FIST & THE ANALYTICAL HIERARCHY PROCESS: COMPARATIVE MODELING

THESIS

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Abstract

FIST is an emerging and unproven rapid acquisition model. There are four FIST values that stand for *Fast*, *Inexpensive*, *Simple*, and *Tiny* and 18 FIST activities. The premise of the FIST theory is that programs that emphasize these four values will be successful in delivering weapon systems on time and within budget by utilizing the tools and activities presented in the FIST model.

The purpose of this research was to develop an Analytical Hierarchy Process (AHP) model to be applied as a comparative tool against the original FIST model. The AHP model is developed through an experiment that surveys project managers from military and civilian sectors. The results determine the strengths, weaknesses, repeatability, and validity of the FIST model. Additionally, recommendations are provided for future use and improvements of the FIST framework. As an added benefit, value differences between different segments of program managers are examined to determine if there are any ideological disconnects in the community.

The results suggest that the FIST model is reproducible with the AHP theory and that there are certain program characteristics that denote if a program would benefit from being developed by FIST. However, there are distinct weaknesses to the model that signify not all programs would succeed if FIST was employed during development. Eleven additional activities are recommended for inclusion in the FIST model. Overall, FIST is a starting point that requires additional attributes to truly be among the viable solutions to the Department of Defense acquisition problem.

Dedicated to my wife and newborn daughter. Thank you for all the support, encouragement, and understanding.

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Trevor A. Gustafson

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FIST & THE ANALYTICAL HIERARCHY PROCESS: COMPARATIVE MODELING

I. Introduction

Ward (2004) created the acquisition model named FIST with the goal of producing an effective change in the United States (U.S.) Department of Defense (DoD) acquisition processes. The Analytical Hierarchy Process (AHP) is a proven decision-making theory that provides decision-makers with a framework for decomposing and structuring a decision problem. The purpose of this thesis is to create a comparative model of FIST utilizing AHP. This research tests the decision-making ability of AHP against an emerging FIST theory on successful system development and delivery.

General Issue

The U.S. DoD defines the defense acquisition system as, "The management process by which the Department of Defense provides effective, affordable, and timely systems to the users" (DoD Directive, 2003:4). According to the U.S. Government Accountability Office (GAO), the share of programs with a 25 percent or more increase in program acquisition unit cost has increased to 44 percent (GAO, 2008). This is an increase of seven percent from 2000 to 2008. A subsequent GAO report stated that the total cost of the DoD's current portfolio of 96 major defense acquisition programs has grown by over $74.4 billion, or five percent of the $1.58 trillion overall budget, in only one year (GAO, 2012). Decomposing the budget reveals acquisition inefficiencies in production attribute $31.1 billion to the growth with an additional $29.6 billion due to quantity changes (GAO, 2012). The DoD is clearly failing to provide users with the promised effective, affordable, and timely systems.

Over the next 10 years, $600 billion in budget cuts will impact the DoD. These budget cuts will lead to the "smallest U.S. Air Force in history in terms of personnel, smallest ground force since 1940, and smallest number of Navy ships since 1915" (Hodge, 2012). If budget cuts are administered indiscriminately across all programs, individual acquisition programs could realize as much as a nine percent reduction in budget. With almost half of all DoD programs already over budget, financial cuts would be devastating. American Enterprise Institute scholar Mackenzie Eaglen stated "the cut in the program side now is tending to hurt programs that are safety nets to bridge the military for the next conflict" (Hodge, 2012). U.S. military forces may be fighting future wars with outdated technology due to a failed acquisitions process.

Budget overruns are not the only problems facing DoD acquisitions. In 1986, the Packard Commission stated, "Unreasonable long acquisitions cycles – ten to fifteen years for major weapon systems is a central problem from which most other acquisition problems stem" (Blue Ribbon, 1986:8). The GAO states that the average delay in delivering initial operational capability for major defense acquisition programs has increased by 32 percent, or 23 months, since the completion of the first schedule estimates for the program. Longer development times lead to bloated budgets and technology designed to counter threats that may no longer exist (Ward, 2009:11). This was the case with the U.S. Army Comanche helicopter program that began in 1982 with the intention of countering Soviet Union capabilities. In 2004, the Army cancelled the Comanche program after having spent 22 years and $6.9 billion developing the weapon system (Ward, 2012b). No Comanche helicopters were built and the doctrinal niche that the system filled disappeared. During the Comanche's 22-year development time, new wars and threats emerged that made the Comanche's mission obsolete and too expensive to continue development. When weapon systems have too long of a development timeline, the technology becomes obsolete, and the threat may have already vanished (Ward, 2012b).

Based on the above, the current environment of DoD acquisitions produces defense programs that are inefficient, unaffordable, and behind schedule. This acquisitions environment cannot coexist with the budget cuts set to occur in 2013, and war-fighters cannot wait decades to receive new weapon systems. An effective change in the way the DoD manages the acquisition process must transpire for the war-fighter to continue to receive the weapons needed to conduct and win future wars.

Background

"Innovation is not necessarily or even primarily a function of budget. Many of the interwar innovations came at a time of low budgets and small forces" (Fitzsimonds and Van Tol, 1994:29). This idea was further developed by Ward and Quaid (2006b), who stated that restrained program budgets allow program managers to reject requirements creep and remain focused on the primary mission of the weapon system. When program managers are not allowed to use additional funding and schedule delays as tactics to solving programmatic issues, innovation often occurs to solve the problems. Innovations may include accepting reduced performance or creating cost-effective solutions. Smaller budgets produce shorter schedules because programs cannot afford a prolonged development. Shorter schedules lead to less personnel turnover in the program office and greater accountability because project managers are forced to witness the outcome of any program management oversights. Additionally, shorter schedules provide the user with a new weapon system sooner and releases funding for other programs. According to Ward (2009:1), "Smaller expenditures clearly correlate with better operational performance and… better programmatic outcomes."

Ward (2009:iv) outlines the FIST value set as an effective approach to system development, which "enhances project stability, increases project leader's control and accountability, optimizes failure, fosters 'luck,' and facilitates learning." The FIST model stands for *Fast, Inexpensive, Simple,* and *Tiny*. Project managers should emphasize these mutually reinforcing values when making programmatic decisions.

Fast is a value that can be expressed in a program through maintaining deadlines, reducing development times, and placing an emphasis on program speed. Program managers do not accept schedule delays as solutions to problems. Instead, tradeoffs are made to solve the problem within the time allotted, even at the cost of reduced system performance. Programs that value being *Fast* benefit from having increased reliability in funding and requirements, and decreased personnel turnover and obsolescence. Under this value, program offices provide the war-fighter with weapon systems ahead of schedule. Fielding weapon systems sooner allows the technology to be deployed against the threat it was designed to counter instead of decades in the future on an unknown battlefield, facing unknown threats (Ward, 2009:9-14).

Inexpensive is a trait found in programs that work within the budget and deliberately seek low-cost solutions. Program managers are willing to sacrifice project performance and attributes, as well as contractually incentivize contractors to finish under budget, to ensure program costs remain under control while meeting program objectives. Having a small budget fosters innovation because project managers must expend funds wisely and create unique, low-cost solutions (Ward, 2009). Ward (2009) states that there is an inverse relationship between cost and effectiveness; this concept means that programs become less effective when additional funding is used as a program management tool. *Inexpensive* is related to *Fast* in that small budgets cannot afford long, expensive schedules. *Inexpensive* is also related to *Simple* due to small budget programs choosing to leverage existing technology instead of developing new, unnecessary state-of-the-art technology (Ward, 2009).

The concept of *Simple* refers to maintaining a focus on meeting reasonable operational requirements and leveraging available technology. Too often, program managers, engineers, and users interpret complex technology as sophisticated solutions. Complexity and beyond state-of-the-art technology increase schedules, budgets, and risks because the program must bear the burden of developing and debugging new technology from concept to delivery. *Simple* can also be interpreted as reducing the length and complexity of formal procedures, briefings, and contracts. *Simple*, by its very definition, reinforces the values of *Fast* and *Inexpensive* (Ward, 2009).

The last value of *Tiny* is an "inescapable outcome of the three previous values. If your project is inexpensive, it has a *Tiny* budget. If it is *Fast*, it has a *Tiny* schedule. A simple project has a *Tiny* degree of complexity" (Quaid & Ward, 2006:31). The *Tiny* value means having a small project team that can effectively communicate with one another and to external parties. At some point, a large team becomes counterproductive to the program (Ward, 2009).

Problem Statement

The FIST model is an emerging and unproven theory that has not been tested thoroughly. The purpose of this thesis is to discover the strengths and weakness of the FIST model by comparing it to a proven decision-making theory, AHP. Furthermore, this research highlights if the FIST process is reproducible and reliable for analyzing acquisition programs and successful system development. Next, is FIST a valid program management tool that can be used in the acquisition community? In other words, does FIST have enough depth and thoroughness to allow a program manager to use the FIST framework to successfully manage a program? A byproduct of this research examines the value differences in the military and civilian project management communities. Lastly, areas of improvement to the FIST model and recommendations for future use are given.

Methodology

The FIST values can be used as criteria for decision-makers as they choose among alternatives and make funding decisions for programs. AHP incorporates intangible and qualitative criteria into a quantitative decision-making process. The FIST values can be applied to AHP as criteria to quantitatively establish the best choice among alternatives. Criteria weights will be derived through an experiment by polling program managers in the military and civilian industries. The FIST model's internal reliability is tested as a product of the experiment results. The AHP model is then used to create an evaluation framework for programs. This framework can be used to evaluate acquisition programs at competition or any point during development. Eleven programs from Ward's (2009) thesis will be analyzed by an AHP model based on the FIST values and FIST grading rubric.

This research produced a best-to-worst ranking of the 11 programs using the AHP model. By comparing the AHP model results with FIST results, it is hoped that insights into FIST's application, strengths, weaknesses, and repeatability can be discovered. If FIST can be substantiated to be as accurate as a proven decision-making process, such as AHP, it will significantly advance the knowledge and validity of the emerging theory. Furthermore, the internal validity of the FIST model can be determined by gaining consensus from the program management community on which aspects of the FIST model are deemed most important. FIST advertises itself to be the solution to a troubled DoD acquisition system with looming budget cuts. This research should further FIST's argument for adoption, recommend improvements, or expose FIST's limitations.

Assumptions/Limitations

The Systems Engineering Efficiency Research (SEER) project was created to provide greater visibility into the FIST model. A SEER phase I report was completed at Arizona State University by Wu and Bhattacharya (2012).   This thesis creates a comparative model of FIST and AHP. The AHP model created will investigate the 11 programs that Ward (2009) analyzed. It is assumed that Ward (2009) ranked the programs correctly using available information and the FIST scoring rubric. The AHP model will only be as accurate as the depth of information available to analyze.

Information on programs may be difficult to unearth due to individual program sensitivities, classification, and age.

Additionally, the AHP methodology limits the number of alternatives to nine (Triantaphyllou and Mann, 1995). Therefore, this research was not able to analyze all 22 programs from Ward's (2009) thesis. Lastly, the alternatives analysis will have to be conducted by only the primary researcher of this study. It would be difficult to find participants that are experts on each of the programs being evaluated. The alternatives analysis was built off of Ward's (2009) research. Since mission analysis was a significant portion of his thesis, these researches choose to search for evidence that was missing or inconclusive from his original examination.

Preview

The FIST model has been promoted as the solution to the currently unsustainable state of DoD acquisitions. Chapter II will provide an extensive literature review of related material on both the FIST model and the application of the AHP to weapon system development and screening. Chapter III will describe the methodology of creating the AHP model to which the FIST results will be compared. Furthermore, the process of analyzing and ranking the 11 weapon system programs will be described. The results of the AHP analysis will be presented in Chapter IV along with a restatement of Ward's (2009) FIST results on the same programs. Chapter V will provide a comparison of FIST to AHP and discuss the strengths, weaknesses, and any recommended improvements to the FIST model. Additionally, program characteristics will be highlighted that indicate if a program should be developed under the FIST framework.

II. Literature Review

With a development structure that has "unreasonably long acquisitions cycles" and cost overruns due to acquisition inefficiencies, the current Department of Defense (DoD) acquisition environment cannot be sustained with $600 billion in budget cuts beginning in 2013 (Blue Ribbon, 1986:8). The United States (U.S.) DoD value system rewards weapon systems under development that have large budgets, long timelines, and complex technologies. Often, this practice leads to programs that overpromise performance and overrun schedules. Ward (2009) developed FIST in an attempt to change DoD acquisitions and provide program managers with an alternative value set to utilize. The FIST model states that program managers should focus on the values of being *Fast*, *Inexpensive*, *Simple*, and *Tiny* when managing weapon system development (Ward, 2009). The proposed result is a program that remains on schedule, on budget, and delivers only the necessary technology to fulfill the capabilities required by the war-fighter. Since FIST is an emerging and less mature model, this thesis uses the proven decision-making theory of the Analytical Hierarchy Process (AHP) as a comparative model to the FIST framework.

A chronological review of FIST publications will show the evolution of the theory. Next, a brief history of AHP will be presented along with evidence that demonstrations AHP as an effective comparative model. Lastly, current literature describing project management and rapid acquisition success factors will be examined as evidence of important activities not included in the FIST model.

Relevant Research

The FIST concept has evolved from a series of publications beginning with *Doing Less with More* in which *Inexpensive* is described (Ward, 2004). *Simple* is explained in Ward's (2005) publication, *The Simplicity Cycle*. Ward (2006) introduces *Fast* through a publication entitled *It's About Time* and *Tiny* through, *FIST, Part 5*. Ward continues to publish material promoting the FIST model, its advantages, and uses.

Revolutions in Military Affairs

"Future revolutions will occur much more rapidly, offering far less time for adaptation to new methods of warfare… rapid response to changing conditions in order to survive in an intensely competitive environment is surely instruction for military affairs" (Fitzsimonds and Van Tol, 1994:29). This means that the DoD should have a flexible acquisitions system that delivers new capabilities rapidly to counter emerging threats not previously envisioned. The F-22 Raptor is an example of a program that was initiated in 1985 with a designed operational capability to counter Soviet Union fighter aircraft. By 2005, when the Initial Operating Capability (IOC) was achieved for the F-22, the Soviet Union threat no longer existed, but a new terrorist threat had emerged. The F-22 program expended $32.1 billion in procurement costs. Currently, the Raptor lacks a viable opponent and adds little value to counter the insurgency threat (Ferran et al., 2012). Although this article was written 10 years before the FIST model first appeared, it serves as support for the FIST value of *Fast*. According to Ward (2009), a *Fast* acquisition system will produce weapon systems that can counter current threats. Threats and capability gaps are not always predicted 20 years in advance to allow time for weapon development. An extended development timeline produces systems that may be obsolete at completion or worse, may not be ready when needed, thereby preventing the U.S. from winning future engagements.

The article states that often innovation stems from small budgets. Small budgets force project managers to be more resourceful and exercise unconstrained thinking to solve problems when adding cost is not a viable option (Fitzsimonds and Van Tol, 1994:29). The authors cite the development of the devastating German Blitzkrieg as an example of an innovation developed under the tight budget restrictions of the Versailles Treaty after World War I (WWI). Blitzkrieg was a revolution in military tactics that used speed, deception, and surprise to defeat a numerically superior force. Germany forced France's surrender in a 6-week campaign during World War II (WWII) using Blitzkrieg (Fitzsimonds and Van Tol, 1994:24). The Blitzkrieg development supports the FIST value of *Inexpensive* by demonstrating innovation and technology advancement with a small budget. Inexpensive technologies can prove just as effective if resourcefully employed. Furthermore, Blitzkrieg is an example of the FIST value of *Simple* since the same technology utilizing aircraft, tanks, radios, and soldiers were common to both sides in WWII. Operational exploitation of these resources allowed Blitzkrieg to become an effective, not complex, technologically-superior weapon system.

Doing Less with More: The Pitfalls of Overfunding

The FIST model is not directly mentioned in this article, but the concept is clearly being formed (Ward, 2004). This article is the first installment of a five-part series describing FIST. The purpose of this article is to describe the significance of the *Inexpensive* portion of the FIST model but also provides support for the *Fast* value.

The conclusion of the article states, “It is hard to avoid concluding that small teams + thin budgets + short timelines tends to = significant innovation and combat effectiveness” (Ward, 2004:34). This formula for success unmistakably resembles the *Fast*, *Inexpensive*, and *Tiny* aspects of FIST. Ward (2004) supported his equation with two examples of weapon system developments, the Bazooka and the M16 Assault Rifle.

The U.S. created the Bazooka during WWII with a development time of 30 days and at a cost of $19 per unit. Immediate fielding of the Bazooka allowed the war-fighter to provide critical feedback on the Bazooka’s flaws and shortcomings. The resulting feedback allowed the engineers to make corrections to the design and add necessary upgrades based on actual battlefield recommendations. Because the Bazooka was inexpensive to produce, there was little fear in allowing soldiers to combat field-test the new technology (Ward, 2004).

The M16 Assault Rifle took 20 years to develop and, like the Bazooka, initially did not perform as expected. The differences in programs are that design flaws in the Bazooka were quickly identified and corrected, allowing the weapon to be reissued during WWII. User feedback for the M16 required 20 years to be incorporated into the design of the weapon. “It does show the M16’s decades-long, disciplined, neat, orderly, and well-funded development effort didn’t guarantee the system’s operational effectiveness over the Bazooka’s month-long, quick-and-dirty, low cost approach. The key to field success in both situations was… actual field experience and direct user feedback” (Ward, 2004:32).

These two weapon system anecdotes provide the basis for the FIST model. Furthermore, the Bazooka – M16 comparison supports Ward's (2004) formula that rapid development of inexpensive and simple technologies produce superior results and combat-effective systems. Being *Fast* in weapon development is a key in this article as it allows user feedback to be directly integrated into the final product. "Technology developers tend to have facts about technology and fantasies about the operational (i.e. combat) environment. In contrast, users tend to have facts about the operational environment, and fantasies about what technology can do" (Ward, 2004:32). Being *Inexpensive* allows more units to be produced, tested, and fielded. More testing is completed on inexpensive systems because there is less fear of destroying the low-cost unit (Ward, 2004).

The last point in this article states that DoD acquisition professionals view programs that have more funding as prestigious and advantageous for their careers. Furthermore, expensive acquisition programs receive more oversight regardless of the capability or importance. Instead of rewarding successful program managers with more expensive programs, they should be challenged to oversee a program with smaller funding where mistakes cannot be overcome by a huge budget. Next, programs that provide a vital capability should be considered a major defense acquisition program (MDAP) even if the funding level is below requirements. According to the article, DoD acquisitions should start to place emphasis on programs that deliver critical capabilities to the war-fighter, not just expensive programs (Ward, 2004).

On Failure

Failures in acquisition programs are inevitable. An important aspect of the FIST model is that failures in FIST programs are optimized failures. Optimized failures are where "exposure to loss is low and opportunities for learning are high" (Ward et al., 2009:26). In traditional large programs that take decades to develop, failures are expensive with few lessons learned to prevent future project management disasters from occurring. Many of the original decision-makers in large programs have moved on to different jobs and do not have the opportunity to witness the outcome. "Learning requires both observation of the phenomena and timely reflection followed by action" (Ward et al., 2009:26).

By FIST programs maintaining fast schedules, FIST failures are more likely to convey meaningful insights to project managers because the project team is still intact to witness the consequence of their decisions. The lessons learned will be used in future programs and passed on to upcoming project managers. Additionally, since the FIST approach promotes inexpensive programs, failures are more tolerable and affordable.

In the 1990s, NASA initiated a program coined Faster, Better, Cheaper. Then NASA administrator Daniel Goldin stated, "[A] project that's 20 for 20 isn't successful. It's proof that we're playing it too safe" (Ward et al., 2009:27). Rather than measure failure based on a per-attempt basis, perhaps the acquisition community should judge failure on a per-dollar basis. This is because one failed Major Defense Acquisition Program (MDAP) could cost more than a dozen FIST program failures (Ward et al., 2009:27).

Faster, Better, Cheaper Revisited

Goldin (1992) originated NASA's goal to produce missions that were faster, better, and cheaper. In 8 years under the *Faster, Better, Cheaper* (FBC) initiative, 16 missions were launched with ten successes and six failures. Missions included "five missions to Mars, one mission to the moon, three space telescopes, two comet and asteroid rendezvous, four Earth-orbiting satellites, and one ion propulsion test vehicle" (Ward, 2010:50). One successful mission example from FBC is the Near Earth Asteroid Rendezvous (NEAR) project that launched in 1996. The program was completed in 27 months and for $122 million instead of the previously estimated $200 million. The FBC initiative was cancelled in 1999 after four out of five missions failed. The success rate was deemed unacceptably low (Ward, 2010).

Looking further into the data shows that the FBC missions were incredibly low cost. The 1997 Pathfinder mission to Mars cost one-fifteenth that of the traditionally managed Viking mission (Ward, 2010). Furthermore, all 16 FBC missions combined cost less than the Cassini mission to Saturn. For the cost of one traditional NASA mission, FBC launched ten successful missions and was able to leverage the lessons learned from an additional six failed missions. "The only real constraint on our activity is the amount of time and money we can spend. In other words, the important thing is not how much success we get out of 100 tries, but rather, how much success we get out of 100 dollars" (Ward, 2010:50).

McCurdy observed that failed FBC missions were due to project leaders having "reduced cost and schedule faster than they lessened complexity" (Ward, 2010:51). McCurdy concludes, "Engineers and other experts can reduce the cost of spaceflight and the time necessary to prepare missions for flight. Moreover, they can do so without significant loss of reliability. They can also do so with only modest reductions in spacecraft capability" (Ward, 2010:52).

Successful missions, such as NEAR, used 3-minute meetings and 12-line schedules. Additionally, many good ideas engineers created were rejected because it would have increased the schedule, budget, or both. NEAR's project manager states, "Had I incorporated even half of these good ideas, the spacecraft would never have been built. Only those changes that could be made with negligible or minimal disruption were even considered" (Ward, 2010:52).

Under FBC, NASA "created a cultural framework of principles, priorities, and values, which shaped their decision-making and guided their organizational behavior" (Ward, 2010:52). Project managers sought out solutions to problems that allowed them to maintain schedule and budget while only minimally impacting capability. FIST values are extremely similar to those found in the FBC initiative and FIST advocates programs analogous to those under FBC.

The Simplicity Cycle

The concept of *Simple* and *The Simplicity Cycle* was first described in a publication by Ward (2005) however a later, self-published book describes the concept in greater detail. Ward (2011:8) defines complexity by stating, "Lots of interconnected parts equal a high degree of complexity. Few interconnected parts equal a low degree of complexity." An efficient system should strive to have just the right amount of interconnected parts so that each component contributes to the overall operation of the system. Furthermore, an efficient system operates with as little waste and effort as possible (Ward, 2011). Figure 1 depicts the Simplicity Cycle. *Goodness* is depicted on the horizontal axis and is described as the functionality, utility, and design maturity of the program. A high level of goodness is the overall goal of the Simplicity Cycle. System *Complexity* is on the vertical axis.

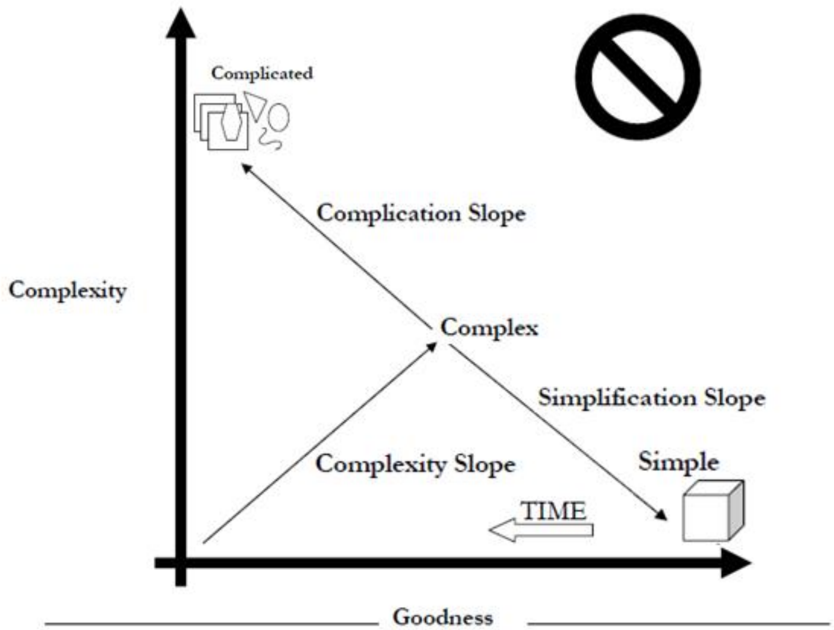


Figure 1: The Simplicity Cycle (Ward, 2011)

When development begins, programs are at the origin of the diagram. The first movement from the origin is towards the middle of the figure where *Goodness* and *Complexity* both increase proportionally.   This progress in program development is the *Complexity Slope* and "can be described as learning and creating" (Ward, 2011:18). The middle of the chart is the region of the *Complex*, in which increasing *Complexity* no longer increases *Goodness*. From this region, only two paths are possible. Continuing to the upper right quadrant is unfeasible. "There is a real danger in believing that the upper right quadrant is either reachable or desirable" (Ward, 2011:38). Eventually, every system reaches a point where *Complexity* and *Goodness* no longer increase proportionally. At this intersection, managers must decide to simplify and streamline the existing design, or to continue trying to increase *Complexity*.

One of the paths from this middle region is the *Complication Slope*. The *Complication Slope* unnecessarily increases the complexity of the system at the cost of reducing the *Goodness*. The perceived benefits gained from *Complexity* are overshadowed by the problems created. The second path out of the region of *Complex* is the *Simplification Slope*. The *Simplification Slope* represents the improvement in *Goodness* through simplifying the system and reducing the number of interconnected parts (Ward, 2011). "Complexity in this context is connected to the idea of efficiency. And a high level of complexity indicates excessive inefficiency" (Ward, 2011:26).

Complexity is necessary and unavoidable in every project. However, what Ward (2011) refers to as *complicatedness* should be avoided. *Complicatedness* is the inclusion of non-value-added parts that end up weakening the design (Ward, 2011). "Increasing complexity beyond the degree required to reach the region of the Complex actually indicates a decrease in understanding design maturity, and functional utility – that is, a decrease in goodness" (Ward, 2011:30).

At the end of the *Simplification Slope*, the product has *Goodness* with the least *Complexity* required. However, as time progresses and new technologies, trends, and threats change, the simple product has less and less *Goodness* and transitions down the x-axis toward the origin. It is at this point that the *Complexity Slope* begins again in order to improve the product and incorporate new technology. The process of learning on the *Complexity Slope* and simplifying on the *Simplification Slope* resembles a sine wave and can continue infinitely (Ward, 2011).

The Simplicity Cycle describes the *Simple* value in FIST. Creating a *Simple* weapon system does not mean that the product lacks sophistication, complexity, or technological advancements. It means that the weapon system is refined, and all the parts add value to the overall operation of the system.

It's About Time

In this article, Ward and Quaid (2006) offer a brief history of acquisition timelines and include examples from various experts to support the position that the DoD acquisition cycle is too prolonged. In 1986, the Chairman of the Joint Chiefs of Staff stated, "the most important way technology could enhance our military capability would be to cut the acquisition cycle time in half" (Ward and Quaid, 2006:14). Development timelines in the private industry for cars, aircraft, electronics, and spacecraft has decreased by 50-75 percent due to competition. The Boeing Company cannot afford to design a new aircraft unless the development time is less than two and half years. While the development trend in private industry decreases, the same trend in all branches of the military has increased or remained relatively unchanged (Ward and Quaid, 2006). Figure 2 illustrates this point by comparing the automobile industry's development timelines to the branches of the military.

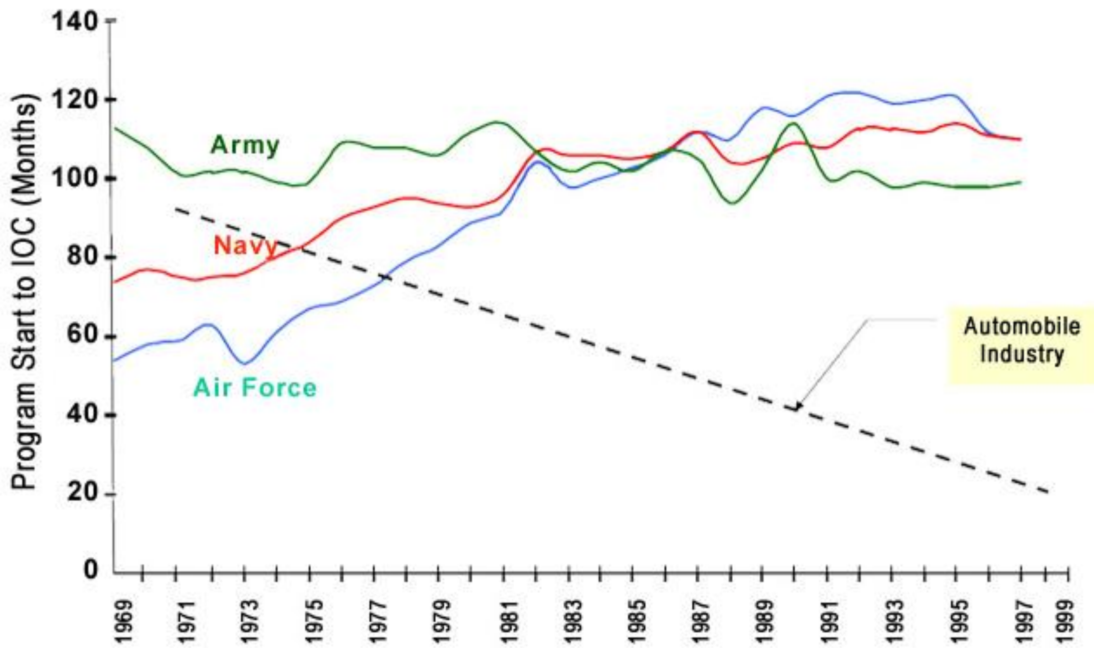


Figure 2: Average Development Cycle Times (Ward and Quaid, 2006)

The authors state that 90% of the DoD contracts contain no schedule incentive to finish early. Whether contractors finish a milestone on time or late, there is no impact. Furthermore, some contractors are even penalized if they submit a proposal that includes a schedule that finishes early. They are deemed non-responsive bidders. Without competition and incentives, the development timelines have only increased for the DoD. McNutt (1998) examined 320 defense projects and concluded that an average defense project could be completed in 50-65 percent of the scheduled time (Ward and Quaid, 2006).

Ward and Quaid (2006) emphasize that the DoD development time needs to be completed much faster. Additionally, private industry has been able to achieve shorter timelines with astonishing results. The authors conclude the article with three recommendations. First, an aggressive goal should be set to reduce development time by 50 percent. This reduction can be accomplished by individual project managers or DoD-wide. Second, "start generating, collecting, tracking, analyzing, and publishing cycle-time metrics. Then discontinue/disallow the practice of dictating schedules" (Ward and Quaid, 2006:17). Project managers should include schedule incentives in contracts and seek contractors that set aggressive schedules. Last, personnel in the acquisition system who are content with the status quo should be removed or retrained. Shortening the development timeframe may produce new issues, but program timelines should be fixed, and the resulting problems should be addressed as they arise (Ward and Quaid, 2006:17).

