike Fighter program as an example (GAO report 07-360, p. 5, 7.

or constant unavailability of the new system. In addition to this problem the life-cycle cost for legacy systems might also increase due to higher maintenance cost as they have to be kept in service until a certain number of the new system replacing it is available.

H. CHALLENGES & OPPORTUNITIES

1. Flexible Budgets

Changing the budgeting process and funding laws is difficult to achieve, but smart decisions in this area save taxpayer's money and reap huge benefits. Some changes can be implemented over time if the impacts and consequences of the suggestions are understood and properly addressed.

Sub-optimized practices and relationships contribute to the waste of resources and reward system inefficiencies. The schedule driven budget cycle must support the event driven acquisition cycle more functionally. This includes the necessary amendments to budgeting laws and procedures, which will eliminate waste in the current processes. There must be incentives for all stakeholders, including members of Congress, major defense contractors, the Services, and the acquisition community, to make the right decisions, encourage honest and accurate estimations, and reward the efficient use of taxpayer money.

2. Higher Accountability for Services

The Services must take more pride in their ownership of new programs. Warfighters need support throughout the procurement process in order to deliver a usable solution, or "best bang for the buck" systems. Because overall numbers decline and manpower resources become scarce, there must be enough capabilities to assign users to the different programs and involve them early. This also applies to Combatant Commanders, whose contributions in requirement generation, evaluation and testing are mandatory to quickly detect misfits, design miscues, and suitability issues. This is a vital role in the success of the program.

The current fight over different concepts and popular programs hurts the Services and users more than anything else. Once supplementary funding is deeply curtailed or eliminated, the distribution fight among the Services will intensify. The Services must understand that this behaviour is not helpful to anyone. Duplicate capabilities are a waste of resources and should be reduced or eliminated. The efforts to achieve the desired joint capabilities must be aligned. This would allow the Services to contribute their strengths and share the burdens and responsibilities of modern warfare equally. The solution is to stop fighting over resources.

This competition over funding can appear to be driven by parochial interests rather than any real warfighter need. This mode of thought is counterproductive to achieving weapon systems that are flexible and capable enough to meet the future needs of net-centric warfare and increased interdependencies. The pride of the Services cannot come before the best interests of the warfighters and taxpayers in decision making. Increasing monetary pressures will be a decisive factor driving a development within the civilian and political environment into a healthier direction based on the real needs of the Services over time.

3. Less Misuse of the Funding and Acquisition Processes

The Services and their acquisition forces are the least powerful stakeholders in the acquisition process. Nevertheless, they are assigned responsibility whenever an error occurs in a procurement program. This is true no matter whether it is Congress cutting funding in an irresponsible way, contractors trying to maximize profits on an ambiguous contract, or if the user/combat developer communities are providing poor program requirements.

The acquisition workforce itself has made the best of this situation inventively. There are many bad practices that can be observed throughout various programs. Program Managers and contractors start their programs with overoptimistic assumptions regarding their schedule and cost. Once the program starts and the first problems appear they are quite often ignored and not aggressively addressed. This happens because some contractors and Program Managers did not expect to deal with a difficult situation early

in the acquisition process and fear for their program. This tends to happen especially if a major problem surfaces at this early stage of the process that might result in a cancellation of the program or major cut to it's funding.. Unfortunately, this causes the problem to arise later, when it is too late to solve or too costly to redesign. The contractor is not interested in disclosing the problem until production because the program might be cancelled early, and usually does not make any significant profit until the production phase. The result of this delayed fault detection and recovery is late design changes, which overruns cost and schedule.

Program managers have learned how to get support for their programs, establish connections with members of the Congress. They know how to drain funding from programs that suffer for any reason or can not spend their appropriated funding within the given time constraints. While other, less experienced programs are hammered for cost and schedule overruns, program managers gain additional reserves for small uncertainties and glitches in their program.

At the end of the fiscal year, every Program Manager prepares contingency plans. They include preparation of contracts they could sign immediately to spend money that other programs were not able to contract could not before the accounts expired.

4. Better Quality for the Warfighters

Every stakeholder should behave in the best interest of the overarching goal to achieve the best possible results for affordable warfighter capability. The goal of the acquisition process is to deliver the most suitable, capable, affordable, and current solution to the warfighter. This calls for robust designs resulting in high quality products that are easy to maintain, support and dispose of. Accurate requirements, incentives, and flexible rules and regulations are powerful tools that contribute to this task; small changes in attitude and behaviour can also make a significant difference in estimations of cost and schedule, and boost performance for the new systems needed. Aligned software and hardware requirements, and strategic partnerships among all stakeholders, will deliver better quality, more quickly, and at lower prices to customers.

5. More Trust in the System

Re-establishing a flow of processes that are transparent and meet the goals of the acquisition process, the current debate over programs that are more expensive and prolonged than originally planned must be ended. Huge organizations like the DoD adapt slowly, and inhibit change. It is necessary that incentives, which are generally slow, do not cannibalize strengths as a price of change.

I. CONCLUSIONS

The generation and alignment of requirements for software and hardware for new major defense programs are complex processes themselves. Aligning requirements among the different stakeholders within an organization as large and diverse as the Department of Defense is difficult and requires the understanding of the stakeholders with regard to their contribution, role and responsibility in the acquisition process. Key stakeholders outside of DoD, like members of Congress, the Media, and Lobbyists make it even more difficult for the acquisition community to deliver effective and suitable capabilities to warfighters. Nevertheless requirements generation, implementation and verification will remain one of the major challenges for the future. It will be decisive to change current procedures to allow a better preparation of this essential work before the start and contracting of new programs.

