U.S. Air Force Agile Development Methodology for Addressing Future Air Operations Capabilities

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ABSTRACT

A single cohesive collection of capability is required to present air power operations within the USAF and joint community. The Air, Space and Cyber Constructive Environment (ASCCE) represents air, space, cyber and intelligence, surveillance and reconnaissance (ISR) capabilities during joint battle staff training and experimentation. The Air Force Modeling and Simulation Toolkit (AFMSTT) primarily portrays detailed air operations and is a key component of the ASCCE. The Air Force must modernize or replace AFMSTT to address the multiple training challenges of the future which includes the emergence of 5th generation capabilities, Multi Domain Command and Control (MDC2) employment in joint environments, and reduction of the exercise footprint or Human in the Loop (HITL) and the integration of Live, Virtual and Constructive simulation into blended training environments. ASCCE is the USAF-endorsed air component of multiple joint service training environments such as Joint Live Virtual and Constructive Confederation (JLVC), Joint Land Component Constructive Training Capability (JLCCTC) and the Battle Lab Collaborative Simulation Environment (BLCSE). Integration into these environments requires continuous sustainment, testing and coordination activities that must be considered in the modernization approach. There are emerging approaches to this continuous cycle of modernization such as the activities of the Kessel Run facility that require further examination. Kessel Run Experimentation Laboratory (KREL) provides an agile approach to development and is specifically addressing efforts such as the modernization of Air Operation Center components. There are preliminary successes and lessons learned from this approach. This paper will provide a proposed methodology to take advantage of agile software development activities and address the migration to a future simulation capability into a modular, open system architecture that reduces sustainment and HITL through artificial intelligence. Addressing future synthetic training requirements based on warfighter execution of employment strategies is critical to warfighters readiness for real world operations.

ABOUT THE AUTHOR

Dr. Lillian Campbell-Wynn currently serves as a Modeling and Simulation Technology advisor to the Air Force Agency for Modeling and Simulation (AFAMS). In this role, she coordinates with Air Force MAJCOMs to capture training requirements for modeling and simulation capabilities. She collaborates with other services, industry and academia in identifying potential technological solutions, policy creation or implementations that may address the issues or challenges. Prior assignments include Simulation Training and Instrumentation Command, now Program Executive Office Simulation Training and Instrumentation as a Chief Information Officer (CIO), Deputy CIO, and Information Technology Program Manager. Special assignments include working as a Program Analyst at Army Material Command, Army Modeling and Simulation Office, International Defense Cooperation Office, American Embassy, Paris France and Information System Command. Dr. Campbell-Wynn has served as the USAF lead to the AF Mentor Protégé' program influencing the teaming of small and large business for contracts in modeling and simulation. Education includes a Bachelor of Business Administration, Texas A&M, Masters of Business Administration, Florida Institute of Technology. Masters of Science in Information Resources Management, Syracuse University, Masters and Doctorate of Modeling and Simulation, Industrial Engineering, University of Central Florida, National Defense University, CIO certification.

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BACKGROUND

The use of traditional software development and acquisitions approaches are sometimes difficult in keeping pace with changes in operational concepts or advances in technology. The Department of Defense (DoD) requires a rapid method of acquiring new capabilities to meet our emerging warfighting needs. Our current decision support systems such as the Programming Planning Budget and Execution System (PPBES) and Joint Capability Integrated Development System (JCIDS) are not always perfect for meeting the required rapid requirements. These approaches work best when there is certainty and stability and we can measure and value outputs, not just outcomes.

The Air Force Life Cycle Management Center (AFLCMC) Air Operations Program Office was asked to determine how to bring agile software development and Development Operations (DevOPs) to scale within the DoD through the problem set of modernizing the Air Operations Center (AOC), critical to real world operations and training.