FIST, Part 5

This article concludes Ward and Quaid's (2006b) five-part series on FIST by describing the *Tiny* value. The authors describe the four FIST values as a "collection of philosophical assertions, designed to drive actions and inform decision-making" (Ward and Quaid, 2006b:31). To follow the FIST model properly, all aspects of a project need to be *Tiny* or no larger than necessary. Schedules, budgets, and complexity should be minimized. Large program offices, unnecessary paperwork, and complex schedules hinder programs from achieving *Tiny*. "Smaller teams are better able to communicate with internal and external team members… adding more people becomes counterproductive" (Ward and Quaid, 2006b:32). The F-16 is an example of *Tiny* in that the statement of work was 25 pages long, and contractor proposals were limited to 50 pages. The F-16 was completed in half the time and for half the price and size of its predecessors. The results are an agile fighter that is operational in 24 different countries, with over 4,000 aircraft eventually being produced (Ward and Quaid, 2006b).

The authors conclude by stating that customers already desire products that are faster, cheaper, simpler, and tiny. Such products as cell phones, computers, ATMs, and fast food are examples of this trend. "Bringing the FIST values to work simply involves approaching system development and acquisitions the same way we approach other things in life: with a preference for rapid availability, inexpensive quality, simple interfaces, and smaller sizes" (Ward and Quaid, 2006b:33).

The Effect of Values on System Development Project Outcomes

In Ward's (2009) master's thesis, 22 acquisition projects are investigated for value clues that suggest if the program incorporated *Fast*, *Inexpensive*, *Simple*, or *Tiny* elements of the FIST model. The programs receive a score of 10, 5, 0, or -5 for each of the four FIST values. Appendix A contains the FIST grading rubric used to score each program. The most *FISTy* programs receive a score of 40 and programs that appear to ignore the FIST model all together, obtain a score of -20. The programs receive an outcome score of an 'A' if the program met or surpassed operational requirements and delivered an operational capability. The programs receive an 'F' if it was cancelled, rejected by users, or failed to deliver operational capabilities. By comparing the programs' FIST score with the actual outcome, Ward (2009) attempts to validate the FIST model.

The results of Ward's (2009) analysis are in Appendix B. Six of the 22 programs have contradicting FIST and outcome scores. The F-20 Tigershark and XP-75 Eagle were both high FIST scoring programs that ended up as failures. Conversely, Ward (2009) indicates that the F-15 Eagle, C-5 Galaxy, V-22 Osprey, and NASA's Viking Mission were all low FIST scoring programs. Although these programs were an operational success, they delivered the system behind schedule and over budget. Cutting-edge technology was preferred over mature, proven technology which led to delays and cost overruns. While these programs were an operational success, the system development was far from exemplary. Two of the programs received mediocre scores, the MRAP at 15 points and the E-3 Sentry at 5 points. The MRAP and E-3 are both operationally successful but not conclusively *FISTy*. The remaining 14 programs have matching FIST and outcome scores (Ward, 2009).

Ward (2009) states that FIST enhances program stability. By being *Fast*, a program is completed in a timely manner before new developments in technology, threats, or changes in the political environment can render the system obsolete. The system can be developed quickly and avoid costly changes and enhancements that cause delay and budget overruns. By being *Inexpensive*, programs reduce the chance of having funding cut or not secured for future years. Small budget programs are less likely to have funds relinquished because there are no excess funds in the tight budget. Lastly, keeping a project *Simple* by using existing technology enhances the accuracy of the budget and schedule estimates since new technology, with many unknown factors, is not included in the program (Ward, 2009).

According to Ward (2009), FIST programs are easier to cancel because they are a smaller investment with small, streamlined teams. Many programs become so large they are impossible to cancel. The V-22 Osprey had nearly 2,000 suppliers spread across 40 states. Furthermore, Congressmen would lose too many constituent jobs if the program was cancelled. FIST programs, by design, are small in footprint, funding, and personnel. Ward (2009:86) contends that FIST is a "single idea, with four internally-consistent and mutually-reinforcing elements, not as a series of independent alternatives for project leaders to weigh against each other in trade-off analyses." Project managers should not focus on picking two elements or sacrificing one value for another. Pick all three FIST values with *Tiny* being an inescapable outcome of *Fast*, *Inexpensive*, and *Simple*. By a project being *Simple*, it will inherently have a shorter development timeline and lower costs because risky technology is not being used. On the other hand, achieving a complex, beyond-state-of-the-art technology may not be attainable with a tight budget and strict schedule. This is further evidence that FIST is a value set that must be incorporated as a single idea (Ward, 2009).

The use of mature technology in system development is a significant theme in FIST literature and for the *Simple* value. Mature technology can decrease the schedule and budget through reduced risks and greater understanding of the capability of the technology. Ward (2009:89) states "mature technology is almost always available, and project leaders need only resist the temptation to stake their outcome on a hoped-for-but-currently-unavailable technology." In support of mature technology, Ward (2009) cites a 1983 Time Magazine article that argues complex weapons cost too much, are consequently produced in less quantity, and result in questionable effectiveness. The article continues to state "whether a weapon can be afforded in adequate numbers should be a more important concern than whether it is state-of-the-art…" (Isaacson, 1983:12). Technological breakthroughs can rarely be accomplished successfully in the timeframe of a project. Project managers should leverage existing scientific discoveries and research in order to create captivating ways to deliver new capabilities.

> There is a significant difference between being Fast, Inexpensive and Simple, and merely being Hasty, Cheap and Simplistic. Adhering to a project's schedule or budget is meaningless if the necessary requirements are not satisfied by the expenditure, and mature technologies are only good if they perform the required functions. (Ward, 2009:94)

The FIST literature suggests that failure to understand the FIST values could result in a failed project. FIST is most successful when done iteratively and risky when used only once. Ward (2009) lists the following general principles to be used as FIST vectors.

FIST Heuristics (Ward, 2009:102-103)

1. Spending less time gives you more time.
2. To finish early, start early.
3. The tortoise was faster than the hare.
4. The distance between planning and execution should be as short as possible (i.e. if you wait to the last minute, it only takes a minute – so take the minute now.)
5. If I don't have enough money, don't give me more time.
6. The best way to run a program is quickly. (Gregory, 1985:162)
7. The best way to unleash talent is not to have too much of it.
8. Talent trumps process.
9. Generalize the people, specialize the tools (the Batman Principle).
10. You can't make a discovery according to a schedule.
11. Don't deal with complexity by adding more complexity. Deal with complexity by removing it.
12. Worse is better (aka the best is the enemy of the good enough).
13. Theory Y management is simpler than Theory X.
14. Complexity and reliability are inversely proportional.
15. Only ask for one miracle per program. (Rep. Heather Wilson, House Intelligence Committee)
16. Don't tinker – it increases complexity, costs time, costs money, introduces instability.
17. Increasing complexity is a cost. (Spinney, 1993:3)
18. Better, faster, cheaper – if you pick two, you'll only get two.
19. Better, faster, cheaper – pick three.
20. The project leader's influence over the development is inversely proportional to the budget and schedule.
21. FIST failures are optimized failures.

History of AHP

The history of AHP traces back to the 1960's when founder Thomas Saaty was overseeing research projects for the Arms Control and Disarmament Agency at the U.S. Department of State. Thomas Saaty is one of the forerunners of Operations Research and author of the first Mathematical Methods of Operations Research textbook and the first queuing textbook (Forman and Gass, 2001:4). During Saaty's tenure at the U.S. Department of State, he was afforded a generous budget that allowed him to be able to recruit a talented team of some of the world's leading economists and game and utility theorists. However, Saaty (1996) was disappointed with the results produced by the team, stating:

> Two things stand out in my mind from that experience. The first is that the theories and models of the scientists were often too general and abstract to be adaptable to particular weapon tradeoff needs. It was difficult for those who prepared the U.S. position to include their diverse concerns… and to come up with practical and sharp answers. The second is that the U.S. position was prepared by lawyers who had a great understanding of legal matters, but were not better than the scientists in accessing the value of the weapon systems to be traded off.

Years later at the Wharton School, Saaty (1987) recognized the absence of a practical systematic approach to decision-making and priority setting. From 1971 to 1975, Saaty (1987) developed AHP as a solution to help ordinary people solve complex decisions. Since then, AHP has received widespread acceptance in the U.S. and throughout the world. Some of the world's leading information technology companies as well as the American Society of Testing and Materials (ASTM) have implemented AHP as the "standard practice for multiattribute decision analysis" (Forman and Gass, 2001:5). Furthermore, AHP has been utilized extensively in numerous universities and in the

Central Intelligence Agency. "The best way we can describe AHP is to describe its three basic functions: (1) structuring complexity, (2) measuring on a ratio scale, and (3) synthesizing" (Forman and Gass, 2001:4).

A Hybrid Approach to Screen Weapon Systems Projects

Greiner et al. discuss the topic of the U.S. DoD making informed decisions about converting resources and development proposals into fielded weapon systems. Past research has shown that the DoD has screened, evaluated, selected, and allocated resources for programs while not taking advantage of available structured decision methodology. The authors investigate using a hybrid decision support methodology which integrates AHP with a 0-1 integer portfolio optimization modeling for screening weapon systems in development.

Their methodology uses a mathematical model created by combining AHP with integer programming to optimize a portfolio of defense programs. While AHP is a stand-alone technique that derives an overall priority for the alternatives, it cannot, however, optimize the selection of projects in light of budget, resource, technology, and other constraints. Integer programming is utilized to provide this optimization capability to the model. This model is applied to 15 historical developmental programs with six independent Air Force personnel acting as evaluators (Greiner et al., 2003).

The model provides each of the 15 programs a *fully fund* or *do not fund* status. Three overall funding solutions are developed by the model. The original Air Force solution to the portfolio is used as a baseline for comparing new solutions. Each solution is judged based on how many programs are able to be funded with higher priority programs being valued higher. The three new solutions each surpass the original Air Force solution by using less funding and having a greater overall portfolio value. The hybrid optimized solution has a 51.1% improvement over the Air Force solution (Greiner et al., 2003:198-200). These results demonstrate that the AHP model can be used to reduce program costs and fund more valuable programs to the war-fighter.

The "Real" Success Factors on Projects

A comprehensive answer to which factors lead to project success has been researched since at least the late 1960s. A successful project can be interpreted in a variety of ways. *Project success* is defined as the project outcomes measured against the overall objectives of the project (Cooke-Davies, 2002). P*roject success* focuses on whether the project met the stakeholders' vision, needs, and capability requirements (Cooke-Davies, 2002). *Project management success* is calculated against the traditional performance measures of cost, time, and quality (Cooke-Davies, 2002). *Success factors* are inputs into the management system that produce successful projects either directly or indirectly (Cooke-Davies, 2002). FIST judges programs based on their *project management success*. The FIST framework proposes that through rapid *project management success, project success* will follow.

Cooke-Davies (2002) analyzed 136 European projects to develop critical factors to project success. Some of the prominent factors are maintaining a 3-year or less development timeline and "allow changes to scope only through a mature scope change control process" (Cooke-Davies, 2002:186). Additionally, organizations should align their decision-making and strategy with the current projects being developed. This idea shows that rapid acquisition organizations need to be structured in a way that enables rapid development.

Cooke-Davies (2002) found that comparing project performance to the budget was a better measure of success than comparing it to the schedule. Furthermore, delivering *project success* is harder than achieving *project management success* because program management delivers only a product or service and it is left to operations management to optimize the benefits derived from the product. Project success cannot be measured until after project completion. However, project management performance can be measured throughout the life of the project.

The article concludes that research and development (R&D) projects should maximize the return on R&D by improving the time to market. Releasing a new R&D product as soon as possible keeps the technology relevant and in a competitive position (Cooke-Davies, 2002).

Expedited Systems Engineering for Rapid Capability and Urgent Needs

Lepore et al (2012). conducted interviews with over 30 individuals and organizations, in both the DoD and civilian sectors, with experience in rapid development. The goal of the research is to identify factors that contribute positively to rapid acquisition outcomes. "One can hypothesize that certain critical success factors from those organizations that do rapid acquisition may well be transferrable to traditional acquisition" (Lepore et al., 2012:3). This hypothesis is similar to the FIST concept. The research team found that 11 observations emerged from the interviews. These observations are integrated with current best practices to produce a proposed rapid acquisitions framework (Lepore et al., 2012).

- Use Mature Technology – Focus on the State of the Possible
- Incremental Deployment (Development) is Part of the Product Plan
- Strive for a Defined Set of Stable Requirements Focused on Warfighter Needs
- Work to Exploit Maximum Flexibility Allowed
- Designing out All Risk Takes Forever…Accept Some Risk
- Keep an Eye on "Normalization"
- Build and Maintain Trust
- Populate Your Team with Specific Skills and Experience
- Maintain High Levels of Motivation and Expectations
- The Government Team Leads the Way
- Right-size the Program - Eliminate or Reduce Major Program Oversight

Many of these observations are similar to the principles found in FIST. However, many findings are missing from the FIST framework. Incremental development is a key concept in this article. This tool, also referred to as *Generational Development*, intentionally plans for future technology advancements to be incorporated into the system. Incremental development provides faster upgrade possibilities, extended system lifespan, and the flexibility to change to a dynamic operational environment (Lepore et al., 2012).

Another seemingly absent area in FIST is a thorough requirements gathering activity. Lepore et al. (2012) emphasize the importance of stable, capability-based requirements, generated in face-to-face meetings with the customer, early in the process. Then, project teams must fight possible scope creep and additional requirements to maintain the rapid development timeline (Lepore et al., 2012). Next, the authors observe that in rapid acquisitions, it is often impossible to provide the user with a 100% solution to meet their needs. Often customers' capability requirements will be met with a *23% to*

80% solution (Lepore et al., 2012). The last prominent observation in relation to FIST is the concept of ambidextrous organizations. This dual structured organization has an exploring team that generates new technologies and an exploiting team which focuses on efficiently executing a program using program management techniques (Lepore et al., 2012).

Summary

The DoD acquisition processes is too lengthy, costs too much, and develops overtly complex technologies (Blue Ribbon, 1986). A proposed solution named FIST has been developed and published through a series of articles. The FIST literature uses historical examples of weapon system programs that illustrate the FIST values and how they can lead to successful project development.

The computer, airline, and electronic industries have been forced to shorten their development times by 50-75 percent in the last 50 years to remain competitive. Over the same timeframe, the average development times for the military have increased or remained the same (Ward and Quaid, 2006b). Currently, military development length is four times that of the automotive industry. The private industry has pioneered the movement of shortening development times while maintaining project success.

The literature and historical examples suggest that large budgets are not necessary for technological advancements. Having an *Inexpensive* project can compel project managers to be resourceful and innovative by working within the confines of their budget. Furthermore, inexpensive projects often develop simple technology because expensive, drawn-out testing cannot be financed. *Simple* technology can be fielded and receive feedback more rapidly. Complex and expensive technology may never be released to the field due to an overwhelmingly long development process required to produce state-of-the-art technology. Ward (2011) attempted to show through *The Simplicity Cycle* that project development reaches a certain point where adding complexity to a system reduces the overall goodness and functionality of the end-product. The last FIST value of *Tiny* is an inescapable result of the first three values. To honor the first three values, *Tiny* must be incorporated throughout the program, generating smaller development teams, schedules, and reducing unnecessary paperwork.

AHP is a proven decision-making tool that has been used in a wide variety of fields. It has already been employed to create criteria weights for a portfolio of development projects that require a funding decision. There are additional factors outside of cost, schedule, and quality that have an impact on project success. Understanding these factors can be used to improve the FIST model.

III. Methodology

The methodology used to subject the FIST model to a theory-testing empirical study will be the Analytical Hierarchy Process (AHP). The development of the theory-testing model is directly influenced by Ward's (2009) FIST thesis rubric and FIST values. Criteria weights for the model are derived from an experiment that is completed by civilian and military program managers. The results of the experiment are used to show which activities different groups of project managers value. The AHP model results produce a rank order of the programs from most successful to least successful based on the criteria and weights in the AHP model. The AHP results can then be compared to the FIST results, as well as the actual outcomes of the programs. A comparison of this data highlights the strengths, weaknesses, repeatability, and validity of the FIST model. The outcome of this research provides recommended changes and future applications of the FIST model.

Ward's (2009) FIST methodology is first examined in this chapter to create a better understanding of this research's chosen approach. Once the weaknesses to the FIST methodology are explained, the process of creating an AHP model is described. Next, the empirical steps used to produce the FIST-AHP model and the alternatives analysis is explained. The last section of this chapter is devoted to the participants that comprise this research.

FIST Methodology

The FIST methodology is a combination of reflective practice and case study research. Ward (2009:4) describes reflective practice as the "examination of one's experiences combined with formal academic knowledge in order to establish deeper understanding of the practice in question." This means that much of the FIST framework was developed from anecdotal personal experience and observations. "The initial FIST research clearly belongs in the realm of reflective practice, since its foundation largely rests on 'knowing-in-practice,' and was bolstered by, rather than established on, academic oriented studies" (Ward, 2009:4). While Ward (2009) was initially commended and labeled a *Reflective Practitioner* by Dr. Alexander Laufer of Israel's Technion University, this methodology has been scrutinized as being too subjective to one person's interpretation of case studies and personal experiences.

> Ward's use of quotations and interviews were manipulated by interpretation and used to fit into the FIST model. Although, some statements and quotes that were on target with the concept values that FIST conveys Ward choose wisely to sculpt other phrases and statements to make a direct tie to aspects of FIST, which were clearly not directly specified or intended for it. (Tran and Ocampo, 2012:8-9)

Much of the case study research methodology is based on Eisenhardt's (1989) research, in which the process for building a theory based on case studies is explained. This research includes selecting "cases which are likely to replicate or extend the emergent theory" (Eisenhardt, 1989:537). Eisenhardt (1989) also advocates the use of multiple investigators, which Ward (2009) uses to a small extent in the analysis. Ward (2009) chose to have only six of the 22 case studies investigated by an independent party. He states the benefits to case study research include its replication because the grading rubric and case study information is available to other researchers. However, four of the six co-evaluators produced different scores from the case studies. The E-3 Sentry case study, in which Ward (2009) gave the program an overall low score of 5, received a high score of

25 from the co-evaluator. These differing results were not examined in the thesis and only provided as reference in his appendices. The co-evaluator rankings are in Table 1.

Table 1: Co-Evaluator FIST Rankings

ALTERNATIVES	F	I	S	T	TOTAL	OUTCOME
NASA Pathfinder Mission - Ward	10	10	10	10	**40**	A
Co-Evaluator	5	10	10	10	**35**	A
F-16 Falcon - Ward	10	10	10	10	**40**	A
Co-Evaluator	10	10	10	10	**40**	A
NASA NEAR Mission - Ward	10	10	10	10	**40**	A
Co-Evaluator	10	10	10	10	**40**	A
F-20 Tigershark - Ward	5	10	10	10	**35**	F
Co-Evaluator	0	10	10	10	**30**	F
E-3 Sentry (AWACS) - Ward	5	0	0	0	**5**	A
Co-Evaluator	10	10	5	0	**25**	A
F-15 Eagle - Ward	-5	-5	-5	-5	**-20**	A
Co-Evaluator	n/a	0	0	0	**0**	A

Ward (2009) uses the strengths of case study research to support his methodology. However, the weaknesses of this methodology are not addressed in his thesis. The strengths of case study research are described by Eisenhardt (1989) as being able to create a novel theory from insights that arise from contradicting evidence. Furthermore, the emerging theory is likely to be testable because the concepts can easily be measured and hypothesized (Eisenhardt, 1989). Lastly, “The likelihood of a valid theory is high because the theory-building process is so intimately tied with evidence that is very likely that the resultant theory will be consistent with empirical observation” (Eisenhardt, 1989:547). This strength leads directly into a weakness of case study methodology.

Eisenhardt (1989) states that a resultant theory, built-off case studies, is likely to be empirically valid. However, FIST lacks empirical studies. FIST’s scientific basis is tenuous without additional empirically based studies to support the theory. To truly validate FIST as an applicable rapid acquisition approach, numerous quantitative, theory-testing studies are required.

> Such theories are likely to be testable, novel, and empirically valid, but they do lack the sweep of theories… They are essentially theories about specific phenomena… ultimately they are not theories about organization in any grand sense. Perhaps 'grand' theory requires multiple studies – an accumulation of both theory-building and theory-testing empirical studies. (Eisenhardt, 1989:547)

Theory-building from case studies also risks the phenomenon of not being able to rise to a level generality. In other words, such theories are only valid for small subset of the population. The resultant theories can be narrow and idiosyncratic (Eisenhardt, 1989). With only 22 programs analyzed by Ward (2009), there is a great possibility that FIST has limited usage.

The AHP Process

Saaty (1990) developed AHP as a multi-criteria decision-making approach. AHP is a decision support tool that can solve complex decision problems with numerous criteria. AHP permits decision-makers to model intricate problems as a hierarchical structure that shows the relationship between the goal, primary criteria, sub-criteria, and alternatives. The application of AHP includes studies in project management, environmental policy, information systems, risk assessment, and project screening (Greiner et al., 2003). AHP is an appropriate methodology for insight into FIST because AHP can integrate quantitative and qualitative criteria into the decision-making process. The decision-makers' input is vital to accurate model creation.

The first step in AHP is to define the objective or goal of the model. Next, the alternatives, primary criteria, and sub-criteria are established. The criteria should be chosen to "represent the problem as thoroughly as possible, but not so thoroughly as to lose sensitivity to change in the elements" (Saaty, 1990:9). Decision-makers can visualize an overall assessment of the complex relationships that compose a problem by arranging the goals and criteria of a problem into a hierarchy structure. Furthermore, decision-makers can compare the criteria at each level of the hierarchy to make sure they are the same order of magnitude. "A decision-maker can insert or eliminate levels and elements as necessary to clarify the task of setting priorities or to sharpen the focus on one of more parts of the system" (Saaty, 1990:9). As seen in Figure 3, the decision-makers decompose the problem into a decision hierarchy starting with the goal through the criteria, sub-criteria, and alternatives at the lowest level.

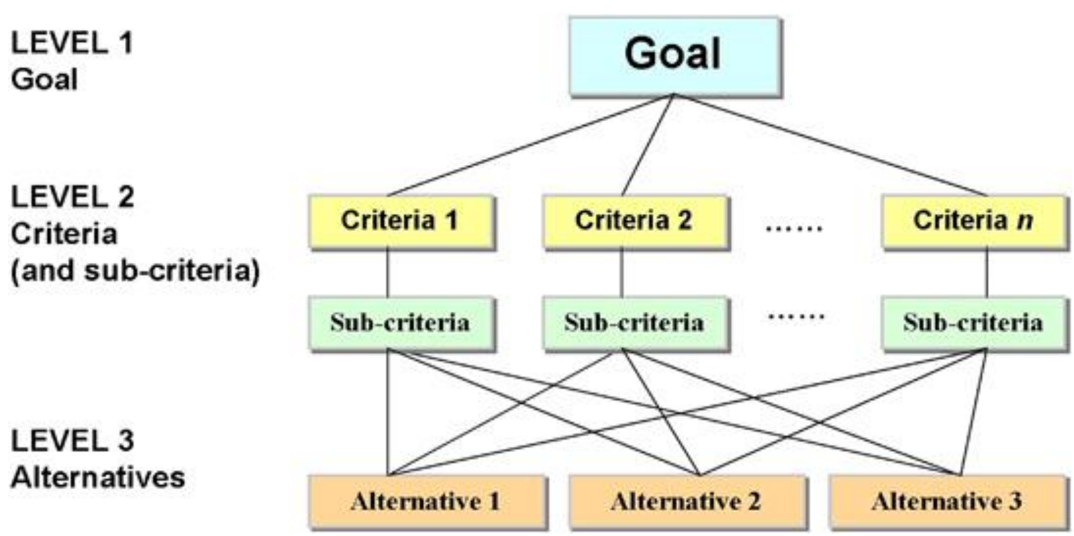


Figure 3: Decision making as a Hierarchical Structure (Yau, 2009)

Saaty (1990:12) states the "most effective way to concentrate judgments is to take a pair of elements [criteria] and compare them on a single property without concern for other properties or other elements." This is the second step of AHP in which decision-makers use pairwise comparisons of second level criteria to determine criteria weights. The comparisons are accomplished by judging which criterion is more beneficial to the overall goal of the system. Pairwise comparisons are completed for the primary decision criteria by comparing two criteria at a time, based on their importance to the overall goal. Values of one through nine and their reciprocals are given to each pairwise comparison. Table 2 provides an explanation of the values.

Table 2: The Fundamental Scale (Saaty, 1990:15)

Intensity of Importance on an Absolute Scale	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over
5	Essential or strong importance	Experience and judgment strongly favor one activity over
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in
9	Extreme importance	The evidence favoring one activity over another is of the
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix

Once the pairwise comparisons are completed, a judgment matrix for each level of the hierarchy will be created. Figure 4 depicts a judgment matrix for weights (W) and

(n) number of decision criteria (C). Each W in the matrix represents the fundamental scale value associated with the pairwise comparison of the two criteria. To calculate the weights of each criterion, the maximum left eigenvector is approximated by multiplying the elements in each row with each other and then taking the n^{th} root. These values are normalized by dividing the value by their sum to produce the final priority vector, or weight, of each criterion (Triantaphyllou and Mann, 1995).

$$
\begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array}
\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\
\begin{bmatrix} \omega_{11} & \omega_{12} & \cdots & \omega_{1n} \\ \omega_{21} & \omega_{22} & \cdots & \omega_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ \omega_{n1} & \omega_{n2} & \cdots & \omega_{nn} \end{bmatrix} \end{array}
$$

Figure 4: Judgment Matrix

The judgment matrix must be consistent, in that $A_{12} = A_{13} \times A_{32}$. The consistency of the matrix is calculated through the consistency ratio (CR). A judgment matrix is considered adequate if the corresponding CR is less than 10%. To establish the CR, first the maximum eigenvalue (λ_{max}) must be calculated by summing each column of the judgment matrix and multiplying that value by the vector weight. Then the consistency index (CI) is calculated using the formula:

$$CI = \frac{(\lambda \text{max} - \text{n})}{(n-1)} \tag{1}$$

Last, the CR is determined by dividing the CI by the Random Consistency index (RCI) that is provided in Table 3 (Triantaphyllou and Mann, 1995).

Table 3: RCI Values for Different Values of n (Triantaphyllou and Mann, 1995:5)

n	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

At this point, all the criteria and sub-criteria have priority vectors. The alternatives now need to be analyzed using the established framework. If a problem has N number of criteria and M alternatives, the decision-maker must now create N judgment matrices. This produces one matrix per criteria in order to compare all alternatives against each other based on the lowest-level criteria. The same pairwise comparison process is completed to derive priority vectors for each alternative under each criterion. Figure 5 shows the final decision matrix. Value a_{11} in the decision matrix represents the priority vector for alternative one (A_1) under criteria one (C_1) (Triantaphyllou and Mann, 1995). W_n represents the weight of each criterion as established in step two of the process.

		Criterion			
	C_1	C_2	C_3	…	C_N
Alt.	W_1	W_2	W_3	…	W_N
A_1	a_{11}	a_{12}	a_{13}	…	a_{1N}
A_2	a_{21}	a_{22}	a_{23}	…	a_{2N}
A_3	a_{31}	a_{32}	a_{33}	…	a_{3N}
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
A_M	a_{M1}	a_{M2}	a_{M3}	…	a_{MN}

Figure 5: Decision Matrix (Triantaphyllou and Mann, 1995)

The final priority of the alternatives is denoted as A^i_{AHP} and is calculated by the following formula (Triantaphyllou and Mann, 1995:2):

$$A^i_{AHP} = \sum_{j=1}^{N} a_{ij}\, w_j, \quad for\ i = 1, 2, ,3, ,\ldots M. \quad \ldots \qquad (2)$$

This formula establishes the final weight through the summation of the alternatives' priority vector (a_{ij}), multiplied by that criteria's weight (w_j).

The FIST-AHP Model

Ward (2009) uses 18 activities in the FIST rubric to score acquisition programs. These 18 activities are used to create the hierarchical structure in Figure 6. More information is available about the FIST rubric in Appendix A.

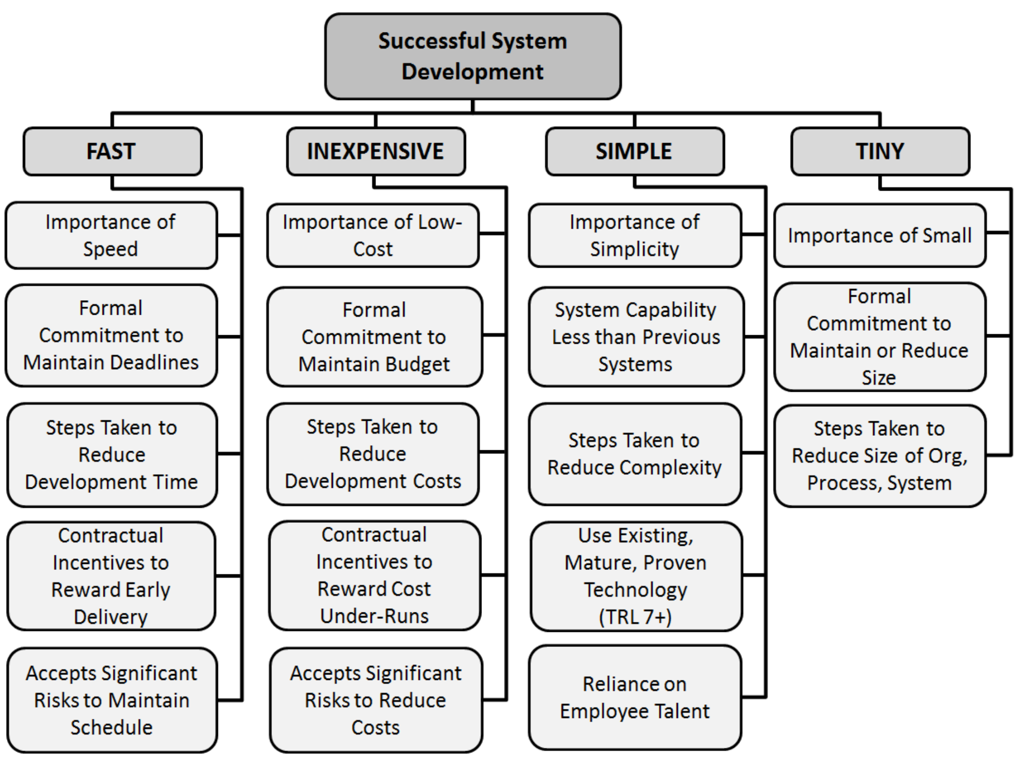


Figure 6: FIST Hierarchal Structure

To calculate the weights of both the FIST values and the FIST sub-criteria activities, an experiment is used to survey participants for pairwise comparisons between all the FIST values and FIST activities using the fundamental scale. Participants' answers are recorded in Microsoft Excel and transferred into Expert Choice ™ for analysis. Appendix C contains the directions of the experiment while Appendix D and E show a sample of the actual experiment. Appendix D asks participants to compare the FIST values of *Fast*, *Inexpensive*, *Simple* and *Tiny*. Since most participants are unaware of the FIST model, definitions of each value, based on Ward's (2009) thesis, are provided in this section of the experiment. Participants will make high-level judgments based on which FIST values they deemed most important to successful project development. The outcome of this section of the experiment produces the weights for each of the four FIST values. More information on participants is found in a forthcoming section.