No new regulation, changed process, or single source can solve the challenges of this unique business environment. It will be individual stakeholders who will create a successful and efficient program. Their passion and supportive interaction is what will make a real difference. The acquisition workforce will need tools that are flexible enough to deal with long term planned replacement of systems, urgent battlefield needs, commercial items acquisition and contingency acquisition at the same time. The legal framework has to allow this flexibility, maintain contractor oversight and foster competition

A variety of new, different approaches are discussed below in the recommendation section. Only a mix of the effort, honesty, willingness, and cooperation

of individuals in the acquisition process will create positive change. As an additional challenge, there is a common resistance to change in organizations. There are also tradeoffs in their organizational structure and ability to support attributes like efficiency, adaptability and creativity. The Acquisition workforce has to be big and experienced enough to deal with these challenges and should be allowed to operate in an environment that imposes as few legal restrictions as possible but enough guidance to focus on efficient use of taxpayer money and high quality products for their customers. This approach will increase individual responsibilities on one hand and accountability for decisions and actions on the other hand.

J. RECOMMENDATIONS

1. Software Requirements and Software Development

a. Software Planning and Requirements Formulation

Software planning and requirements formulation are a very tough tasks. It is common for the complexity of functional needs and environments to be partially unknown in the early phases of software planning. The formulation of requirements involves at least some insight into the actual coding language and processes. . This is important not so much which language is actually used for coding but to ensure the coding language is sate of the art and will be sustainable over the envisioned lifetime of the new system. The most time and money goes into configuring the architectural framework and laying out the software design this complex process to sort out the functional needs that will be represented by the software, needed interfaces and data flow, amounts, and interdependencies. Coding is usually a minor problem. This can easily lead to the misperception that coding immediately produces the expected results, but this is not the case. To verify that the software meets the actual needs a considerable amount of testing is still mandatory.

Testing is important. To achieve reliable results in coding, the rule of thumb is “code a little, test a lot.” Statistics can be discouraging; software development

lacks history and experience when compared to most hardware development, which uses mature processes and metrics. The software environment is immature.

There is professional help available to provide competent assistance with the software development challenge. A major professional institution to assist is the Software Engineering Institute[45]. This organization is federally funded and can provide a lot of assistance in a great variety of developing and interoperability aspects of a major program. It should be used, which is the first recommendation. Seeking help from commercial programs, information websites, and federally funded institutions like the SEI can help accommodate the special needs for a program. A small variety of available software tools is listed in Table 6, but there are many more possibilities for assistance or obtaining a deeper insight into software development techniques.

The second recommendation is to develop an IPT that allows the software developer to obtain all information necessary about the operational background of the new system. Contrary to the current JCIDS process, this information should be obtained by the combatant commanders, who are most familiar with user needs, and approved in the JCIDS process. This will ensure alignment with military doctrine as well as joint and net-centric perspectives. The detected capability gap will be more understood and articulated and redundant capabilities within the Services will no longer be produced.

After the operational requirements are fully developed, there must be a constant exchange of information between the users and the software developers so that any identified requirements changes are discovered early in the process, before significant reengineering is required.

b. Contractors, Software Development and Coding

Software development requires an experienced and mature developer. Software developers should be comfortable with the prime contractor's specific environment as well as the unique governmental needs and procedures. This can be

[45] Software Engineering Institute, http://www.sei.cmu.edu/ ast. Last accessed February 2008.

achieved by fostering strategic partnerships with the few contractors who have proven to be capable of producing results that meet the needs of the government.

Another need is an IPT of users and software coders. This is required to maintain close control of the software development and provide software coders with necessary information about integration, common, current systems, and data presentation and exchange for facilitate effective software. Better results will be produced with less training for the new system, and therefore the numbers and size of errors, changes and late modifications to the user's requirements will be reduced.

Applying software metrics to this phase is also necessary. The contractor must be aware that his efforts to develop the software are appreciated, but also that inefficient procedures, excessive coding scrap, and poor results are not acceptable. This includes a metric for suitable an efficient coding. SLOCs are no longer an effective metric for software development. Numbers of functional points or other functionally oriented metrics are now used. An even better ratio of functional points represented by lines of codes used to achieve this goal should be requested. However, this ratio will be different depending on the maturity of the technique that must be represented, moved, provide data, or aid decisions. Nevertheless, this thought can be captured in a matrix, and better efficiency can be requested as part of a long term, strategic partnership. Incentives for efficient coding and thorough testing will produce faster results with higher quality.

c. Software Security and Maintenance

Software security and maintenance are valid concerns in every major weapon, information, and network system. A lot of emphasis is placed on establishing joint and net-centric warfare capabilities for warfighters. Large, complex networks, information systems, and data handling systems are especially vulnerable to espionage, hacking, spoofing, electronic countermeasures and exposure to the enemy. This applies particularly to ground and airborne systems. High value targets must be protected during wartime from any deterioration of capabilities to maintain information superiority and provide soldiers with the ability to make decisions, move first, and take advantage of surprise. This goal can be achieved by protecting crucial systems like satellites, networks,

and internet. These systems should be virtually unbreakable so they are always available when needed. Another method of achieving this is, once the network is safe, is to allow small software updates that are not downward compatible and protected.

2. Operational and Functional Hardware Requirements

a. Requirements Formulation

Operational and functional requirement formulation must be the job of experienced users on the battlefield. Combatant Commanders, pilots, and platoon leaders are good examples. The operational aspect is best represented by the Combatant Commanders level; functional needs are closely related to users like pilots and leaders on the ground.