The Air Operations Center (AOC) is the Air Component Commander's Central Command and Control (C2) node that provides the capability to plan, direct, and assess the activities of assigned and attached forces. It provides the capability to plan, direct, and assess the activities of assigned and attached forces. The AOC as a weapon system is not just Air Force, but joint. The joint force headquarter for the operational branch , the senior Air Force headquarters for the administrative branch lateral headquarters, other joint force components, subordinated assigned and attached Air Force units and other functional and geographic AOCs are necessary. According to documentation from the Curtis E. Lemay Center for Doctrine Development and Education (Annex 3-30 Command and Control) an AOC, along with the subordinated C2 elements are tailored and are capable of accomplishing the following tasks:

- Develop component strategy and requisite planning products
- Task, execute, and assess day to day component operations
- Plan and execute intelligence, surveillance, and reconnaissance tasks appropriate to assigned missions
- Conduct operational level assessment

Products that are used to support the functions of an AOC are provided by the Weapons System baseline managed by AFLCMC for real world operations and training exercises. The simulations such as AFMSTT components used in training stimulate systems such as the Theater Battle Management Core System within the AOC. In August 2017, the Service Acquisition Executive (SAE) initiated the AOC Pathfinder as a portfolio of agile development efforts to prove the scalability of agile methodologies within the Air Force and modernize the AOC. The AOC Weapon Systems Program Management Office partnered with the Targeting and Geospatial Intel (GEOINT) Program office since many of their products and applications are integrated into the AOC to form the Kessel Run Experimentation Lab (KREL). KREL directly supports the Air Force Material Command, Detachment 12. What started out as a very small team of six people is now a formally established organization with approximately five hundred billets across three locations. Constant collaboration occurred between these two program offices to tackle their efforts of modernization together. Their vision is to revolutionize the way the Air Force builds and delivers software. Their mission is to continuously delivery war-winning software that their Airmen love through early and continuous involvement in design and development (Sanders, 2018).

The Air Force Agency for Modeling and Simulation (AFAMS) embarked on a mission to learn as much as possible regarding the activities, processes, successes and lessons learned from the Kessel Run team. As the lead agent for the Air Space and Cyber Constructive Environment (ASCCE), AFAMS is focused on meeting the requirements of its customer with the appropriate modeling and simulation products to support training, mission rehearsal and experimentation. Based on the interface with the various Major Commands (MAJCOMS) and their associated distributed simulation centers supporting training events and experimentations, AFAMS participated in site visits and discussions with the Kessel Run team to determine how their agile development approach to AOC modernization can in turn support the modernization of legacy simulation capabilities for air operations and command and control. The findings, lessons learned and recommendations are reported.

METHODOLOGY

AFLCMC hypothesized that executing a Lean Agile software approach, execution of a DevOps IT culture, and Lean Startup entrepreneurial management methods/culture that are collectively optimized will produce valuable outcomes and accountability in conditions of extreme uncertainty (Reis, 2011). The initial goal was to craft a new methodology using agile DevOPs within the DoD. They used innovative contracting techniques such as Other Transaction Authority (OTAs) to obtain the contracting to enable the government team to establish the right DevOps culture, establish a DevOPs Information Technology (IT) architecture and then develop the methodology of agile development. AFLCMC is using the Air Operations Center (AOC) Pathfinder, AOC Program Management Office (PMO), Defense Digital Service (DDS) and the Defense Innovation Unit Experimental (DIUX) partnership to prove these methods of Lean Agile development can achieve valuable software release faster, higher quality, greater security and reduced risk. The contractor development teams are led by government leads. They ask their customers to identify the work that offered the highest value and this determined the prioritization of the tasks for the designers and engineers with the design always centered on the user. From multiple meetings with the users, the production managers gain more understanding in discovery and framing of the requirements.

Kessel Run Experimentation Laboratory Goals

The team's goals are outlined below:

- Fix outmoded architecture; establish private cloud-native infrastructure and Platform as a Service (PaaS) which includes development, test and production instances in multiple domains.
- Fix our broken culture: Pivotal labs engagement to learn by doing, lean startup, design thinking/User Experience (UX), and extreme Programming (XP)
- Employ lean Startup entrepreneurial methodologies; optimized for successes and accountability in conditions of extreme uncertainty.

The Kessel Run team was determined to move from the old waterfall approach to requirements determination and software development. Figure 1 represents the waterfall acquisition approach to development, whereby the focus is on gaining the majority of the requirements up front before true design, development test, evaluation and delivery of a product occurs. It is linear. As all deliverables are based upon documented requirements, a customer may not see what will be delivered until it's almost finished (Lotus, 2018). Due to the time it takes to deliver software, there is the possibility that the technology may not meet customer expectations and technology can become obsolete. After delivery, changes may be difficult and costly to implement (See Figure 1).