Additional demographic information was gathered in the experiment such as the number of years' experience in project management, if the participant has official leadership experience, and the participants' highest rank obtained while in project management. This demographic information was used to divide participants into the following groups: All Participants, Leaders, Non-Leaders, Military, Civilian, Consistent Responses, and Expert Responses. Consistent responses are determined if the resulting consistency ratio (CR) of the judgment matrix is less than 10%. Experts were segregated from the population if they had more than 15 years of experience in project management or an advanced academic degree directly related to project management. The variations in organizational values between military and civilian, leaders and non-leaders, as well as experts to all others, will come to light through the analysis of the data. Civilian project management firms must not only be successful in project management but also be able to create profit, otherwise the company would be bankrupt. Gaining insight from this population of successful project managers will be invaluable to improving the DoD acquisitions and analyzing the FIST model.

The next section of the experiment is described in Appendix E. It combines all 18 activities in Ward's (2009) FIST rubric. The activities were presented in a randomly assorted order so that it was not easily discernible which activity was related to each FIST value. Furthermore, participants were not informed that the activities were related to the FIST values in the first section of the experiment. This was purposely designed to prevent participants from attempting to judge the 18 activities artificially more or less significant to match their answers in the first section. The answers to this second section serve two purposes. First, the pairwise comparisons form the weight of each sub-criterion for the model. Second, the internal reliability of the FIST model can be analyzed. If the FIST model is consistent, then the summation of the activities under each FIST value should match the rankings completed in the first section of the experiment. For example, if a participant ranked *Fast* as the most important FIST value in the first section, then the summation of the five separate *Fast* activities in part two should be greater than the summation of activities for *Inexpensive*, *Simple*, or *Tiny*. If participants deem *Fast* as the most influential value but then rank the *Inexpensive* tasks as the most important group of activities, a disconnect in the model becomes apparent or the activities are not properly designed to cover the FIST value. A disconnect in FIST values and activities could lead to recommendations to change, remove, or add activities to better encompass the FIST values.

Once all the pairwise comparisons for the FIST values and FIST activities were collected from the participants, the data was inputted into the software program called Expert Choice ™. Expert Choice ™ uses AHP to allow the decision-maker to decompose the problem into a hierarchy of criteria and sub-criteria. In this case, the criteria are the four FIST values and the sub-criteria are the 18 FIST activities. The decision-maker then inputs the pairwise comparison judgments into the program to arrive at overall weights for the criteria. The participants' responses to the experiment create the weights for the criteria and sub-criteria. By selecting certain participants' responses to be included in a model, it is possible to create seven different models that are not mutually exclusive to represent All Participants, Leaders, Non-Leaders, Military, Civilian, Consistent Responses, and Experts. Once the models were created, an alternatives analysis was conducted and the subsequent judgments were placed into Expert Choice ™ to be evaluated by the different models.

It was not possible to have participants become familiar enough with each alternative to be able to pass proper judgments on programs and make comparisons. However, participants' opinions were used for the criteria because they were basing their judgments on experience in project management. Expert Choice ™ is then used to calculate an overall score for each program. High scores are related to programs that exhibit FIST qualities and low scores are representative of programs that ignored the FIST theory of development. Additionally, Expert Choice ™ can provide additional analysis such as sensitivity graphs to help explain the results.

Miller (1956) showed that participants cannot simultaneously compare more than seven objects, plus or minus two, at one time. Saaty (1990) set the upper limit of alternatives in AHP to nine (Triantaphyllou and Mann, 1995). Taking this upper limit into account, 11 programs are used as alternatives from Ward's (2009) 22 original programs to be analyzed under the AHP model. The reason for increasing the number of alternatives over the rule of nine is that a large number of alternatives are required to see if the FIST process is reproducible and to be able to encompass the entire spectrum of programs. A variety of programs can test if FIST is adequately generalizable to be used on space, aircraft, and ground vehicle programs. Alternatives were also selected that had contradicting FIST and real-world scores. These contradicting alternatives can highlight weaknesses in FIST. Programs that score mediocre on the FIST scale do not strongly suggest if the mission is a failure or success. These alternatives were chosen to analyze missions that are only partially *FISTy*.

The primary researcher selected 11 programs that best covered a variety of outcomes, FIST scores, and types of programs. Included in the analysis were space launch, helicopter, fighter aircraft, cargo aircraft, and ground vehicle development programs. Table 4 shows the missions selected for AHP analysis, the real-world outcome grade, and the original FIST score from Ward's (2009) thesis.

Table 4: Missions Analyzed Under AHP Model

MISSION	OUTCOME	FIST SCORE
NASA Mars Pathfinder	A	40
P-51 Mustang	A	35
A-10 Thunderbolt II	A	35
F-20 Tigershark	F	35
XP-75 / P-75 Eagle	F	25
MRAP	A	15
E-3 Sentry AWACS	A	5
NASA Mars Viking Mission	A	-10
C-5 Galaxy	A	-15
V-22 Osprey	A	-20
RAH-66 Comanche	F	-20

Alternatives Analysis

Each of the 11 missions was analyzed independently and received a *Poor*, *Average*, *Good*, or *Excellent* rating for the 18 FIST activities. The rating was qualitatively determined by the author on how well the program incorporated the FIST activity in the program's development, not necessarily the outcome. This score is determined through case study analysis. It is worth noting that a mission could receive an *Excellent* score for fully incorporating a certain FIST activity even if the outcome from that activity was negative. Appendix F contains the results of the alternative analysis of the 11 programs. Once the qualitative score was determined for each program based on each activity, a quantitative pairwise comparison was completed by using Saaty's fundamental scale. This pairwise comparison is then entered into Expert Choice ™. Expert Choice ™ evaluates the data according to the criteria weights of that model. The output is a rank ordering of mission from most *FISTy* to least. The alternatives' pairwise comparison does not change between models. The only changes that occur between models are the criteria weights. The weights are reflections of the category of program manager whose opinion was used in that model.

A large portion of the alternatives analysis builds off the examination already completed by Ward (2009). Since mission analysis was a significant portion of his thesis, this analysis chooses to build off his foundation rather than scrutinize his examination. If Ward (2009) provides evidence that a mission integrated or ignored certain FIST activities, that proof was used in this analysis. Where evidence was missing or not mentioned, further research was then conducted into confirming the activity's presence or absence in the mission development.

Participants

As of September 2012, there were 2,258 Air Force officers in the acquisition career field of project management. To collect a statistically correct sample with a 95% confidence level with ± 10 confidence interval, 92 participants should be surveyed. However, due to this large number of participants and the length of the experiment, the experiment was sent to military, government civilian, and civilian project managers to gain enough of a consensus to be able to draw a conclusion on the FIST model. As previously stated, this provides the added benefit of gathering data from a diverse population, thereby adding to the breadth of the analysis. This research was able to obtain 75 responses, with only 33 participants being active duty Air Force officers. With 33 responses, a confidence interval of ± 16.94 at the 95% confidence level is achieved.

One of the civilian project management firms selected for the experiment was Parsons Brinkerhoff (PB). Twenty-eight civilian participants were surveyed from PB. PB was founded in New York City in 1885 and today employees 14,000 people in 150 offices on five continents. "Parsons Brinckerhoff is a global consulting firm assisting public and private clients to plan, develop, design, construct, operate and maintain thousands of critical infrastructure projects around the world" (Parsons Brinckerhoff, 2012). PB's projects include infrastructure, transportation, power, energy, community development, water, mining, and environment. Respondents from PB have managed such programs as the $2.5 billion Woodrow Wilson Bridge Replacement program and the $5 billion Washington Metropolitan Area Transit Authority Capital Improvement Program. "Program management is a partnership with owners that fosters effective, cost-efficient and innovative project delivery... Program management at Parsons

Brinckerhoff means working with our clients to anticipate the key issues that could impact successful completion of not only the individual projects that make up a program, but the overall program itself" (Parsons Brinckerhoff, 2012). Due in part to the immense project management experience from PB respondents, an expert AHP model was able to be developed.

Summary

Ward's (2009) theory-building methodology utilizing reflective practice merged with case study research has been criticized as being too subjective and lacking theory-testing empirical studies. *Grand* theories require the accumulation of multiple theory-building and theory-testing empirical studies to support the framework and generalize its use for a wider audience (Eisenhardt, 1989). FIST's scientific foundation is unsubstantiated without further empirical based studies.

To summarize the AHP methodology, project managers from across a variety of disciplines were surveyed to collect their opinions on the FIST values and 18 sub-criteria activities. Those opinions, or pairwise comparisons, were used to determine criteria weights in seven different AHP models. Furthermore, those pairwise comparisons were used to examine the internal reliability of the FIST model itself by comparing FIST values with FIST activities. Once the AHP models were developed, 11 selected programs were used as alternatives. The results show a rank order of the 11 programs from most *FISTy* to least. From the results, conclusion can be drawn about the reliability, strengths, and weaknesses of FIST.

IV. Analysis and Results

As per the approach outlined in the methodology chapter, the results will be presented and then further separated into seven groups according to participant category: *All Participants*, *Leaders*, *Non-Leaders*, *Military*, *Civilian*, *Consistent Responses*, and *Experts*. Seven Analytical Hierarchy Process (AHP) models were created, one for each group, to compare the values of each group of project managers. The only differences between the models are the criteria weights derived from the different groups of project managers. The pairwise comparisons for the alternatives remain the same for all models but the end results will differ due to differences in criteria weights.

The experiment collected 75 responses from project managers. The participants' identities are anonymous, and any voluntary feedback on the experiment that is used in this thesis was approved by the participant. Forty participants were civilians with no military experience, and 35 participants were military project managers ranging in rank from Second Lieutenant to Lieutenant Colonel. There were also two government civilians (GS) in the military group who are project managers that work for the Air Force as civilians. Forty-three participants had leadership positions in project management, and 32 participants had no leadership experience. CGO is an abbreviation of Company Grade Officer and represents the ranks of Second Lieutenant, First Lieutenant, and Captain. FGO stands for Field Grade Officer and represents the ranks of Major, Lieutenant Colonel, and Colonel. While the sample of GS and FGOs is too small to interpret, their inclusion in the various models bolsters the number of participants. To increase the reliability of the models, more participants are required. Table 5 depicts the number of participants in each group.

Table 5: Participants by Model

	All	Leader	Non-Leader	Military	Civilian	Consistent	Expert
Avg. Years of Experience	**11.21**	**14.53**	**6.94**	**5.83**	**15.85**	**8.41**	**17.25**
CGO	28	12	16	28	0	14	0
FGO	5	4	1	5	0	3	3
GS	2	1	1	2	0	0	0
Civilian	40	25	15	0	40	11	34
TOTAL	**75**	**42**	**33**	**35**	**40**	**28**	**37**
Leaders	42	42	0	17	25	10	25
Non-Leaders	33	0	33	18	15	18	12
TOTAL	**75**	**42**	**33**	**35**	**40**	**28**	**37**

All Participants Results

The *All Participants* model includes every response to the experiment with no distinction for military, experience, or consistency of answers. As seen in Table 6, there were 75 participants with an average of 11.2 years of project management experience. These 75 responses created the model seen in Table 7. The numbers in the table denote the priority vector or weight of each criterion.

Table 6: All Participants Model Demographic

DEMOGRAPHICS	
Avg. Years of Experience	**11.21**
CGO	28
FGO	5
GS	2
Civilian	40
TOTAL	**75**
Leaders	42
Non-Leaders	33
TOTAL	**75**

Table 7: All Participants FIST-AHP Model

FIST-AHP MODEL	All
FAST	**0.324**
Accept risk in order to maintain schedule	0.135
Formal commitment to maintain deadlines	0.249
Concrete steps taken to actually reduce development time	0.243
Contractual incentives to reward early delivery	0.171
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	0.202
INEXPENSIVE	**0.216**
Formal commitment to maintain budget	0.226
Importance of low-cost (Choosing a Low Cost Design / Solution)	0.211
Contractual incentives to reward cost under-runs	0.161
Concrete steps taken to actually reduce development cost	0.270
Accept Risk to Reduce Cost	0.132
SIMPLE	**0.313**
System capability less than previous systems (Design Optimized for Main Objective)	0.108
Heavy reliance on existing, mature, proven technology (TRL 7+)	0.186
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	0.246
Importance of Simplicity (Design, Organization, Documentation)	0.272
Emphasis on the importance of and reliance on employees' talent	0.188
TINY	**0.147**
Importance of Small (Small Design, Minimum Documentation, Small Budget)	0.293
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	0.381
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	0.326

Of the four FIST values, *Fast* was ranked the highest at 0.324, followed by *Simple* (0.313), *Inexpensive* (0.216), and *Tiny* (0.147). The sub-criteria activities are only compared to other activities within the same FIST value. In other words, each *Fast* activity is only compared to other *Fast* activities. The activity weights represent which activity is deemed most prominent only under that FIST value. A comparison cannot be made between different FIST sub-criteria activities using this model. For example, one cannot compare the *Fast* activity of *Formal commitment to maintain deadlines* to the *Inexpensive* activity of *Concrete steps taken to actually reduce development cost* because the activities are part of different FIST values.

However, in order to be able to compare all the FIST activities to one another, regardless of FIST value, a sub-criteria model was created. This model is based on responses from project managers that compared all the FIST activities to one another with no distinction for which activities belonged to each FIST value. Table 8 shows a ranked order of the FIST activities from most valued to least in regard to system development and project management. The top three activities are *Importance of Simplicity*, *Importance of Low-Cost*, and *Formal Commitment to Maintain Deadlines*. Interestingly, each of these top activities belongs to a different FIST value (*Simple*, *Inexpensive*, and *Fast*). The least valued activities are *Accept Risk to Reduce Cost*, *System Capability Less than Previous System*, and *Importance of Small*.

Table 8: All Participants Sub-Criteria Model

SUB-CRITERIA MODEL	All	
	RANK	WEIGHT
Importance of Simplicity (Design, Organization, Documentation)	1	0.083
Importance of low-cost (Choosing a Low Cost Design / Solution)	2	0.081
Formal commitment to maintain deadlines	3	0.081
Concrete steps taken to actually reduce development time	4	0.079
Heavy reliance on existing, mature, proven technology (TRL 7+)	5	0.077
Deliberate steps taken to actually reduce complexity in many areas	6	0.076
Formal commitment to maintain budget	7	0.068
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	8	0.065
Concrete steps taken to actually reduce development cost	9	0.064
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	10	0.051
Contractual incentives to reward early delivery	11	0.043
Emphasis on the importance of and reliance on employees' talent	12	0.041
Accept risk in order to maintain schedule	13	0.039
Contractual incentives to reward cost under-runs	14	0.037
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	15	0.031
Accept Risk to Reduce Cost	16	0.031
System capability less than previous systems (Design Optimized for Main Objective)	17	0.027
Importance of Small (Small Design, Minimum Documentation, Small Budget)	18	0.025

Using the model developed in Table 7, the 11 programs were evaluated based on the 18 sub-criteria activities. Appendix G contains the raw results from Expert Choice ™. Table 9 summarizes the results of the *All Participants* model. The missions are ranked from most *FISTy* to least. The *Actual Outcome* column identifies if the program was deemed a real world success qualitatively by delivering promised capabilities and fulfilling program requirements. An outcome score of an 'A' signifies a successful program and an 'F' signifies a failure. This score does not take into account if the program remained on budget or schedule, only if the eventual product was an operational success.

The *FIST Value Ranking* column shows a rank order of importance for the FIST values derived from Table 7. The *FIST Combined Activity Ranking* column is a summation of the activities in Table 8, per FIST value. By comparing the *FIST Value Ranking* and *FIST Combined Activity Ranking* columns, one can infer on the internal validity of the model.

Table 9: All Participants Model Results

All							
Alternatives	**Actual Outcome**	**Priority**	**Standardized**	**FIST Value Ranking**		**FIST Combined Activity Ranking**	
A-10 Thunderbolt II	A	0.17	1	FAST	0.324	FAST	0.307
NASA Mars Pathfinder	A	0.169	0.996	SIMPLE	0.313	SIMPLE	0.304
F-20 Tigershark	F	0.126	0.743	INEXPENSIVE	0.216	INEXPENSIVE	0.281
P-51 Mustang	A	0.111	0.655	TINY	0.147	TINY	0.107
MRAP	A	0.109	0.642				
XP-75 / P-75 Eagle	F	0.103	0.609				
E-3 Sentry AWACS	A	0.091	0.537				
C-5 Galaxy	A	0.07	0.412				
NASA Mars Viking Mission	A	0.018	0.107				
V-22 Osprey	A	0.017	0.099				
RAH-66 Comanche	F	0.016	0.093				

In this model, the A-10 Thunderbolt II and NASA Mars Pathfinder mission were the highest ranked programs. This shows that these programs were the most *FISTy* in their development. The A-10 and Mars Pathfinder were also deemed a success operationally. The V-22 Osprey and RAH-66 Comanche had exceedingly low scores because their development was lengthy, expensive, and complicated. The V-22 was considered an operational success despite its poor development whereas the RAH-66 was a total failure by not delivering a single aircraft. It is worth noting that the F-20 Tigershark and XP-75 Eagle received high FIST scores while being considered failures operationally. This disconnect will be further examined in Chapter V. This model has matching internal validity as participants ranked the FIST values and FIST activities in the same order of importance.

Leaders Results

This model includes all the respondents who stated they have leadership positions in the project management field. This model contains both military and civilian leaders and will serve as a basis of comparison against the *Non-Leader* model. By observing the difference in the values, conclusions can be drawn as to whether project managers are using the same vision as the leaders. The difference in values could account for some project management failures. As shown in Table 10, there were 42 participants in this model with an average of 14.5 years of experience.

Table 10: Leader Model Demographic Information

LEADER DEMOGRAPHICS	
Avg. Years of Experience	**14.53**
CGO	12
FGO	4
GS	1
Civilian	25
TOTAL	**42**
Leaders	42
Non-Leaders	0
TOTAL	**42**

Table 11 displays the weights derived from the leaders' input. Leaders' emphasized the importance of *Fast* and *Simple* values and placed low prominence on *Tiny*. *Tiny* seems to be a low ranked FIST value because many projects are not supposed to be small such as cargo aircraft, bridges, or highway systems. Based on feedback from project managers, the *Tiny* concept was understood as maintaining a small team and minimal documentation. Nevertheless, leaders did not rank *Tiny* as a highly important value.

Table 11: Leader FIST-AHP Model

FIST-AHP MODEL	Leader
FAST	**0.337**
Accept risk in order to maintain schedule	0.151
Formal commitment to maintain deadlines	0.277
Concrete steps taken to actually reduce development time	0.210
Contractual incentives to reward early delivery	0.161
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	0.201
INEXPENSIVE	**0.208**
Formal commitment to maintain budget	0.252
Importance of low-cost (Choosing a Low Cost Design / Solution)	0.192
Contractual incentives to reward cost under-runs	0.161
Concrete steps taken to actually reduce development cost	0.251
Accept Risk to Reduce Cost	0.144
SIMPLE	**0.290**
System capability less than previous systems (Design Optimized for Main Objective)	0.125
Heavy reliance on existing, mature, proven technology (TRL 7+)	0.169
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	0.250
Importance of Simplicity (Design, Organization, Documentation)	0.270
Emphasis on the importance of and reliance on employees' talent	0.187
TINY	**0.165**
Importance of Small (Small Design, Minimum Documentation, Small Budget)	0.301
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	0.374
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	0.325

The sub-criteria model, shown in Table 12, allows all the FIST activities to be compared to each other. Leaders deemed *Formal commitments to maintain deadlines* and *budget* as the most important activities in the FIST framework.

Table 12: Leaders Sub-Criteria Model

SUB-CRITERIA MODEL	Leader	
	RANK	WEIGHT
Formal commitment to maintain deadlines	1	0.090
Formal commitment to maintain budget	2	0.077
Importance of Simplicity (Design, Organization, Documentation)	3	0.069
Concrete steps taken to actually reduce development time	3	0.069
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	3	0.069
Concrete steps taken to actually reduce development cost	4	0.068
Importance of low-cost (Choosing a Low Cost Design / Solution)	5	0.062
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	6	0.061
Contractual incentives to reward early delivery	7	0.052
Contractual incentives to reward cost under-runs	8	0.051
Emphasis on the importance of and reliance on employees' talent	10	0.049
Accept risk in order to maintain schedule	9	0.049
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	11	0.045
Heavy reliance on existing, mature, proven technology (TRL 7+)	12	0.044
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	13	0.040
Accept Risk to Reduce Cost	14	0.040
Importance of Small (Small Design, Minimum Documentation, Small Budget)	15	0.036
System capability less than previous systems (Design Optimized for Main Objective)	16	0.029

Table 13 summarizes the results of the *Leaders* Model. The shaded cells in the *FIST Value Rankings* and *FIST Combined Activity Rankings* columns represent inconsistencies in this model. The leaders ranked *Simple* as the second most influential FIST value. However, the summation of all the FIST activities shows leaders place more importance on *Inexpensive* activities rather than *Simple* activities. With the project managers being leaders in this model, it is not surprising that they ranked individual budget activities high. There are minimal differences between this model and the *All Participants* model results.

Table 13: Leaders Model Results

Leader							
Alternatives	Actual Outcome	Priority	Standardized	FIST Value Ranking		FIST Combined Activity Ranking	
NASA Mars Pathfinder	A	0.17	1	FAST	0.337	FAST	0.329
A-10 Thunderbolt II	A	0.17	0.999	**SIMPLE**	**0.29**	**INEXPENSIVE**	**0.298**
F-20 Tigershark	F	0.126	0.74	**INEXPENSIVE**	**0.208**	**SIMPLE**	**0.252**
P-51 Mustang	A	0.113	0.662	TINY	0.165	TINY	0.121
MRAP	A	0.11	0.646				
XP-75 / P-75 Eagle	F	0.1	0.588				
E-3 Sentry AWACS	A	0.091	0.537				
C-5 Galaxy	A	0.069	0.407				
NASA Mars Viking Mission	A	0.018	0.108				
V-22 Osprey	A	0.017	0.099				
RAH-66 Comanche	F	0.016	0.093				

Non-Leaders Results

The *Non-Leader* model consists of 33 participants who answered they had no leadership experience in project management. With an average of 6.9 years of experience, this model is almost half military and half civilian. The purpose of this model is to capture the opinion of the project managers who oversee the daily activities of a project. These are the frontline project managers who interpret and execute the strategic direction of leadership into managing the project. Table 14 summarizes the participants who were used in creating this model.

Table 14: Non-Leader Model Demographic Information

NON-LEADER DEMOGRAPHICS	
Avg. Years of Experience	**6.94**
CGO	16
FGO	1
GS	1
Civilian	15
TOTAL	**33**
Leaders	0
Non-Leaders	33
TOTAL	**33**

Table 15 displays the *Non-Leader* model weights for each FIST value and activity. *Simple* was the most important FIST value in this model followed by *Fast*. This differs from that of the leadership model where *Fast* is the highest ranked value.

Table 15: Non-Leader FIST-AHP Model

FIST-AHP MODEL	Non-Leader
FAST	**0.305**
Accept risk in order to maintain schedule	0.114
Formal commitment to maintain deadlines	0.209
Concrete steps taken to actually reduce development time	0.294
Contractual incentives to reward early delivery	0.184
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	0.200
INEXPENSIVE	**0.225**
Formal commitment to maintain budget	0.192
Importance of low-cost (Choosing a Low Cost Design / Solution)	0.237
Contractual incentives to reward cost under-runs	0.159
Concrete steps taken to actually reduce development cost	0.259
Accept Risk to Reduce Cost	0.115
SIMPLE	**0.346**
System capability less than previous systems (Design Optimized for Main Objective)	0.088
Heavy reliance on existing, mature, proven technology (TRL 7+)	0.212
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	0.239
Importance of Simplicity (Design, Organization, Documentation)	0.270
Emphasis on the importance of and reliance on employees' talent	0.189
TINY	**0.124**
Importance of Small (Small Design, Minimum Documentation, Small Budget)	0.281
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	0.392
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	0.326

Table 16 depicts a rank order of which FIST sub-criteria activities *Non-Leaders* considered most valuable. These results are consistent with the previous models' results.

Table 16: Non-Leaders Sub-Criteria Model

SUB-CRITERIA MODEL	Non-Leader	
	RANK	WEIGHT
Concrete steps taken to actually reduce development time	1	0.084
Importance of Simplicity (Design, Organization, Documentation)	2	0.082
Concrete steps taken to actually reduce development cost	3	0.080
Heavy reliance on existing, mature, proven technology (TRL 7+)	4	0.074
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	5	0.072
Importance of low-cost (Choosing a Low Cost Design / Solution)	6	0.065
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	6	0.065
Formal commitment to maintain deadlines	7	0.064
Formal commitment to maintain budget	8	0.057
Emphasis on the importance of and reliance on employees' talent	8	0.057
Contractual incentives to reward early delivery	9	0.052
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	10	0.047
Contractual incentives to reward cost under-runs	11	0.042
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	12	0.037
Accept risk in order to maintain schedule	13	0.034
Accept Risk to Reduce Cost	14	0.031
Importance of Small (Small Design, Minimum Documentation, Small Budget)	14	0.031
System capability less than previous systems (Design Optimized for Main Objective)	15	0.026

Table 17 provides a summary of the results for this model. The *Non-Leader* model was consistent in that participants' judgments on the FIST values matched those of the FIST activities.

Table 17: Non-Leaders Model Results

Non-Leader							
Alternatives	**Actual Outcome**	**Priority**	**Standardized**	**FIST Value Ranking**		**FIST Combined Activity Ranking**	
A-10 Thunderbolt II	**A**	0.169	1	SIMPLE	0.346	SIMPLE	0.311
NASA Mars Pathfinder	**A**	0.168	0.991	FAST	0.305	FAST	0.299
F-20 Tigershark	**F**	0.127	0.75	INEXPENSIVE	0.225	INEXPENSIVE	0.275
P-51 Mustang	**A**	0.109	0.645	TINY	0.124	TINY	0.115
XP-75 / P-75 Eagle	**F**	0.108	0.637				
MRAP	**A**	0.107	0.633				
E-3 Sentry AWACS	**A**	0.091	0.539				
C-5 Galaxy	**A**	0.07	0.416				
NASA Mars Viking Mission	**A**	0.018	0.104				
V-22 Osprey	**A**	0.017	0.098				
RAH-66 Comanche	**F**	0.016	0.094				

There are minimal differences in this model's rankings of alternatives compared to the previous models. Specifically, the MRAP was ranked sixth in this model and the XP-75 Eagle was ranked fifth. Most models reversed this ranking with the MRAP being ranked higher than the XP-75. Lastly, this is the first model to rank both the *Simple* value and combined *Simple* activities as most important.

Military Results

The *Military* model consists of only military officers and government civilian project managers. Their experience in project management is shaped by DoD policy and government programs. This model was used as a basis of comparison against the *Civilian* model in order to discern if the military was ignoring any private industry practices in project management. These project managers have an average of 5.8 years of experience, which is the least experience of all the models. Almost half of this model's participants are leaders, but the vast majority are young CGOs. Table 18 summarizes the participants for this model.

Table 18: Military Model Demographic Information

MILITARY DEMOGRAPHICS	
Avg. Years of Experience	**5.83**
CGO	28
FGO	5
GS	2
Civilian	0
TOTAL	**35**
Leaders	17
Non-Leaders	18
TOTAL	**35**

The FIST-AHP model is shown in Table 19. *Simple* and *Fast* are the highest ranked FIST values, with *Simple* marginally more important. *Tiny* is by far the least significant value to this group of project managers.

Table 19: Military FIST-AHP Model

FIST-AHP MODEL	Military
FAST	**0.325**
Accept risk in order to maintain schedule	0.129
Formal commitment to maintain deadlines	0.190
Concrete steps taken to actually reduce development time	0.290
Contractual incentives to reward early delivery	0.169
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	0.221
INEXPENSIVE	**0.232**
Formal commitment to maintain budget	0.190
Importance of low-cost (Choosing a Low Cost Design / Solution)	0.255
Contractual incentives to reward cost under-runs	0.157
Concrete steps taken to actually reduce development cost	0.276
Accept Risk to Reduce Cost	0.123
SIMPLE	**0.327**
System capability less than previous systems (Design Optimized for Main Objective)	0.105
Heavy reliance on existing, mature, proven technology (TRL 7+)	0.224
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	0.257
Importance of Simplicity (Design, Organization, Documentation)	0.272
Emphasis on the importance of and reliance on employees' talent	0.142
TINY	**0.115**
Importance of Small (Small Design, Minimum Documentation, Small Budget)	0.276
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	0.397
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	0.327

Table 20 shows a rank order of the FIST activities that military project managers' value. Military project managers find it important to be proactive in reducing both development time and cost. Furthermore, low-cost solutions are a highly ranked activity. Further differences between military and civilian project management values will be explored in Chapter V.

Table 20: Military Sub-Criteria Model

SUB-CRITERIA MODEL	Military	
	RANK	WEIGHT
Concrete steps taken to actually reduce development time	1	0.083
Importance of low-cost (Choosing a Low Cost Design / Solution)	2	0.082
Concrete steps taken to actually reduce development cost	3	0.075
Importance of Simplicity (Design, Organization, Documentation)	4	0.074
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	5	0.073
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	5	0.073
Heavy reliance on existing, mature, proven technology (TRL 7+)	6	0.068
Formal commitment to maintain deadlines	8	0.062
Formal commitment to maintain budget	7	0.062
Contractual incentives to reward cost under-runs	9	0.053
Contractual incentives to reward early delivery	10	0.051
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	11	0.042
Accept risk in order to maintain schedule	11	0.042
Accept Risk to Reduce Cost	12	0.038
Emphasis on the importance of and reliance on employees' talent	13	0.037
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	14	0.031
System capability less than previous systems (Design Optimized for Main Objective)	15	0.027
Importance of Small (Small Design, Minimum Documentation, Small Budget)	16	0.026

The results of the military model are summarized in Table 21. The shaded cells represent disconnects between FIST values and FIST activities. For example, the military valued *Simple* (0.327) as the highest FIST value but the combination of the five *Simple* activities (0.279) ranked third in the sub-criteria model. This could be due to *Simple* and *Fast* being closely ranked in the FIST-AHP model. Moreover, combining military leaders and non-leaders may have disrupted the consistency of this model.