The Combatant Commanders have a significant role in formulating requirements. They distinguish actual “needs” from “nice to have” demands. They are the most suitable individuals for this decision because they have the required level of operational insight and are near enough to the battlefield that they will not cut out essential attributes needed for success in the intended environment. However, Combatant Commanders do not have enough time to explicitly draft requirements for closing detected capability gaps. This problem could be solved if requirement specialists were easily accessible to them. The specialist would prepare preliminary performance specifications to be reviewed by the Combatant Commander and JCIDS process.

b. Requirements/Implementation

Requirements can be difficult to grasp, formulize or phrase. It is even more difficult to translate requirements into a language that leaves no room for ambiguity and gives contractors all the information necessary to understand the operational environment, complexity of work, and technological risks involved in the new system.

The first recommendation is to use contracting specialists. Once a requirement is clear and approved, it should reviewed by a contract specialist. In an ideal case, there would be only a few questions about incentives and metrics needed to verify

and incentivize the performance. When the requirement is implemented into the contract, it is essential that the contractor has the same interpretation of the stated requirement as its developers.

Apart from a detailed RFP and solicitation, a pre- award conference with possible contractors is the best alternative to communicate the government's needs to the contractors. This could eliminate a lot of confusion, but requires detailed and professional preparation by the government. The contractor must demonstrate, in a pre-award conference, an understanding of the complexity, functional needs, and risks incorporated in the requirements. This means they must be given access to critical information before the conference in order to prepare.

c. Performance Control

There has been a huge amount of effort put into creating, wording, and implementing requirements into the contract; so much that the important step of linking them to the expected performance is diluted. Every requirement must be traceable to measurable performance metrics within the program. The current reward structure and incentives for the contractor must directly relate to these metrics to at least meet the objectives as stated in the contract. No fees or awards should be paid for objectives covering mandatory items of the contract. However, there must be enough incentives for delivering superior quality and performance on or ahead of schedule. A matrix of possible incentives is presented in Table 7. A current problem is the lack of incentives for a contractor to perform well and deliver quality and capabilities that exceed the government requirements. This is especially true for contracts that provide award fees on performance as stated in the contract. Every incentive given to a contractor should be based on verification and non arbitrary or ambiguous metrics and data. These incentives need to adapt to the needs of every single program, and suggest a more suitable incentive structure than ones in the past.

3. Acquisition Process and Management

a. Funding

Funding for the Department of Defense is based on four major factors: percentage of GDP, national needs in other departments, security environment, and requests from the Department of Defense. The first recommendation is to reverse the process of funding. Congress and the President of the United States must agree on a budget for the Department of Defense based on the criteria above. Once the amount is determined, the Secretary of Defense and the Joint Chiefs of Staff should prioritize national defense needs according to suggestions of the Services, based on the insights of their Combattant Commanders for new programs and their justification. Once this priority list is established, money should be divided among programs suggested by the Services in an order governed by this list. The President, Secretary of Defense, Joint Chiefs of Staff, and Service Chiefs would shift programs producing redundant capabilities to a specific Service, or they would be cancelled.

The Accountability of the Services would be greater, if they were not competing for money directly from their sister Services, but instead for a fair partial share depending on national security, joint and network needs, and their unique capabilities. When the Services know how much money to expect, they can develop a plan for distributing it to programs that contribute the most to national needs. Everything that is not covered in this plan, like inadequate numbers of units within a program or smaller programs will appear in a gap list. This will identify the program, its least operational units/systems, how many of those units are desired, and how many are covered by funding. With these numbers, the Department of Defense could reach a compromise with Congress over additional funding and major contractors capable of providing the systems according to the budget. With this reversed flow, unit numbers and prices become much more reliable, and planning by contractors, the Services, and Department of Defense becomes easier.

Another change should be implemented for time effective appropriation of money. Money that can not be spent during final three months should be partially

recoverable by the Services if a plan for the use of this money in the upcoming fiscal year for a purpose can be provided. An incentive to save money could definitely be reached at a share ratio Treasury/Service of 30/70 or above.

These recommendations are not easily achieved. They ask for a considerable change of legal framework and individual attitude. Nevertheless, they seem to be worthwhile in the long run because they address several problem areas: jealousy among the Services, the influence of lobbyists and parochial working politicians, and dishonesty in projections of cost and schedule.

b. Cutting Edge Technologies

New materials, technological breakthroughs, and unprecedented technological capabilities are fascinating, but they come at a price. The research and development of new cutting edge technologies is costly, takes time, and bears the risk of total failure because of unexpected technical difficulties, material problems, and immature software. Regardless of this, requirement requests for these technologies are implemented in too many major programs.

R&D efforts before the beginning of a program are insufficient, and there are too many immature components demanded. SBIRS high is a good example of the common mistake of rushing too early into a program without understanding the necessary background: complexity, software size, maturity level of components, and other challenges. Fascination with future possibilities impedes reasonable and intensive risk analysis. Overoptimistic assumptions lead to decisions lacking adequate standards, knowledge and wisdom.

Development of those high risk areas must be separated from the program, and be treated like an upgrade that, although planned for, is not absolutely certain. It is better to delay a program an extra year to clarify maturity levels and build realistic confidence in the program than it is to rush into production without proper knowledge. The costs and schedule delays of programs where immature technology was accepted during CDR or production should have taught this lesson.

Money must be appropriated before for cutting edge technology is implemented into a program. The Department of Defense can assist in identifying promising technology to implement in future programs. The defense industry can provide information regarding the release dates of these technologies with a reasonable monetary effort; this will achieve the maturity needed for implementation into defense related programs. Industry and government must be mutually patient. While one must wait for technology to mature before introducing into defense programs, the other must wait to earn the money necessary to nurture this maturity.

Technology must remain relevant enough to maintain an advantage over the enemy. Depending on the complexity of the system, this can mean gathering information, processing data, denying information and intelligence, moving first, or destroying targets while maintaining low vulnerability. When the lives of soldiers are involved, winning by only a margin is certainly not desirable.