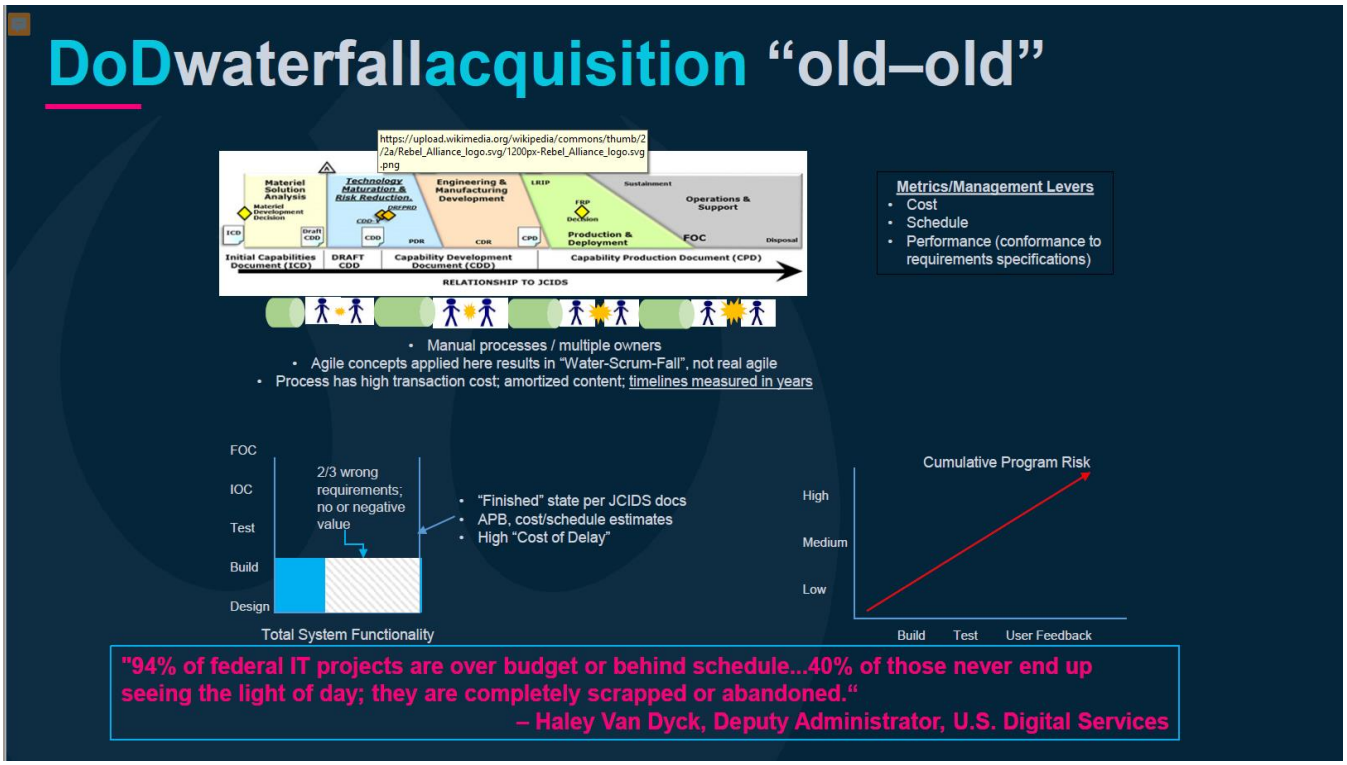

Figure 1. DoD Waterfall Acquisition Approach

WHY AGILE DEVELOPMENT

Many would ask the questions as to why would we tackle agile development. Agile is an iterative, team-based approach to development. This approach emphasizes the rapid delivery of an application in complete functional components (Lotz, 2018). Industry data documented to support waterfall software development indicates that 67% were wrong requirements for replacing legacy systems (Humble, et al, 2015). 90% were wrong for net-new capabilities (Humble, et al, 2015). The traditional acquisition models are only successful one third of the time and the other two thirds of what we build wastes time, is not used or may create negative value, and frustrates our users. Sometimes users don't know what they want and neither do the developers; collaborative experimentation, continuous feedback from end users and rapid iteration builds good software. This is accomplished with frequent user working group meetings and more specification on the requirements. Many government agencies still use the traditional waterfall methodology.

Agile development can deliver very narrow slices of total system utility and actually solve the user's biggest problems and get the most use. It can build out the rest in a prioritized fashion. Agile development solves the most pressing needs and provides the most useful capability before a waterfall development could even get out of the requirements process. Iterative feedback provides all parties insight to when "enough is enough" (Sanders, 2018). Figure 2 represents a new way of doing business within DoD and will allow our warfighters to receive products in a more timely fashion (See Figure 2).

