

DoD Acquisitions Reform: Embracing and Implementing Agile

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Over the last decade, the President and Congress have tasked the Department of Defense (DoD) with reducing expenditures and finding areas for cost savings. DoD officials have responded with initiatives such as Better Buying Power, Should Cost and Bending the Cost Curve. Senior leaders are debating which functional areas need to be cut given the reduced budget. What if we could keep our core functions, while simultaneously reducing costs? This paper purports that one avenue to accomplish this is to overhaul the overly rigid, bureaucratic acquisitions process. The new acquisitions guidance, DoDI 5000.02, represents a step in the right direction by allowing for an incremental delivery process, but implementation of Agile principles are lacking. In these times of fiscal austerity, the DoD must focus on Agile implementation in three main areas: training, business process re-engineering and contracting guidance.

It is beyond the scope of this paper to identify a solution that will positively affect the vast array of acquisitions projects. In order to offer specific recommendations and bound the topic of research, the focus of this paper is on information technology (IT) acquisitions specifically, which includes business systems, command and control, computing and communications infrastructure, Intelligence Surveillance and Reconnaissance (ISR), and space and cyber weapon systems. The rationale for this focus is that, “at the core of the ability to achieve integration and maintain agility is the ability of the DoD to produce and evolve software” (Critical Code: Software Producibility for Defense, 2010). In 1960, software accounted for 8% of the functionality in the F-4, compared with 80% of the functionality in the F-22 (Critical Code: Software Producibility for Defense, 2010). As Figure 1 below illustrates, the amount of software embedded in weapons systems is continuing to increase. As best stated by an Air Force general officer, “The B-52 lived and died by the quality of its sheet metal. Today, our aircraft will live or die by the quality of our software” (Hagan, Hurt, & Sorenson, 2). The F-35 is currently DoD’s most costly program and it is experiencing critical software issues. Eighty percent of the issues identified by the Autonomic Logistics Information System (ALIS), which determines potential maintenance problems, are false positives (Everstine, 2015). These examples

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illustrate software’s critical role in the weapons of the future. The change in methodology this paper elaborates upon can also be applied to areas outside of software, but this has been the primary area of applicability. It is important to demonstrate successful application of the below principles in software development to make a business case for extending these principles to other areas like manufacturing.

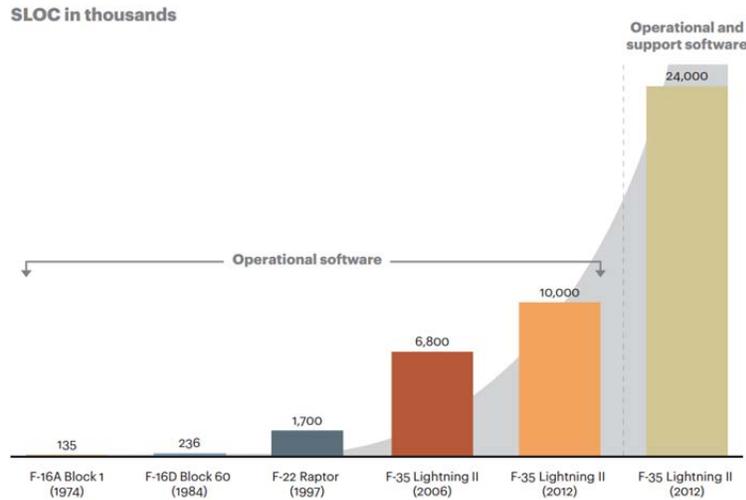


Figure 1: Growth in Software Lines of Code (SLOC) in Avionics Software (Hagan, C., Hurt, S., & Sorenson, J, 2012)

At first glance, the acquisitions field might not seem like the most obvious place to maximize value or create cost savings for the Air Force. Comparatively speaking, procurement, the area most often associated with acquisitions, is only the third highest expenditure in the Air Force’s portion of the FY16 Defense Budget, falling behind Operations and Maintenance, and Military Personnel costs (SAF/FMB, 2015). However, the lifecycle-centric nature of the acquisitions enterprise means that funding for an acquisition can come from research, development, test and evaluation, procurement, or operation and maintenance funds. When one takes this into account, acquisitions potentially affects 75% of the Air Force’s projected FY16 budget, or up to \$91 billion dollars.

The last decade has seen numerous efforts by the Air Force, the DoD, and Congress to reform how agencies implement the acquisitions process because of a perception that the system is broken. Unfortunately, this is not a new trend. According to one count by former Secretary of Defense Donald Rumsfeld, between 1975 and 2001 there were “128 different studies and reports on reforming the [acquisitions] system” (Spring, 2005). Certainly, the last fifteen years yielded significant evidence that the acquisitions process is far from efficient. Between 2001 and 2011, the DoD spent \$46 billion dollars on twelve weapons systems that it ultimately cancelled with no tangible result (Reed, 2011). According to the GAO, the 98 Major Defense Acquisitions

Programs from FY10 were collectively \$406 billion dollars over budget and averaged 22 months behind schedule since their first full estimate (Hofbauer, Sanders, Ellman, & Morrow, 2011). In short, the DoD spends a large amount of money for projects that are either not delivered or are delivered far over budget and significantly behind schedule.

What drives this deficiency? Why can't the acquisitions process deliver the required products on time and on budget? One serious issue might be the acquisitions process itself. For the last twenty plus years, the Air Force has used the waterfall approach for software development as illustrated in Figure 2 below. This approach is very linear in nature and relies on several key assumptions, which include well-defined requirements and changes to the requirements will be very limited and small in nature (Leffingwell, 2007). Given the rapid rate at which technology advances, these are no longer valid assumptions upon which the Air Force and its acquisitions programs can rely. Any changes made to the requirements, even those that are realized to be obsolete based on new information, must go through a very rigorous engineering change proposal (ECP) process. The sheer amount of documentation required in this process causes schedule delays and is accompanied by a hefty price tag. An estimate from 1992 showed that over a six month period, one program cost \$22 million dollars and more than 325,000 man hours to deal with the bureaucratic requirements (Spring, 2005). The bottom line is that this model is an anachronism; this process is wholly ineffective for an age of rapidly changing technologies and a very dynamic threat environment. Using this process, it takes an average of 81 months to develop new software for the Air Force, while most private companies plan on a 12-18 month cycle to deliver new software to put them within the two year cycle of technology development dictated by Moore's Law (Modigliani & Chang, 2014).