The *Military* model ranked the XP-75 Eagle fourth. This is the highest this program was ranked in any of the models. This failed WWII fighter aircraft outranked the successful P-51 Mustang.

Table 21: Military Model Results

Military							
Alternatives	Actual Outcome	Priority	Standardized	FIST Value Ranking		FIST Combined Activity Ranking	
A-10 Thunderbolt II	A	0.17	1	SIMPLE	0.327	FAST	0.311
NASA Mars Pathfinder	A	0.166	0.976	FAST	0.325	INEXPENSIVE	0.31
F-20 Tigershark	F	0.123	0.722	INEXPENSIVE	0.232	SIMPLE	0.279
XP-75 / P-75 Eagle	F	0.112	0.657	TINY	0.115	TINY	0.099
P-51 Mustang	A	0.109	0.642				
MRAP	A	0.108	0.631				
E-3 Sentry AWACS	A	0.094	0.55				
C-5 Galaxy	A	0.068	0.397				
NASA Mars Viking Mission	A	0.018	0.103				
V-22 Osprey	A	0.017	0.097				
RAH-66 Comanche	F	0.016	0.093				

Civilian Model Results

This population of participants was selected from private industry companies specializing in the project management profession. These project managers have completed such projects as hospitals, highway systems, and bridges. Since most project managers in these companies started out as engineers and became project managers as they advanced and gained knowledge, this model has an average of 15.9 years of project management experience. The civilian project managers do not have any experience with DoD projects, and their experience is acquired from profit and performance driven goals. Not only must these project managers ensure the project reaches completion with the desired capabilities, but they must earn a profit. Therefore, these project managers are particularly concerned with maintaining the schedule and budget. Table 22 summarizes the demographics of the civilian participants.

Table 22: Civilian Model Demographic Information

CIVILIAN DEMOGRAPHICS	
Avg. Years of Experience	**15.85**
CGO	0
FGO	0
GS	0
Civilian	40
TOTAL	**40**
Leaders	25
Non-Leaders	15
TOTAL	**40**

The *Civilian* model is summarized in Table 23. Civilian project managers ranked *Fast* as the highest FIST value followed by *Simple* and *Inexpensive*. The *Civilian* model is similar to the *All Participants* and *Leader* models.

Table 23: Civilian FIST-AHP Model

FIST-AHP MODEL	Civilian
FAST	**0.321**
Accept risk in order to maintain schedule	0.138
Formal commitment to maintain deadlines	0.308
Concrete steps taken to actually reduce development time	0.205
Contractual incentives to reward early delivery	0.169
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	0.181
INEXPENSIVE	**0.200**
Formal commitment to maintain budget	0.260
Importance of low-cost (Choosing a Low Cost Design / Solution)	0.177
Contractual incentives to reward cost under-runs	0.163
Concrete steps taken to actually reduce development cost	0.262
Accept Risk to Reduce Cost	0.138
SIMPLE	**0.298**
System capability less than previous systems (Design Optimized for Main Objective)	0.110
Heavy reliance on existing, mature, proven technology (TRL 7+)	0.155
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	0.231
Importance of Simplicity (Design, Organization, Documentation)	0.267
Emphasis on the importance of and reliance on employees' talent	0.237
TINY	**0.181**
Importance of Small (Small Design, Minimum Documentation, Small Budget)	0.308
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	0.368
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	0.324

Table 24 depicts the FIST activities in order of importance judged by civilian project managers. One point of interest is that civilians ranked accepting risk as low in importance. Furthermore, the civilians ranked *Emphasis on the importance of and reliance on employees' talent* higher than any other model.

Table 24: Civilian Sub-Criteria Model

SUB-CRITERIA MODEL	Civilian	
	RANK	WEIGHT
Formal commitment to maintain deadlines	1	0.097
Formal commitment to maintain budget	2	0.075
Importance of Simplicity (Design, Organization, Documentation)	3	0.074
Concrete steps taken to actually reduce development cost	4	0.070
Emphasis on the importance of and reliance on employees' talent	5	0.069
Concrete steps taken to actually reduce development time	6	0.067
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	7	0.063
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	8	0.058
Contractual incentives to reward early delivery	9	0.052
Importance of low-cost (Choosing a Low Cost Design / Solution)	10	0.050
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	11	0.048
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	12	0.047
Contractual incentives to reward cost under-runs	13	0.043
Heavy reliance on existing, mature, proven technology (TRL 7+)	14	0.042
Accept risk in order to maintain schedule	14	0.042
Importance of Small (Small Design, Minimum Documentation, Small Budget)	15	0.041
Accept Risk to Reduce Cost	16	0.034
System capability less than previous systems (Design Optimized for Main Objective)	17	0.028

The results from the *Civilian* model are presented in Table 25. There is only a slight inconsistency between the FIST values and FIST activities of *Simple* and *Inexpensive*. The alternatives rankings are similar to previous models with no noteworthy differences.

Table 25: Civilian Model Results

Civilian							
Alternatives	**Actual Outcome**	**Priority**	**Standardized**	**FIST Value Ranking**		**FIST Combined Activity Ranking**	
NASA Mars Pathfinder	**A**	0.172	1	FAST	0.321	FAST	0.321
A-10 Thunderbolt II	**A**	0.169	0.983	**SIMPLE**	**0.298**	**INEXPENSIVE**	**0.272**
F-20 Tigershark	**F**	0.13	0.755	**INEXPENSIVE**	**0.2**	**SIMPLE**	**0.271**
P-51 Mustang	**A**	0.113	0.657	TINY	0.181	TINY	0.136
MRAP	**A**	0.11	0.64				
XP-75 / P-75 Eagle	**F**	0.095	0.554				
E-3 Sentry AWACS	**A**	0.089	0.519				
C-5 Galaxy	**A**	0.072	0.417				
NASA Mars Viking Mission	**A**	0.019	0.109				
V-22 Osprey	**A**	0.017	0.099				
RAH-66 Comanche	**F**	0.016	0.092				

Consistent Response Results

The *Consistent* model was developed due to the AHP principle that judgment matrices are only considered adequate if the consistency ratio (CR) is less than 10%. Expert Choice TM software calculates the CR for both the FIST value experiment and the FIST sub-criteria activities experiment. Almost all participants had valid FIST value CRs because there are only six judgments required. The fewer the number of judgments, the easier it is to gain consistency. The FIST sub-criteria activities model had 153 judgments and consistency was much more difficult to maintain. Therefore, only participants who have a CR of 0.10 or less in the FIST sub-criteria model are included in this model. Table 26 outlines the demographics for this model's participants. This model contains 28 participants and is a combination of military, civilian, leaders, and non-leaders with an average experience of 8.4 years. The model does not reflect the beliefs of a certain group or experience level of project managers but rather participants who were consistent in their answers. The benefit of consistency is that the results should be more valid in that they do not contradict each other. Likewise, perhaps more time and thought was put into answering the comparisons to obtain acceptable consistency.

Table 26: Consistent Model Demographic Information

CONSISTENT DEMOGRAPHICS	
Avg. Years of Experience	**8.41**
CGO	14
FGO	3
GS	0
Civilian	11
TOTAL	**28**
Leaders	10
Non-Leaders	18
TOTAL	**28**

Table 27 describes the *Consistent* model and weights for each criterion. *Simple* and *Fast* were heavily favored in this model. Tiny was ranked of low importance in this model similar to the previous models described.

Table 27: Consistent FIST-AHP Model

FIST-AHP MODEL	Consistent
FAST	**0.297**
Accept risk in order to maintain schedule	0.127
Formal commitment to maintain deadlines	0.229
Concrete steps taken to actually reduce development time	0.280
Contractual incentives to reward early delivery	0.159
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	0.206
INEXPENSIVE	**0.206**
Formal commitment to maintain budget	0.225
Importance of low-cost (Choosing a Low Cost Design / Solution)	0.281
Contractual incentives to reward cost under-runs	0.138
Concrete steps taken to actually reduce development cost	0.246
Accept Risk to Reduce Cost	0.111
SIMPLE	**0.374**
System capability less than previous systems (Design Optimized for Main Objective)	0.098
Heavy reliance on existing, mature, proven technology (TRL 7+)	0.243
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	0.244
Importance of Simplicity (Design, Organization, Documentation)	0.269
Emphasis on the importance of and reliance on employees' talent	0.146
TINY	**0.123**
Importance of Small (Small Design, Minimum Documentation, Small Budget)	0.248
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	0.456
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	0.296

The sub-criteria model is presented in Table 28. Many of the *Simple* activities are ranked high in this model. The *Consistent* model results are shown in Table 29. The model's consistency matches as the FIST values and FIST activities match in order of importance.

Table 28: Consistent Model Results

SUB-CRITERIA MODEL	Consistent	
	RANK	WEIGHT
Importance of Simplicity (Design, Organization, Documentation)	1	0.082
Importance of low-cost (Choosing a Low Cost Design / Solution)	2	0.081
Concrete steps taken to actually reduce development time	3	0.078
Heavy reliance on existing, mature, proven technology (TRL 7+)	4	0.075
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	4	0.075
Formal commitment to maintain deadlines	5	0.073
Formal commitment to maintain budget	6	0.067
Concrete steps taken to actually reduce development cost	7	0.066
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	8	0.064
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	9	0.055
Contractual incentives to reward early delivery	10	0.047
Emphasis on the importance of and reliance on employees' talent	11	0.043
Contractual incentives to reward cost under-runs	12	0.041
Accept risk in order to maintain schedule	13	0.037
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	14	0.032
Accept Risk to Reduce Cost	15	0.031
System capability less than previous systems (Design Optimized for Main Objective)	16	0.028
Importance of Small (Small Design, Minimum Documentation, Small Budget)	17	0.027

Table 29: Consistent Sub-Criteria Model

Consistent							
Alternatives	Actual Outcome	Priority	Standardized	FIST Value Ranking		FIST Combined Activity Ranking	
NASA Mars Pathfinder	A	0.169	1	SIMPLE	0.374	SIMPLE	0.303
A-10 Thunderbolt II	A	0.168	0.997	FAST	0.297	FAST	0.299
F-20 Tigershark	F	0.128	0.756	INEXPENSIVE	0.206	INEXPENSIVE	0.286
P-51 Mustang	A	0.111	0.655	TINY	0.123	TINY	0.114
XP-75 / P-75 Eagle	F	0.11	0.651				
MRAP	A	0.105	0.622				
E-3 Sentry AWACS	A	0.093	0.549				
C-5 Galaxy	A	0.068	0.402				
NASA Mars Viking Mission	A	0.017	0.103				
V-22 Osprey	A	0.016	0.097				
RAH-66 Comanche	F	0.016	0.092				

Expert Model Results

The *Expert model* was developed to incorporate all the project managers who had 15 years of experience or more in project management, advanced degrees in management, or taken part in large programs. Most of the participants that meet these criteria are civilians with the addition of three Lieutenant Colonels. The average experience of this group is 17.2 years and is the most experienced of all the models. This model is considered the most useful in analyzing FIST because these respondents have participated in a litany of projects varying in size and complexity. Having experienced many different projects, these 37 participants understand what activities and philosophies are truly beneficial to a project. Table 30 shows the demographics of the expert population.

Table 30: Expert Model Demographic Information

EXPERT DEMOGRAPHICS	
Avg. Years of Experience	**17.25**
CGO	0
FGO	3
GS	0
Civilian	34
TOTAL	**37**
Leaders	25
Non-Leaders	12
TOTAL	**37**

Experts ranked the *Fast* and *Simple* values exceptionally high compared to *Inexpensive* and *Tiny*. Table 31 shows the weights of the four FIST values and 18 FIST activities. This is the only model that does not rank *Tiny* as the lowest value.

Table 31: Expert FIST-AHP Model

FIST-AHP MODEL	Expert
FAST	**0.326**
Accept risk in order to maintain schedule	0.141
Formal commitment to maintain deadlines	0.295
Concrete steps taken to actually reduce development time	0.198
Contractual incentives to reward early delivery	0.178
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	0.188
INEXPENSIVE	**0.182**
Formal commitment to maintain budget	0.257
Importance of low-cost (Choosing a Low Cost Design / Solution)	0.174
Contractual incentives to reward cost under-runs	0.165
Concrete steps taken to actually reduce development cost	0.270
Accept Risk to Reduce Cost	0.133
SIMPLE	**0.309**
System capability less than previous systems (Design Optimized for Main Objective)	0.112
Heavy reliance on existing, mature, proven technology (TRL 7+)	0.156
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	0.245
Importance of Simplicity (Design, Organization, Documentation)	0.269
Emphasis on the importance of and reliance on employees' talent	0.218
TINY	**0.183**
Importance of Small (Small Design, Minimum Documentation, Small Budget)	0.326
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	0.344
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	0.330

Table 32 lists the FIST activities in order of importance according to the experts. It is interesting to note that *Heavy reliance on existing technology*, *Accepting project risk to reduce cost*, and *maintain schedule* were all low-ranked activities. These activities were much higher ranked in other models.

Table 32: Expert Sub-Criteria Model

SUB-CRITERIA MODEL	Expert	
	RANK	WEIGHT
Formal commitment to maintain deadlines	1	0.096
Formal commitment to maintain budget	2	0.075
Importance of Simplicity (Design, Organization, Documentation)	3	0.073
Concrete steps taken to actually reduce development cost	4	0.070
Concrete steps taken to actually reduce development time	5	0.066
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	5	0.066
Emphasis on the importance of and reliance on employees' talent	6	0.062
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	7	0.057
Contractual incentives to reward early delivery	8	0.056
Importance of low-cost (Choosing a Low Cost Design / Solution)	9	0.050
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	10	0.048
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	11	0.046
Accept risk in order to maintain schedule	12	0.044
Contractual incentives to reward cost under-runs	13	0.043
Importance of Small (Small Design, Minimum Documentation, Small Budget)	13	0.043
Heavy reliance on existing, mature, proven technology (TRL 7+)	14	0.042
Accept Risk to Reduce Cost	15	0.034
System capability less than previous systems (Design Optimized for Main Objective)	16	0.028

The experts' results are summarized in Tabled 33. The inconsistencies are highlighted where *Inexpensive* is the lowest ranked value, but the second ranked cumulative FIST activity. It is worth noting that there is only a small difference in the ranking between *Inexpensive* and *Simple* in the *FIST Combined Activity Ranking*. Furthermore, it is a reoccurring theme that *Inexpensive* FIST activities are receiving a higher ranking than the *Inexpensive* FIST value. This could be due to *Inexpensive* not being fully understood as a value but appreciated when decomposed into activities.

Table 33: Expert Model Results

Expert							
Alternatives	Actual Outcome	Priority	Standardized	FIST Value Ranking		FIST Combined Activity Ranking	
NASA Mars Pathfinder	**A**	0.17	1	FAST	0.326	FAST	0.328
A-10 Thunderbolt II	**A**	0.169	0.992	**SIMPLE**	**0.309**	**INEXPENSIVE**	**0.272**
F-20 Tigershark	**F**	0.129	0.757	**TINY**	**0.183**	**SIMPLE**	**0.262**
P-51 Mustang	**A**	0.113	0.663	**INEXPENSIVE**	**0.182**	**TINY**	**0.137**
MRAP	**A**	0.111	0.652				
XP-75 / P-75 Eagle	**F**	0.096	0.563				
E-3 Sentry AWACS	**A**	0.088	0.516				
C-5 Galaxy	**A**	0.072	0.423				
NASA Mars Viking Mission	**A**	0.019	0.109				
V-22 Osprey	**A**	0.017	0.1				
RAH-66 Comanche	**F**	0.016	0.093				

Summary

The purpose of this chapter was to describe the seven models derived from the acquisition experiment and the ensuing alternatives ranking. The various models were purposely developed to facilitate a comparison analysis between the different populations of project managers. It is now possible to quantitatively analyze any differences between civilian project managers and their military counterparts which could explain the separation in performance. Additionally, other questions can be evaluated such as, is leadership and non-leaders valuing the same ideas? Could the differences between the two groups be due to leaders' antiquated view of project management? Or, is it that non-leaders do not have the experience embodied by leadership, to run a successful project? Lastly, based on the *All Participants* and *Experts* models, is FIST a valid model to develop a program? Now that the results have been presented and described, the significance of the results can be explored in Chapter V.

V. Conclusions and Recommendations

The purpose of this research was to empirically theory-test FIST through the development of an Analytical Hierarchy Process (AHP) model to be applied as a comparative tool. It appears certain programs are more determined to succeed under FIST than other types of programs. Direct comparisons between similar programs will be explored to reveal FIST short comings. These new insights will lead to recommendations for changes to the FIST model, FIST's validity, and future use. Last, the difference in results between groups of program managers will reveal insights into the values of each population.

Results Discussion

When a program receives a high FIST score, either under Ward's (2009) FIST model or the FIST-AHP model, this means the program was developed in accordance to the FIST theory. This does not mean that the program will be an operational success. Table 34 shows how each project management group ranked each program. The table is sorted by the *All Participants* model, and the shaded cells represent deviations from this model.

Table 34: Alternatives Analysis Results

ALTERNATIVES ANALYSIS RESULTS										
Alternatives	OUTCOME	WARD'S	All	Leader	Non-Leader	Military	Civilian	Consistent	Expert	AVERAGE
A-10 Thunderbolt II	A	2 (35)	1	2	1	1	2	2	2	1.57
NASA Mars Pathfinder	A	1 (40)	2	1	2	2	1	1	1	1.43
F-20 Tigershark	F	2 (35)	3	3	3	3	3	3	3	3.00
P-51 Mustang	A	2 (35)	4	4	4	5	4	4	4	4.14
MRAP	A	4 (15)	5	5	6	6	5	6	5	5.43
XP-75 / P-75 Eagle	F	3 (25)	6	6	5	4	6	5	6	5.43
E-3 Sentry AWACS	A	5 (5)	7	7	7	7	7	7	7	7.00
C-5 Galaxy	A	7 (-15)	8	8	8	8	8	8	8	8.00
NASA Mars Viking Mission	A	6 (-10)	9	9	9	9	9	9	9	9.00
V-22 Osprey	A	8 (-20)	10	10	10	10	10	10	10	10.00
RAH-66 Comanche	F	8 (-20)	11	11	11	11	11	11	11	11.00

Remarkably, there are not significant differences between the models. Also, the results are similar to Ward's (2009) ranking of the programs. This is not surprising as the AHP model is based on the FIST rubric with the only alterations being different weights for each activity. Therefore, the results are artificially correlated due to having the same activities for measures.

Table 35 is the accumulation of all FIST rankings to date on Ward's (2009) original 22 programs. In the table, the bold program title represents Ward's (2009) original FIST ranking. The *Co-Evaluator* rankings are also taken from his thesis. The *Primary Investigator* ranking represents the research completed in this thesis that analyzes the previously stated 11 programs. The *Capstone Report* ranking is acquired from the capstone project report on FIST completed by Tran and Ocampo (2012).

Table 35: FIST Rankings of all 22 Programs

ALTERNATIVES	F	I	S	T	TOTAL	OUTCOME
NASA Pathfinder Mission	10	10	10	10	**40**	**A**
Co-Evaluator	5	10	10	10	**35**	**A**
Primary Investigator	10	10	10	10	**40**	**A**
NASA NEAR Mission	10	10	10	10	**40**	**A**
Co-Evaluator	10	10	10	10	**40**	**A**
F-16 Falcon	10	10	10	10	**40**	**A**
Co-Evaluator	10	10	10	10	**40**	**A**
A-10 Thunderbolt	10	10	10	5	**35**	**A**
Capstone Report	5	5	5	0	**15**	**A**
Primary Investigator	10	10	10	10	**40**	**A**
Pave Low III	10	10	10	10	**40**	**A**
Skunkworks	10	10	10	10	**40**	**A**
P-51 Mustang	10	5	10	10	**35**	**A**
Primary Investigator	10	5	10	10	**35**	**A**
F-5 Freedom Fighter	5	10	10	10	**35**	**A**
F-20 Tigershark	5	10	10	10	**35**	**F**
Co-Evaluator	0	10	10	10	**30**	**F**
Primary Investigator	5	10	10	5	**30**	**F**
AD Skyraider	10	5	10	5	**30**	**A**
E-3 Sentry (AWACS)	5	0	0	0	**5**	**A**
Co-Evaluator	10	10	5	0	**25**	**A**
Primary Investigator	5	10	5	5	**25**	**A**
XP-75 Eagle	10	10	5	0	**25**	**F**
Primary Investigator	0	10	5	-5	**10**	**F**
C-5 Galaxy	0	-5	-5	-5	**-15**	**A**
Primary Investigator	5	5	5	0	**15**	**A**
Capstone Report	0	5	0	0	**5**	**A**
MRAP	10	0	5	0	**15**	**A**
Primary Investigator	5	-5	0	-5	**-5**	**F**
F-15 Eagle	-5	-5	-5	-5	**-20**	**A**
Co-Evaluator	n/a	0	0	0	**0**	**A**
Crusader Artillery	-5	-5	0	-5	**-15**	**F**
NASA Viking Mission	0	-5	-5	0	**-10**	**A**
Primary Investigator	-5	-5	-5	-5	**-20**	**A**
V-22 Osprey	-5	-5	-5	-5	**-20**	**A**
Primary Investigator	-5	-5	-5	0	**-15**	**A**
Future Imagery Architecture	-5	-5	-5	-5	**-20**	**F**
Division Air Defense (DIVAD)	-5	-5	-5	-5	**-20**	**F**
F-22 Raptor	-5	-5	-5	-5	**-20**	**F**
RH-66 Comanche	-5	-5	-5	-5	**-20**	**F**
Primary Investigator	-5	-5	-5	-5	**-20**	**F**

It is immediately evident that there is a better rankings consensus among programs that scored extremely well or extremely poor. This is not a strength of the FIST model as these programs were such standout developmental successes or failures that their performance is evident. What is interesting is how dissimilar many of the rankings are for programs that were not such obvious successes or failures. The FIST rubric's reliability is crucial for programs with undistinguished development. For example, the C-5 Galaxy program received a -15 score from Ward (2009) but a 15 and 5 from subsequent investigators. Furthermore, the MRAP received a FIST score of 15 from Ward (2009) as well as an A for outcome but this research ranked the program with a FIST score of -5 and an F for outcome. Table 35 shows that there are significant deviations between rankings completed by different investigators. If the original FIST rubric analysis was truly reproducible, these rankings should be significantly more similar.

The FIST-AHP model is largely able to replicate Ward's (2009) findings by analyzing missions based on each of the 18 FIST activities. However, the same replication is not realized when the programs are scored based on the four FIST values. The difference is accounted for in the subjectivity of the four FIST values. Multiple researchers can read the same case study and leave with differing opinions on a program's incorporation of the FIST values because of the vagueness of the rubric and definition of the values. However, when researchers are only analyzing one of the 18 FIST activities at a time, the subjectively is reduced. As seen in the alternatives analysis, when the researcher scrutinizes one discrete event in a program history, it becomes apparent if the activity was completed, ignored, or if the information was not available.

XP-75 Eagle vs. P-51 Mustang

The XP-75 Eagle and P-51 Mustang are two WWII fighter aircraft that score well under the FIST model but operationally, are opposites. The failed XP-75 Eagle program receives lower scores in the AHP model than in the FIST model. The XP-75 performed poorly in the *formal commitment to maintain deadline* activity as a six month delay ended up cancelling the program. The delay forced production to occur too late in the war. Also, the *Tiny* aspect of the program was not appreciated as the XP-75 was substantially heavier than any other successful WWII fighter aircraft (Holley, 1987:592). The factor that led to these problems was utilizing the FIST activity, *heavy reliance on existing, mature, proven technology*. "… More and more evidence emerged to indict the whole scheme to use off-the-shelf stock components to build a superior high-performance aircraft" (Holley, 1987:591). Consequently, the XP-75 had to be continuously modified and redesigned to use preexisting parts from other airframes successfully. These factors drove down the XP-75's score under the AHP model. A sensitivity graph comparing these two programs is shown in Figure 7. The graph shows that the *Tiny* aspect of the P-51 program was significantly better than the XP-75.

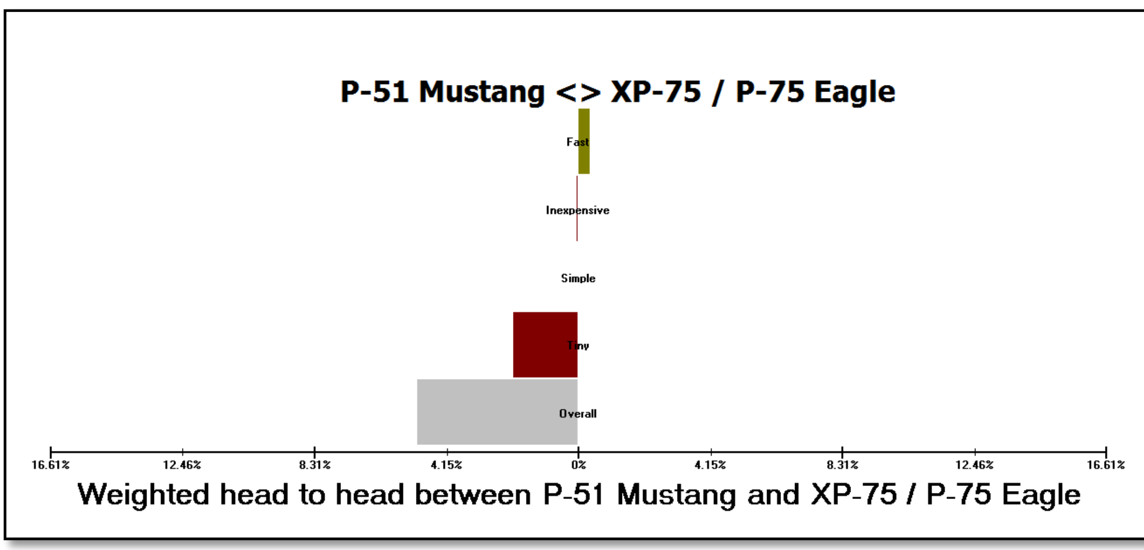


Figure 7: P-51 vs. XP-75 Sensitivity Graph

During the same time as the XP-75, the P-51 Mustang was an operational success and follower of the FIST theory. The Mustang was developed quickly in 117 days and was a cost effective capability to field (Ward, 2009). The P-51 was simple and "does not to any extent embody previously unknown engineering features, but rather employed refinements of known accepted practices" (Nelson, 1944:129). Furthermore, the Mustang was *Tiny*. It could easily be maintained with existing tools and did not require an extensive supply chain (Sanders, 1942).

So why was the XP-75 a failure and the P-51 a success if both programs score well under the FIST model, both were developed during the same time period, and both had similar capabilities? The key is the use of existing technology. The P-51 refined existing technology to design a superior aircraft, whereas the XP-75 tried to brute-force, piecemeal an advanced aircraft from parts in production from other airframes. This teaches a valuable lesson in how to incorporate existing technology. If done inappropriately, the consequences can ruin a program through costly redesigns and schedule delays. "Many assume that reuse of existing components will reduce risk and deployment time directly. Rather, a different risk is realized – the risk of using a component in a potentially different application, with an unknown requirements and development (and manufacturing) history" (Lepore et al., 2012:20).

This example also highlights a weakness in the FIST model. The FIST model should advocate incremental development to accompany the use of existing technology. When existing technology and incremental development are utilized from the beginning of a program, known and unknown technical enhancements can be integrated into the system easily. Incremental development is successful when employing "open architectures, modular concepts, clearly defining system interfaces, and utilizing industry standards" (Lepore et al., 2012:20). The pairing of existing technology and incremental development reduces system complexity, extends system lifecycle, and enhances the system's ability to adapt to emerging threats and technology. Upgrading a current system is much more cost efficient and faster than developing a whole new platform, merely to incorporate a single new piece of technology. By planning to use incremental development from project initiation, upgrading is easy and efficient because the system has been modularly designed with appropriate interfaces to accept advancements. "The record of North American's P-51 Mustang fighter proves, however, that it is both possible and practical to create a single basic design that can be modified, as military needs dictate, to keep abreast of requirements" (Nelson, 1944:127).

NASA Mars Viking vs. Pathfinder Mission

The NASA Viking and Pathfinder missions were both operational successes but on opposite ends of the spectrum in terms of following a FIST development. The Viking mission was launched in 1975 and upon landing on Mars in 1976, was the first space probe to obtain images of the surface of Mars. Originally designed to operate for 90 days on the Martian surface, the Viking spacecraft collected data for six years (Viking: Mission to Mars). The Mars Pathfinder was launched 20 years later in December 1996. The purpose of its mission was to demonstrate the technology to deliver a lander and rover on the Martian surface in a low cost and efficient manner.

The Viking mission is considered a developmental failure when viewed through a FIST framework (Ward, 2009). The Viking mission was rampant with complexity, delays, and cost overruns. The project team was massive and geographically spread out.

Conversely, the Pathfinder mission followed the FIST ideology almost perfectly by adhering to an aggressive schedule and budget by sacrificing performance and system redundancy. *Inexpensive* was the primary driver of the Pathfinder mission, and *Simple* and *Tiny* were the means of achieving it (Ward, 2009). A sensitivity graph in Figure 8 compares the two NASA programs which clearly shows the Pathfinder mission as the more *FISTy* program.

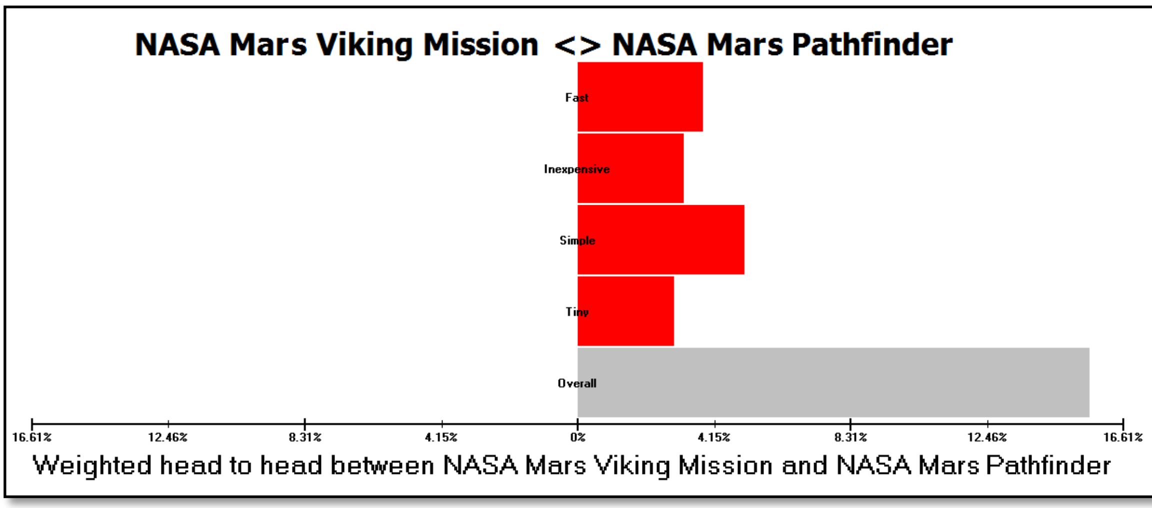


Figure 8: Viking vs. Pathfinder Sensitivity Graph

This example is used to expose another weakness of the FIST methodology. This weakness is that certain programs are a better fit for FIST than others. The Pathfinder mission had 20 years of technology advancements and gained knowledge from the Viking mission to use during its development. "The Viking team didn't know the Martian atmosphere very well, we had almost no idea about the terrain or the rocks…" (Viking: Mission to Mars). While it is stated that the Pathfinder team was asked to design, build, and launch their spacecraft in three years as opposed to the six years afforded to the Viking mission, the Pathfinder program was replicating much of the existing technology developed by the Viking mission (McCurdy, 2001). The timeline did not need to be as long as the Viking mission, which produced the first two spacecraft to land on Mars successfully (Viking: Mission to Mars). The Pathfinder team had information available to them on the atmospheric and surface conditions of Mars as well as shock and vibration environments experienced by the Viking lander and rover. Therefore, the Pathfinder team had a baseline to work from and could sacrifice redundancy and performance without the fear of crippling the entire mission.