Scarce budget resources force the consideration of cutting back on these technologies. These technologies should not be renounced, but allowed the opportunity for maturity and better performance after upgrades. New open architectures provide this opportunity; A vast number of programs could prevent many problems, risk, and uncertainty. We must implement a better sanity check available to the acquisition community to decide whether cutting edge technology is mature enough to be implemented into a program or not. The maturity levels for components alone does not provide enough information as it evaluates partial aspects only but does not incorporate the integration and interface requirements of multiple components for modern systems-of-systems. The contractor can provide this information if they are not pressed to develop cutting edge technology and their program simultaneously, while under considerable schedule pressure.

c. Legal Restrictions

A factor that that has not been discussed yet is the impact of current legal restrictions on the acquisition process itself. The lists in Tables 3, 4 and 5 illustrate the amount of guidance, laws and regulations that apply to the acquisition process. For

Program Management the AKSS /DAU website list 529 mandatory documents that apply, for Software Acquisition Management alone 60 binding documents. It is assumed that these are intended to assist the acquisition workforce. Unfortunately, every major scandal and unsuccessful program was followed by an outcry from Congress for more regulations and guidance in the hope of eliminating the problem, but additional oversight adds to the management burden and may actually have an opposite result.

The diminished contracting workforce cannot keep up with updates, new regulations, and changing guidelines. The intended purpose of assisting them is missed. The flood of regulations, laws and guidance hampers their ability to do their job. Many laws and regulations apply to an era of stable environments during the Cold War, when conventional planning for war and economies largely focused on continental needs. But the environment has changed. Global economies and interdependencies, national and social needs, regional conflicts and asymmetric warfare need different planning, guidelines and laws to guide the way.

Global interdependencies drive the first recommendation. It is time to share responsibilities and privileges equally among allies. The demand for more adjustment, consultation, and combined effort is essential for addressing global challenges and threats in the near and long term future. National protection of defense contractors is a limiting factor to competition and a waste of resources. Like sharing capabilities within the Services, allies have to share their defense industry capabilities to allow competition, better pricing, and quality warfighting capabilities.

The U.S. is no exception. The Buy American Act is a legacy that does not fit a global economies and defense efforts perspective. Sharing technologies among allies reduces procurement cost and produces innovation and higher levels of standardization. The security issue within this approach can be solved with a similar approach to the one discussed in the section about software security and maintenance. The impact on the defense industry would be more competition, and the danger for national workplaces could be minimized by arrangements where the systems are actually produced. Opening up national restrictions will allow a broader base of expertise and production. Cooperation in developing future systems will also stabilize.(See page 13)

d. Acquisition Flexibility

Change in the acquisition environment calls for a variety of acquisition tools and processes. Some of the new procurement methods are evident in the area of contingency contracting. This type of procurement will be a part of fast responses to imminent needs in the future, especially during times of war. Lessons learned from recent years are applied, like the need for more continuous oversight and clearly expressed requirements, are useful for satisfying urgent needs.

FAR part 13.5[46] contains an opportunity for easing the acquisition process for commercial item acquisition that is widely not applied. This particular section of the FAR is dedicated to easy acquisition procedures and save transaction costs to reduce the workload for the acquisition and contracting workforce. This section's implications, as intended by Congress, are not commonly known or practiced. This section can save the Services approximately $9300 per transaction[47] and significantly reduce the workload. Last year alone, the Navy alone had 60,000 transactions that would have qualified under this section[48]. A simple clarification and reminder to all contracting specialists could reduce their workload and initiate instant savings.

To use the latest improvements to diminish legal restrictions for procurement efforts and enhance acquisition flexibility like the Federal Acquisition Reform Act (FARA), Federal Acquisition Streamlining Act (FASA) and Service Acquisition Reform Act (SARA) are additional opportunities to booster commercial item acquisition and competition..

Global changes, different war environments and smaller armed services have created another challenge that requires focus and oversight. About 60% of the acquisition budget has already been spent on services, most of which are outsourced to civilian contractors. So much money is involved that promises made by the contractors

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[46] See also FAR, part 13 Simplified Acquisition Procedures, subpart 13.5 Test Program for Certain Commercial Items.

[47] According to comments in MN3304 contacting class, Yoder Cory.

[48] According to comments in MN3304 contracting class, Yoder Cory.

and random controls are not reliable. There is a need for a workforce large enough for constant oversight over performance, progress of the contract, and clear metrics for evaluation of their performance. Many complaints about lost money during contingency contracting and service contracts implicate the lack of availability and responsibility for oversight and follow up of the project or service. Evaluations based simply on the completion of a project are arbitrary, and do not achieve the best results possible based on the money used.

Early service pioneers like postal services, catering agencies, warehouses, construction businesses and maintenance branches provide great models for the evaluation criteria that will allow a better determination of contractor performances. Combined with realistic requirement descriptions, these criteria will produce better results from outsourced services.

K. SUMMARY

The present difficulties in the acquisition process do not mean it is a broken system. Many aspects of the acquisition process have improved over time because of many adjustments made and lessons that have been incorporated into the best practices and regulations. There are deficiencies that must be addressed, but this is not an uncommon occurrence for complex organizations and processes. Sometimes the acquisition and contracting community is held responsible for inefficiencies, bad judgements and political decisions. They knew the decisions were wrong as far as the efficiency of the acquisition process was concerned, but could not prevent those decisions. As a consequence they suffered from those decisions made at a level out of their range of control. to be made and suffered from the consequences of those decisions out of their range of control. This should a frustration; there was no way to avoid this from happening, which is proof of the need for change and optimization in these processes. As economics, political and social environments, global challenges and war change, processes, regulations and laws need to adapt accordingly. It is impossible to keep up because the acquisition process cannot change over night, and requirements rapidly change as experienced in recent years. The acquisition process is adaptive. As the

best practices and learning are applied to current acquisition processes, they become more reliable. They will become even more reliable as more of the budget is spent on commercial services, which are easier to apply than cutting edge software, hardware, and program development. The identification of software and hardware-requirements, and their alignment with the different processes will always be crucial. This allows new systems within the right framework begin, as well as save money, allow quick procurement, and deliver the highest quality available to warfighters.