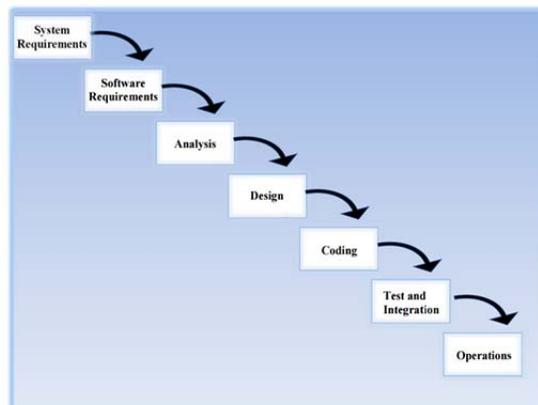


Figure 2: Waterfall Process (Palmquist, Lapham, Miller, Chick, & Ozkaya, 2013)

The solution to this problem is a new process for acquisitions. The 2015 updates to the DoD acquisitions guidance, DoDI 5000.02, recognized the need for an alternative to the linear software development model illustrated above. The guidance included a model that allows for incremental software development, but does not specifically mention Agile within the document. It is important to note that incremental development does not necessarily mean that an

organization is implementing Agile principles, which will be elucidated below. The next step is for the Air Force to take the implementation steps needed to ensure that an environment exists in which Agile can succeed. At a minimum, the Air Force needs a new approach to software acquisitions in order to maximize functionality of new systems, while simultaneously keeping our existing systems technology up to date. This system needs to make requirement prioritization and regular contact between contractor and the end user a priority, which minimizes requirements creep by forcing the customer to stay focused on the most important issues while keeping them aware of limitations. It could also reduce the need for excessive bureaucracy and paperwork requirements by utilizing the customer/contractor interaction to fulfill the same documentation purpose. Finally, the new process needs to be scalable and potentially applicable to the realm of hardware as well. The good news is there is a process that fulfills all of these requirements, and the process is Agile Development.

A New Model: Agile Development

As described above, a rigid acquisitions process cannot support the fluid contingency operations in which we operate. The next question is, why Agile? Adding flexibility and increasing capabilities should be the goal, not ditching both. The Air Force's 30-year strategy mentions agility twenty-one times in its twenty pages, with Secretary James specifically citing agility as a way of "breaking paradigms and leveraging our technology", especially through how "we acquire and field weapons systems" (U.S. Air Force, 2014). With Agile, not only do we build flexibility demanded from senior Air Force leadership, but we also obtain finite improvements and results from the Agile method.

The Agile Development process began a few decades ago with the growing need to keep pace with the rapidly increasing software development process. Moore's Law, developed by Gordon Moore in the 1970's, brought to realization that computing power, and the technologies associated with it, would double every eighteen to twenty-four months. This exponential increase in software requires an acquisitions process that finds the ability to match that evolutionary speed. In Agile, we find that match. The core tenets of Agile include focusing on small, frequent capability releases; valuing working software over comprehensive documentation; responding rapidly to changes in operations, technology, and budgets; and actively involving the users throughout development to ensure high operational value (Magliani and Chang, 2014). The Agile life-cycle exhibits a circular approach in which development stages begin and are tested at the end of each stage, or iteration as illustrated in the Figure 3 below. The Agile Methodology website notes that "in an agile paradigm, every aspect of development – requirements, design, etc. – is continually revisited throughout the lifecycle" (Agile Methodology, 2008). Continually revisiting requirements throughout development allows more flexibility and adaptability to changes as they arise.

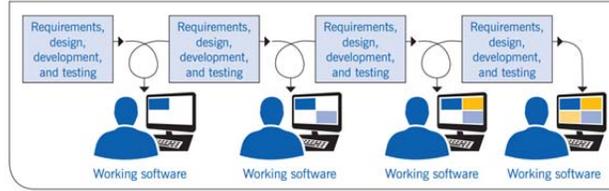


Figure 3: High Level Agile Process (Gorans & Kruchten, 2014)

The Agile approach to software development is a set of principles. The IT industry has developed multiple Agile methods that are tailored to the specific needs of different types of IT projects. It is outside the scope of this paper to describe the numerous methodologies in depth, given that the focus is on implementing an environment in which any of the Agile processes can succeed if implemented properly. It is important to note that there are methodologies for smaller efforts in addition to scalable models for larger, more complex efforts. These earlier methodologies include, but are not limited to, Scrum, Kanban, Extreme Programming and Crystal. Although some of the methodologies are ‘heavier’ when compared to others, all of these methods are extremely ‘lightweight’ when compared to the documentation that is required in the traditional waterfall approach.

Specific models for enterprise level efforts include Scaled Agile Framework, Disciplined Agile Delivery, Large Scale Scrum and Scaled Scrum (Mike Cottmeyer, personal communication, August 31, 2015). This is not meant to be an all-inclusive list of Agile methodologies and novel approaches may be developed based on the rapidly evolving nature of software development. The scalable models conform with the same principles as the earlier models, but they illustrate how to integrate multiple teams depending upon the size of the project and provide a portfolio view. In order to demonstrate the differing levels of effort, Figure 4 below illustrates a typical Scrum process, whereas Figure 5 offers a Scaled Agile Framework model.