What this comparison shows is that FIST is a poor fit for programs accomplishing a first-time feat with minimum proven technology and information available. There are always going to be programs that are the first to use a new technology or fill a new capability gap. These programs cannot effectively be fully *Simple* or inherently *Fast* and *Inexpensive* because the purpose of such programs is to advance the DoD capability beyond what is currently available. If the purpose of a program was not to improve the capability of a currently available system, then the current solution would simply be maintained. There is always going to be a need to improve military capability in order to remain ahead of the enemy and adapt to the ever-changing battlefield. Maturing new technology and incorporating it into a system takes a certain amount of time that is only hampered if developed under the FIST theory. The V-22 Osprey and F-22 Raptor would look much different if they were developed by FIST. Instead of an advanced technology platform, the programs would probably consist of upgrades to current systems in which the proven worth of the upgrades could be questioned in the coming years. FIST may be considered a Band-Aid solution model that produces an immediate product but requires a better solution to be fully developed in the future.

The FIST theory has advantages in certain programs, but if FIST was blindly applied to all programs, the DoD portfolio would be full of cheap and available systems that do not fully meet the users' needs. FIST advocates accepting risks, reducing capability, and using low-cost solutions in order to maintain schedule and budget constraints. This philosophy can be advantageous for repetitive and non-critical missions. It can be argued that if a program is too expensive and lengthy, it will never be produced or used on the battlefield. This was witnessed with RAH-66 Comanche helicopter program that was described in Chapter I. The reverse of this argument is also valid. A system being developed to win the next war is rendered useless if its capability is reduced beyond a certain point only to maintain the artificial budget and schedule. Reflecting on the two NASA Mars missions, the weakness in FIST's *Simple* value is observed:

> Inexpensive was the primary driver, and simplicity had to be enforced to bring the program in on budget. Simplicity was implemented, but forced a reduction in capability. These capability cutbacks were often to the disappointment of the users (i.e. the science community), who had to sacrifice the number and types of instruments, as well as the duration of the mission. While the Pathfinder development team was able to take advantage of technical learning curves and didn't have to pay the cost of invention by their focus on simplicity, the users weren't getting the latest cutting edge science results. According to the FIST principles, however, reductions in capability along with the use of mature technology are both expected in the pursuit of simplicity. (Ward, 2009:115)

At what point does the simplification of a mission, in order to meet schedule and budget constraints, cause the project to become obsolete or not worth the cost of production? *Simple* is a double-edged sword with one side being too complex and expensive to pursue and the other being not technologically advanced to meet the user's requirements.

F-20 Tigershark vs. F-16 Fighting Falcon

The F-20 Tigershark fighter aircraft program was a privately funded venture by the Northrop Corporation. In 1986, the program was cancelled after ten years and over $1.2 billion spent in development (Martin and Schmidt, 1987). Northrop and FIST consider the development of the F-20 to be a success. However, not a single F-20 was sold to foreign or domestic markets to replace the aging F-5 Freedom Fighter. The F-20 program started out with a one page memo stating the Tigershark should have 80 percent of the capability of the F-16 at half the cost (Martin and Schmidt, 1987). The first Tigershark was produced 32 months after program initiation and was one month ahead of schedule. After 1500 test flights, Northrop considered the Tigershark to be comparable to the F-16 in performance but vastly superior in maintainability and reliability (Martin and Schmidt, 1987).

The F-20 represents another example of a program that fits well with the FIST framework. The F-20 did not push the technological boundary, was not the first-of-a-kind product, and had extensive data from previous fighter development programs to leverage. Northrop "obviously benefitted from the technical lessons learned during the development of the F-15 and F-16. They did not push for the cutting edge of technology… Northrop's willingness to derate extra performance for extra reliability and maintainability reflected this realization" (Martin and Schmidt, 1987:9).

The F-20 Tigershark's main competitor was the F-16. The F-20 was characterized as an "intermediate-level fighter with less than top-line capabilities and technologies" (Martin and Schmidt, 1987:21). The F-20s focus was on maintainability, reliability, and cost effectiveness of the aircraft. This adheres to the FIST mindset. With the lenient export policies of the Reagan administration, the F-16 became available for purchase by foreign countries. Countries such as Venezuela and Taiwan demanded the highest level of performance in their fighter purchase and chose the F-16 over the F-20 (Martin and Schmidt, 1987). Furthermore, the F-16 was being sold at cut-rate prices with the tab partially being picked up the U.S. Government (Eskow, 1986). While the F-20 program is a FIST developed system, the simplicity of the airframe ended up being its undoing. Ward (2009:64) states, "The FIST values are very possibly the primary cause of the failure."

It can be argued that the F-20 customers did not have the same values as the Tigershark's developmental team. Customers ended up valuing performance over reliability and maintainability. Also, most foreign countries did not have the need, from a threat standpoint, or the budget to support the F-16 purchase. However, countries viewed the F-16 as an advanced fighter that was thoroughly tested and qualified to outmatch the F-20. If a country purchased the F-20, a neighboring enemy could threaten the whole fleet by purchasing F-16s. "Thus, the foreign governments reasoned, it would be foolish to spend $20 million on a plane the Americans won't fly when you can pay less than that for one they will fly" (Eskow, 1986:145).

The F-16 Fighting Falcon was not analyzed in this research but was included in Ward's (2009) thesis. The F-16 was a banner program for following FIST. The difference is that while *Simple* did contribute to the aircraft's successful development, it did not decrease the performance below what customers deemed acceptable levels.

Simple is a complicated value to master in the FIST theory. Too much *Simple* and the project becomes the F-20 and is outclassed in performance. Not enough *Simple* and the program turns into the never-ending development like the RAH-66 Comanche and is never produced. A project manager on the NASA Near Earth Asteroid Rendezvous (NEAR) program stated, “had I incorporated even half of these good ideas, the spacecraft would never have been built. Only those changes that could be made with negligible or minimal disruption were even considered” (Laufer, 2000:123). Recommendations for how to achieve *Simple* will be discussed in detail later.

V-22 Osprey

The V-22 Osprey program began in the wake of the failed 1980 Iran hostage rescue. Military planners realized the need for a system to have the range and speed of a fixed-winged aircraft but the agility and vertical landing of a conventional helicopter. The V-22 is a tilt-rotor aircraft capable of short takeoff and landing as well as vertical takeoff and landing. The Osprey combines the performance of a helicopter with the long range capability of a turboprop aircraft. The V-22 took 25 years to develop, and price-per-aircraft was double that of the original estimate. The Osprey received the worst possible FIST score in Ward’s (2009) thesis and was also ranked low in the FIST-AHP model. The program clearly did not follow a FIST mindset for development. Ward (2009) characterized the V-22 as an operational triumph but cautioned that the platform’s short track record had not confirmed the Osprey as a true success. Since the time of his thesis, the V-22 has made impressive strides operationally.

On 22 March 2011, two V-22 Ospreys launched from a Marine amphibious assault vessel in the Mediterranean Sea, and within 90 minutes, rescued an Air Force pilot who crashed in Libya. "It was the first time Marines had used the V-22 in such a mission, and the operation went very well owing to the fact that the V-22 is the only aircraft in the world that can fly as far and fast as a turboprop airplane, and then hover or land like a helicopter" (Thompson, 2011). In Ward's (2009:184) thesis, the V-22 received the lowest *Simple* score possible, and he stated, "Simpler, mature alternatives are available, such as the EH-101… Project leaders consistently reject these alternatives in favor of the new, exciting 'breakthrough' tilt-rotor capability." In fact, the V-22 is changing the way the military conducts operations in a way that any conventional helicopter cannot match. "The unrefueled combat radius of the V-22 is more than twice that of the aging Sea Knight helicopters it is replacing, and the V-22 flies over a hundred miles per hour faster" (Thompson, 2011). Search-and-rescue missions are conducted in hostile territory, and the V-22 is less susceptible to damage than a conventional helicopter due to its speed, reduced noise, and design for survivability. "Designers have built so much protection and redundancy into the V-22 that it is probably the safest rotorcraft ever constructed" (Thompson, 2011). It is easy to see why the Osprey received such low scores for Simple, but contrary to Ward's (2009) assertion that alternatives are available like the EH-101, the V-22 is operationally unrivaled. The V-22 is truly a unique capability that is saving lives, impressing commanders, and increasing operational mission success. "As one Marine commander in Iraq put it, the Osprey 'turns Texas into Rhode Island,' greatly increasing the reach of U.S. ground forces with an aircraft that is both more versatile and more survivable than any conventional helicopter" (Thompson, 2011).

The V-22 is an example of a program that is not a good fit for the FIST model. It is a new, costly technology that was required to be developed to fill a capability gap. Merely upgrading current helicopters would not fulfill the capability gap the V-22 is currently accomplishing. If future tilt-rotor aircraft models are produced, the program should consider the FIST approach to development because the technology has been matured by the V-22 platform. When a critical need is realized, utilizing the FIST mentality will create a temporary fix, only postponing the complete solution that needs to eventually be developed.

Mine-Resistant Ambush Protected (MRAP) Vehicle

The MRAP program is clearly a program that should have grasped the FIST concept during development. There is an urgent need to provide troops with vehicles that can provide protection from roadside bombs. Improvised explosive devices (IED) are the biggest single killer of U.S. troops in Afghanistan and Iraq (Sisk, 2012). The flat-bottomed Humvee was not adequately protecting troops from this threat.

There are four reasons the MRAP is the perfect program, from the onset, to be developed under FIST. First, the system needs to reach the war-fighter as quickly as possible. Every day the troops are without this capability, casualties are occurring. The FIST value of *Fast* can help accomplish rapid development. Second, a vast number of MRAPs are needed on the battlefield to ensure every unit has access to the system. Creating an inexpensive system will ensure enough MRAPs can be produced to meet demand. The *Inexpensive* value in the FIST theory will provide guidance to achieve a cost-effective solution. Third, the blast-defecting, V-shaped hulls are not advanced technology that requires time and money to develop. The technology is not complicated as the MRAP is fundamentally a Humvee with protection from IEDs. FIST's *Simple* value can ensure the program maintains performance while not slowing down development to incorporate every brilliant idea engineers cultivate. Fourth, the MRAP must consider the *Tiny* value of FIST. The MRAP should have weight constraints that allow it to be transported by helicopter, ship, and aircraft. If the weight is not controlled, there will be little difference between the MRAP and the medium-armored class of vehicles. Also, the supply chain, such as replacement parts and tools required to service the vehicle should be minimized to improve the maintainability and reliability of the vehicle. *Tiny* has the potential to ensure these characteristics are considered and planned for during development.

The MRAP scored 15 out of 40 possible points in Ward's (2009) thesis and averaged fifth place out of 11 in the AHP model. The program certainty exhibited some aspects of FIST, especially *Fast*, but not to the extent possible. While considered an operational success by Ward (2009), the MRAP in 2012 is already seeing a decreased role. The last MRAP was moved out of Iraq in April of 2012. In Afghanistan, only limited numbers are still in use (Ewing, 2012). As of September 2012, the Marine Corps' plan is to retain about 2,500 of the 27,740 vehicles that were produced. The price of the MRAP is between $535,000 and $600,000 depending on the model, but with spare parts and upgrades, the vehicle costs an average of $1.29 million each (Sisk, 2012). "The heavily-protected vehicles were no more effective at reducing casualties than the medium armored vehicles" and the MRAPs are "three times as expensive as medium protected vehicles" (Rohlfs and Sullivan, 2012). Now, having spent nearly $50 billion on the MRAP fleet, the military finds little use for it. Consequently, many newly produced

MRAPs will never see the theater and instead will be placed straight into storage (Rogers, 2012).

It can be argued that the MRAP was a limited success but ended up being too heavy and expensive. The MRAP is seeing an early retirement after only five years of service. This analysis considers the MRAP a failure due to its limit role and short operational life. This example is used to show that if FIST was properly utilized on the MRAP program, the cost and weight might have been reduced to acceptable levels. Additionally, the MRAP program highlights many of the characteristics that make a program acceptable to be developed by FIST.

Programs Fit for FIST

The MRAP concept is an example of a program that fits perfectly within the FIST framework for development. Four characteristics have emerged from the analysis that point towards a program using FIST for development:

- Urgent Need Capabilities
- Budget Constrained Programs
- Repeated Programs
- Not Advancing Technology

Urgent Need Capabilities

FIST works particularly well with programs that have an urgent need to reach the battlefield. In this case, the project development team must rely on mature technology and maintaining deadlines over developing the complete solution. “Rapid programs rarely provide the customer with 100% of what they ask for. Interviewees expressed the typical ‘80% solution’ concept, but also a more realistic… ‘23% solution’ in practice”

(Lepore et al., 2012:23). It is more important for the system to reach the battlefield and be used to win the current war, or save lives, than to delay development in pursuit of the never-ending 100% solution. Incremental development and clear customer requirements can be applied to get a product quickly into production with the ability to upgrade future versions with maturing technology that would otherwise drag development pace to a crawl. Fielding the system quickly and then developing modular block upgrades will save money and time as well as increase the lifespan of the system. Furthermore, customers often ask for more capability than they actually need and there is simply not enough time to give the customer everything. Customers have unrealistic expectations of the current state of technology, difficulty of requests, and the price of certain capabilities. Collaborating in face-to-face meetings with the customer and developing a stable set of realistic requirements is crucial to delivering an operationally successful system. Requirements should be certified with the customer early and often to establish needs based on capabilities. Requirements creep negatively impacts a program's schedule, budget, and design, and also weakens the scope. If the project team is uncertain of the main purpose of the system due to requirements creep, the operational success is in jeopardy. "The acquiring organization must be willing to push back against unfeasible requirements, or schedule impacting requirements, in the interest of time" (Lepore et al., 2012:22). Incremental development and requirements definition are two areas the FIST theory currently does not incorporate. With research such as that published by Lepore et al., showing the importance of these activities in rapid acquisition, these tools should be added to the FIST model to ensure urgent needed weapon systems reach the war-fighter in a timely manner.

Budget Constrained Programs

Programs that have small, constrained budgets are good candidates for FIST development. Project teams that realize they will not receive additional funding, or that future funding could be in danger, would benefit from the FIST framework. Inexpensive programs do not have the budget for a long, drawn-out schedule or for maturing technology that is currently undeveloped. FIST optimizes programs with small budgets by using the *Simple* and *Tiny* values as tools to maintain schedule and budget. FIST emphasizes implementing existing technology, accepting risks, creating a small development team, seeking low-cost solutions, and formally committing to the budget and schedule.

The A-10 Thunderbolt II aircraft is a concrete example of a budget constrained, successful FIST program. In the early 1960s, the Air Force emphasized strategic bombing and air superiority over close air support (CAS). While CAS was officially an Air Force role, the Air Force did not have a dedicated aircraft specifically designed for ground attack and CAS. As a result, the Army started arming helicopters to supplement CAS. In 1966, The Research and Development Corporation (RAND) conducted a CAS study and stated, “The Air Force should take immediate and positive steps to obtain a specialized close air support aircraft, simpler and cheaper than the A-7, and with equal or better characteristics than the A-1” (Goldberg and Smith, 1971:33). This statement shows, from project initiation, that the A-10 should be simple and inexpensive and also utilize technology that is already fielded. These characteristics are the strengths of the FIST model.

During the A-10 program development timeline, the Air Force was advancing the expensive stealth technology and there was little room in the budget for the A-10 to be costly. Therefore, the emphasis was on fulfilling the capability gap of CAS with the most cost-effective solution possible. What resulted was a proposal for 600 aircraft with a design-to-cost goal of $1.4 million unit flyaway cost (FY70$) (Jacques, D. and Strouble, 2008). The program produced an aircraft that met cost goals and fulfilled the CAS role. In fact, the A-10 is still in use today and has proven its worth in combat over many airframes that cost exponentially more to produce.

As further evidence of the importance of incremental analysis in rapid acquisitions, the A-10 developed several different packages of technology in order to meet the initial operational capability (IOC) of December 1970. "The avionics for the A-X were specified in terms of a 'skeleton' package (below minimum requirements), a 'lean' package (met only minimum requirements), and three add-on packages that would supplement the 'lean' package" (Jacques and Strouble, 2008:20). Each add-on package increased the strike capability of the A-10 but was presented as options to the Air Force, each with different costs. This allowed the Air Force to choose the A-10 package that matched the budget with the potential to upgrade in the future should the threat environment change. Incremental development is a technique that fields the system quickly and inexpensively while leaving room for future add-ons to increase the capability to the desired level. The added benefit of quick delivery and incremental improvement is receiving early feedback from the war-fighter on the system. Perceived upgrades and planned future capabilities may not be required or may go a different direction than initially realized. It is impossible to understand fully how the system will be deployed in the field and which upgrades will be required as opposed to which upgrades are a waste of development time and funding. Allow the war-fighter to use the basic system as quickly as possible and incorporate their feedback into block upgrades instead of pursuing enhancements that engineers stateside deem as important.

Repeated Programs

The previously compared NASA Mars Viking and Pathfinder missions lead into the next characteristic of a program fit for FIST. Programs that are repeated or have vast historical data are acceptable programs to be developed under FIST. The Mars Viking mission was not *FISTy* in its development because it was accomplishing a first-of-a-kind mission with little information on the Martian environment. The Mars Pathfinder mission, launched 20 years later, was *FISTy* and leveraged the lessons learned and data derived from the Viking mission to speed up development and reduce costs. The Pathfinder team was able to scale-back technology and redundancy in order to maintain schedule and budget.

Repeat programs, often frequent with space launch missions, can utilize FIST by striving to reuse proven technology and leveraging data from previous efforts. The focus should be on integrating the legacy system with new, developed technology as necessary based on mission requirements. Existing technology can be innovatively integrated into a platform to create a short term, rapid solution. In rapid acquisitions, there is not sufficient time to mature unproven technology. Immature technology is a pitfall that requires time and money to foster. “In Technology Readiness Level (TRL) terms, this means nothing less than a TRL 6, preferably 7 or 8” to incorporate technology into a rapid development program (Lepore et al., 2012:19). The MRAP vehicle could have taken a FIST approach to development by taking advantage of existing vehicle designs and adding the blast-deflecting hulls. Utilizing proven technology and designs, minimizes rework which generally does not add value to a program. "Rework is perhaps the most common form of time-sink that system development projects experience" (Lepore et al., 2012:36). Instead of testing, verification, and validation of an entire design, attention can be centered on the upgrades such as the mine-resistant hull of the MRAP. Any program that is merely an evolution of previous systems should employ FIST in order to maintain focus on developing the end product quickly while avoiding the pitfalls of beyond-state-of-the-art technology and requirements creep.

Not Advancing Technology

FIST, with the addition of incremental development, could be used when a system can meet user requirements without the use of immature technology. If the technology needed is already in use in other platforms, or is at a sufficient readiness level, the program can be developed rapidly. There are many benefits to rapid development including greater stability in project requirements, funding, and personnel. The project is completed so fast that there is a reduced chance of leadership and political change affecting the program. More importantly, the war-fighter receives the capability before the threat environment can change and render the platform obsolete.

FIST can ensure the program makes the correct trade-offs between performance, cost, and time. Incremental development can ensure the program plans for advancements to be seamlessly incorporated into the design in the future. This will keep the system relevant and allow emerging technology to be matured in the labs instead of in the program office where it would hold up production.

The A-10 Thunderbolt II aircraft serves as yet another example of the use of existing technology innovatively assembled to create a superior capability. Engineers chose a simple design and did not hold up production for the latest advancements because the technology was readily available to build a CAS aircraft that met Air Force criteria. "The nose of the plane is pointed at the target and a burst of cannon shells squeezed off—simply, quickly and efficiently" (Burton, 1993:25).

Programs Unfit for FIST

Certain programs in the analysis were operational successes with imperative capabilities. Nevertheless, they were developmental failures and did not resemble the FIST methodology. While these capabilities still needed to be developed, program characteristics emerged that showed certain types of programs do not fit the FIST development model:

- Large Systems
- Inherently Expensive
- First-of-a-Kind Programs
- Advancing Technology

Large Systems

One of the most misunderstood FIST values during the experiment was *Tiny*. Project managers understood the concept of reducing the team size, process, and documentation but thought it had little to do with overall program success when compared to the other values. When managing programs, such as massive highway systems or the C-5 Galaxy aircraft, the best solution was not to reduce the size of the project because size is what made the project a success. If the C-5 Galaxy was reduced in size, it would not meet operational objectives. Large projects, such as cargo aircraft, naval ships, civilian bridges and buildings, need to be large by design. Massive projects often have long schedules due to the amount of work that needs to be accomplished. Longer schedules produce larger budgets. Often complications arise on large programs because there are more areas for problems to surface and there may be remarkably little historical data to leverage.

When the C-5 was developed in 1970, it was the largest aircraft in the world (Griffin, 2005). Making an aircraft larger than anything else built before is bound to have unknown issues and a lack of existing technology. This makes the *Simple* value hard to enforce. "But building a big airplane like the C-5A was not just a matter of scaling up the smaller C-141. When the increase in size passed a certain point, technical challenges and changes cropped up" (Gregory, 1989:110). Large programs require a larger project team compared to smaller endeavors. More workers, machinery, and larger facilities are required to complete the work.

All four FIST values seem to have issues with a program that is characteristically large. Of course, large programs can find value in following FIST, such as using existing technology where possible, maintaining the deadline and budget, and choosing low-cost, simple solutions. Yet, many of these concepts are basic project management skills, not unique ideas belonging to FIST. Project managers are always attempting to complete programs on schedule, budget, and performance while making tradeoffs for capability, risk, and cost. Large programs just do not fit the FIST model because FIST emphasizes a fast pace, lowest-cost, simple solution, and small-as-possible system. Large programs often have to invent their own technology to handle the load or expanse of the project because there may be no other project like it in the world. Immature technology has proven to be slow, expensive, and complicated to develop. This illustrates that large programs may not be able to employ FIST successfully.

Inherently Expensive Programs

Programs that are inescapably expensive are going to be a poor fit for the FIST model. Expensive projects can occur when a program is developing an emerging technology, completing a first-of-a-kind task, or conducting a project that is so vast, it has a great deal of oversight and unforeseen issues. Expensive programs are projects that are so imperative to national defense or saving human life that corners cannot be cut and risks cannot be accepted.

In some fields, such as space launch programs, the customer may state there is no limit to the amount of additional funding they would pay to increase mission reliability from 99.5 to 99.9 percent. That is how important success is to certain missions. Space and material programs are decidedly different. Often satellites are irreplaceable if lost due to a launch anomaly. The reason is that satellites are often so complex, one-of-a-kind, and expensive that funding will never exist to replicate the undertaking. Often the space community will never observe the outcome of the technology developed in a lost satellite mission because the program will never be repeated.

When a program's success is vital to win the next war, defend national security, or maintain the U.S. technological advantage, the program is going to be inherently expensive. These types of programs are needed to be accomplished to maintain battlefield superiority regardless of cost or schedule. As a closing example, the V-22 Osprey may have taken 25 years and billions in cost overruns to produce, but there is not a system capable of replicating its versatility. Now that the V-22 is operational, it is saving lives, raising morale, and changing military doctrine unlike any conventional helicopter.

First-of-a-Kind Programs

First-of-a-kind, revolutionary programs are undertakings that have little to no legacy systems and historic information to exploit. In this analysis, the V-22 Osprey's tilt-rotor, the C-5 Galaxy's size, and the NASA Viking mission's first landing on Mars all represent projects that blazed a new path technologically. These three missions were all operational successes and all considered FIST failures. These missions dealt with unknown challenges and technology. Existing, proven technology was either limited or non-existent. Therefore, producing unique solutions was costly, time consuming, and decisively not *FISTy*. The pattern from the analysis indicates that programs that are first-of-a-kind are all FIST failures. Some of these FIST failures are operational successes, and some are disasters, such as the RAH-66 Comanche.

While these aforementioned programs were not *FISTy*, they were not developed under the rapid development mindset. The solution to first-time projects may be a term known as technical debt. Technical debt was developed by Cunningham (2013) in the early 1990s in relation to software design and was later applied to rapid acquisitions in a technical report published by the Systems Engineering Research Center. Technical debt "is a way to describe the risks and compromises made in rapid acquisitions" (Lepore et al., 2012:26). Technical debt includes the processes or technology that is chosen not to be completed immediately, but to be delayed until it is more developed or understood. The development progresses by designing the areas or subsystems that are understood, all the while leaving room in the design to include the postponed technology. When the deferred technology has reached an adequate level of maturity, it can be designed into the system or incorporated via a modular upgrade to existing units. As more and more items are postponed for development, technical debt is incurred. Interest is *paid* on this debt by having to revisit and incorporate the postponed technology into the system while hoping the design has left adequate room without too much costly redesign. Programs should not get into too much technical debt by attempting to incorporate vast amounts of immature technology on the gamble that it will be ready for integration during program development. Cunningham explains technical debt in the following interview excerpt:

> Let's take part of what we understand and express that. And then react to that and express more. And react to that and express more. It's an incremental approach. I think it's important if you're going to take an incremental approach, you might learn something tomorrow that influences design decisions you've made today. That should be considered a good thing – to be able to take tomorrow's learning and not discard it because you've made a decision today. That requires a set of practices that were unfamiliar early on… where you had to make a bunch of decisions up front early. (Cunningham, 2013)

When too much technical debt is accumulated, the engineers try to utilize too much advanced technology and are never able to finish the program. However, when technical debt is executed properly, the project team is able to delay final decisions about emerging technology until later in the program when the advancements are better understood. Minimizing and choosing only key sub-systems to postpone will add to the success of utilizing the tool of technical debt.

Advancing Technology

When the purpose of a program is to adapt cutting-edge technology into a system, so as to deliver an innovative capability, FIST is not an appropriate model to follow.

Also, FIST is not advantageous for research labs that are maturing a technology to be used in future programs. The reason being, FIST is designed to meet a war-fighter need quickly, with available technology, so that the new system can be deployed against the enemy of the current engagement, not the next war. Advanced technology is always going to need to be developed in order to stay ahead of enemy capabilities. Failures in advanced technology programs still provide a leap forward in technology that can be harnessed in other programs inexpensively. Optimizing the failure can occur anywhere from learning from mistakes to capitalizing on newly developed technology. The solution to developing advanced technology may lie in an ambidextrous organizational structure.

Lepore et al. (2012) explores the concept of an ambidextrous organization. Ambidextrous organizations consist of an exploration and exploitation structure. The exploration structure is tasked with inventing and developing new technology and is commonly associated with the early concept development phase. "Personnel working in exploration structures tend to be rewarded for taking risks, generating new information or technologies, and creating new opportunities for the program" (Lepore et al., 2012:42). The exploitation structure is focused on implementing the technology developed by the exploration team. "Exploitation generally has substantial routines in place, including milestones, project management practices, and specific work activities identified that should be performed in particular order" (Lepore et al., 2012:42).

Technology development should take place in an exploration structure in which the team's priority is to create technology that is suitable to be used in a weapon system. The exploitation structure should develop actual weapon systems, utilizing only technology that has been advanced far enough by the exploration team to be used in a program. With exploration and exploitation organizations working in concert, the exploitation team can use incremental development and technology debt to incorporate new technology from the exploration team. The exploration team should keep the exploitation unit abreast of the current advances in technology with realistic timeframes so projects are not artificially delayed for technology that is years from maturity.

FIST Activities

One of the many outcomes stemming from the experiment was a ranking of the FIST activities from most important to project development success to least. Table 36 shows how each of the seven groups of project managers ranked the FIST activities. The table is sorted by the *All Participants* model. The *Rank* column lists the ranking of each activity corresponding to each group. The *Weight* column represents the priority vector or weight of that activity. The combined weight for each project manager group adds up to 1.0.

Table 36: FIST Activities Ranking

SUB-CRITERIA MODEL	All		Leader		Non-Leader		Military		Civilian		Consistent		Expert		AVERAGE	
	RANK	WEIGHT	RANK	WEIGHT	RANK	WEIGHT	RANK	WEIGHT	RANK	WEIGHT	RANK	WEIGHT	RANK	WEIGHT	RANK	WEIGHT
Importance of Simplicity (Design, Organization, Documentation)	1	0.083	3	0.069	2	0.082	4	0.074	3	0.074	1	0.082	3	0.073	2	0.077
Importance of low-cost (Choosing a Low Cost Design / Solution)	2	0.081	5	0.062	6	0.065	2	0.082	10	0.050	2	0.081	9	0.050	5	0.067
Formal commitment to maintain deadlines	3	0.081	1	0.090	7	0.064	8	0.062	1	0.097	5	0.073	1	0.096	4	0.080
Concrete steps taken to actually reduce development time	4	0.079	3	0.069	1	0.084	1	0.083	6	0.067	3	0.078	5	0.066	3	0.075
Heavy reliance on existing, mature, proven technology (TRL 7+)	5	0.077	12	0.044	4	0.074	6	0.068	14	0.042	4	0.075	14	0.042	8	0.060
Deliberate steps taken to actually reduce complexity in many areas	6	0.076	6	0.061	5	0.072	5	0.073	8	0.058	4	0.075	7	0.057	6	0.067
Formal commitment to maintain budget	7	0.068	2	0.077	8	0.057	7	0.062	2	0.075	6	0.067	2	0.075	5	0.069
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	8	0.065	3	0.069	6	0.065	5	0.073	7	0.063	8	0.064	5	0.066	6	0.066
Concrete steps taken to actually reduce development cost	9	0.064	4	0.068	3	0.080	3	0.075	4	0.070	7	0.066	4	0.070	5	0.070
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	10	0.051	11	0.045	10	0.047	11	0.042	11	0.048	9	0.055	11	0.046	10	0.048
Contractual incentives to reward early delivery	11	0.043	7	0.052	9	0.052	10	0.051	9	0.052	10	0.047	8	0.056	9	0.050
Emphasis on the importance of and reliance on employees' talent	12	0.041	10	0.049	8	0.057	13	0.037	5	0.069	11	0.043	6	0.062	9	0.051
Accept risk in order to maintain schedule	13	0.039	9	0.049	13	0.034	11	0.042	14	0.042	13	0.037	12	0.044	12	0.041
Contractual incentives to reward cost under-runs	14	0.037	8	0.051	11	0.042	9	0.053	13	0.043	12	0.041	13	0.043	11	0.044
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	15	0.031	13	0.040	12	0.037	14	0.031	12	0.047	14	0.032	10	0.048	13	0.038
Accept Risk to Reduce Cost	16	0.031	14	0.040	14	0.031	12	0.038	16	0.034	15	0.031	15	0.034	15	0.034
System capability less than previous systems (Design Optimized for Main Objective)	17	0.027	16	0.029	15	0.026	15	0.027	17	0.028	16	0.028	16	0.028	16	0.028
Importance of Small (Small Design, Minimum Documentation, Small Budget)	18	0.025	15	0.036	14	0.031	16	0.026	15	0.041	17	0.027	13	0.043	15	0.033

Military vs. Civilian

The *Military* model will be compared to the *Civilian* model to discern any differences in project management values between the two communities. The civilians selected for the experiment primarily have experience in infrastructure and transportation projects. While this differs from military weapon system development, the scope of the civilian projects is large enough to validate the comparison. The strength behind the civilian responses is that this group has many years of experience in the field, plus they manage for profit in a competitive industry. If civilian project managers allow cost increases to absorb their profit margins, their job and company are in danger. The civilian project management world is competitive with multiple firms bidding for projects. This competition sharpens civilian project managers' skill set and forces the deficient managers out. Table 37 illustrates how the military and civilian project managers ranked the 18 FIST activities.