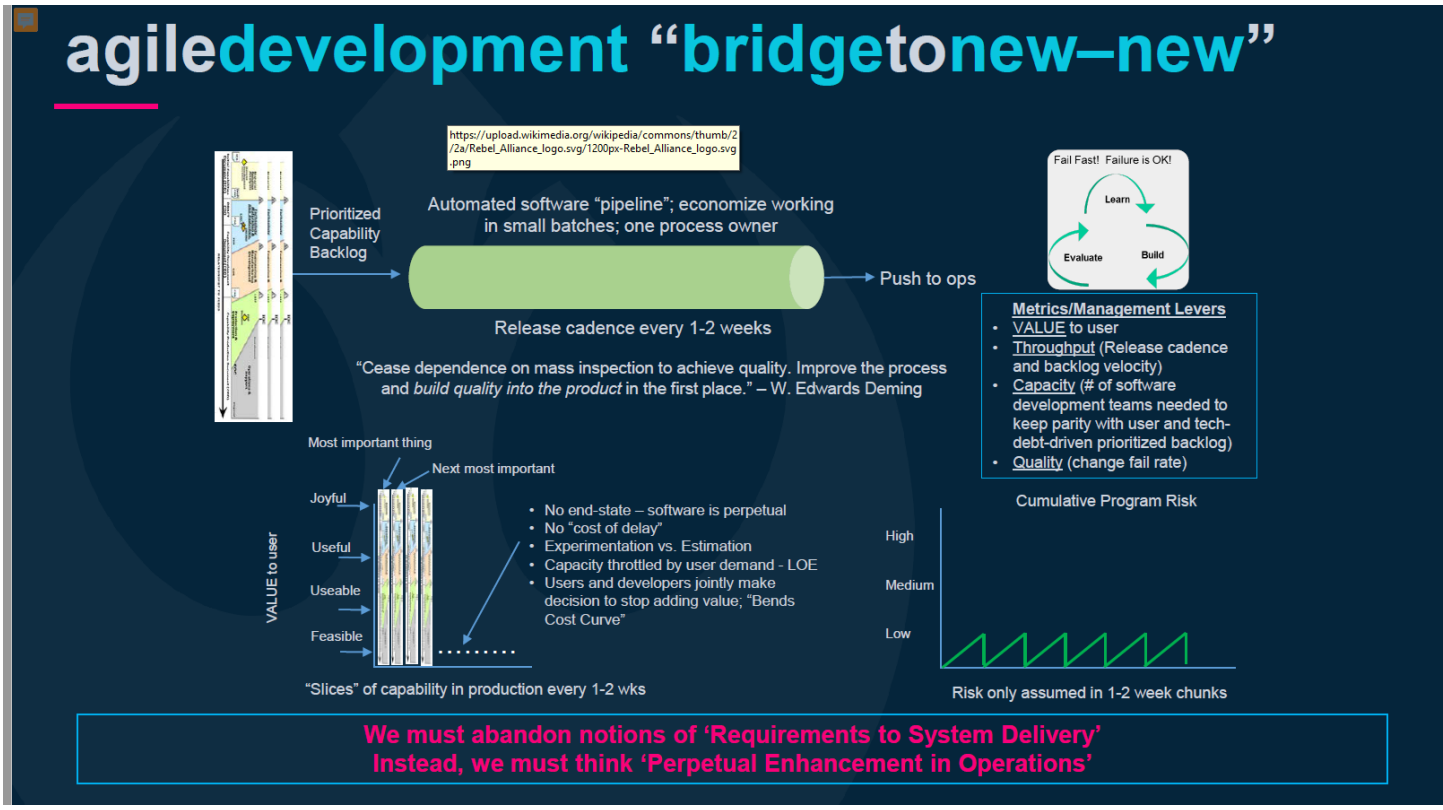

Figure 2. Agile Development: Bridge to New

Figures 3 and 4 represent the Kessel Run's team approach to continuous integration to produce the continuous delivery of products. Continuous integration is a process that ensures that software is always in a buildable sate. Concourse is the continuous integration system utilized within Kessel Run. It is installed within Amazon Web Services (AWS) GovCloud and is owned and managed by the Kessel Run team (Altizer 2018). According to Altizer, it provides benefits in that tests, security scans, code quality, standards and software packaging are s automated. This system provides the core capability to reliably reproduce all versions of a specific piece of software. Kessel Run's biggest hurdle was to implement an architecture to enable the development and delivery of software. The focus was on delivery of a safe, secure and repeatable architecture; the essence of continuous delivery (See Figure 3). The emphasis was on phased software development based on the priority of the customers. There are tight controls on testing code before release to control quality. The code did not go to the next phase if there was any failure in test. Cybersecurity requirements of the software was considered and implemented throughout the process.