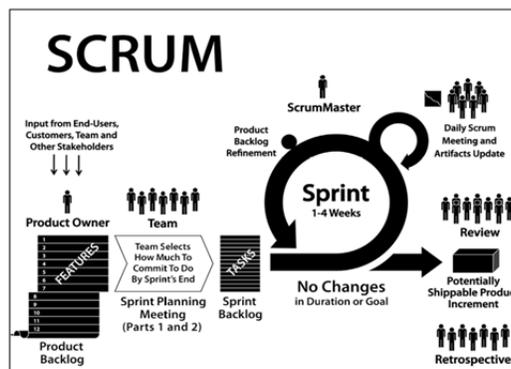


Figure 4: Overview of Scrum Process (Glaiel, 2012)

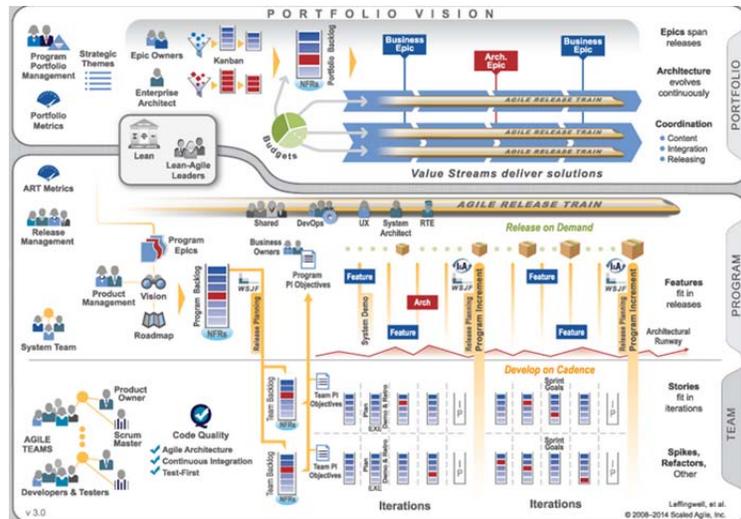


Figure 5: Scaled Agile Framework Model (Wrubel , Miller, Lapham, & Chick, 2014)

For the purposes of this analysis, the focus will be on implementation of Agile principles in software development. However, Agile methodologies can be used to improve efficiency in other industries. One example is Toyota Motor Corporation’s automobile production line, which uses a system called Kanban, literally translated to “signboard.” “Just-in-Time” was the original idea. Promoted by Toyota vice-president Taiichi Ohno, he called for the use of Kanban to ensure Toyota produced “only what is needed, when it is needed, and in the amount needed” (Toyota, 2015). Inspired by the supply chain at supermarkets, Kanban are slips of paper, barcodes, or other means of tracking inventory. Through carefully tracking and managing their supply chain throughout the production cycle, Toyota is able to eliminate overproduction by only restocking production parts that have been used. By keeping local inventory small, Toyota production plants are able to keep a wider variety of parts on hand, which leads to the ability to produce vehicles with different specifications at any time. When parts are used in production, a Kanban slip informs the supply chain that more of those parts are needed at the production plant (Toyota, 2015). The end result of this process is that Toyota is able to efficiently produce more automobiles, with less parts, and respond with agility to changes in market demand. This example illustrates the success of Agile within the manufacturing industry. More research is needed to determine if a similar model can be used for non-software-centric acquisitions in the DoD.

Reductions in cost through continuous improvement allows for a greater return on our investment. A group of researchers from MIT found that using Agile in software development can lead to anywhere from “5% to 61% reductions in cost, 24% to 58% reductions in development time, and 11% to 83% reductions in product defects” (Glaeil, Madnick, and Mouton, 2013). According to a 2011 report from the Standish Group, Agile projects are three

times more successful than traditional projects (Cohn, 2011). A survey on the literature of Agile’s return on investment (ROI), as shown in Figure 6 below, further illustrates the numerous benefits of this process. These reductions in cost, coupled with a proven return on investments, shows that using the Agile method not only works but is a viable option going forward. Thus far, we have identified the inadequacies of the current waterfall process and made a business case for Agile adoption. Next, we will elaborate upon the fundamentals of Agile and the different methodologies that conform to Agile principles.

Year	Source	Findings	Responses
1998	Harvard (Thomke et al., 1998)	50% reduction in engineering effort 55% improvement in time to market 925% improvement in number of changes allowed	391
1998	Harvard (MacCormack, 1998)	48% productivity increase over traditional methods 38% higher quality associated with more design effort 50% higher quality associated with iterative development	29
1999	Boston College (Fichman et al., 1999)	38% reduction in time to produce working software 50% time to market improvement 50% more capabilities delivered to customers	28
2003	Reifer Consultants (Reifer, 2003)	20% reported productivity gains 10% reported cost reductions 53% reported time-to-market improvements	78
2003	Shine Technologies (Johnson, 2003)	49% experienced cost reductions 93% experienced productivity increases 88% experienced customer satisfaction improvements	131
2004	CIO Magazine (Prewitt, 2004)	28% had been using agile methods since 2001 85% initiated enterprise-wide agile methods initiatives 43% used agile methods to improve growth and marketshare	100
2006	Digital Focus (Digital Focus, 2006)	27% of software projects used agile methods 23% had enterprise-wide agile methods initiatives 51% used agile methods to speed-up development	136
2006	Version One (Version One, 2006)	86% reported time-to-market improvements 87% reported productivity improvements 92% reported ability to dynamically change priorities	722
2006	AmbySoft (Ambler, 2006)	41% of organizations used agile methods 44% reported improved productivity, quality, and costs 38% reported improvements in customer satisfaction levels	4,232
2007	AmbySoft (Ambler, 2007)	69% of organizations had adopted agile methods 89% of agile projects had a success rate of 50% or greater 99% of organizations are now using iterative development	781
2007	UMUC (Rico, 2007)	70% of developers using most aspects of agile methods 26% of developers had improvements of 50% or greater Agile methods are linked to improved website quality	250

Figure 6: Literature Review of Agile ROI (Rico, 2015)

Examples of Agile within DoD

Acquisitions in the private sector are inherently different than government acquisitions due to issues such as funding stream, regulations, and documentation requirements, among others. Thus, the next question posed was whether or not Air Force programs are executing Agile today. Market research and discussions with other program managers revealed that Agile is being conducted by at least five program management offices (PMOs) in three different MAJCOMs.