Table 37: Military vs. Civilian Activity Ranking

SUB-CRITERIA MODEL	Military		Civilian	
	RANK	WEIGHT	RANK	WEIGHT
Concrete steps taken to actually reduce development time	1	0.083	6	0.067
Importance of low-cost (Choosing a Low Cost Design / Solution)	2	0.082	10	0.050
Concrete steps taken to actually reduce development cost	3	0.075	4	0.070
Importance of Simplicity (Design, Organization, Documentation)	4	0.074	3	0.074
Deliberate steps taken to actually reduce complexity in many areas	5	0.073	8	0.058
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	5	0.073	7	0.063
Heavy reliance on existing, mature, proven technology (TRL 7+)	6	0.068	14	0.042
Formal commitment to maintain deadlines	7	0.062	1	0.097
Formal commitment to maintain budget	7	0.062	2	0.075
Contractual incentives to reward cost under-runs	8	0.053	13	0.043
Contractual incentives to reward early delivery	9	0.051	9	0.052
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	10	0.042	11	0.048
Accept risk in order to maintain schedule	10	0.042	14	0.042
Accept Risk to Reduce Cost	11	0.038	16	0.034
Emphasis on the importance of and reliance on employees' talent	12	0.037	5	0.069
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	13	0.031	12	0.047
System capability less than previous systems (Design Optimized for Main Objective)	14	0.027	17	0.028
Importance of Small (Small Design, Minimum Documentation, Small Budget)	15	0.026	15	0.041

The first difference that is immediately apparent is how significantly civilians emphasize *Formal commitment to maintain deadlines* and *budget*. Civilians ranked maintaining deadlines as their most prominent activity and maintaining budget as their second most important activity. Both these activities tied for seventh place in the military model. This can indicate that civilian project managers are more aware of the schedule and budget than their military counterparts. The military uses schedule delays and cost overruns as project management tools to solve problems. The civilian industry is more focused on accomplishing the task in the timeframe given and with the allowable budget. One of the civilian responses to the experiment provided the following feedback:

> Project has scope/schedule/budget and quality - all are inter-related. Based on my experience on managing engineers in design, the only way to control the budget (cost of the work) is to manage the schedule. If you give an engineer three months to do a design, he will work on it for three months. You can demand the same design be done in two months, and you will get the same level of design, but at 2/3rds the cost and in 2/3rds the time.

This feedback may be the driving force behind why civilians and experts ranked *Fast* as by far the most important FIST value. The military ranked *Simple* as the most important FIST value. This value difference could be due to the fact that the military does not deal with profits to the extent that transpires the private industry. The military is focused on providing the best capability to the battlefield, whereas civilian project managers are determined to complete the project based on the client's goals. "As consultants, we work for our clients and various clients have various goals - managing a project for a client measures success by attaining the client's goals." This feedback, provided by another civilian project manager, demonstrates how their priorities change based on the client's needs. In the military, if a capability is required promptly, project managers' mindset should change to reflect accomplishing the project as fast as possible. However, if the goal of the project is to develop advanced technology, the priority should be to increase capability over project pace.

Next, the military stressed three tasks that their civilian contemporaries did not value as highly:

- *Concrete steps taken to actually reduce development time*
- *Importance of low-cost*
- *Heavy reliance on existing, mature, proven technology*

The first reason that may explain this difference could be that the civilians surveyed do not develop technology to the extent of the military. However, if civilians are concerned with profits, why do they not value low-cost solutions? The answer is that the low-cost FIST activity may be too vague. One civilian respondent commented:

> Importance of low-cost can have a few very different interpretations. What is the project's objective: lowest design cost, lowest construction cost, or lowest lifecycle cost? Often getting the lowest lifecycle cost on a highway facility means higher capital construction costs - think Portland Cement Concrete (PCC) pavement versus asphalt pavement. PCC will cost more to install, but last and perform better over a longer term.

Choosing the lowest cost solution may not always be the best course of action as life cycle costs could overwhelm any savings realized during development. "Experience indicates that a large percentage of the total cost for many systems is the direct result of the downstream activities associated with the operation and support of these systems, whereas the commitment of these costs is based on the engineering and management decision made in the early conceptual and preliminary design stages of the life cycle" (Blanchard and Fabrycky, 2005:582). Therefore, low-cost solutions during development may not be optimal if other costs are not taken into consideration such as testing, production, training, operations, maintenance, retirement, and disposal.

For the FIST activity of *Heavy reliance on existing technology*, one civilian project manager responded "… using tried and true existing systems is good, but it stifles innovation." Civilian project managers commented that they are always looking for innovative ways of completing a project better, faster, or for a lower overall cost. Lastly, civilian project managers de-emphasized concrete steps to reduce development time. This could be contributed to civilian project managers simply not having a lot of experience in development since the nature of their projects mainly encompasses infrastructure and transportation that already has established mature technology.

It is worth noting that civilian project managers ranked the activities of accepting risk lower than the military ranked these activities. Risks are often viewed as negative and should be avoided or mitigated. In rapid acquisitions, risk taking may be the only course of action available to deliver technology to the battlefield. Additionally, civilians greatly highlighted the importance of relying on employee talent. This leads directly into one of the key observations from Lepore et al. (2012). Based on interview analysis conducted in that research, project manager autonomy is vital. Placing decision-making at the lowest level "shortens the process, reduces opportunity for stall time, and fosters close relationships" (Lepore et al., 2012:27). In order to have confidence and trust in the low-level project managers, leadership must rely on the talent in their organization. The private industry understands this concept and eliminates some of the time-consuming bureaucracy and oversight that plagues the military. Civilians trust the project managers running the program to make the correct decisions.

Leaders vs. Non-Leaders

This comparison is between both civilian and military project managers who have assumed a leadership position and those project managers who have no leadership experience. The purpose of this comparison is to see if there are any disconnects between leaders and those carrying out the vision of the leaders. Table 38 provides a direct comparison of the FIST activity rankings between the two groups.

Table 38: Leader vs. Non-Leader Activity Ranking

SUB-CRITERIA MODEL	Leader		Non-Leader	
	RANK	WEIGHT	RANK	WEIGHT
Formal commitment to maintain deadlines	1	0.090	7	0.064
Formal commitment to maintain budget	2	0.077	8	0.057
Importance of Simplicity (Design, Organization, Documentation)	3	0.069	2	0.082
Concrete steps taken to actually reduce development time	3	0.069	1	0.084
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)	3	0.069	6	0.065
Concrete steps taken to actually reduce development cost	4	0.068	3	0.080
Importance of low-cost (Choosing a Low Cost Design / Solution)	5	0.062	6	0.065
Deliberate steps taken to actually reduce complexity in many areas	6	0.061	5	0.072
Contractual incentives to reward early delivery	7	0.052	9	0.052
Contractual incentives to reward cost under-runs	8	0.051	11	0.042
Emphasis on the importance of and reliance on employees' talent	9	0.049	8	0.057
Accept risk in order to maintain schedule	10	0.049	13	0.034
Formal commitment to maintain or reduce size of: Design, Requirements, Technology	11	0.045	10	0.047
Heavy reliance on existing, mature, proven technology (TRL 7+)	12	0.044	4	0.074
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation	13	0.040	12	0.037
Accept Risk to Reduce Cost	14	0.040	14	0.031
Importance of Small (Small Design, Minimum Documentation, Small Budget)	15	0.036	14	0.031
System capability less than previous systems (Design Optimized for Main Objective)	16	0.029	15	0.026

Leaders prefer to have a *Formal commitment to maintain deadlines* and *budget* while non-leaders favor *Concrete steps taken to actually reduced development time* and the *Importance of simplicity*. This observation is characteristic of many organizations in which leaders are not heavily involved in the daily activities and judge progress and performance based on how well the schedule and budget are being followed. Workers, on the other hand, prefer simplicity in design, documentation, and organization so that they clearly understand the framework for managing the project. A complicated reporting structure with massive amounts of unnecessary documentation buries project managers under a mountain of tasks and hinders their ability to manage a project.

Non-leaders also have a strong preference for utilizing proven and existing technology whereas leaders show exceedingly little emphasis in this area. This disconnect could create problems through leadership expecting more cutting-edge, innovative technology to be included in projects. Non-leaders see the difficulty in managing and maturing new technology and prefer proven technology that has known capabilities and reduced risks. Emerging technology will have many unknown flaws where proven technology has significantly less unknown problems that negatively affect development.

Leaders ranked contractual incentives and accepting risks as a higher valued activity than non-leaders. This could be due to the fact that these are activities that upper management approves and has input in during the project. Non-leaders focused in more on R*elying on employees' talent* and taking *Concrete steps to reduce development time* and *cost*. If a project manager can streamline development, the other activities such as risks, incentives, and maintaining a schedule will all be positively affected.

The conclusion from this comparison shows that leadership is more interested in a project that maintains the given schedule and budget while developing innovative solutions that use unproven technology. Leaders are willing to accept risks and provide contractual incentives to bring a project in on time and budget. Non-leaders are focused on concrete steps to improve development in both time and cost. If development can be improved, the deadlines and budget will be met, and there is less need to accept risks and provide incentives to complete the project. Furthermore, non-leaders would rather rely on their talent and a simplified process for managing a project. Leaders view the tried-and-true project management process and required documentation as a safety net so that if the project fails, the blame cannot be placed on them for trying a new method of project management. Adding further evidence to this trend, leaders ranked the FIST value *Fast* as most important and non-leaders ranked *Simple* as the most crucial value.

Experts

The experts' top five activities for project management are:
1. *Formal commitment to maintain deadlines*
2. *Formal commitment to maintain budget*
3. *Importance of Simplicity*
4. *Concrete steps taken to actually reduce development cost*
5 (Tied). *Importance of Speed*
5 (Tied). *Concrete steps taken to actually reduce development time*

These activities are extremely important to successful project management based on experts' opinion in project management. Three of these activities fall under the *Fast* category, two under *Inexpensive*, and one under *Simple*. While these activities are not unique to FIST, the activities should remain as cornerstones to the FIST model.

The least valued activities by experts are the following:
12. *Accept risk in order to maintain schedule*
13 (Tied). *Importance of Small*
13 (Tied). *Contractual incentives to reward cost under-runs*
14. *Heavy reliance on existing, mature, proven technology*
15. *Accept Risk to Reduce Cost*
16. *System capability less than previous systems*

As shown by these activities, experts do not place significance on accepting risks to further a project, using contractual incentives, or using proven technology. Experts agree that the *Importance of small* is minimal as some projects are inherently large by nature. Across all groups, *System capability less than previous systems*, was not valued or understood. These activities are candidates for improvement or elimination for the FIST model.

One interesting note is that both civilians and experts did not value low-cost solutions, and instead emphasized employee talent much more than other groups of project managers. As stated earlier, low-cost solutions during development could have unforeseen life-cycle cost consequences. Also, relying on employee talent can speed up a project by placing decision-making authority with the front-line project managers. Experts, like the civilian model, ranked *Fast* as the most important FIST value. Based on feedback from the experiment, civilians and experts alike believed controlling the schedule would, in turn, control the budget and the program in general. If the schedule allowed time for the development of innovative solutions, the project manager should set-aside time to explore the new technology.

Poor FIST Activities

System capability less than previous systems, was commonly the lowest ranked activity and the least understood throughout all the models. One civilian project manager commented, "I also had trouble with the activities that *dumbed* down and reduced the capability of the current widget. I find it hard to believe that you would want to develop a new version of something that would have less capability." This activity was difficult to understand while completing the alternatives analysis. It was not clear exactly what this activity meant.

Importance of small was the next activity that was ranked low in all models. This activity was part of the *Tiny* FIST value. *Tiny* was ranked last of the four values in all models except in the experts' model where it is essentially tied for last with *Inexpensive*. Overall, the three *Tiny* activities ranked in the bottom half of the analysis in all project manager groups. Whether this value and activities are misunderstood or not valued, this is clearly a weakness in the FIST model. Obviously, changes will need to be made to the *Tiny* value in order to create a stronger, better-rounded model.

Feedback from one expert stated that some activities would negate having to complete the other activities. Therefore, if a project manager took the FIST framework and tried to enforce all the activities in an attempt to be *FISTy*, they would be duplicating some efforts and confusing the project team by administering multiple methods of achieving the same ends. For example, using proven technology and accepting risks are opposites. Project managers use proven technology so they have less risk to accept.

The last piece of constructive feedback comes from an expert with 36 years of experience who stated, "I believe that perhaps this is a bit too academic and generic and maybe I have had too much PM [project management] experience." The FIST values, activities, and framework are hard to criticize because they represent good project management ideals. However, there seems to be little depth to the model that can be used to actually run a program.

Recommendations

FIST should be viewed as a rapid development acquisition model. It is not a perfect fit for all programs. NASA experimented in 1990s with *Faster, Better, Cheaper* and FIST seems to be a projection of this mentality into the DoD acquisitions. The analysis of historic weapon system development has revealed many strengths and weaknesses of the FIST model. The ranking of FIST values and activities by a wide spectrum of project managers has exposed flaws in the FIST ideology. This section will provide recommended changes to the FIST model.

Inexpensive

The first two FIST values of *Fast* and *Inexpensive* basically translate to the concepts of time and cost on the *Iron Triangle* of project management. This leaves *Simple* and *Tiny* to account for the quality aspect of the *Iron Triangle*. The only recommended change to *Inexpensive* is under the activity of *Importance of low-cost*. This should have a caveat that project managers should consider the lifecycle costs to ensure a tradeoff during development does not create excessive costs in downstream phases of the system. Other than this recommendation, *Fast* and *Inexpensive* are straight forward project management concepts that are not new to the profession.

Simple

The *Simple* activity of *System capability less than the previous system* should be eliminated or further expanded so that it can be understood. Instead of this activity, it is recommended to add generational development as a *Simple* activity. Generational development is described in a technical report on rapid capability by Lepore et al. (2012). This concept is similar to incremental development except it is determined to be used from the beginning of development as a way for known and unknown technology advancements to be seamlessly incorporated into the system. This technique fits perfectly with the FIST mindset because it allows a weapon system to use existing technology in order to rapidly release the product to the war-fighter. The added benefit is the ability to upgrade the system in the future with technology that can mature outside of the weapon system program where it will not delay progress. As Cunningham (2013) stated “you might learn something tomorrow that influences design decisions you’ve made today. That should be considered a good thing – to be able to take tomorrow’s learning and not discard it because you’ve made a decision today.” In the future, generational development will allow platforms to be upgraded instead of the development of a new weapon system. Engineers and project managers need to be aware of the technology improvements on the horizon and should target those areas in the system for easy incremental upgrades.

Awareness of technological breakthroughs leads into the next recommendation. To expand the *Simple* activity of *Importance of simplicity*, development organizations should have an ambidextrous organization. As previously explained, the organization consists of an exploration structure that seeks and matures new technology and an exploitation structure that takes the established technology to be assimilated into a system. Each structure communicates frequently with each other to share knowledge on advancements and requirements to create a symbiotic relationship. This consistent communication enables the exploration structure to maintain focus on developing technology that is needed to fill a capability gap. At the same time, it allows the exploitation structure to understand what technology is available for integration and which is too immature to be used in the current system.

The next recommendation surrounds the activities of the *Reliance on employees’ talent* and the *Tiny* activity, *Importance of small*. This explanation should be expanded to include a definition of a successful small project team. It is not adequate to merely state: have a small project team. The project team must consist of people with the right background, education, and experience for the project. Allowing important programs to handpick their personnel will ensure the required skill sets for a project are covered by experts on the team. The low-level project managers should be empowered with decision-making authority and the freedom to keep the program pace moving rapidly. In a rapid development or FIST program, the employees should be comfortable with taking risks and working in an unstructured and ambiguous environment. Minimize the reporting structure and keep it informal to reduce time-consuming oversight reviews. Decisions to proceed should not be halted until the weekly leadership meeting but rather should occur spontaneously and informally as decisions arise. One way to reduce organizational complexity is to co-locate the project team (Lepore et al., 2012). Informal learning can transpire simply by being located near other members of the project team.

Employees and leadership should accept that failures and mistakes occur but are acceptable in rapid acquisitions as long as the lessons learned are spread throughout the community and not repeated. Technology advances from failed programs can be leveraged in future systems. Lastly, employees should understand the goals of the client or war-fighter and design their system, schedule, budget, and risk acceptance level accordingly. Each project should have a different mindset based on the customer's requirements.

Tiny

The *Tiny* value is predominantly the lowest ranked FIST value and among the least emphasized activities. The *Tiny* value does not appear to be as well-designed and comprehensive as the other values. This leaves the possibility for much improvement. In fact, with the correct additions, *Tiny* could be the key to the FIST model.

The most important activity, when starting a project, is to gather the requirements from the customer. Requirements shape the project and provide guidance. This activity is not present in the FIST model. If a customer needs a rapid capability, they should first meet with the exploitation team to develop concrete requirements. Often customers are unaware of the realistic technology available and what capabilities they truly need to satisfy the mission. It will be the job of the exploitation team to develop realistic requirements in face-to-face meetings with the customer, using only technology deemed mature by the exploration team. The requirements should be linked to capabilities in an operational context. The requirements should not focus on encompassing a specific technology. The end product may be hampered if specific technology is specified than if the design was left open for the project team to develop as they see fit. Once a minimum set of capability-based requirements are developed, the project team needs to lock the requirements in and fight any unfeasible changes or additions to the requirements. Changing requirements once design progress is underway, destabilizes and weakens the scope of the project. Scope creep negatively impacts cost, schedule, and performance by altering the direction and design of the program. The program team should frequently validate requirements with the customer because mistakes become more expensive the further in development they are realized.

As Lepore et al. (2012) states, rapid programs typically produce 80% solutions or less. This is advantageous in rapid acquisitions because there is not enough time to satisfy all of the customer’s needs. Project teams could spend months and millions of dollars chasing the last 20% of a solution. At this point, the law of diminishing returns takes effect. Showing the customer the drastic decrease in cost and schedule associated with developing the 80% solution, generally receives wholehearted approval. If the customer requires a solution greater than 80%, perhaps their need is not as urgent, and they should meet with the exploration team to develop future technology to meet their capability in the five to ten year timeframe.

Incremental development plays a role with developing a customer approved solution. Similar to the A-10 Thunderbolt II program, the project team can present the customer with different technology packages along with the cost and time associated with developing each. A rapid system can reach the battlefield with the promise of upgrades being included in the future to increase the capability to meet the user's requirements. Initial war-fighter feedback can shape and direct future upgrades in a direction different than originally planned.

The last recommendation is to manage the technical debt. Technical debt is accumulated as more and more immature technology is designed into the system. The team must, at some point in the future, rework the configuration of the system to accommodate the unknown final form of the technology. The advantage to technical debt is postponing uncertain decisions to the future when they may be better understood. The disadvantage is that if too much uncertainty is left to the end of the program, the project may fail or never reach production. It is recommended that if a program is pushing the technological boundary with a specific subsystem, such as the V-22 Osprey's tilt-rotor capability, the beyond state-of-the-art technology should be limited to that single area. A single innovation is manageable by using the tools and techniques described. However, if the program attempts to invent advancements throughout the project, the system will never reach completion and the mounting risks will halt the progress until failure ensues.

Conclusion

The FIST model and the FIST-AHP model scrutinize projects solely based on their development process. If a project receives a high FIST score, this only means that the development resembled the FIST framework. The FIST score has no bearing on the operational success of the program. Furthermore, programs could achieve developmental success and not follow the FIST model because FIST is not the only feasible rapid acquisition model. A true measure of success for the FIST model would be how close FIST developmental success corresponds to operational success. If a development model does not consistently produce operationally successful programs, the model is worthless. Merely being able to replicate FIST results utilizing AHP is not as strong of an indicator of the FIST model's usefulness. As witnessed in this analysis, high scoring FIST programs can fail operationally and low scoring FIST programs can succeed.

Ward's (2009) original thesis results were able to be replicated by the FIST-AHP model. This is not surprising because the FIST-AHP model is based on the FIST rubric. Therefore, programs that scored well based on the FIST rubric correspondingly scored well in the FIST-AHP model. The true value of this comparison is in finding program characteristics that determine if a program is a good or poor fit for being developed by FIST.

The four characteristics of a program that are appropriate for FIST development are:

- Urgent Need Capabilities
- Budget Constrained Programs
- Repeated Programs
- Not Advancing Technology

The four program characteristics that emerged that show FIST as an inappropriate method of development are:

- Large Systems
- Inherently Expensive
- First-of-a-Kind Programs
- Advancing Technology

Next, the experiment results produced a ranking of the 18 FIST activities in order of importance by each project management group. There are distinct disconnects between the military and civilian project managers, as well as leaders and non-leaders. These results present many challenges, and although civilians complete different ventures than military project managers, civilians must be proficient in order to remain profitable. Private industry organizations will not bid on a job if a profit cannot be made on the project. This is a luxury the military is not afforded. Next, if leaders are developing overall strategies but this vision is not being translated and pursued by non-leaders, the organization is going to fail. Both parties must work together to understand the upper management view of project management as well as the daily, practical side of running a program.

The seven project management groups produced rankings that highlighted poor FIST activities. The *Tiny* activities were not valued nor understood as clearly as the other values. Overall, *System capability less than previous systems* is the most confusing activity for respondents and was consistently ranked low. In response to these criticisms, the following activities are proposed to be added to the FIST framework to account for weak areas.

Inexpensive

- Importance of Low Lifecycle Cost Solutions

Simple

- Generational Development
- Ambidextrous Organization (Exploring and Exploiting Structures)
- Empowered, Co-located Employees
- Manage to the Customer's Goals (Schedule, Budget, Risk)

Tiny

- Small, Handpicked, Experienced Team
- Maintain Stable, Realistic, Needs-Based Requirements
- Face-to-Face Requirements Agreement with Customer
- Minimize Scope Creep / Additional Requirements
- Strive for 80% Solution
- Minimize Technical Debt

These additions to FIST will organize the program office into an ambidextrous, dual structure. The exploring team develops and matures technology. The exploiting team works with the customer to develop requirements and produces a system utilizing only technology regarded as mature by the exploring team. Next, develop upfront, realistic requirements with the customer that are traced to capabilities. Stable, realistic requirements will mean the difference in program success and failure. Last, utilize incremental development to field the basic system rapidly with the future potential to be upgraded and fully meet the users' needs. System operation may be different once it is used on the battlefield. Incremental development allows flexibility to gauge the amount of improvement that is actually needed to perform the tasks.

DoD acquisitions have reached a crossroads where manning and funding are drastically being reduced, yet the war-fighter needs remain the same. The only way to survive this changing climate is to adapt to a new way of doing business. FIST is one rapid acquisition model that seeks to be the solution. By combining FIST with the recommendations presented in the research, as well as the conclusions resulting from other rapid development studies, a well-rounded successful model can be developed. The solutions do not lie with more oversight, bloated budgets, or increased manning. It is in the best interest of the DoD to correct the current system by following a rapid acquisitions model that substantially reduces the development time and accepts risks and failures. All rapid programs will not be successes, but with smaller schedules and budgets, the failures will not be catastrophic or insurmountable.

Future Research

This research produced the first intensive theory-testing empirical study of FIST. Multiple theory-building and theory-testing empirical studies are required to support the scientific basis of FIST as well as generalize its use for a wider range of acquisition programs. This research produced program entry criteria for the use of FIST in development and 11 additional FIST activities. A theory-building empirical study can be completed merging FIST with the recommendations in this research as well as testing the FIST entry criteria. Furthermore, a statistical analysis of the results found in this research could be completed to evaluate convergent and discriminate validity as well as the reliability of the FIST measures themselves. Much of the recent FIST literature has been completed by Ward and used as exposure and promotion of the model. Very little research has been published that examines and improves the model.

Some of the best lessons learned about FIST were from the informal feedback project managers included with the experiment. Feedback was not solicited in the experiment but proved to be enlightening when provided. Future researchers could conduct interviews with experienced project managers. The interviews should focus on successful rapid development activities to further refine the framework. The participants could be from different areas of development including space, material, defense contractors, and civilian projects. This could help generalize the theory to be usable in a variety of programs.

Further analysis into ambidextrous organizations, requirements gathering techniques, and incremental development could be accomplished to expand these ideas into the FIST model. These three areas proved to be weak or missing areas in the original FIST model and important activities in rapid acquisitions. Providing a more specific framework for FIST could help establish the philosophy as more usable. Many project managers commented that FIST was too vague if they were to attempt to use it on their next project. If the values *Fast*, *Inexpensive*, *Simple*, and *Tiny* are supposed to direct programs during development, there should be tools and techniques on how to do so. Also, programs were proven to be *FISTy* and operational failures. Unless it can be proven that FIST run programs can produce operationally successful programs, there is little chance the DoD will adapt the model.

Overall, FIST is a starting point that requires additional research into rapid acquisition best practices. As is, FIST is certainly not strong enough to be the cure-all for the acquisition woes. However, it is undoubtedly a step in the right direction to improve DoD spending and project development because it questions the status quo and aims to prevent complacency. The better the FIST concept can be explained and understood, the better chance project managers will direct future projects under the FIST banner and produce actual FIST managed programs for future studies to examine.

Appendix A: FIST Rubric (Ward, 2009:106-107)

FIST Rubric				
	High **10 pts**	**Medium** **5 pts**	**Low/No** **0 pts**	**Opposite** **-5 pts**
Fast Is Good	Strong, explicit affirmation of the importance of speed. Formal commitment to maintaining deadline (contractual, etc). Contractual incentives to reward early delivery. Concrete steps taken to actually reduce development timeline. Accepts significant risks in order to maintain schedule.	Modest, occasional affirmation of the importance of speed, with caveats. Modest, informal commitment to maintain or reduce deadline. Contractual incentives to reward on-time delivery. Few steps taken to reduce timeline. Accepts moderate risks in order to maintain schedule	Little to no mention of the importance of speed. No commitment (beyond the ordinary) to maintain deadline. No steps taken to reduce timeline or reward on-time / early delivery.	Ambivalence or antipathy towards speed. Explicit support for "taking as much time as we need" Active attempts to increase timeline. Accepts schedule delays rather than accept risks.
Inexpensive Is Good	Strong, explicit affirmation of the importance of low-cost. Formal commitment to maintain budget (contractual, etc) Contractual incentives to reward cost under-runs. Concrete steps taken to actually reduce development cost. Accepts significant risks in order to reduce costs.	Modest, occasional affirmation of the importance of low-cost, with caveats. Modest, informal commitment to maintain or reduce budget. Few concrete steps taken to reduce cost. Accepts moderate risks in order to maintain costs.	Little to no mention of the importance of low cost. No commitment (beyond the ordinary) to maintain budget. No steps taken to reduce cost.	Ambivalence or antipathy towards low-cost. Explicit support for "spending as much money as we need to" Active attempts to increase budget. Accepts cost increases rather than accept risks.
Simple Is Good	Strong, explicit and frequent affirmation of the importance of simplicity. Deliberate steps taken to actually reduce complexity in many	Modest, occasional affirmation of the importance of simplicity, with caveats. Modest attempts to reduce complexity in	Little to no mention of the importance of simplicity. No mention of steps taken to reduce complexity.	Ambivalence or antipathy towards simplicity. Explicit support for / pride in complexity. Active attempts to

	areas (organization, technology, communication, etc). Heavy reliance on existing, mature, proven technology (TRL 7+). System capability less than previous systems. Frequent emphasis on the importance of and reliance on talent.	some areas. Primarily relies on mature technologies, with some new developments. System capability moderately less than previous systems. Occasional mention of the importance of and reliance on talent.	No mention of technology maturity levels. No mention of the importance of and reliance on talent. System capabilities match or moderately exceed previous systems.	increase complexity. Heavy reliance on new developments and technology breakthroughs System capabilities significantly exceed previous systems. Explicit reliance on formal, structured process, control and compliance.
Tiny Is Good	Strong, explicit affirmation of the importance of small. Formal commitment to maintain or reduce size. Concrete steps taken to actually reduce size (of org, process, sys, documentation, etc).	Modest, occasional affirmation of the importance of small, with caveats. Modest, informal commitment to maintain or reduce size. Few steps taken to reduce size.	Little to no mention of the importance of small. No commitment (beyond the ordinary) to maintain size. No steps taken to reduce size.	Ambivalence or antipathy towards small, lean or streamlined approaches. Explicit support for / pride in bigness. Active attempts to increase size.

Outcome	**A**	**F**
	Met or surpassed all or most operational requirements, including maintainability and reliability Delivered operational capability Users expressed satisfaction Delivered within a reasonable margin of original cost and schedule baseline Program replicated or imitated by subsequent projects	Mission failed to meet or surpass a significant number of requirements System rejected by users Program cancelled before delivery Delivered after adding substantial funding and substantial schedule increase Operational use is severely restricted to a subset of original operational vision or requirement set.