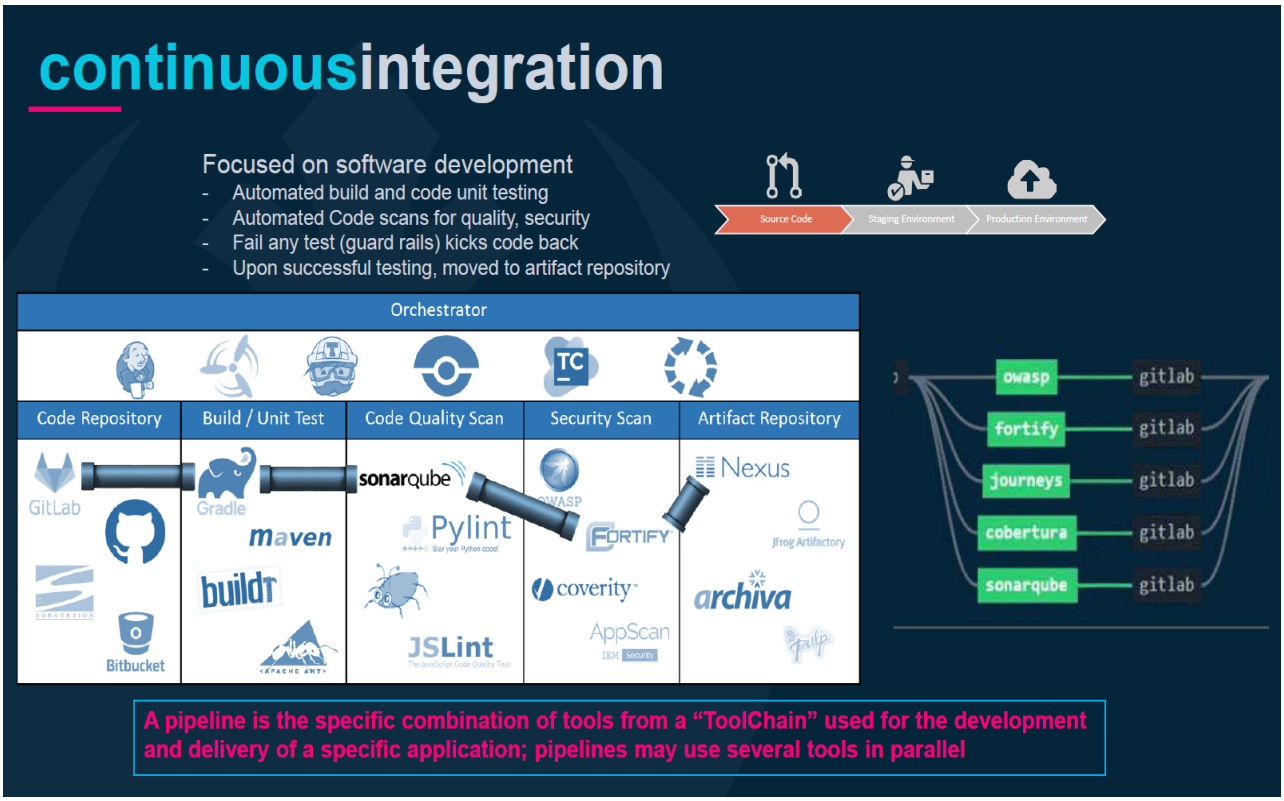

Figure 3. Continuous Integration

Continuous delivery is the ability to get new features, configuration changes and bug and vulnerability fixes into the hands of users, safely, quickly and in a sustainable way (Altizer, 2018). When there is an expectation to enable continuous delivery from idea to production, there are guardrails and common practices that are established. The Kessel Run team implemented the tight controls on the actual deployment or release of software. Automation and standard procedures are implanted throughout the development test process to ensure success. Failures of any component, kicks the code back and the process starts over again. If issues were not identified, software is moved to a repository and the staging environment to address the deployment or release phase (See Figure 4).