L. FUTURE RESEARCH

Future research is needed in the problem areas mentioned that but not explicitly covered. The most interesting fields at this point are:

1. Behaviour of the DoD acquisition process regarding resistance to change in policy and change[49].
2. The willingness off political forces to align budgeting with the needs of the acquisition process.
3. The influence of changes in the acquisition process moving towards a joint acquisition authority, rather than the sole responsibility of the services for "their" programs.
4. The impact of an increasing amount of the defense budget for use on contractor services, and the government's ability to require new systems and modernize equipment.
5. How building strategic partnerships with contractors can reduce contracting regulations and save costs.

[49] See also Business Dynamics, Systems Thinking and Modeling for a Complex World, Sterman John D., p. 10, Chapter 1.1.2.

Exerpts from laws, regulations and guideline documents for the acquisition process[50]

Table 3. Federal Law

2006 Quadrennial Defense Review (QDR) Strategic Communication (SC) Execution Roadmap
Bid Protests at GAO: A Descriptive Guide Sixth Edition
Changes to Process Standards Canceled Without Replacement on Existing Contracts Under the Single Process Initiative
DoC Guide on Section 845/804 Other Transactions OTs for Prototype Projects
DoD Evaluating the Price of Commercial Items in a Sole-Source EnvironmentInformation GuideVolume 2
DOL Employment Law Guide
DOL Federal Contract Compliance Manual
E-Authentication Guidance for Federal Agencies
EX. ORD 12995, Amendment to EX. ORD. NO.12873; Federal Acquisition, Recycling, and Waste Prevention
EX. ORD NO. 13148; Greening the Government through Leadership in Environmental Management
EX. ORD. NO.11514; Protection and Enhancement of Environmental Quality
EX. ORD. NO.12114; Environmental Effects Abroad of Major Federal Actions
EX. ORD. NO.12196; Occupational Safety and Health Programs for Federal Employees
EX. ORD. NO.12591 Facilitating Access to Science and Technology
EX. ORD. NO.12770; Metric Usage in Federal Government Programs
EX. ORD. NO.12829 National Industrial Security Program
EX. ORD. NO.12856; Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements
EX. ORD. NO.12885; Amendment To Executive Order No.12829
EX. ORD. NO.12958 Classified National Security Information
EX. ORD. NO.12968 Access to Classified Information
EX. ORD. NO.13010 Critical Infrastructure Protection
EX. ORD. NO.13025; Amendment to EO 13010; Presidents Commission on Critical Infrastructure Protection
EX. ORD. NO.13026; Administration of Export Controls on Encryption Products
EX. ORD. NO.13041 Further Amendment to Executive Order 13010
EX. ORD. NO.13064 Further Amendment to Executive Order 13010; Critical Infrastructure Protection
EX. ORDER NO. 13392; Improving Agency Disclosure of Information
Ex.Ord. 13423 Strenghening Federal Environmental, Energy, and Transporation Management
Executive Order: Providing Opportunities for Service-Disabled Veteran Businesses to Increase Their Federal Contracting and Subcontracting
Executive Order: Strengthening Federal Environmental, Energy, and Transportation Management
Export Administration Regulations Database
Field Manual (FM) 3-100.21 (formerly FM 200-21), Contractors on the Battlefield
GSA Acquisition Letter V 04-05: Purchases on Behalf of Other Agencies
Industrial Security Letter ISL 2006-02
Instructions for Modular Open Systems Approach (MOSA) Implementation; USD (AT&L) Memo
MARCOR Project Officers Certification and Accreditation Handbook E. Certification Analysis Requirements
MARCOR Systems Cost Analysis Handbook E. Life Cycle Cost Estimate (LCCE) Example
MARCOR Systems Cost Analysis Handbook II. Users Manual, Summary Version Life Cycle Cost Model (SVLCCM),Version 3.2
NAVSUP P-505 Preparing Hazardous Materials for Military Air Shipments

[50] See also https://akss.dau.mil/Lists/Policy/Documents/ for more information.

Federal Law (continued)