The team interviewed two PMOs to offer examples of Agile success stories, which are provided below.

Two programs using Agile methodologies appeared in Special Operations Command (SOCOM). One example is the Lead-Off-Hitter (LOH) program, which develops software updates for the MQ-9 Reaper. Traditionally, the Air Combat Command (ACC) Operational Flight Program (OFP) handled software development for the MQ-9. Delivery of requirements usually occurred after four to five years, typically coupled with cost growth. In one cycle, the program office conducted 11 requirements modifications and costs grew by over \$12M from 2006 to 2013. SOCOM leadership deemed this typical cost growth and late delivery schedule insufficient to meet the warfighters' needs, and as a result stood up the LOH program. This program office operates under the following principles: schedule driven releases over the traditional content releases, limited technical scope based on release schedule, regular end-user participation, and require documentation when necessary. The program began with awarding a two-year cost plus fixed fee contract for \$16M, and operates on a six-month delivery cycle. Although requirements changes, to include additions and deletions, occur on a weekly basis, the program office has experienced zero cost growth. Requirements are simply prioritized, with no contract modification needed, based on the need of the end-user. From February 2014 to June 2015, the program office delivered four releases that are supporting over 800 requirements and are working an additional 1,000 requirements. The team also fixed 182 software defects and resolved 92 known anomalies (Jamieson Pierce, personal communication, August 14, 2015).

Another example within SOCOM is the MALET JSIL Aircrew Training Device (M-JADT) team. The original MQ-9 trainer is a plug-and-play training device developed by the Army to address a capability gap in Reaper training. Using Agile, AFSOC built, tested, and fielded an MQ-9 variant based on the Army's MQ-1C trainer in five months. The team accomplished this feat with an 85% reduction in cost and schedule compared to the original plug-and-play trainer developed by the Army. Each AFSOC trainer is \$70K and can be delivered 60 days after initial order. Six trainers have been fielded, with an additional fourteen more being made (Jamieson Pierce, personal communication, August 14, 2015).

Given that SOCOM operates within different acquisition regulations, it was important for the team to find Agile examples outside of the special operations community. The Patriot Excalibur (PEX) program in Air Force Material Command has been executing Agile, specifically Extreme Programming (XP) with a Scrum management philosophy, since 2003. The program automates squadron processes in three areas: scheduling, training, and standards and evaluation. Squadrons have voluntarily adopted the program and it now serves over 700 AF and Air National Guard squadrons. Prior to Agile adoption, PEX operated on an 18 month delivery cycle and received low customer satisfaction (Garcia-Miller, Lapham, Boston, Sharp, & Goshorn, 2011). The development team suggested the program office switch to an Agile process given the

current schedule and satisfaction issues. The result is a 22-week release schedule, that on average addresses 480 requirements and 10 software defects (Johnson, Cheng, Misiarezek, Greytak, & Boston, 2011). The program office attributed success to three factors, besides those inherent in XP and Scrum. The first is adequate Agile training in the program office by professionals. In order to ensure success, the program halted work to focus on training and hired consultants. Second, continuous engagement with the end user is absolutely vital. PEX hosts an annual user forum, attended by over 200 users in 2011, to obtain new user stories and solicit feedback on the current application. User interaction is more than just an annual occurrence; subject matter experts (SMEs) reside within the PMO and work alongside the development team. The last, and one of the most important success factors mentioned, is a flexible contract vehicle (Garcia-Miller, Lapham, Boston, Sharp, & Goshorn, 2011). Given the flexible nature of Agile user stories and constant reprioritization, it is critical to have a contract strategy that is flexible and will not require a modification with each change. The PEX PMO used a cost plus incentive fee time and materials contract. Kelly Goshorn, the PEX PM for over 16 years, states this was a key success factor. The time and materials contract gave her team the flexibility needed when it came to user story development that is not available with either fixed-price or cost reimbursable contracts (Kelly Goshorn, personal communication, August 17, 2015). The PEX PMO received several awards in recognition for its continued success, to include, the 2003 Crosstalk award for The Top 5 Quality Software Programs in the U.S. government and a finalist for the 2008 AF Chief of Staff Team Excellence Award (Garcia-Miller, Lapham, Boston, Sharp, & Goshorn, 2011).

The F-22 program office is not currently conducting a complete Agile effort, but an Iterative model that applies some agile tenets. They are moving to the Scaled Agile Framework (SAFe) for a software modernization effort. An avionics engineer mentioned that conducting a project of their magnitude with a traditional agile approach would be extremely difficult and having a scalable model, like SAFe, is vital. The team has noticed several benefits with the agile aspects of the Iterative methodology, although it is too early to classify the implementation as successful. Early testing of the software has led to the discovery of defects that would have caused major setbacks if found at the end of development, per the waterfall methodology. Agile metrics are another tool the program office found extremely beneficial. Metrics included, defect tracking, task completion and the speed at which the development team completed the tasks, to name a few. These metrics provided early insight into possible schedule issues and allowed for adjustment early in the process (Bradley Bernard, personal communication, August 17, 2015). The examples cited above illustrate that even with the bureaucratic DoD processes, program offices are successfully implementing Agile principles.

The question becomes, how can the Air Force emulate these successes on a much larger scale? As emphasized by Mr. Jamieson Pierce from the Lead-Off-Hitter program, Agile is not the silver bullet that will solve all of the Air Force's acquisitions issues. It would also be

incorrect to assume that anyone can manage an Agile project successfully. A GAO report identified 14 factors that are inhibiting Agile adoption and application in DoD (Government Accountability Office Effective, 2015). Generally speaking, these factors can all be tied back to trying to implement Agile by simply adding to current processes and models of operation, rather than understanding that Agile requires a completely new process in and of itself (Mueller, 2). The next section of this report addresses the steps that the Air Force must take in order to ensure successful implementation of Agile on a wide scale, which includes training, business process updates, and contracting guidance.