Appendix B: Project Scores and Grades (Ward, 2009:61)

System Name	F-Score	I-Score	S-Score	T-Score	FIST Score	Outcome
NASA Pathfinder Mission	10	10	10	10	40	A
F-16 Falcon	10	10	10	10	40	A
NASA NEAR Mission	10	10	10	10	40	A
Skunkworks	10	10	10	10	40	A
Pave Low III	10	10	10	10	40	A
P-51 Mustang	10	5	10	10	35	A
F-5 Freedom Fighter	5	10	10	10	35	A
A-10 Thunderbolt	10	10	10	5	35	A
F-20 Tigershark	5	10	10	10	35	F
AD Skyraider	10	5	10	5	30	A
XP-75 Eagle	10	10	5	0	25	F
MRAP	10	0	5	0	15	A
E-3 Sentry (AWACS)	5	0	0	0	5	A
NASA Viking Mission	0	-5	-5	0	-10	A
C-5 Galaxy	0	-5	-5	-5	-15	A
Crusader Artillery	-5	-5	0	-5	-15	F
F-15 Eagle	-5	-5	-5	-5	-20	A
V-22 Osprey	-5	-5	-5	-5	-20	A
F-22 Raptor	-5	-5	-5	-5	-20	F
RH-66 Comanche	-5	-5	-5	-5	-20	F
Future Imagery Architecture	-5	-5	-5	-5	-20	F
Division Air Defense (DIVAD)	-5	-5	-5	-5	-20	F

Appendix C: Experiment Directions

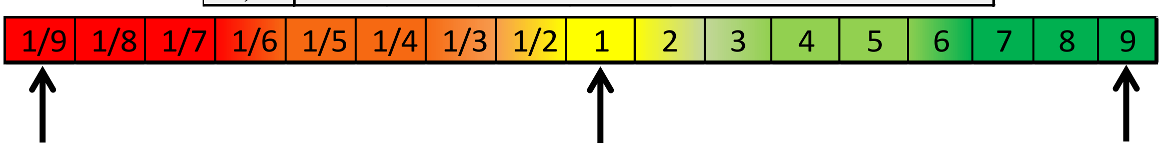
DIRECTIONS

-Please fill out the **BLUE** cells in the attached Excel spreadsheet based on your experience and judgment in project management. There are **2 TABS** to complete (Tab 1 and Tab 2).

-Select the appropriate cell and use the drag-down menu in each **BLUE** cell to select your ranking.

-Two activities will be presented, a "Green Activity" and a "Red Activity". Rank your preference of the Green Activity over the Red Activity in respect to importance to successful acquisition system development and delivery. Only judge the two activities compared to each other and do not let previous judgments influence your decision. The below table describes the rankings:

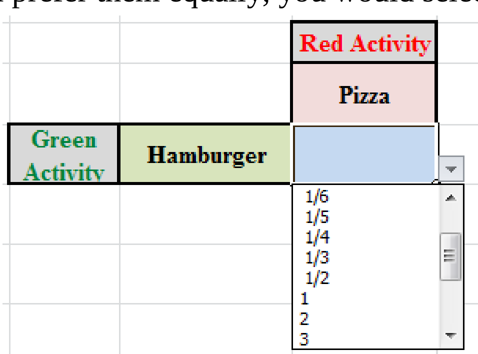
Value	Definition
1	**Equal Importance** Between Green Activity and Red Activity
3	**Moderate Importance** of Green Activity over Red Activity
5	**Strong Importance** of Green Activity over Red Activity
7	**Very Strong Importance** of Green Activity over Red Activity
9	**Extreme Importance** of Green Activity over Red Activity
2,4,6,8	Intermediate Values Between the two Adjacent Judgments
1/9, 1/8, 1/7, 1/6, 1/5, 1/4, 1/3, 1/2	If **Red Activity is more Important** than the Green Activity, Use the Reciprocal (Fraction) Value **Example:** (1/9 = Red Activity Extreme Importance over the Green Activity)



Red Activity Most Important   Equal Importance   **Green Activity** Most Important

Example

The **BLUE** cell below would be read: **Hamburger is _______ favorable to Pizza**. In the **BLUE** cell, you would select the "down arrow" to select your rank. If you highly prefer **Hamburgers**, you would select 7, 8, or 9. If you highly prefer **Pizza**, you would select 1/7, 1/8, or 1/9. If you prefer them equally, you would select 1.



Appendix D: Experiment Tab 1

		Red Activity		
		INEXPENSIVE	SIMPLE	TINY
Green Activity	FAST			
	INEXPENSIVE			
	SIMPLE			

Number of Years Experience in Project Management?	
Have you ever been in an Official Leadership Position?	
What is/was your highest Rank while in Project Mgmt?	

DIRECTIONS

Please Complete the **9 Blue Cells**. See Below for Definitions

Value	Definition
1	**Equal Importance** Between Green Activity and Red Activity
3	**Moderate Importance** of Green Activity over Red Activity
5	**Strong Importance** of Green Activity over Red Activity
7	**Very Strong Importance** of Green Activity over Red Activity
9	**Extreme Importance** of Green Activity over Red Activity
2,4,6,8	Intermediate Values Between the two Adjacent Judgments
1/9, 1/8, 1/7, 1/6, 1/5, 1/4, 1/3, 1/2	If **Red Activity is more Important** than the Green Activity, Use the Reciprocal (Fraction) Value **Example:** (1/9 = Red Activity Extreme Importance over the Green Activity)

1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9

Red Activity Most Important — Equal Importance — **Green Activity** Most Important

DEFINITIONS

Fast: Programs emphasize staying on schedule and maintaining deadlines. Program managers seek short development timelines, incentivize contractors for early delivery, and do not use schedule slips as an option.

Inexpensive: Programs pursue low-cost solutions and are willing to sacrifice performance and accept risks to maintain cost / budget. Contractors are incentivized for cost under runs.

Simple: Programs seek to reduce complexity in their developing technology, design, documentation, and organization. The project focus is on a narrow set of stable and attainable requirements utilizing existing technology to meet the operational need rather than high-tech, complex solutions.

Tiny: Programs utilize small project teams, minimum documentation, and develop smaller systems.

*<Insert **Green Activity**>*
is _____ Favorable to
*<Insert **Red Activity**>*

→

Example (Cell D4):
Fast is __________
Favorable to **Inexpensive**

Appendix E: Experiment Tab 2

DIRECTIONS Please Complete all the **Blue Cells**. ← Green Activities →	Red Activities → Accept risk to reduce costs	Importance of Speed (Project Pace, Schedule, Deadlines)	Emphasis on the importance of and reliance on talent	Concrete steps taken to actually reduce size of: (Project Team, Process, Documentation)	Contractual incentives to reward early delivery	Importance of Simplicity (Design, Organization, Documentation)	Formal commitment to maintain or reduce size of: (Design, Requirements, Technology)
Formal commitment to maintain budget							
Importance of low-cost (Choosing a Low Cost Design / Solution)							
System capability less than previous systems (Design Optimized for Main Objective)							
Contractual incentives to reward cost under-runs							
Accept risk in order to maintain schedule							
Importance of Small (Small Design, Minimum Documentation, Small Budget)							
Heavy reliance on existing, mature, proven technology (TRL 7+)							
Formal commitment to maintain deadlines							
Concrete steps taken to actually reduce development time							
Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)							
Concrete steps taken to actually reduce development cost							
Formal commitment to maintain or reduce size of: Design, Requirements, Technology							
Importance of Simplicity (Design, Organization, Documentation)							
Contractual incentives to reward early delivery							
Concrete steps taken to actually reduce size of: Project Team, Process, Documentation							
Emphasis on the importance of and reliance on employees' talent							
Importance of Speed (Project Pace, Schedule, Meeting Deadlines)							

Concrete steps taken to actually reduce development cost	Deliberate steps taken to actually reduce complexity in many areas (Technology, Communication, Organization)	Concrete steps taken to actually reduce development time	Formal commitment to maintain deadlines	Heavy reliance on existing, mature, proven technology (TRL 7+)	Importance of Small (Design, Minimum Documentation, Current Technology)	Accept risk in order to maintain schedule	Contractual incentives to reward cost under-runs	System capability less than previous systems (Design Optimized for Single Task)	Importance of low-cost (Choosing a Low Cost Design / Solution)

Value	Definition
1	**Equal Importance** Between Green Activity and Red Activity
3	**Moderate Importance** of Green Activity over Red Activity
5	**Strong Importance** of Green Activity over Red Activity
7	**Very Strong Importance** of Green Activity over Red Activity
9	**Extreme Importance** of Green Activity over Red Activity
2,4,6,8	Intermediate Values Between the two Adjacent Judgments
1/9, 1/8, 1/7, 1/6, 1/5, 1/4, 1/3, 1/2	If **Red Activity is more Important** than the Green Activity, Use the Reciprocal (Fraction) Value **Example:** (1/9 = Red Activity Extreme Importance over the Green Activity)

1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9

Red Activity Most Important — Equal Importance — **Green Activity** Most Important

<*Insert* ***Green Activity***>
is _____ Favorable to
<*Insert* ***Red Activity***>

Example (Cell D4):
Formal Commitment to Maintain Budget
is ___________ Favorable to
Accept Risk to Reduce Cost

Appendix F: Alternatives Analysis

Each mission is analyzed according to each of the 18 FIST activities and receives a *Poor*, *Average*, *Good*, or *Excellent* rating. The rating is based on how well the program incorporated the activity in the development and not necessarily the outcome. A large portion of this alternatives analysis builds off the examination already completed by Dan Ward in his 2009 AFIT thesis.

NASA VIKING MISSION

Sources: -McCurdy, 2001
-NASA Case Study: Searching for Life on Mars
-Ward, 2009

FAST

Accept Risk to Maintain Schedule

Poor: Used redundancy to mitigate risk. "Viking was a classic NASA mission: complex, redundant and expensive" (McCurdy, 2001:61).

"The Viking team was committed to taking as much time as necessary to ensure optimal performance and minimize risks on this very difficult mission" (Ward, 2009:169).

Formal Commitment to Maintain Deadlines

Poor: "By 1971 Viking's launch date had already been pushed back from 1973 to 1975 due to Congressional budget cuts" (NASA Case Study:1).

Concrete Steps Taken to Reduce Development Time

Poor: "It didn't help that Viking was running well over initial planning estimates for the mission to Mars" (NASA Case Study:1).

Contractual Incentives to Reward Early Delivery

None found.

Importance of Speed

Poor: "The Pathfinder team, moreover, was asked to design, build, and prepare their spacecraft for launch in just 3 years. The Viking team had taken 6" (McCurdy, 2001:61).

INEXPENSIVE

Formal Commitment to Maintain Budget

Poor: "When the project began, Viking managers estimated that the imaging system could be designed and built for $6.2 million. The actual cost ($27.3 million) was 4 times that amount" (McCurdy, 2001:70).

Importance of Low-Cost

Poor: "NASA officials originally estimated that they could develop the biology package for $11.3 million. The actual cost was $59.5 million" (McCurdy, 2001:72).

Contractual Incentives to Reward Cost Under-Runs

None Found.

Concrete Steps Taken to Actually Reduce Development Cost
Poor: "When the project began, Viking managers estimated that the imaging system could be designed and built for $6.2 million. The actual cost ($27.3 million) was 4 times that amount" (McCurdy, 2001:70).

"NASA officials originally estimated that they could develop the biology package for $11.3 million. The actual cost was $59.5 million" (McCurdy, 2001:72).

"[the Viking's computer's] cost grew from $3.4 to $28.1 million" (McCurdy, 2001:74).

Accept Risk to Reduce Costs
Poor: Used expensive solutions instead of accepting any risk. "Viking team members designed an elaborate landing system, with computers, parachutes, radar altimeters, and a throttleable rocket engine. They developed a redundant radio communication system…" (McCurdy, 2001:65).

<u>SIMPLE</u>
System Capability Less Than Previous Systems
Poor: "The Viking landers had more capability than the Pathfinder spacecraft" (McCurdy, 2001:68).

Heavy Reliance on Existing, Mature, Proven Technology
Poor: Simple designs proposed were rejected in favor of complex solutions. "The technical challenges for Viking were no less daunting than the fiscal ones. Nobody had landed on Mars before, so the spacecraft itself required significant innovative technology. The opportunity to conduct experiments on the planet's surface led to an extremely ambitious scientific agenda featuring thirteen instruments" (NASA Case Study:1).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Poor: "Scientists recommended that project engineers incorporate a simpler design with less capability… The technically sophisticated design was retained" (McCurdy, 2001:71).

Importance of Simplicity
Poor: Complex designs and solutions were preferred.

Emphasis on the Importance of and Reliance on Employees' Talent
No explicit comments found but mission was successful and completed a difficult task.

<u>TINY</u>
Importance of Small
Poor: "The biology package weighed 33 pounds and contained 40,000 parts" (McCurdy, 2001:72).

"The Viking cameras were bulky affairs… Each lander had two" (McCurdy, 2001:70).

Formal Commitment to Maintain or Reduce Size
Poor: "The only way to pack four experiments into a small, lightweight container was to make the package complex. In an instrument this complex, any single-point failure threatened the whole system" (McCurdy, 2001:72).

"The computer on the Viking lander weighed 52 pounds… The Viking lander required 17 times as much electric power as the Pathfinder lander" (McCurdy, 2001:74).

Concrete Steps Taken to Actually Reduce Size
Poor: "The Viking project, at the height of its activity, employed 538 people at the Langley Research Center, 1,650 people at the Martin Marietta Aerospace Center, an unknown number of people at the Jet Propulsion Laboratory, and 69 scientists on 13 advisory teams" (McCurdy, 2001:75).

OUTCOME
Success: "The program was clearly successful, as Viking operated for years in one of the most difficult environments NASA has ever attempted" (Ward, 2009:169)

"Although the resulting images were spectacular, Viking program managers paid for this decision with substantial cost overruns" (McCurdy, 2001:71).

NASA PATHFINDER MISSION

Sources: -McCurdy, 2001
-Ward, 2009

FAST

Accept Risk to Maintain Schedule

Excellent: "Simplicity demanded that the team be willing to take risks that are not common on interplanetary missions" (Ward, 2009:115).

Formal Commitment to Maintain Deadlines

Excellent: "The Pathfinder team, moreover, was asked to design, build and prepare their spacecraft for launch in just 3 years. The Viking team had taken 6" (McCurdy, 2001:61).

Concrete Steps Taken to Reduce Development Time

Excellent: "To leave time for testing, Spear insisted that contractors and subsystem managers deliver their hardware no later than halfway through the development cycle. This was a demanding requirement inasmuch as the development phase had already been cut to just three years" (McCurdy, 2001:130).

Contractual Incentives to Reward Early Delivery

Poor: "No evidence was presented that contractual incentives were made to deliver on time" (Ward, 2009:114).

Importance of Speed

Excellent: "Within aerospace circles, the cost and schedule goals given to the Pathfinder team were widely thought to be impossible" (McCurdy, 2001:61).

INEXPENSIVE

Formal Commitment to Maintain Budget

Excellent: "The Viking team spent $27.3 million to develop the cameras for their landers, approximately $100 million in inflation-adjusted dollars. The Pathfinder team spent just $7.4 million" (McCurdy, 2001:70).

"Proponents of the 'faster, better, cheaper' initiative asked the Pathfinder team to put a lander and a rover on the surface of Mars for one-fourteenth of the inflation-adjusted cost of the 1976 Viking mission" (McCurdy, 2001:61).

Importance of Low-Cost

Excellent: "They called it 'Pathfinder' because the project blazed the trail for a new generation of low-cost spacecraft" (McCurdy, 2001:62).

Contractual Incentives to Reward Cost Under-Runs

None Found

Concrete Steps Taken to Actually Reduce Development Cost
Excellent: "The Pathfinder team clearly saved money by reducing capability" (McCurdy, 2001:69).

Accept Risk to Reduce Costs
Excellent: "To further reduce mission costs, the Pathfinder team accepted risks that Viking team members had been unwilling to endure" (McCurdy, 2001:65).

<u>SIMPLE</u>
System Capability Less Than Previous Systems
Excellent: "The Pathfinder team clearly saved money by reducing capability" (McCurdy, 2001:69).

Heavy Reliance on Existing, Mature, Proven Technology
Excellent: "[Donna] Shirley promised to build a free-ranging rover and stay within NASA's $25 million cap. To avoid cost overruns, she relied heavily on existing technology" (McCurdy, 2001:73).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Excellent: Sacrificed performance, and the number and type of instruments on the mission to stay simple. The landing concept on an inflatable airbag was extremely simpler than previous methods.

Importance of Simplicity
Excellent: "The concept for actually landing the Pathfinder on Mars is the paragon of simplicity" (Ward, 2009:115).
"Inexpensive was the primary driver, and simplicity had to be enforced to bring the program in on budget. Simplicity was implemented, but forced a reduction in capability" (Ward, 2009:115).

Emphasis on the Importance of and Reliance on Employees' Talent
Average: No explicit comment but the team was collocated and could not solve problems by pulling in more people or spending money. The team's talent had to create solutions.

<u>TINY</u>
Importance of Small
Excellent: "Pathfinder was a small spacecraft, deliberately made so in order to fit on the most inexpensive launch vehicle possible (Delta II)" (Ward, 2009:115).

Formal Commitment to Maintain or Reduce Size
Excellent: "The Pathfinder development and operations teams were deliberately kept small, with most of the development work done in-house at JPL. This allowed the team to avoid hiring people to coordinate the dispersed activities and further reduced the size of the management and advisory teams. The intentionally short duration and simple design

of the mission allowed the operations team to be kept to a few dozen people" (Ward, 2009:115).

Concrete Steps Taken to Actually Reduce Size
Excellent: "The Mars Pathfinder team also saved money by employing fewer people" (McCurdy, 2001:74).

OUTCOME
Success: "The Pathfinder program's embodiment of the FIST principles resulted in a successful mission, according to the requirements and expectations. The team met its budget, timeline, and mission parameters" (Ward, 2009:115).

MRAP

Sources: -Sullivan, 2008
-Jones, 2007
-Ward, 2009
-Sisk, 2012
-Rogers, 2012

<u>FAST</u>

Accept Risk to Maintain Schedule

Good: "DOD recognized that no single vendor could provide all of the vehicles needed to meet requirements quickly enough and invited vendors to offer their nondevelopmental solutions" (Sullivan, 2008:5).

Formal Commitment to Maintain Deadlines

Excellent: The program also undertook a concurrent approach to producing, testing, and fielding the vehicles. To expand limited existing production capacity, the department awarded indefinite delivery, indefinite quantity (IDIQ) contracts to nine commercial sources for the purchase of up to 4,100 vehicles per year from each vendor" (Sullivan, 2008:2).

Concrete Steps Taken to Reduce Development Time

Excellent: "DOD used a tailored acquisition approach to rapidly acquire and field MRAP vehicles" (Sullivan, 2008:2).

Contractual Incentives to Reward Early Delivery

Not explicitly mentioned: "The IDIQ contracts required these initial vehicles to be produced within 60 days. However, in less than three weeks, five of the vendors demonstrated their reliability to produce vehicles meeting Marine Corps survivability requirements, production numbers and delivery timelines" (Jones, 2007).

Importance of Speed

Excellent: "DOD designated the MRAP program as DOD's highest priority acquisition, which helped contractors and other industry partners to more rapidly respond to the urgent need…" (Sullivan, 2008:2).

<u>INEXPENSIVE</u>

Formal Commitment to Maintain Budget

Poor: "The cost for individual production models of the MRAP ranged from $535,000 to $600,000, but field models including spare parts and upgrades came to an average of $1.29 million" (Sisk, 2012).

Importance of Low-Cost

Poor: "To date, more than $22 billion has been appropriated to acquire more than 15,000 MRAP vehicles…" (Sullivan, 2008:1).

Contractual Incentives to Reward Cost Under-Runs
Average: "…using 9 different IDIQ contracts could foster competition between vendors, which is precisely the kind of thing a project leader would do to express the Inexpensive value" (Ward, 2009:162).

Concrete Steps Taken to Actually Reduce Development Cost
Poor: "MRAP leaders emphasized speed and sacrificed cost, potentially driving up costs to a greater degree than necessary" (Ward, 2009:161).

Accept Risk to Reduce Costs
Poor: "MRAP leaders emphasized speed and sacrificed cost, potentially driving up costs to a greater degree than necessary" (Ward, 2009:161).

SIMPLE
System Capability Less Than Previous Systems
Good: Utilized commercially available components and a not complex technology.

Heavy Reliance on Existing, Mature, Proven Technology
Good: "…relied heavily on commercially available products" (Sullivan, 2008:2).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Good: "DOD used a tailored acquisition approach to rapidly acquire and field MRAP vehicles. The program established minimal operational requirements and relied heavily on commercially available products" (Sullivan, 2008:2).

Importance of Simplicity
Average: "Unfortunately, the vendors are not working from a common blueprint and each type of MRAP is different from the others, making maintenance and operations slightly more complicated" (Ward, 2009:162).

Emphasis on the Importance of and Reliance on Employees' Talent
Good: "…invited vendors to offer their nondevelopmental solutions" (Sullivan, 2008:5).

TINY
Importance of Small
Poor: "Five versions of the MRAP were produced, weighing from 13–28 tons" (Sisk, 2012).

"Back in 2007, General Jim Conway, then the Marine commandant, questioned the need for so many of the heavy vehicles. "Those vehicles weigh 40,000 pounds each in the larger category,' he said. 'Frankly, you can't put them in a helicopter and you can't even put them aboard ship.' As for their use after these wars? 'Wrap them in shrink wrap and put them in asphalt somewhere is about the best thing that we can describe at this point,' he said. 'And as expensive as they are, that is probably not a good use of the taxpayers' money'." (Rogers, 2012).

Formal Commitment to Maintain or Reduce Size
Poor: "27,740 MRAPs rolled off the assembly lines of seven manufacturers" (Sisk, 2012).

Concrete Steps Taken to Actually Reduce Size
Good: Reduced acquisition process for rapid acquisition of vehicle.

<u>OUTCOME</u>
Mixed: "MRAPs with their V-shaped, blast-deflecting hulls are 'one of the most important acquisitions to come off the line since World War II,' [Deputy Defense Secretary Ash] Carter said. It is, he added, the Defense Department's most important program 'in the last decade'." (Rogers, 2012).

"The $47.7 billion era of the MRAP came to an official close Monday [1 October 2012]" (Sisk, 2012).

"Marine Lt. Gen. Richard Mills testified that 'The Marine Corps has a little over 4,000 of them. We intend, as we come out of Afghanistan, to retain about 2,500'." (Sisk, 2012).

"In 2010, USA Today reported that MRAPs cut casualties from 2000 to 2010 by 30%, perhaps saving dozens of lives each month. In 2011, the Pentagon MRAP shop estimated that MRAPs saved up to a stunning 40,000 lives — 10,000 in Iraq and 30,000 Afghanistan" (Rogers, 2012).

"Chris Rohlfs and Ryan Sullivan wrote in Foreign Affairs that 'the heavily-protected vehicles were no more effective at reducing casualties than the medium armored vehicles.' And the MRAPs are 'three times as expensive as medium protected vehicles'." (Rogers, 2012).

P-51 MUSTANG

Sources: -Baugher, 2012
-Bjarnoe, 2006
-Carson, 1985
-Nelson, 1944
-Saunders, 1942
-Ward, 2009

<u>FAST</u>

Accept Risk to Maintain Schedule

Good: Implicit that risk was accepted rather than creating a schedule delay in order to maintain delivery agreement of September 1941.

Formal Commitment to Maintain Deadlines

Excellent: "… North American promised to deliver 320 of the new aircraft before September 1941, only 17 months after the signing of the agreement…" (Carson, 1985:33).

Concrete Steps Taken to Reduce Development Time

Excellent: "… when developing the P-51 a kind of modularization and parallelization of the sub-processes was applied. The airframe was for example divided into sections which could be developed independently as the interfaces were defined from the beginning which is the same principle used in contemporary modular product-architectures. This made it possible to execute parallel product development and set-based design, which means that several designs of the same module were developed concurrently and consequently the decision about the final design could be postponed. The result of this made it possible to work with new, advanced designs in a very limited time frame" (Bjarnoe, 2006:44).

Contractual Incentives to Reward Early Delivery

None Found

Importance of Speed

Excellent: "The P-51 was designed and built in 117 days" (Ward, 2009:136).

<u>INEXPENSIVE</u>

Formal Commitment to Maintain Budget

Average: "…the Mustang's economy is an implicit value rather than an explicit" (Ward, 2009:137).

Importance of Low-Cost

Good: "…the Mustang is consistently described in terms of its 'economy of operation,' and praised for being 'economical to produce'." (Ward, 2009:136).

Contractual Incentives to Reward Cost Under-Runs
None Found

Concrete Steps Taken to Actually Reduce Development Cost
Good: "The record of North American's P-51 Mustang fighter proves, however, that it is both possible and practical to create a single basic design that can be modified, as military needs dictate, to keep abreast of requirements." (Nelson, 1944:127)
"…does not to any extent embody previously unknown engineering features, but rather employed refinements of known accepted practices" (Nelson, 1944:129).

Accept Risk to Reduce Costs
Good: "During the P-51B-10-NA and P-51C-1-NT production run, it was decided to omit the olive drab camouflage and to deliver the aircraft in their natural metal finish. The objective was now to try and bring the Luftwaffe into battle, not to hide from it. This move saved extra cost, weight, and drag" (Baugher, 2012).

SIMPLE

System Capability Less Than Previous Systems
Excellent: "These achievements are, from an engineering standpoint, remarkable—because they were accomplished by a plane that does not to any extent embody previously unknown engineering features, but rather employed refinements of known accepted practices" (Nelson, 1944:129).

Heavy Reliance on Existing, Mature, Proven Technology
Excellent: "…does not to any extent embody previously unknown engineering features, but rather employed refinements of known accepted practices" (Nelson, 1944:129).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Excellent: "The record of North American's P-51 Mustang fighter proves, however, that it is both possible and practical to create a single basic design that can be modified, as military needs dictate, to keep abreast of requirements" (Nelson, 1944:127).

Importance of Simplicity
Excellent: "It is an extremely simple airplane and has such perfect handling qualities as to put a smile of joy on the face of any fighter pilot" (Sanders, 1942).

Emphasis on the Importance of and Reliance on Employees' Talent
None found but due to the success of the project, the team must have relied on talent to maintain the performance and schedule constraints.

TINY

Importance of Small
Excellent: "The P-51 is requested in preference to the P-47 because of its smaller size, ease of maintenance, economy of operation, range and because many of the accessories for it are already available in this area [Karachi Air Base, India]" (Sanders, 1942).

Formal Commitment to Maintain or Reduce Size
Excellent: “The problem of supply of a new airplane is not as great as it first seems due to the fact that engines, guns, radios, instruments, and man [sic] other parts are the same as those used on P-40s” (Sanders, 1942).

Concrete Steps Taken to Actually Reduce Size
Excellent: “…the P-51 could be maintained easily with existing supplies and tools” (Ward, 2009:136).

“… they already had a clear idea of what they wanted and… they used the data from Curtis… to cut trial and error time and to find tune their own concept of what a modern fighter should be” (Carson, 1985:33).

OUTCOME
Success: “The P-51 Mustang is one of the most famous and successful fighter aircraft of the WWII era, both operationally and programmatically. It was an engineering, logistical and operational success, and sets an example we would do well to follow even today” (Ward, 2009:135-136).

XP-75 EAGLE

Sources: -Holley, 1987
-Ward, 2009

FAST

Accept Risk to Maintain Schedule

Excellent: "One can only speculate that it was the urgent necessity of getting a superior fighter into production as rapidly as possible that led to the experiment" (Holley, 1987:592).

"To make matters worse, the Allison engine, which had been rushed into production before it was thoroughly debugged, was not performing up to expectations…" (Holley, 1987:590).

Formal Commitment to Maintain Deadlines

Poor: "When air force [sic] officers estimated that it would take at least six months to eliminate these problems, pushing the projected date for reaching peak production past the middle of 1945, it was clear that the time had come to kill the whole project" (Holley, 1987:591).

Concrete Steps Taken to Reduce Development Time

Excellent: "… the air force [sic] took steps to shorten the delays—first, by increasing the number of experimental models to be procured from two to eight to be sure there would be a sufficient number to carry out exhaustive flight tests, and second, by issuing a letter of intent to contract for a mass-production order for 2,500 P-75's" (Holley, 1987:588).

Contractual Incentives to Reward Early Delivery

Poor: Cost Plus Fixed Fee contract (Holley, 1987:587).

Importance of Speed

Excellent: "Deliveries were expected to begin by May 1944, approximately nine months hence, a phenomenally short time for such a complex undertaking" (Holley, 1987:588).

INEXPENSIVE

Formal Commitment to Maintain Budget

Average: "Total cost of the production contract was estimated at $325 million with a unit cost of approximately $100,000" (Holley, 1987:588).

Importance of Low-Cost

Average: "… the Materiel Command signed a cost-plus-fixed-fee contract for two experimental fighters, XP-75, at the relatively modest estimated cost of $428,271, for delivery in six months" (Holley, 1987:587).

Contractual Incentives to Reward Cost Under-Runs
Average: "…a fixed fee of no more than $75,163 or 2.65 percent of the original estimated total, a figure well below the usual 4 or 5 percent fee" (Holley, 1987:589).

Concrete Steps Taken to Actually Reduce Development Cost
Good: "Only the main fuselage itself would have to be developed anew. By such short-cuts, the plane was expected to be ready for flight testing in six months" (Holley, 1987:587).

Accept Risk to Reduce Costs
Good: "In September 1941, the corporation [General Motors] approached Maj Gen O.P. Echols, the commanding general of Materiel Command, with a proposal to develop a fighter aircraft in a remarkably short time by using, as far as possible, structures, controls, and accessories already in full production for other aircraft in order to obviate the need for long delays in tooling up for production" (Holley, 1987:587).

SIMPLE
System Capability Less Than Previous Systems
Average: "Project leaders severely underestimated the complexity involved with integrating pieces of existing airframes into a new airframe. Each of those pieces had been optimized for the original aircraft, and most had to be modified before they could be used on the P-75. The designers seemed to have aimed for simplicity but instead achieved simplisticness" (Ward, 2009:158).

Heavy Reliance on Existing, Mature, Proven Technology
Excellent: "Only the main fuselage itself would have to be developed anew. By such short-cuts, the plane was expected to be ready for flight testing in six months" (Holley, 1987:587).

"… more and more evidence emerged to indict the whole scheme to use off-the-shelf stock components to build a superior high-performance aircraft" (Holley, 1987:591).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Good: "…structures, controls, and accessories already in full production for other aircraft in order to obviate the need for long delays in tooling up for production" (Holley, 1987:587).

Importance of Simplicity
Good: "By enlarging the tail surface, most of the apparent instability could be overcome, but this meant it would no longer be possible to use the ready-built, off-the-shelf stock design already in production…" (Holley, 1987:590).

Emphasis on the Importance of and Reliance on Employees' Talent
None Found

TINY

Importance of Small

Poor: "Each such modification added weight…" (Holley, 1987:590).

Formal Commitment to Maintain or Reduce Size

Poor: "Echol's espousal of the XP-75 is all the more curious in view of the massive size of the plane. With its 49-foot wingspan, it was substantially heavier than virtually any other successful World War II fighter" (Holley, 1987:592).

Concrete Steps Taken to Actually Reduce Size

Poor: "The remedy, eventually devised, was to extend the ailerons out to the wingtips to insure greater stability and control. But this, too, required reworking the standard ready-built wings…" (Holley, 1987:590).

OUTCOME

Failure: "Every new model aircraft has bugs which have to be ironed out; this was to be expected. But the faults encountered in the XP-75 were more than minor. The test pilot reported that the plane lacked stability and displayed a distressing tendency to stall and spin when making tight turns, the maneuver most essential to fighter aircraft" (Holley, 1987:589).