OFPP Memorandum, “Directly Interested Party” Clarification Memo
OFPP Memorandum, 2005 Alternative Dispute Resolution Awards in Acquisition
OFPP Memorandum, Agency Requirement for a plan to Transition to the Federal Procurement Data System (FPDS)
OFPP Memorandum, Avoiding Duplication of Agency Activities with the Presidential E-Government and Lines of Business Initiatives
OFPP Memorandum, Buy American Reporting Requirement
OFPP Memorandum, Buying Accessible Electronic and Information Technology and Complying with Section 508 of the Rehabilitation Act
OFPP Memorandum, Contractor Responsibility Determinations and Indefinite-Delivery Contracts
OFPP Memorandum, Developing the Acquisition Management Skills of the Architectural and Engineering Workforce
OFPP Memorandum, Development of “Green” Plans for Competetive Sourcing
OFPP Memorandum, Establishment of Interagency Acquisition Working Group
OFPP Memorandum, Federal Acquisition Institute Board of Directors Charter
OFPP Memorandum, Implementing Management Controls to Support Increased Micro-purchase Threshold for Hurricane Katrina Rescue and Relief Operations
OFPP Memorandum, Implementing Strategic Sourcing
OFPP Memorandum, Limitation on Use of Special Micro-purchase Threshold Authority for Hurricane Katrina Rescue and Relief Operations
OFPP Memorandum, M-02-05, Use of Government Purchase and Travel Cards
OFPP Memorandum, M-04-12, Performance Periods in Public-Private Competitions
OFPP Memorandum, M-05-01, Report to Congress on FY 2004 Competitive Soourcing Efforts
OFPP Memorandum, M-06-01, Report to Congress on FY 2005 Competitive Sourcing Efforts
OFPP Memorandum, Publication of Brand Name Justifications
OFPP Memorandum, Recession of Monthly Reporting on Electronic Commerce Statistics to the General Services Administration
OFPP Memorandum, Report on Competitive Sourcing Results, Fiscal Year 2004
OFPP Memorandum, Request Contracting Information on Contractors Operating in Iraq
OFPP Memorandum, Revised FAR Process
OFPP Memorandum, The Federal Acquisition Certification in Contracting Program
OFPP Memorandum, The Presidents Welfare to Work Program
OFPP Memorandum, Update on the Electronic Subcontracting Reporting System
OFPP Memorandum, Utilization of Commercially Available Online Procurement Services
OFPP Policy Letter 05-01, Developing and Managing the Acquisition Workforce
OFPP Policy Letter 80-1; Section 211 of Public Law 95-507, Subcontracting: Agency Coordination with the Small Business Administration Resident Procurement Center Representatives
OFPP Policy Letter 80-2, Supp 1; Regulatory Guidance on Section 211; of Public Law 95-507
OFPP Policy Letter 80-4; Womens Business Enterprise Program
OFPP Policy Letter 91-3; Reporting Nonconforming Products
OFPP Policy Letter 92-1; Inherently Governmental Functions
OFPP Policy Letter 92-4; Procurement of Environmentally-Sound and Energy-Efficient Products and Services
OFPP Policy Letter 93-1 (Reissued); Management Oversight of Service Contracting
OFPP Policy Letter 99-1, Small Business Procurement Goals
OMB Circular A-1; Bureau of the Budgets System of Circulars and Bulletins to Executive Departments and Establishments; Revised
OMB Circular A-102; Grants and Cooperative Agreements With State and Local Governments; Revised
OMB Circular A-109; Major Systems Acquisitions
OMB Circular A-11; Preparing and Submitting Budget Estimates
OMB Circular A-110; Uniform Administrative Requirements for Grants and Agreements With Institutions of Higher Education, Hospitals,...;
OMB Circular A-122; Cost Principles for Nonprofit Organizations

Federal Law (continued)

OMB Circular A-123; Management Accountability and Control
OMB Circular A-126; Improving the Management and Use of Government Aircraft; (Revised)
OMB Circular A-127; Financial Management Systems; Revised -- Transmittal Letter 2
OMB Circular A-129; Policies for Federal Credit Programs and Non-Tax Receivables
OMB Circular A-130 Management of Federal Information Resources
OMB Circular A-131; Value Engineering
OMB Circular A-133; Audits of States, Local Governments, and Non-Profit Institutions
OMB Circular A-134; Financial Accounting Principles and Standards
OMB Circular A-135; Management of Federal Advisory Committees
OMB Circular A-136, Financial Reporting Requirements
OMB Circular A-16; Coordination of Surveying, Mapping, and Related Spatial Data Activities; Revised
OMB Circular A-19; Legislative Coordination and Clearance; Revised
OMB Circular A-21; Cost Principles for Educational Institutions
OMB Circular A-25; User Charges; Revised -- (Transmittal Memorandum No.1)
OMB Circular A-34; Instruction on Budget (Superceded by OMB Circular A-11, Part 4) Execution
OMB Circular A-45; Rental and Construction of Government Quarters; (Revised)
OMB Circular A-50; Audit Followup; Revised
OMB Circular A-76
OMB Circular A-76 (Revised) Transmittal Memorandum No.22; Performance of Commercial Activities
OMB Circular A-76; Revised Supplemental Handbook; Performance of Commercial Activities
OMB Circular A-76; Transmittal Memorandum No.20; Implementation of the Federal Activities Inventory Reform Act of 1998 (Public Law 105-270) (FAIR Act)
OMB Circular A-87; Cost Principles for State, Local and Indian Tribal Governments; Revised
OMB Circular A-89; Federal Domestic Assistance Program Information; Revised
OMB Circular A-94; Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs; Revised
OMB Circular A-97; Rules and Regulations Permitting Federal Agencies to Provide Specialized or Technical Services to State and Local Units of Government Under Title III of the Intergovernmental
OMB M-3-14, Reducing Cost and Improving Quality in Federal Purchases of Software
OMB Memorandum 04-07, Report to Congress on FY 2003 Competitive Sourcing Efforts
OMB Memorandum M-00-07 Incorporating and Funding Security in Information Systems Investments
OMB Memorandum; Compensation Benchmark Amount Pursuant to Section 808 of Public Law 105-85
OMB Privacy Policies and Data Collection on DoD Public Web Sites
Presidential Policy on Offsets in Military Export
Protests, Claims, and Alternative Dispute Resolution (ADR) as Factors in Past Performance and Source Selection Decisions
SECNAVINST 5510.36A DEPARTMENT OF THE NAVY (DON) INFORMATION SECURITY PROGRAM (ISP) INSTRUCTION
Technology Protection -- ProgramManagement Education
United States Code