Training

An SEI report on considerations for Agile implementation within the DoD identified training as a foundational concern (Lapham, Considerations for Using Agile in DoD Acquisition, 2010). Changing from the traditional acquisition processes to Agile methodologies will force some culture shock, as well as some organizational resistance. A source of this shock and resistance is simply a reaction to the unknown. Training and familiarization will smooth the transition to Agile while building the skillsets personnel need to succeed.

The first step in implementing Agile methodologies in the Air Force is to address how personnel are trained. The primary training focus would be for the broader acquisition community, to include the program manager, contracting officer, engineering, and the user community, among others. Simply training the program manager is insufficient, because Agile requires buy-in from the entire government team. As subsequent sections will demonstrate, a contracting officer's understanding of Agile methodologies is needed in order to execute a flexible contracting strategy that supports Agile, while engineering expertise can be used to develop a business process more conducive to Agile. It is imperative that senior leaders also receive training because their buy-in is often critical for program success. Currently, the Air Force acquisition workforce is trained by the Defense Acquisition University (DAU), and the vast majority of the courses are delivered through online courseware (DAU, 2013). Despite the widespread commercial usage of Agile principles, DAU's list of 182 courses does not contain a single course focusing on Agile methodologies for program management (DAU, 2015).

There are three courses of action (COAs) the Air Force could pursue to ensure acquisitions officers are properly equipped to run programs utilizing Agile methodologies. First, DAU could develop courseware that prepares acquisitions officers to manage programs that utilize one or more of the Agile methodologies. Second, DAU could transform itself to deliver an accredited Master's degree in Program Management. Third, the Air Force could pay an established private institution to deliver the training. These COAs are not necessarily mutually exclusive. The first two COAs are long term solutions needed in order to implement Agile, while accounting for unique Air Force requirements. The third option is the optimal solution to assist programs in the short term.

The private sector has increasingly been using Agile to quickly and efficiently produce software for their customers (Northern, Mayfield, Benito, & Casagni, 2010). Agile training has been in high demand across the IT industry and has since migrated into other industries. Today, there are numerous companies and intuitions offering coaching, classes, or certifications in Agile methodologies. The Project Management Institute (PMI) is the premier institution for project management professionals, and they offer 2- or 3-day courses on Agile, at a cost of \$1,545 or \$2,275, respectively (PMI, 2015). An additional \$495 would enable an acquisitions professional to test for a certification from PMI in Agile practices. Acquisitions officers would then be able to certify, similar to the current certifications obtained through DAU, that they meet a professional standard and have a basic understanding of Agile methodologies from an academic perspective. Requiring an Agile certification for program offices using an these methodologies would bring the career field in line with the customers they often support and would further professionalize the career field. During the last 10 years, DoD Information Assurance (IA) personnel with elevated decision authority, or elevated access to Information Systems, were required to obtain and maintain a requisite certification in the fundamentals of IT Security. Additional members of the DoD performing an IA role may be required to maintain certifications commensurate with their responsibilities (IASE, 2015). It can be argued that acquisitions professionals who manage programs with large dollar values, large scope of impact or increased risks associated with the program, should be required to maintain a professional certification in Agile practices.

Education regarding Agile principles from an academic perspective is vital, but it cannot be supplanted for coaching from experienced Agile practitioners. Numerous companies offer coaching services and tools, many specializing in a certain Agile methodology, to other businesses. In order to offer operational experience to the Agile workforce, continuing education could utilize Agile coaches or mentors to run quarterly training sessions that focus on applying certain Agile methodologies to specific programs. Although quarterly training will provide practical examples, it cannot serve as the only hands-on training. Coaches and mentors should provide one-on-one training to individual programs due to the unique nature of each program and the numerous methodologies available. As mentioned by one program office, Assistance and Advisory Services (A&AS) contracts offer one avenue for obtaining this type of expertise (Michael Bigelow, personal interview, September 1, 2015).

These same coaches and mentors should be utilized to bring Agile courseware to DAU. The cost of adding Agile courseware to DAU would have to be examined, but the FY14 budget request from DAU included \$19 million for curriculum development (DAU, 2013). DAU should prioritize incorporation of Agile courseware into future development plans. Additionally, according to a report from 2010, DAU and the DoD do not track metrics to determine the long-term effectiveness of the training they provide (Government Accountability Office, 2010). The GAO recommended the implementation of such metrics, but the recommendation was not accepted by the DoD. As part of the non-concur by the DoD, it was indicated that metrics in place sufficiently capture the effectiveness of DAU's training (Government Accountability Office, 2010). However, these metrics do more to capture DAU's capacity to support the

acquisitions career field, rather than the actual effectiveness of the acquisitions career field. The adoption of Agile would allow for effectiveness metrics to be analyzed by DAU, DoD, and GAO, since such metrics are common in Agile programs.

Once established, DAU could move to become an industry leader by developing a true Master's Program, much like an online degree offered by the civilian academic community. The program could be structured in 9-week terms. Courseware would be comprised of discussion boards, collaborative projects, case studies, papers, and exams, all presented and proffered by a professor in the field of study related to the courseware. This would help change the Air Force's and the DoD's views of acquisitions from an assignment or career field to a true profession. As previously stated, Agile is not a one size fits all solution, nor does it keep programs immune from failure. Training and professional Agile coaches and mentors are a critical first step that will lead to the successful implementation of Agile. After adequate training is provided, DoD must ensure the business processes support Agile principles.

Business Process Reengineering

Training is a necessary first step to ensure that the acquisitions community and support staff is familiarized with the specific Agile methodology being proposed by the contractor. As mentioned earlier, the new DoDI 5000.02 allows for incremental delivery, but the Air Force has not considered the differences inherent in an Agile business process. The waterfall methodology relies on immense amounts of documentation to track and report progress. Due to the nature of the acquisition phases of development, testing, and delivery, this documentation allowed the Air Force to report progress at milestones and attempt to peek behind the curtain. It is incorrect to assume that Agile does not provide any documentation. Relative to the old model, Agile focuses on providing just enough documentation to ensure continuity of operations and success of the program. The bottom line is that working software is valued over copious amounts of documentation. The question then becomes, given the inherent differences and the continuous end-user involvement, how is an Agile business process structured?