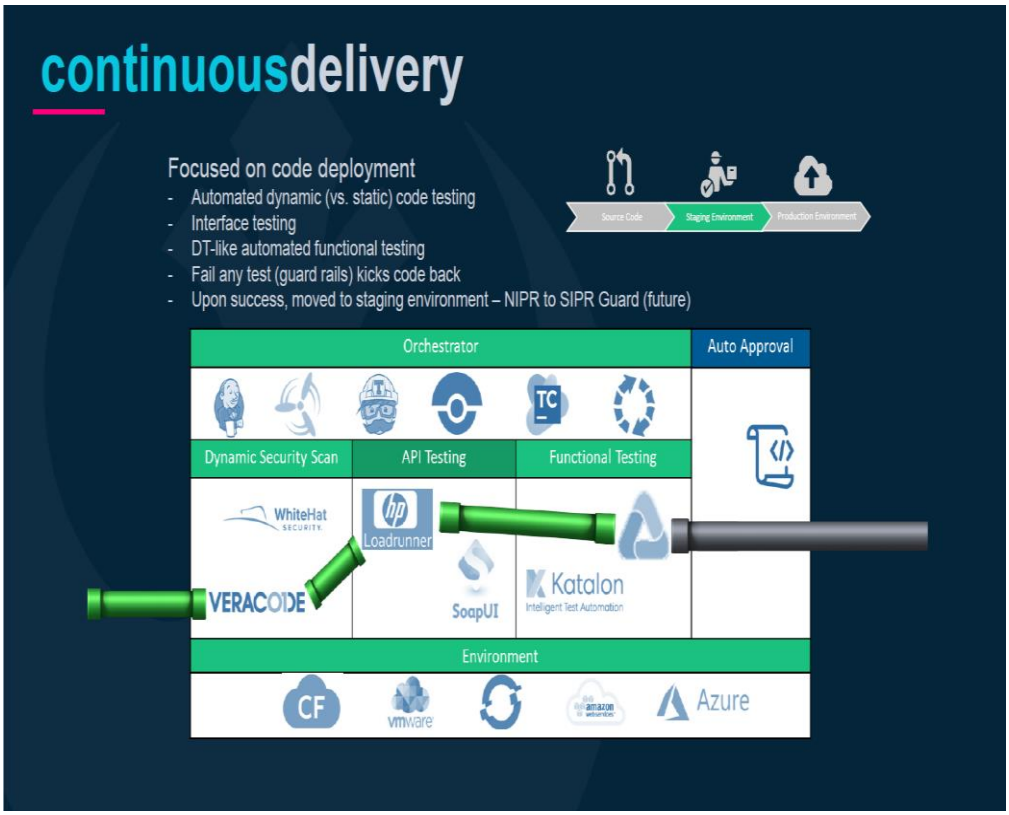

Figure 4. Continuous Delivery

APPROACH TO CONTRACTING

The Kessel Run Team takes advantage of innovation in contracting. They recommend smarter, leaner, cleaner and more concise documentation. They utilize the contracting offices to dominate the regulatory gray area and owned the narrative. Where appropriate, management does not recommend long source selections. They never crossed the line, but were able to obtain the services that were needed. On a larger scale they pursued Federal Acquisition Regulation (FAR) Part 16 types of contracts and the best of class in Indefinite Delivery, Indefinite Quantity (IDIQ) Contracts. IDIQ contracts provide for an indefinite quantity of services for a fixed time. They are often used when the government can't determine, above a specified minimum, the precise quantities of supplies or services that the government will require during the contract period (General Service Administration, 2019). IDIQs help streamline the contract process and speed service delivery. IDIQ contracts are most often used for service contracts and architect-engineering services.

The establishment of the Kessel Run Experimentation Lab was completed by a small business development program which was instrumentation in providing the software environment and management services. The 8(a) program is a small, business, socioeconomic authority that allows you to reach out to the contract and sole source in some cases with a small business under the 8 (a) program through Small Business Administration (SBA, 2019).

The use of Schedule 70 based Blanket Purchase Agreement (BPA) was researched. Schedule 70 is a long-term contract issued by the U.S. General Services Administration (GSA) to a commercial technology vendor. An award of a Schedule 70 contract signifies that the GSA has determined that the vendor's pricing is fair and reasonable and the vendor is in compliance with all applicable laws and regulations (GSA, 2019).