"On October 4, 1944, the chief of air staff, Lt. Gen. B.M. Giles, signed the order terminating the contract" (Holley, 1987:591).

"The XP-75 / P-75 Eagle project failed to deliver the promised performance, and so the project was cancelled shortly before World War II ended" (Ward, 2009:157).

V-22 OSPREY

Sources: -Cordesman & Kaeser, 2008
-Thompson, 2007
-Thompson, 2011
-Ward, 2009

<u>FAST</u>

Accept Risk to Maintain Schedule

Poor: "Probes into the deadly 2000 crashes revealed that in a rush to deploy the aircraft, the Marines had dangerously cut corners in their testing program. The number of different flight configurations… flown by test pilots to ensure safe landings was reduced by half to meet deadlines. Then only two-thirds of those curtailed flight tests were conducted" (Thompson, 2007:3).

Formal Commitment to Maintain Deadlines

Poor: "… the V-22 has been 25 years in development, more than twice as long as the Apollo program that put men on the moon" (Thompson, 2007:1).

Concrete Steps Taken to Reduce Development Time

Poor: "Not only did the project take 25 years to deliver an operational capability, but in the few instances when project leaders attempted to accelerate the project, they did so by cutting corners on flight tests" (Ward, 2009:183).

Contractual Incentives to Reward Early Delivery

None Found

Importance of Speed

Poor: 25 year development

<u>INEXPENSIVE</u>

Formal Commitment to Maintain Budget

Poor: "It wasn't about saving a bunch of money – it was about doing it" (Ward, 2009:181).

Importance of Low-Cost

Poor: "The aircraft is currently five times more expensive than the system it replaces…" (Cordesman & Kaeser, 2008:24).

Contractual Incentives to Reward Cost Under-Runs

Poor: "There is also no evidence project leaders embraced the Inexpensive value" (Ward, 2009:183).

Concrete Steps Taken to Actually Reduce Development Cost
Poor: "The Pentagon has put $20 billion into the Osprey and expects to spend an additional $35 billion before the program is finished. In exchange, the Marines, Navy and Air Force will get 458 aircraft, averaging $119 million per copy" (Thompson, 2007:1).

Accept Risk to Reduce Costs
None Found

<u>SIMPLE</u>
System Capability Less Than Previous Systems
Poor: "It is intended to execute a variety of missions for the Marine Corps, the Navy and the Air Force, including troop and equipment transport, amphibious assault, search and rescue, and special operations" (Cordesman & Kaeser, 2008:24).

Heavy Reliance on Existing, Mature, Proven Technology
Poor: "Simpler, mature alternatives are available, such as the EH-101" (Ward, 2009"184).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Poor: "…the Osprey is not a simple machine, and there is no evidence the project leaders valued Simplicity" (Ward, 2009:184).

Importance of Simplicity
Poor: "It was very organizationally complex initially, which led to communication troubles" (Ward, 2009:181).

Emphasis on the Importance of and Reliance on Employees' Talent
None Found

<u>TINY</u>
Importance of Small
Poor: "The Osprey is also three times heavier than the helicopter it replaces" (Cordesman & Kaeser, 2008:24).

Formal Commitment to Maintain or Reduce Size
Poor: "Throughout its development, however, the V-22 enjoyed broad and persistent congressional support. The V-22 program has nearly 2,000 suppliers in over 40 states and created jobs in 276 congressional districts" (Cordesman & Kaeser, 2008:26).

Concrete Steps Taken to Actually Reduce Size
Average: "… the Navy and Marine Corps reduced some requirements to allow the aircraft to reach operational readiness" (Cordesman & Kaeser, 2008:25).

OUTCOME
Success: "But as Osprey backers point out, the V-22 can also do more than a conventional helicopter, so much more that there is a credible case it actually is more cost-effective. That case is especially compelling in scenarios where the current search-and-rescue fleet would have trouble reaching distressed pilots in a timely fashion" (Thompson, 2011).

"…the V-22 is the only aircraft in the world that can fly as far and fast as a turboprop airplane, and then hover or land like a helicopter. Within 90 minutes the downed pilot was safely retrieved, opening a new chapter in the expanding chronicle of Osprey successes. The V-22s used in the Libyan rescue mission had been sent to the Mediterranean from a Marine unit operating in Afghanistan's Helmand province, where local commanders have praised the agility and resilience of the aircraft" (Thompson, 2011).

E-3 SENTRY AWACS

Sources: -Cowdery & Skillman, 1995
-GAO, 1973
-Grier, 2002
-Ulsamer, 1974
-Ward, 2009

FAST

Accept Risk to Maintain Schedule

Good: "…the AWACS test program focused on two key objectives from the very beginning: To identify the most difficult task and to ensure that it is being tested early" (Ulsamer, 1974:76).

Formal Commitment to Maintain Deadlines

Good: "On November 7, 1972, Boeing successfully completed the Airborne Tracking Demonstration, 4 months ahead of schedule" (GAO, 1973:1).

Concrete Steps Taken to Reduce Development Time

Good: "Because of the 'crash' nature of the program, most of the system debugging occurred at Boeing" (Cowdery & Skillman, 1995:5).

Contractual Incentives to Reward Early Delivery

None Found

Importance of Speed

Good: 11 year development. "The Brassboard radars were designed, fabricated, tested and installed in the flight test aircraft at Boeing in less than two years… This was rather incredible considering the complexity of the radar and instrumentation" (Cowdery & Skillman, 1995:5).

INEXPENSIVE

Formal Commitment to Maintain Budget

Excellent: "… in January 1973, the approved program was based on a 4 engine rather than an 8 engine configuration; had a program cost of $2,467 million, for a total reduction of $194 million…" (GAO, 1973:2).

Importance of Low-Cost

Excellent: "As of January 19, 1973, the approved program cost estimate was reduced to $2,467 million" (GAO, 1973:3).

Contractual Incentives to Reward Cost Under-Runs

None Found

Concrete Steps Taken to Actually Reduce Development Cost
Excellent: "… some reduction in time-on-station was more than made up for by the lower cost of using TF33 engines already in the Air Force's inventory in surplus quantities" (Ulsamer, 1974:76).

Accept Risk to Reduce Costs
Good: "Because of the success of the radar test program, it became possible to speed up the AWACS test and evaluation schedule across the board" (Ulsamer, 1974:76).

<u>SIMPLE</u>
System Capability Less Than Previous Systems
Poor: "'The total complexity of this system… far exceeds things I've worked on before,' said Ed Froesse, Boeing's vice president for the AWACS program" (Grier, 2002:5).

Heavy Reliance on Existing, Mature, Proven Technology
Excellent: "There is no compelling reason for lengthy airframe and engine testing because the AWACS aircraft is a modified Boeing 707-320… AWACS engines are those of the Air Force's C-141, similarly proved in many years of service" (Ulsamer, 1974:70).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Good: "Budgetary constraints at the time of AWACS's first DSARC in July 1970 caused the Air Force to 'trade down' to a basic AWACS system…" (Ulsamer, 1974:76).

Importance of Simplicity
Average: "… the Pentagon treated development of the system as a high-priority effort. For example, AWACS had its own streamlined procurement rules…" (Grier, 2002:2) "…the aircraft's avionics was often described as highly complex" (Ward, 2009:165).

Emphasis on the Importance of and Reliance on Employees' Talent
None Found

<u>TINY</u>
Importance of Small
Poor: Large project team, large aircraft crew requirement, large airframe, expanding to NATO and allies.

Formal Commitment to Maintain or Reduce Size
Average: "There is no compelling reason for lengthy airframe and engine testing because the AWACS aircraft is a modified Boeing 707-320… AWACS engines are those of the Air Force's C-141, similarly proved in many years of service" (Ulsamer, 1974:70).

Concrete Steps Taken to Actually Reduce Size
Good: "… in January 1973, the approved program was based on a 4 engine rather than an 8 engine configuration; had a program cost of $2,467 million, for a total reduction of $194 million…" (GAO, 1973:2).

OUTCOME

Success: “Twenty-five years ago, on March 24, 1977, Boeing delivered the first basic production version of the E-3 Sentry to Air Force officials at Tinker AFB, Okla. The ensuing quarter century has shown the AWACS to be indispensable, often the first system to go into action when a threat arises and the last to leave once operations cease” (Grier, 2002:1).

RAH-66 COMANCHE

Sources: -CBO, 1997
-Global Security, 2008
-Ward, 2009

FAST

Accept Risk to Maintain Schedule

Poor: No evidence of accepting risks to maintain schedule.

Formal Commitment to Maintain Deadlines

Poor: "…the actual cost and schedule far exceeded estimates" (Ward, 2009:194).

Concrete Steps Taken to Reduce Development Time

Poor: "The helicopter is still in the development stage, which will continue at least through 2004. As recently as 1992, the Army had planned to start buying Comanches in 1996, but it has since delayed the start of production until 2005" (CBO, 1997).

Contractual Incentives to Reward Early Delivery

None Found

Importance of Speed

Poor: "The first helicopter will be combat-ready in September 2009, three years behind the previous schedule. Production and purchase of the first helicopters would begin in fiscal 2006, one year later than planned under the previous schedule" (Global Security, 2008).

INEXPENSIVE

Formal Commitment to Maintain Budget

Poor: "The project was cancelled after spending nearly $7B over two decades" (Ward, 2009:194).

Importance of Low-Cost

Poor: "There is no evidence project leaders deemed it important to deliver a low-cost, simple solution on a short timeline" (Ward, 2009:194).

Contractual Incentives to Reward Cost Under-Runs

None Found

Concrete Steps Taken to Actually Reduce Development Cost

Poor: "The new Acquisition Decision Memorandum (ADM) formally approving the plan added about $3.4 billion to the Comanche's $3.1 billion development program" (Global Security, 2008).

Accept Risk to Reduce Costs
Poor: No evidence found that risks were accepted to reduce costs.

SIMPLE

System Capability Less Than Previous Systems
Poor: "Skeptics of the program suggested that unmanned planes capable of performing the Comanche's surveillance and precision-strike role will be available to the Army prior to the maturing of the Comanche system" (Global Security, 2008).

Heavy Reliance on Existing, Mature, Proven Technology
Poor: "…evidence suggests they were more than willing to sacrifice cost, schedule and usability in order to ensure the Comanche's technologies were cutting-edge, however unproven or unreliable" (Ward, 2009:194).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Poor: Extremely complex program and design.

Importance of Simplicity
Poor: "According to the DOT&E, technical challenges remained for software integration and testing of mission equipment, weight reduction, radar signatures, antenna performance, gun system performance, and aided target detection algorithm performance" (Global Security, 2008).

Emphasis on the Importance of and Reliance on Employees' Talent
None Found.

TINY

Importance of Small
Poor: Large aircraft, high level of technology, large project team.

Formal Commitment to Maintain or Reduce Size
Poor: "Empty weight projections for Block I, II and III aircraft were slightly higher than weight goals for each block" (Global Security, 2008).

Concrete Steps Taken to Actually Reduce Size
Poor: No evidence found

OUTCOME

Failure: Program cancelled after 21 year development and $39 billion spent. Not a single Comanche was produced.

A-10 THUNDERBOLT II

Sources: -Burton, 1993
-Jacques & Strouble, 2008
-Ward, 2009

__**FAST**__

Accept Risk to Maintain Schedule

Good: “The required IOC of December 1970 was considered high risk with respect to cost and schedule, but achievable if the concept definition phase was reduced to a four month contract definition followed by competitive source selection…” (Jacques & Strouble, 2008:21).

Formal Commitment to Maintain Deadlines

Good: “The change to a competitive prototyping approach had a significant effect on IOC, with the new projected IOC now in FY76” (Jacques & Strouble, 2008:30).

Concrete Steps Taken to Reduce Development Time

Good: “The A-X request for proposal (RFP), including all attachments and ‘boiler plate’ was 104 pages, and it limited each contractor’s response to 585 pages. This represented a sizeable reduction in the RFP for its time…” (Jacques & Strouble, 2008:32).

Contractual Incentives to Reward Early Delivery

Good: “Contractors would have 3 months to respond to the RFP and the government intended to complete its evaluation of proposals and make award within a 75 day period” (Jacques & Strouble, 2008:32).

Importance of Speed

Good: “The Air Force also believed the A-10 to be closer to production, thus allowing for faster progress…” (Jacques & Strouble, 2008:39).

__**INEXPENSIVE**__

Formal Commitment to Maintain Budget

Good: “…the simpler design of the A-10 was more likely to allow achievement of the $1.4M flyaway cost…” (Jacques & Strouble, 2008:39).

Importance of Low-Cost

Excellent: “In a force cost analysis, the A-X had the lowest total force cost due to the small force required, which could be traced to high availability over the battlefield, high sortie rates and high sortie effectiveness” (Jacques & Strouble, 2008:27).

Contractual Incentives to Reward Cost Under-Runs

Excellent: “…with contractual incentives to achieve or come under the cost goal” (Jacques & Strouble, 2008:39).

"…the Air Force awarded a cost-plus-incentive-fee contract for approximately $160M" (Jacques & Strouble, 2008:39).

Concrete Steps Taken to Actually Reduce Development Cost
Excellent: "In order to achieve cost savings, the specified performance requirements were not to be considered firm specifications but goals…" (Jacques & Strouble, 2008:33).

Accept Risk to Reduce Costs
Excellent: "The required IOC of December 1970 was considered high risk with respect to cost and schedule, but achievable if the concept definition phase was reduced to a four month contract definition followed by competitive source selection…" (Jacques & Strouble, 2008:21).

SIMPLE
System Capability Less Than Previous Systems
Excellent: "The avionics for the A-X were specified in terms of a 'skeleton' package (below minimum requirements), a 'lean' package (met only minimum requirements), and three add-on packages that would supplement the 'lean' package" (Jacques & Strouble, 2008:20).

Heavy Reliance on Existing, Mature, Proven Technology
Excellent: "The A-X was to use an existing state-of-the-art engine in order to achieve an early IOC [Initial Operating Capability]… The A-X would also use existing state-of-the-art equipment for avionics" (Jacques & Strouble, 2008:18).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Excellent: "In order to reduce these costs, the Air Force was to provide guidance stressing simplicity of design, ease of maintenance, and the importance of keeping costs of the A-X to a minimum" (Jacques & Strouble, 2008:33).

Importance of Simplicity
Excellent: "… it was intended that simplicity of design would lead to a shorter development time, lower life cycle cost, reduced maintenance times, increased sortie rates and the ability to operate from austere bases" (Jacques & Strouble, 2008:22).

Emphasis on the Importance of and Reliance on Employees' Talent
Average: Not explicitly stated however, the project team was small and had to rely on talent to accomplish development.

"In keeping with the philosophy of minimum documentation for the Parallel Undocumented Development phase, the SPO [System Program Office] was to be manned on an austere basis" (Jacques & Strouble, 2008:32).

<u>TINY</u>

Importance of Small

Good: "The representative A-X from DCP-23A [Development Concept Paper] was slightly smaller, lighter and cheaper than that of DCP-23" (Jacques & Strouble, 2008:30).

Formal Commitment to Maintain or Reduce Size

Good: "Dr. John Foster [DDR&E] stated that 'the proposed aircraft seems to be too large… A smaller, less-costly, quick reaction aircraft seems more appropriate" (Jacques & Strouble, 2008:29).

Concrete Steps Taken to Actually Reduce Size

Excellent: "In October 1969, Secretary of the Air Force Harold Seamans chose an alternative that was termed 'Parallel Undocumented Development.' This approach would require a minimal amount of documentation during the competitive prototyping phase to encourage innovation and initiative on the part of the contractors" (Jacques & Strouble, 2008:30).

<u>OUTCOME</u>

Success: "The A-10s turned out to be one of the true success stories of the [first Gulf] war. They represented only 15 percent of the combat aircraft in the war, yet, according to the Air Force Times, 'flew about a third of the total sorties and were responsible for more than half the confirmed bomb damage' against the enemy. Put another way, the A-10 was responsible for more damage to the enemy than all the other combat aircraft put together…" (Burton, 1993:242).

F-20 TIGERSHARK

Sources: -Martin & Schmidt, 1987
-Ward, 2009

FAST

Accept Risk to Maintain Schedule
Average: Rapid aircraft testing (Martin & Schmidt, 1987).

Formal Commitment to Maintain Deadlines
Excellent: "The rollout of the first F-20 Tigershark occurred 32 months after the program go-ahead—it came out a month ahead of schedule" (Martin & Schmidt, 1987:5).

Concrete Steps Taken to Reduce Development Time
Good: "Northrop rapidly tested the Tigershark through its flight envelope in order to enable foreign air force pilots to fly the aircraft as soon as possible for marketing reasons" (Martin & Schmidt, 1987:6).

Contractual Incentives to Reward Early Delivery
None Found

Importance of Speed
Good: One month ahead of schedule (Martin & Schmidt, 1987).

<u>INEXPENSIVE</u>

Formal Commitment to Maintain Budget
Excellent: "The problem was to make this leap while still fielding a relatively inexpensive aircraft, and one that maintained the old F-5 emphasis on reliability and maintainability" (Martin & Schmidt, 1987:2-3).

Importance of Low-Cost
Excellent: "The proposed fixed price for the F-20s was $15 million with support (1985 dollars), substantially less than GD's going price of $18 million for the F-16C" (Martin & Schmidt, 1987:17).

Contractual Incentives to Reward Cost Under-Runs
None Found

Concrete Steps Taken to Actually Reduce Development Cost
Excellent: "It is evident that from early on in the program, Northrop was concerned over the cost-effective producibility of the Tigershark. They took great steps towards ensuring that they would be able to produce a quality product that could be sold for a reasonable price" (Martin & Schmidt, 1987:9).

Accept Risk to Reduce Costs
Excellent: "Northrop management reasoned that the trend of electronic technical progress in the 1970s, in general, had been more performance at less cost with greater dependability…Northrop believed that they would be able to translate these advantages of high technology into the advanced avionics systems of the F-20. The new aircraft would have the extra capabilities associated with a 'top of the line' plane, but at less cost" (Martin & Schmidt, 1987:3).

<u>SIMPLE</u>
System Capability Less Than Previous Systems
Average: "The FX program's F-5G Tigershark had represented a significant leap forward from the old F-5E in terms of technical sophistication and performance. The F-20 Tigershark would be going even further forward" (Martin & Schmidt, 1987:3).

Heavy Reliance on Existing, Mature, Proven Technology
Good: "Northrop put these principles into practice by selecting F-20 subsystems which were either proven, or which had good paper 'specs' with respect to reliability" (Martin & Schmidt, 1987:4).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Excellent: "A corollary to the Northrop philosophy stated above is a willingness to give up a little extra performance in order to make significant gains in terms of affordability, reliability, maintainability, and operability" (Martin & Schmidt, 1987:4).

Importance of Simplicity
Excellent: "Northrop's export fighter program has been characterized by a consistent philosophy. In designing and developing an aircraft, performance must not outweigh cost, reliability, maintainability, and operability… Their typical client country hasn't had the kind of support structure to operate and maintain a 'Ferrari' level aircraft, but has done well with a 'Ford Escort' aircraft" (Martin & Schmidt, 1987:3).

Emphasis on the Importance of and Reliance on Employees' Talent
Good: Northrop challenged the team to build a fighter with 80 percent the capability of the F-16 at half the price. The F-20 was a self-funded venture meant for foreign export sales. They had to rely on their talent to make the program a success (Martin & Schmidt, 1987).

<u>TINY</u>
Importance of Small
Good: "Their typical client country hasn't had the kind of support structure to operate and maintain a 'Ferrari' level aircraft, but has done well with a 'Ford Escort' aircraft" (Martin & Schmidt, 1987:3).

Formal Commitment to Maintain or Reduce Size
Good: "…there was less documentation than what would have accompanied a government sponsored program and the initial CEO design philosophy was kept to just one page" (Ward, 2009:149).

Concrete Steps Taken to Actually Reduce Size
Good: "…the redesigning of the production center to decrease the size and bureaucracy of production" (Ward, 2009:149).

OUTCOME
Failure: "The F-20 program was a resounding failure—Northrop was not able to sell even a single F-20. The Tigershark's limited performance was certainly a contributing factor, as was the change in U.S. policy on weapon exports. However, the primary reason appears to be the striking mismatch between Northrop's design values and the values of its potential clients" (Ward, 2009:148).

C-5 GALAXY

Sources: -AF Studies Board, 2008
-Gregory, 1989
-Griffin, 2005
-Ward, 2009

<u>FAST</u>

Accept Risk to Maintain Schedule

Average: "The SPO's performance in exercising their responsibility to balance the requirements with the design risk was less than stellar" (Griffin, 2005:20).

Formal Commitment to Maintain Deadlines

Good: "…the whole process took seven years, starting with the early vision, to build the program consensus, develop the budget plan, and define the requirements" (Griffin, 2005:16).

Concrete Steps Taken to Reduce Development Time

Average: "The schedule manager presented a list of over 500 tasks that were to be accomplished that week. The manager reported that all items were on track except for some small number of items. Of the late items, most had been resolved and there was a plan to finish the work and get back on schedule. For those unresolved items for which there was no current work-around, the names of the engineers responsible for correcting these problems were shown. On Thursday, the chief engineer visited the desks of the engineers and all the problems had been resolved!" (Griffin, 2005:13).

Contractual Incentives to Reward Early Delivery

Good: Fixed-Price, Incentive Fee Contract (Griffin, 2005:vii).

Importance of Speed

Average: "The first flight of the C-5A occurred on 28 June 1968, 33 months after contract award" (Griffin, 2005:14).

<u>INEXPENSIVE</u>

Formal Commitment to Maintain Budget

Poor: "The Air Force spent over $2 billion more than the original budget, and it took 10 years longer to finish the production with fewer aircraft than originally planned" (AF Studies Board, 2008:38).

Importance of Low-Cost

Poor: "As for the C-5A, it was a watershed. Its cost overrun crossed the billion-dollar line, thus engineering the transition of public perception of the military-buying system and the defense industry from a team that could invent anything, that could turn technology into first-rate hardware unequalled anywhere, to an apparatus that was wasteful, dishonest and incapable of producing anything that worked or stayed within cost targets" (Gregory, 1989:107-108).

Contractual Incentives to Reward Cost Under-Runs
Good: Fixed-Price, Incentive Fee Contract (Griffin, 2005:vii).

Concrete Steps Taken to Actually Reduce Development Cost
Average: "Originally structured to concentrate efforts on monitoring and controlling weight growth, it evolved into a plan dedicated primarily to reduce weight and cost" (Griffin, 2005:28).

"C-5A program was plagued by cost overruns from the very beginning. The cost overrun was not unexpected by either the Air Force or the contractor" (Griffin, 2005:22).

Accept Risk to Reduce Costs
Average: "The SPO's performance in exercising their responsibility to balance the requirements with the design risk was less than stellar" (Griffin, 2005:20).

<u>SIMPLE</u>
System Capability Less Than Previous Systems
Average: "The study outcome narrowed the range of the aircraft weight to between 650,000 and 750,000 pounds, a large increase over the state of the art, but not a quantum leap over vehicles in the inventory or in development during the mid-1960s" (Griffin, 2005:18).

Heavy Reliance on Existing, Mature, Proven Technology
Good: "With respect to the airframe, there is no large advance in the current state-of-the-art, and the technological building blocks are in hand. The Air Force is able to specify the desired performance with precision and with reasonable expectation that this performance can be achieved" (Griffin, 2005:21).

Deliberate Steps Taken to Actually Reduce Complexity in Many Areas
Good: "…the landing gear was somewhat simplified by removing the crosswind feature" (Griffin, 2005:18).

Importance of Simplicity
Good: "Creep comes from "over perfect" engineering: continuously trying to improve an acceptable design to make it better. Systems engineers must follow the mantra of "better is the enemy of good enough." The greatest contributor to requirements creep, however, is often the user. If personnel from the user community have constant access to the contractor, design changes will be continuous and never ending. The C-5 SPO team managed the inputs of non-SPO people by controlling all changes via the SPO's Configuration Control Board (CCB)" (Griffin, 2005:20).

"… the C-5 was to have an unusual drive-through main cabin, with vast cargo doors at both front and rear. In fact, the whole nose section of the airplane swung up and over the cockpit. And the landing gear could kneel, adjusting on the ground for differing loading-ramp heights. On top of that complexity, the C-5A looked like a winged centipede on the ground because of short but heavy struts supporting a couple of dozen balloon tires to allow it to land on grass fields" (Gregory, 1989:109).

Emphasis on the Importance of and Reliance on Employees' Talent
Excellent: "The SPO had the power, ability, priority, and senior leadership support to quickly rally the best minds in the nation" (Griffin, 2005:43).

TINY

Importance of Small
Average: "But building a big airplane like the C-5A was not just a matter of scaling up the smaller C-141. When the increase in size passed a certain point, technical challenges and changes cropped up" (Gregory, 1989:110).

Formal Commitment to Maintain or Reduce Size
Good: "…a well-balanced, well-understood set of requirements that fundamentally remained unchanged throughout the program" (Griffin, 2005:42).

"Requirements were controlled exceptionally well during development" (Griffin, 2005:20).

"When the C-5 aircraft first entered the inventory in 1970, it was the largest aircraft in the world, and it is still the largest transport cargo aircraft in our inventory. It was the first of the behemoths" (Griffin, 2005:v).

Concrete Steps Taken to Actually Reduce Size
Good: "The Air Force included the weight empty guarantee in the systems specification as an attempt to control potential future growth of the aircraft weight empty during development" (Griffin, 2005:43).

OUTCOME
Success: "The success of the C-5 transport aircraft is underscored by the performance of the fleet as an operational system and its heavy lift support in all of our conflicts from Vietnam to Iraq. It still accomplishes tasks that no other military aircraft, such as the new C-17 or any derivative of commercial cargo aircraft, can perform, and has consistently carried more cargo than any other aircraft in the time of war" (Griffin, 2005:vi).

"The C-5A fleet has demonstrated success in operation, but, as will be discussed, the development of the aircraft was plagued by a major technical failure in the design of the structure, most notably the wing and pylon" (Griffin, 2005:5-6).

Appendix G: Alternatives Pairwise Comparisons

Ideal mode		PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE
Alternative	Total	Accept Risk to Maintain Schedule (L: .135)	Formal Commitment to Maintain Deadlines (L: .249)	Concrete Steps Taken to Reduce Development Time (L: .243)	Contractual Incentives to Reward Early Delivery (L: .171)	Importance of Speed (Project Pace, Schedule, Meeting Deadlines) (L: .202)	Formal Commitment to Maintain Budget (L: .226)
NASA Mar's Viking	.088	.068	.201	.068	.108	.073	.076
NASA Mar's	.823	1.000	1.000	.481	.108	.629	1.000
MRAP	.530	.409	1.000	1.000	.560	1.000	.077
P-51 Mustang	.541	.644	.663	.481	.108	.629	.446
XP-75 / P-75 Eagle	.504	1.000	.099	1.000	.108	1.000	.279
V-22 Osprey	.082	.083	.063	.068	.108	.073	.076
E-3 Sentry AWACS	.444	.627	.663	.481	.108	.629	.701
RAH-66 Comanche	.077	.068	.063	.068	.108	.073	.076
A-10 Thunderbolt II	.827	1.000	.391	.481	1.000	.629	1.000
F-20 Tigershark	.614	.211	.663	.254	.108	.330	.677
C-5 Galaxy	.340	.211	.201	.068	1.000	.195	.076

Ideal mode		PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE
Alternative	Total	Importance of Low-Cost (Choosing a Low-Cost Design / Solution) (L: .211)	Contractual Incentives to Reward Cost Under-Runs (L: .161)	Concrete Steps Taken to Actually Reduce Development Cost (L: .270)	Accept Risk to Reduce Costs (L: .132)	System Capability Less than Previous Systems (Designed Optimized for Main Objective) (L: .108)	Heavy Reliance on Existing, Mature, Proven Technology (TRL 7+) (L: .186)
NASA Mar's Viking	.088	.089	.081	.071	.065	.076	.083
NASA Mar's	.823	1.000	.081	.982	1.000	.921	.953
MRAP	.530	.089	.417	.071	.100	.572	.326
P-51 Mustang	.541	.640	.081	.402	.360	.908	.541
XP-75 / P-75 Eagle	.504	.640	.081	.402	.593	.312	.924
V-22 Osprey	.082	.089	.081	.071	.065	.077	.083
E-3 Sentry AWACS	.444	.640	.081	.604	.638	.149	.972
RAH-66 Comanche	.077	.089	.081	.071	.064	.080	.083
A-10 Thunderbolt II	.827	1.000	1.000	1.000	.596	1.000	.972
F-20 Tigershark	.614	.640	.081	.691	.672	.274	1.000
C-5 Galaxy	.340	.089	.588	.214	.190	.321	.378

Ideal mode		PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE
Alternative	Total	Deliberate Steps Taken to Actually Reduce Complexity in Many Areas (Technology, Communiction, Organization) (L: .246)	Importance of Simplicity (Design, Organization, Documentation) (L: .272)	Emphasis on the Importance of and Reliance on Employees' Talent (L: .188)	Importance of Small (Small Design, Minimum Documentation, Small Budget) (L: .293)	Formal Commitment to Reduce Size of: Design, Requirements, Technology (L: .381)	Concrete Steps Taken to Actually Reduce Size of: Project Team, Process, Documentation (L: .326)
NASA Mar's Viking	.088	.085	.075	.082	.086	.081	.060
NASA Mar's	.823	1.000	1.000	1.000	1.000	1.000	.509
MRAP	.530	1.000	.218	.686	.143	.081	.882
P-51 Mustang	.541	.596	.642	.492	.744	.706	.497
XP-75 / P-75 Eagle	.504	.596	.979	.082	.143	.122	.093
V-22 Osprey	.082	.084	.075	.082	.090	.079	.140
E-3 Sentry AWACS	.444	.395	.212	.082	.090	.252	.538
RAH-66 Comanche	.077	.084	.075	.082	.090	.080	.059
A-10 Thunderbolt II	.827	.967	.998	.286	1.000	.978	1.000
F-20 Tigershark	.614	.967	.661	1.000	1.000	.978	.523
C-5 Galaxy	.340	.372	.459	.686	.258	.486	.335

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14. ABSTRACT

FIST is an emerging and unproven rapid acquisition model that stands for *Fast*, *Inexpensive*, *Simple*, and *Tiny*. The purpose of this research is to develop an Analytical Hierarchy Process (AHP) model based on the FIST concepts, to be applied as a comparative tool against the FIST model. The results indicate that the FIST model is reproducible with the AHP theory and that there are certain program characteristics that denote if a program would benefit from being developed by FIST. However, there are distinct weaknesses to the model that signify not all programs would succeed if FIST was employed during development. Eleven additional FIST activities are recommended for inclusion in the model with key activities comprising of an ambidextrous structured organization, better requirements gathering techniques, and utilizing incremental development.

15. SUBJECT TERMS

FIST model, rapid acquisition, acquisition reform, system development methods

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