Systems engineering students at George Mason University conducted research on a question posed by Boeing. Specifically, Boeing asked "whether the Agile methodology can adequately address the rigorous Department of Defense standards and needs for documentation on mission-critical software systems" (Gu, Seung, & Stephen, 2013). A literature review revealed two different perspectives regarding Agile documentation. "Adapted Agile" attempts to conform to the traditional framework, while "Aligned Agile" seeks to implement a more unique Agile-style documentation approach. Adapted Agile proponents argue that Agile does not provide proper documentation, especially for mission critical systems. A disadvantage of this approach is that it inhibits the flexibility Agile exists to provide. An alternative model is Aligned Agile, in which the documentation is actually aligned with the Agile principles. This requires an inherently different management style relative to traditional DoD programs. The concern with the second model is that this approach may be unacceptable for higher visibility, higher cost

DoD programs like nuclear operations. From a documentation perspective, the differences in the two approaches are illustrated in Figure 7 below (Gu, Seung, & Stephen , 2013).

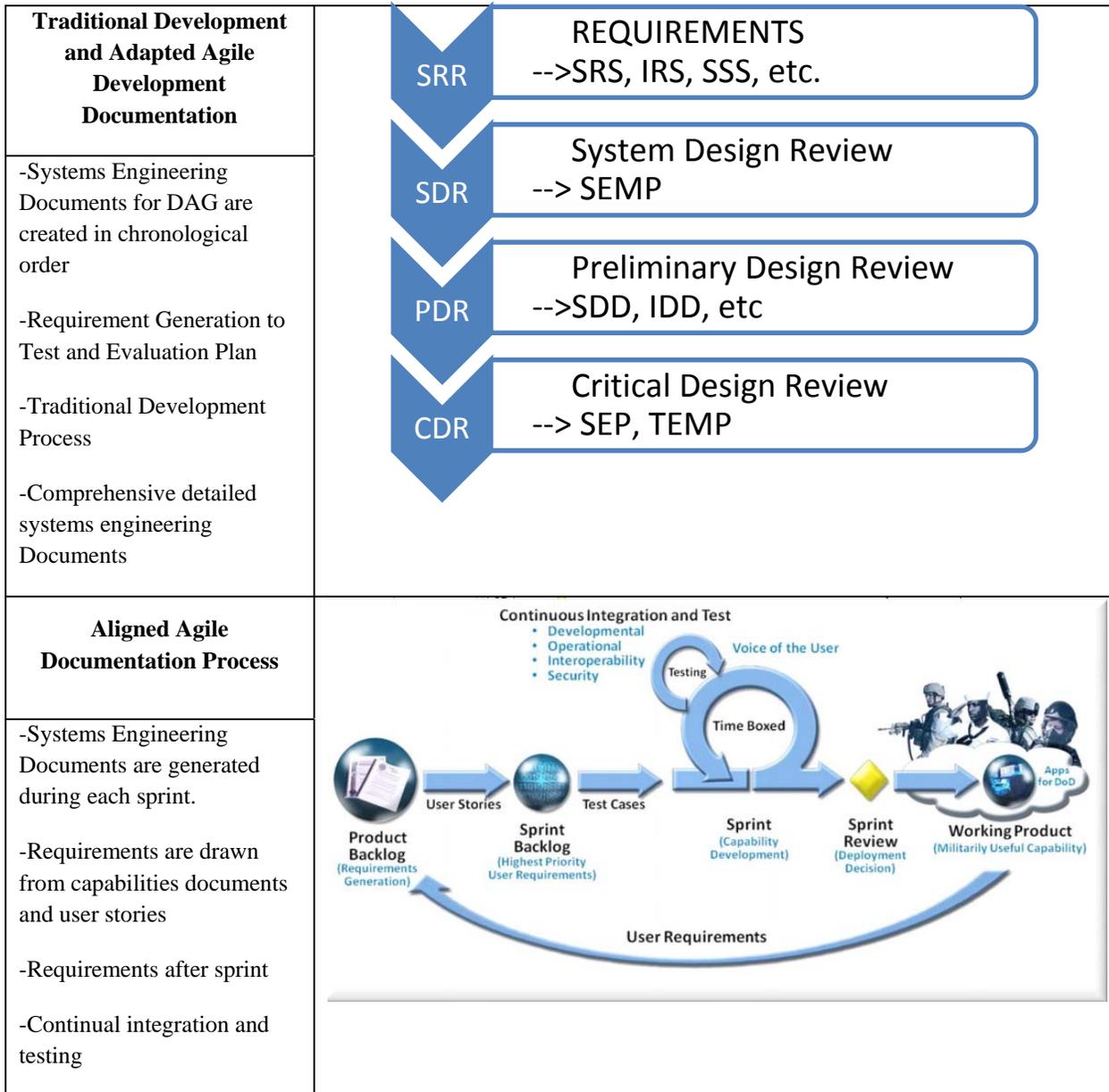


Figure 7: Adapted versus Aligned Agile Documentation (Gu, Seung, & Stephen , 2013)

In an effort to find a middle ground specific to DoD mission critical systems, the research group offered a hybrid model that provides more documentation than Agile typically advocates, but offers the flexibility inherent in the Agile model. This model is known as the Scrum Agile Document Development Framework and is illustrated in Figure 8 below. Rather than specify the

exact documentation that should be provided, this model allows for additional documentation requirements based on the specific project. For example, Acquisition Category (ACAT) I programs, with an acquisition cost of over \$480M (Defense Acquisition University, 2015), require additional documentation given the size of the effort. As illustrated below, a key tenant of this model is the Definition of Done. It is vital that the program office comprehensively address required documentation for the specific program so that it can be entered into the product backlog, tracked and accomplished. Instead of starting with the traditional documentation requirements, and trying to tailor out unnecessary documentation, perhaps it is beneficial to start with the Agile list and add other documentation as required.