The intent is the use the best of breed contracts and have the room to scale on the software development and cloud engineering. Using what is available in the FAR in new and creative ways and exploring what others are doing assisted the Kessel Rum team immensely.

APPROACH TO CYBERSECURITY – RISK MANAGEMENT FRAMEWORK

The Kessel Run program provided the opportunity to demonstrate the successful application of Cybersecurity processes in an agile development environment. AFLCMC assembled the appropriate team of professional to address the cybersecurity challenges and Risk Management Framework (RMF) requirements to field products on DoD networks. Security is top priority and is achieved by maintaining a secure bassline of capabilities, processes and environments that are improving continuously by monitoring key metrics and behaviors, without building unnecessary roadblocks for users (Altizer, 2018). They partnered with Cybersecurity experts consisting of government and civilian security leads as well as industry partners to define the imagined security model for developing and operating applications and platforms to keep pace with modern software delivery needs. The objectives were to ensure the Risk Management Framework credentials such as Authority to Operate or Connect to DoD networks would not be an issue. Highly qualified Cybersecurity professionals with industry leading certifications work closely together as an assessment and accreditation team to continuously improve the organization' s security posture (Altizer, 2018). The Subject Matter Experts (SMEs) worked closely as an assessment and accreditation team to continuously improve the products' security posture. KREL is successful in managing risk early by building security into the DevOPs process which includes several factors as noted by Altizer:

- Incorporating test driven development with user centered design and testing to meet the intent of development and operational tests traditionally before a fielding event of a major system in the DoD.
- Inheriting security controls from an accredited infrastructure and platform instead of accrediting entire systems from the ground up delivery, which breaks the continuously delivery cycle.
- Adopting code and scripts as valid, working documentation instead of unnecessary documents that easily become outdate and prone to error.

Security requirements are planned for early in the design and development processes. They accomplished this by assessing applications, platforms, and infrastructure and providing actual feedback to the Kessel Run product development and platform operation teams. The application assessors have complete access to every document, scan and codebase for all of the applications. The Kessel Run team maintained open communication channels across the board to help facilitate software development lifecycle. Organizations with high delivery performance tend to spend significantly less time remediating security issues (Atlizer, 2018). Currently, their process to obtain the continuous Authority to Operate is approved by the Secretary of the Air Force Chief Information Officer (SAF/CIO).

APPROACH TO METRICS

The Kessel Run Experimentation Lab team is working to automate best practices and lessons learned on the delivery of software. Annually, a "State of DevOps Report" is published by the DevOPs Research and Assessment (DORA) and Puppet Inc. In 2017, the report identified four metrics that if taken together are predictors of high performance in software delivery. They are defined as follows (Kersten 2017):

- Lead Time is identified as the time it takes from code to commit to production successfully.
- Deployment and Frequency is defined as the frequency of software deployment to production.
- Mean Time to restore is defined as the amount of time it takes to fix or correct an outage of software.
- Change Failure Rate is defined as the percentage of change made to an application or platform once pushed out.

The first two metrics measure tempo, while the last two measure stability or quality. Combined they have proven statistically to show not only correlation but causation as a differentiator between high performance and low performance software organizations (Kersten 2017). Kessel Runs is working to adopt and automate these metric as they continue to deliver the software. The information provided from the metrics will serve as a mechanism for improvement.

SUCCESSES

The Kessel Run team was successful in creating an auditable targeting capability and produced products for the 609th AOC in Al Udeid. They have an accredited integration/continuous delivery pipeline that allows the government to iterate on a daily or weekly basis as decided by the priority of their user base.
Through the use of the Air Operations Center (AOC) Pathfinder, AOC Program Management Office (PMO), Defense Digital Service (DDS) and the Defense Innovation Unit Experimental (DIUX) partnership, the team proved methods of Lean Agile development can achieve valuable software release faster, higher quality, greater security and reduced risk. The team has experienced successes such as the following:

- Contract awards within 60 days
- Deployment of unclassified products
- Off premises DevOps environment in 60 days
- Fielding of SIPR network cloud-native DevOps platforms
- First DoD organization to achieve continuous delivery
- First DoD organization to achieve continuous authority to operate due to automation security controls
- Five applications from concept through unclassified development and into operations on SIPR network in an average of 124 days.