Table 4. Statutory Laws

2006 Quadrennial Defense Review (QDR) Strategic Communication (SC) Execution Roadmap
Clean Air Act, 42 U.S.C. s/s 7401 (1970)
Clean Water Act
Clinger-Cohen Act of 1996
Comprehensive Environmental Response, Compensation, and Liability Act (Superfund), 42 U.S.C. s/s 9601, (1980)
DoD 4500.9-R Defense Transportation Regulation, Pt II, Cargo Movement, Attachment V7, FMS Shipments
Emergency Planning & Community Right to Know Act, 42 U.S.C. 11001
Endangered Species Act, 7 U.S.C. 136; 16 U.S.C. 460, (1973)
Environmental Impact Analysis Process (EIAP), 32 CFR 989
Federal Acquisition Reform Act (FARA) of 1996
Federal Acquisition Streamlining Act (FASA)
Federal Information Security Management Act
Freedom of Information Act, 5 U.S.C. s/s 552 (1996)
Marine Protection, Research, and Sanctuaries Act, 33 USC 1401, (1972)
Military Munitions Rule, 42 U.S.C. s/s 300f, (1974)
National Environmental Policy Act, 42 USC, Sections 4321 thru 4347
Noise Control Act, 42 USC 4901, (1996)
Occupational Safety and Health Act, 29 U.S.C. 651, (1970)
Oil Pollution Act, 33 U.S.C. 2702 to 2761
P. L. 107-347 U. S. Code 44 Ch 36, E-Government Act of 2002
P. L. 108-375 SEC. 811. RAPID ACQUISITION AUTHORITY TO RESPOND TO COMBAT EMERGENCIES.
P.L. 100-235 -- (H.R. 145); Computer Security Act of 1987
P.L. 100-533 -- (H.R. 5050); Womens Business Ownership Act of 1988
P.L. 104-106; National Defense Authorization Act for Fiscal Year 1996
P.L. 104-13; Paperwork Reduction Act of 1995
P.L. 104-164 -- (H.R. 3121); Defense and Security Assistance Improvements
P.L. 104-320; The Administrative Dispute Resolution Act of 1996
P.L. 106-79; Department of Defense Appropriations Act, 2000 (Excepts)
P.L. 107-314; Bob Stump National Defense Authorization Act for Fiscal Year 2003
P.L. 97-255 -- (H.R. 1526); Federal Managers Financial Integrity Act of 1982
Pollution Prevention Act 1990, 42 U.S.C. 13101 and 13102, (1990)
Privacy Act of 1974 5 U.S.C. Â§ 552a
Resource Conservation & Recovery Act (RCRA), 42 U.S.C. s/s 6901, (1976)
Section 8088, Public Law 107-248 Registering Financial Management Information Technology Systems with DoD Chief Information Officer
Section 8102 DoD Appropriations Act.doc, P.L. 106-259, Section 8102 (DoD Appropriations Act, 2001)
Services Acquisition Reform Act (SARA) of 2003.
Title 10, Part II, Chapter 87, Section 1702USD/AT&L Authorities and Reponsibilities
Title 10, Part II, Chapter 87, Section 1703Director of Acquisition Education, Training, and Career Development
Title 10, Part II, Chapter 87, Section 1704:Service acquisition executives: authorities and responsibilities
Title 10, Part II, Chapter 87, Section 1721:Designation of Acquisition Positions
Title 10, Part II, Chapter 87, Section 1723:General education, training, and experience requirements
Title 10, Part II, Chapter 87, Section 1724:Contracting positions qualification requirements
Title 10, Part II, Chapter 87, Section 1725:Office of Personnel Management Approval
Title 10, Part II, Chapter 87, Section 1731:Acquisition Corps in General.
Title 10, Part II, Chapter 87, Section 1732:Selection Criteria and Procedures
Title 10, Part II, Chapter 87, Section 1733:Critical Acquisition Positions
Title 10, Part II, Chapter 87, Section 1734:Career Development
Title 10, Part II, Chapter 87, Section 1735:Education, training, and experience requirements for critical acquisition positions
Title 10, Part II, Chapter 87, Section 1737:Definitions and General Provisions
Title 10, Part II, Chapter 87, Section 1741:Policies and programs: establishment and implementation
Title 10, Part II, Chapter 87, Section 1742:Intern Program

Statutory Laws (continued)

Title 10, Part II, Chapter 87, Section 1745:Additional education and training programs available to acquisition personnel
Title 10, Part II, Chapter 87, Section 1746:Defense acquisition university structure
Title 10, Part II, Chapter 87, Section 1761:Management Information Systems
Title 10, Part II, Chpater 87, Section 1701, Management Policies
Title 10, Part II, Chpater 87, Section 1764, Repealed
Title 10, Part IV, Chapter 146, Section 2460: Definition of depot-level maintenance and repair
Title 10, Section 139, U.S.C., Director of Test and Evaluation
Title 10, Section 2302, U.S. Code, Definitions
Title 10, Section 2302d, U.S.Code - Major system: definitional threshold amounts
Title 10, Section 2341, U.S.C., Authority to acquire logistic support, supplies, and services for elements of the armed forces deployed outside the United States
Title 10, Section 2342, U.S.C., Cross-servicing agreements
Title 10, Section 2350a, U.S.C.,Cooperative Research and Development Projects: Allied Countries
Title 10, Section 2364, U.S.C., Coordination and Communication of Defense Research Activities
Title 10, Section 2366, U.S.C., Major Systems and Munitions Programs: Survivability and Lethality Testing Required Before Full-scale Production
Title 10, Section 2377, U.S.C., Preference for Acquisition of Commercial Items
Title 10, Section 2399, U.S.C., Operational Test and Evaluation of Defense Acquisition Programs
Title 10, Section 2400, U.S.C., Low-rate Initial Production of New Systems
Title 10, Section 2430, U.S.C., Major Defense Acquisition Program Defined
Title 10, Section 2432, U.S.C., Selected Acquisition Reports
Title 10, Section 2433, U.S.C., Unit Cost Reports
Title 10, Section 2434, U.S.C., Independent Cost Estimates; Operational Manpower Requirements
Title 10, Section 2435, U.S.C., Baseline Description
Title 10, Section 2440, U.S.C., Technology and Industrial Base Plans
Title 10, Section 2464, U.S.C., Core Logistics Functions
Title 10, Section 2466, U.S.C., Limitations on the Performance of Depot-Level Maintenance of Material
Title 10, Section 2469, U.S.C., Contracts to Perform Workloads Previously Performed by Depot-Level Activities of the Department of Defense; Requirement of Competition
Title 10, Section 2531, U.S.C., Defense memoranda of understanding and related agreements
Title 10, Section II, Chapter 87, Section 1722:Career Development
Title 10, U.S. Military Forces Military Law
Title 10. Section II, Chapter 87, Section 1705:Directors of Acquisition Career Management in the military departments
Title 15, Section 644, U.S. Code, Awards or Contracts
Title 22, Section 2751, U.S.C., Need for international defense cooperation and military export controls; Presidential waiver; report to Congress; arms sales policy
Title 44, Chapter 31, Records Management by Federal Agencies
Title 47, Section 305, U.S.C., Government-Owned Stations
Title 47, Section 901, U.S.C., Definitions; findings; policy (National Telecommunications & Information Administration
Title 47, Section 902, Establishment; assignment functions (National Telecon & Information Administrtion)
Title 47, Section 903, U.S.C., Spectrum management activities, (National Telecommunications & Information Administration)
Title 47, Section 904, U.S.C., General administrative provisions
Title 5, Section 306, U.S.C., Strategic Plans (part of the Government Performance and Results Act)
U.S. Code 10, Chapter 131, Sec. 2220. - Performance based management: acquisition programs