Figure 8: Scrum Agile Document Development Framework (Gu, Seung, & Stephen , 2013)

The figures above illustrate examples of different Agile documentation methodologies. Some of the reviews mentioned in the Agile process above may not necessarily be formal, documented review, but rather they may occur naturally based on the continuous interaction inherent in Agile processes. The documentation required will be specific to each program, but there are certain documents that can serve as a baseline. These documents include a product vision, product backlog, sprint backlog, burndown chart, development team velocity, and definition of done for each of the user stories (Rubin, 2013). This is not an authoritative list, but rather a guide to developing a business process that offers flexibility and allows for the effective implementation of Agile processes. Aside from training and business process reengineering, another area of implementation is the contracting guidance necessary to support Agile projects.

Contracting for Agile

According to a draft Software Engineering Institute report, DoD program managers and engineer staff stated that implementing contracts supporting Agile is challenging (Wrubel & Gross, 2015). The main reason is because contracting for Agile is inherently different than writing a contract under the traditional waterfall approach, and contracting officers lack the training and experience necessary to deal with this change. Under the old process, the program manager gave requirements to the contracting officer at the very beginning of the development effort, and it was assumed that these requirements would not change. If changes needed to be made, they would undergo a rigorous Engineering Change Proposal (ECP), which would necessitate a contract modification. Modifications, especially when changing requirements significantly, lead to questions about scope and could result in having to cancel a contract and re-compete it. In contrast, Agile projects start with a set of broad requirements, and changes in these are expected throughout the life-cycle of the project. A starting point for understanding the differences in these methodologies, from a contractual perspective, is the TechFAR (Technical Federal Acquisition Regulation). The White House published the TechFAR and its primary purpose is to offer tips, guidance, sample language, etc., to assist in the implementation of contracts that support Agile (The TechFAR Handbook for Procuring Digital Services Using Agile Processes, 2014). Figure 9 below, from the TechFAR, illustrates the differences in pre-award and post-award for both traditional and Agile development. The TechFAR serves as a good starting point for contracting officers to begin to understand the differences between traditional and Agile development from a contracting perspective and it contains draft language that serves as an example of how to contract for an Agile process.

Figure 9: Events in Pre-Award and Post-Award (The TechFAR Handbook for Procuring Digital Services Using Agile Processes, 2014)

A Software Engineering Institute (SEI) report noted common misconceptions regarding Agile, which include that Agile does not produce enough documentation, it does not offer enough insight, requirements are nebulous and inherently risky, and finally that iterations will require additional contracting overhead (Wrubel & Gross, 2015). The first two can be addressed in concert. Agile actually offers much greater insight into the development effort relative to the traditional method, even though most Agile processes do not contain traditional milestones (Preliminary Design Review, Critical Design Review). It relies upon constant communication with the Product Owner, frequent release cycles of functional software, early testing and integration, as well as continuous reprioritization of requirements. As a result, the government office obtains a significant amount of insight into the development process and progress towards completion, which is illustrated in Figure 10 below. The lack of insight in the traditional model necessitated copious amounts of documentation. By contrast, given the numerous opportunities for quality checks and feedback, Agile focuses on documentation that is necessary to provide continuity and competition in the future. When deciding to request additional documentation from a contractor executing Agile, it is imperative that both the contracting officer and the program manager ensure the documentation is absolutely necessary, sufficient or whether it is a statutory or regulatory requirement (Wrubel & Gross, 2015).

Figure 10: Many Quality Touch-Points in Agile Development (Wrubel & Gross, 2015)

The next critique is that requirements are poorly defined and inherently riskier than the traditional model. As discussed earlier, a major difference in these approaches is that traditional methods require certainty in requirements at the beginning of the project, despite the fact requirements continually evolve and become more refined throughout project lifecycle. However, this does not equate to less risk in the traditional model. One of the major reasons cited by GAO for program cost and schedule growth in traditional programs, is a lack of understanding or growth in the initial requirements set (Government Accountability Office Military, 2015). By contrast, Agile models focus on a big-picture understanding of the requirements early, while refining the specific requirements as the team approaches the iterations or sprints within which they are contained. This prevents the government from spending money that focuses on all of the requirements at once, and rather on those that are at the top of the priority list.

The key to minimizing contract overhead when executing Agile is to ensure the contract is structured appropriately. In a traditional project, a contract modification is typically required to change requirements; this change process is described as “expensive and time-consuming” (Wrubel & Gross, 2015). Contracts should include information that sets the expectations for the development team as well as the program office. These include identification of the Agile process to be used, specification of the different roles (Product Owner, etc.) and the relative level of involvement, specification of the requirements management process, identification of the expected level of interaction between the contractor and the customer, and identification of release schedules (Northern, Mayfield, Benito, & Casagni, 2010). In Agile, changes to requirements are expected and occur quite frequently. The key to this flexibility is in the contracting strategy chosen.

Finding exactly which contracting strategy provides the flexibility needed for Agile remains a crucial task. Ms. Kelly Goshorn noted that she can tell if an Agile contracting effort will be successful by which contract strategy they have in place (2015). Throughout her tenure as the PEX PM, she used the Time and Materials contract mentioned earlier, which she considers absolutely critical for the success of her effort. This contract type gives the program office the same flexibility it provides to acquisitions officers to change and alter requirements without conducting a time-consuming contract modification. This contract is not preferred by contracting officers because the government bears a significant burden of the risk, and there is little incentive for the contractor to keep costs down. Ms. Goshorn explained that this methodology relies upon a high level of trust between the contractor and development team as well as continuous monitoring of the development effort (Kelly Goshorn, personal communication, August 18, 2015).

Initially, AFSOC’s Lead-Off-Hitter (LOH) program started off with a Level of Effort (LOE) contract, but recently switched to a Cost Plus Fixed Fee (CPFF) construct. The program office decided to switch strategies because LOE is difficult to measure performance and manage. Additionally, minimal control over deliverables exists. The LOH team actually uses six-month schedule driven releases. The program office maintains a “Capability Candidates” list, which currently contains around 88 requirements, and end users may add to anytime. Every six months, the Program Office, the contractor, and the end users meet to review the requirements, arrive at a “definition of done” for each requirement, and prioritize everything on the list. Based on previous releases, the program office knows that the contractor can complete two Large, two Medium, and one Small requirement every six months. Thus, the government office decides which task will be in the next six month release, based on size and prioritization, and the development team begins work. The contracting officer issues a letter to the development team, stating that these are the requirements in the next release, and no modification is required. The schedule remains the driving force behind delivery; if one of the requirements is not complete,

the release will occur as scheduled with the four that are completed. This contract is structured such that it provides the same flexibility as a Time and Materials, and the risks are more evenly shared between the contractor and government.

None of the programs interviewed for this paper used a Firm-Fixed Price (FFP) contract; however, the program managers did offer insight into the viability of this approach. The traditional FFP model with fixed scope is not a good fit given the evolving nature of requirements in an Agile process. One approach that might be conducive to FFP is a very short Agile contract, with regards to time. For example, a program office could solicit proposals for a six month to one year, or enough time for one software release effort that focuses on a very small set of user stories within the Product Backlog. The PMO would need to ensure that the user stories selected were specific enough, even down to the feature level, to allow for the contractors to provide a reliable estimate. This strategy would hinge upon the contracting officer's ability to award the short contracts relatively quickly given the timeframe of each contract. According to a 2009 Standish Group report, small projects have a higher probability of success, stating "software projects with labor costs less than \$750K have a 71% probability of success, those costing between \$750K to \$3M only have a 19% chance of success, and for projects over \$10M, success rapidly falls to an abysmal 2%"(Northern, Mayfield, Benito, & Casagni, 2010). The rationale above can be applied to all of the contracting strategies mentioned. Rather than awarding large, multi-year contracts, the software development community should shift to more frequent awards of smaller efforts.

One final topic deals with how to evaluate contractors submitting proposals under this new process. A necessary factor mentioned by programs using Agile today is the contractor's prior experience with Agile processes. As discussed earlier, in order for Agile to be effective it must be understood and executed effectively. Every Agile methodology is accompanied by various documentation that is used to track progress. In Scrum, for example, teams typically use a product backlog, sprint backlog, and a burndown chart as a minimum. If a contractor is proposing an Agile methodology, it would be beneficial for the government to request documents like those listed above to ensure the contractor is experienced in the methodology they are proposing. Another benefit of Agile methodologies are associated metrics that are produced. Generally speaking, all of the user stories receive a relative size estimate, and development teams have a velocity, or speed at which they accomplish the work. Although velocities are subject to change seeing as each project is different, the contractor could provide metrics from an analogous workload for comparison. Government PMOs could require an oral evaluation during which a contractor actually completes their first sprint, set at a week, based on the information provided in their proposal. After the completion of the first sprint, teams would show their results to the PMO, and present the supporting agile methodology documentation.

This would allow the PM insight into the development team's understanding of the requirements, while illustrating the team's knowledge of the Agile methodology being proposed.

Contracting for Agile is inherently different than contracting for a traditional waterfall project. It is imperative that contracting officers be aware of Agile's common misconceptions, understand the options that exist for Agile contracting, and know the options for evaluation. The key to an Agile contract is providing the flexibility that Agile needs to be effective. As the examples above illustrate, there is no one right contracting strategy, but rather the path chosen is dependent upon each specific situation. Further research is needed in this area, and best practices should be compiled within the acquisitions community to serve as a model for other programs to emulate.

Summary & Recommendations

Full-scale Agile adoption requires the Air Force to focus on providing training and coaches/mentors to the entire program management office, update business processes to only necessitate documentation that is actually needed and provide contracting guidance that ensures the contract strategy provides the flexibility Agile requires. In the short term, training can be achieved through commercial institutions such as PMI. In the long term, DAU should focus on developing Agile courseware, resident courses, and potentially a master's-level curriculum that all cater to the unique environment of Air Force programs. Agile coaches and mentors should be provided for individual programs, given the uniqueness of each program and the multitude of Agile methodologies, to deliver tailored recommendations. The Air Force needs to provide a business process that supports Agile principles, one that values the working product over comprehensive documentation. Guidance could be provided to offer program offices a documentation model to follow and build on as needed, as opposed to every program office individually tailoring the traditional documentation model to fit their specific needs. The final recommendation is to offer contracting guidance to ensure Agile contracts are provided the flexibility that Agile requires to be successful. The Air Force should also begin to gather Agile success stories to share with the larger acquisitions community. Although each program is unique, these successes could offer templates, as well as contracting language and metrics, among other lessons learned, that could ease the transition for other programs, or serve as best practices. In this fiscally constrained environment, the Air Force does not have the time nor the resources for every program to reinvent the wheel for how to implement Agile.

The changes elucidated in this paper will require significant buy-in from senior leadership, the acquisition community, and the end-user community. Senior leadership should be pushing their program managers to adopt Agile strategies over the traditional methodology given the numerous benefits elaborated upon above. A culture change that focuses on delivering

functional capability within months is absolutely critical. Numerous reports and failures of programs illustrate that the current waterfall methodology is antiquated and is unable to meet the demands of a changing threat environment. The recent updates to the DoDI 5000.02 are a positive step in the right direction, but embodying the Agile principles is more than just incremental development; Agile is undoubtedly the acquisitions process for the future. Programs within the DoD are implementing Agile methodologies and realizing success relative to the old processes. The Air Force must change Agile from the exception to the norm for software development programs. Full-scale adoption of Agile processes requires implementation in training, business process re-engineering, and contracting guidance. As suggested by MITRE, partial implementation will not lead to successful results. Agile implemented correctly has the ability to deliver the most needed functional capability on budget and on schedule. The reality is that today's warfighter requires a functional solution that meets 75% of the requirements within months; the current acquisitions process does not meet this need. Agile offers a process that can accomplish this feat and has already demonstrated success in both the private and public sectors (Lapham, et al., 2011). Implementing Agile into the culture of Air Force acquisitions will help propel the Air Force into the future, ensuring innovation and flexibility as we move further into the twenty-first century.

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