Table 5. Federal Acquisition Regulation (Supplements)

AFARS Part 5123, Environment, Conservation, Occupational Safety, and Drug-Free Workplace
AFARS Part 5125, Foreign Acquisition
AFFARS -- Part 5325; Foreign Acquisition; AFAC 96-2
AFMCFARS -- Part 5325; Foreign Acquisition
Air Combat Command FAR Supplement (ACCFARS)
Air Education & Training Command FAR Supplement (AETCFARS)
Air Force FAR Supplement (AFFARS)
Air Force Materiel Command FAR Supplement (AFMCFARS)
Air Force Reserve Command FAR Supplement (AFRC)
Air Force Space Command FAR Supplement (AFSPCFARS)
Air Mobility Command FAR Supplement (AMCFARS)
Army Federal Acquisition Regulation Manual No. 2 (Contingency Contracting)
Army Federal Acquisition Regulation Supplement (AFARS)
Defense Federal Acquisition Regulation Supplement, Procedures, Guidance & Information (DFARS PGI)
Department of Energy FAR Supplement (DEARS)
Environmental Protection Agency Acquisition Regulation (EPAAR)
FORSCOM FAR Supplements
General Services Administration Acquisition Manual (GSAM)
MARCOR Systems Cost Analysis Handbook D.15. Material Consumption
National Aeronautics and Space Administration FAR Supplement (NFS)
National Guard FAR Supplement (NGFARS)
Navy Marine Corps Acquisition Regulation Supplement(NMCARS)
NMCARS Part 5225; Foreign Acquisition; Through Change 97-15
Performance-Based Service Acquisition (PBSA)
U.S. Army Corps of Engineers FAR Supplement (EFARS)
U.S. Special Operations Command FAR Supplement (SOFARS)

Table 6. Helpful tools for developing software[51]

Name	Organization	Owner Organization	Topic
Aircraft Sustainability Model (ASM 7)	**Air Force**	**AFMC**	**AF spec to Action Officers**
Pre-Award Information Exchange System (PIXS 5.0)	**Air Force**	**ASC/SYG**	
SEER-Hardware Estimation Model (SEER-H)	**Air Force**	**ASC/FMCE**	
Formal Risk Analysis (FRISK 4.00)	**Air Force**	**SMC/FMC COTS-Aerospace Corp**	**Cost Management**
PRICE TruePlanning	**Air Force**	**ASC/FMCE**	**Price Estimating - Contracting**
Process Analysis and Project Integrated Environment	**Air Force**	**SMC/Det 11**	**Project Management**
Data Item Descriptions Advisor	**Air Force**	**AFMC**	**Requirements**
Cost/Risk Identification & Management System (CRIMS Air Force SAF/AQXR Send Email	**Air Force**	**SAF/AQXR**	**Risk Assessment**
Security Information Management System (SIMS)	**Air Force**	**AFML/COTS-SIMS Software**	**Security Management**
Applied Computational Fluid Dynamics (ACFD)	**Air Force**	**Eglin Air Force Base**	**Modeling Sim**
AFTOC Management Information System	**Air Force**	**SAF/AFCAA**	**Total Ownership Cost**
Risk AoA (Predictive Risk Analysis for the AoA process)	**Air Force**	**AFMC**	**Cost Analysis; Project Management; Risk Assessment**

[51] See also AT&L Knowledge Sharing System https://akss.dau.mil/default.aspx.

Table 7. Incentives to boost contractor performance

Incentive	**Based on***
Share of cost savings at a certain rate	Cost savings for the government
Additional profit / increased production numbers / strategic partnership with long term contracts	Enhanced mission capabilities in the stated operational environment due to exceeded government requirements
Additional profit or increased production numbers	Design for easy ubgradeability/ interoperability
Additional profit	Better quality and increased MTBF, AoA
Additional profit	Better maintenance support over an extended life-cycle
Additional profit	Low amount of software maintenance needed
Additional profit	Low amount of maintenance needed
Additional profit	Low amount of training needed

*the different sections have to be supported by clear metrics to justify being eligible for an increased amount of profit or other benefit.

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