The Kessel Run team as well as the product portfolio list have expanded since its inception. Initial applications have saved over $6.4M and 1,100 man-hours of previously manual and error-prone effort per month in 609th Combined Air Operations Center (CAOC), Al Udeid Air Base (Sanders, May 2018). The team is working to expand and deliver capabilities across the AOC enterprise in multiple locations.

LESSONS LEARNED

According to Lt Col Jeremiah Sanders, the Air Operations Center Weapon Systems program manager, of AFLCMC, there are several lessons learned from their work. They have validated that valuable software can be achieved, released faster, with high quality, better security and reduced risk (Sanders, 2018).

Leaned startup entrepreneurial management methodologies and culture are optimized for success and accountability in conditions of extreme uncertainty. This is a huge opportunity to champion a better way of meeting warfighting needs. Culture and talent management are their biggest challenges to reaching desired digital transformation. Our knowledge of traditional technologies, development methodologies and Taylor-inspired industrial/general management systems in some cases may be a liability (Sanders, 2018). Achieving continuous delivery is the first big step; without it agile has not manifested. Establishing metrics and implementation takes time. Innovative contracting techniques are a must. It is recommended to reject all in one contracts where it is appropriate.

The program office learned that digital transformation will take time. It is not easy to implement the fundamental technology and architecture shift that are required. There is also no easy button to push for culture and organization function changes that are necessary (Sanders, 2018).

Through their research they determined the following:

- Development Operations results (2016 state of Industry)
    - Meets mission faster – 200X faster change frequency (lead Time) from code to commit production
    - More reliable 60X fewer failures, 24X fasters recovery
    - Better software – 3 X lower change failure rate, 4X faster bug fixes
    - Most cost effective – overall development costs reduces approximately 40%, costs per program down 78%
    - More innovation – 8X more resources driving innovation vs sustaining legacy
    - Morale –Employees 2.2X more likely to recommend their organization; 1.8X more likely to recommend their team as a great working environment (Humble, et al 2015)

The Kessel Run team's learning in applying the agile development support was influenced by methods used in industry. Agile development methods were used in business successfully when used to put out products when not all requirements and outcomes were certain (Ries, 2011).

USE CASE FOR AIR FORCE MODELING AND SIMULATION TRAINING TOOLKIT (AFMSTT) MODERNIZATION

The Air Force Material Command, Detachment 12 is also responsible for the delivery of AFMSTT and meeting the modernization challenge of this capability. AFMSTT is the air operations capability that supports the Air Operations Center in a variety of battlestaff training exercises and experimentation. It integrates with other service capabilities within federations such as the JLVC managed by Joint Staff J7 and the JLCCTC. The Air Warfare Simulation (AWSIM) is the core component of the AFMSTT with other capabilities such as the Command and Control Simulation Interface (CSI), Air Base Sim (ABSIM), Scenario Generation Capability, Graphical Input Aggregate Controller (GIAC), AWSIM Analysis Toolkit (AAT) are all supporting tools. AWSIM is the most legacy component and the approach to providing a major overhaul while still supporting the multiple MAJCOMS and customers that are dependent on this capability for critical warfighter capabilities to increase readiness must be considered.

There is a large user base for this capability and we must think out of the box to address user concerns of providing an intuitive product that is easy to use, models and simulates accurately, addresses emerging requirements of 5th generation capabilities, and reduces the amount of user footprint. The program manager must address the sustainment of millions of lines of old code, multiple point to point connections, and costs of securing talent to perform the expert work. We believe agile development approaches can be applied and successes realized. All the major components of continuous integration and delivery based on multiple user requirements are key to successes. A single cohesive operational baseline is critical.

RECOMMENDATIONS

The same approach of modernizing the AOC baseline may be applied to the AFMSTT modernization or other DoD efforts. The AFMSTT as it exists today will be replaced by the Command and Control Simulation Enterprise Training Tool (C2SET) to address modernization and the inclusion of new capabilities. The future C2SET will have to integrate seamlessly into the overall Air Force Live, Virtual and Constructive environments as required. It may set the standard for constructive simulations. A total assessment of the AFMSTT current capability must be accomplished. Some of the biggest concerns with using the legacy AFMSTT are the amount of resources required to run the models and the aging skilled workforce. Modernization should eliminate Human in the Loop (HITL) and streamline processes, but this can be achieved by user engagement and documentation. Conducting user focused sessions across the MAJCOMS and joint community to clearly understand methods, procedures and processes will be beneficial. It will also aid in the articulation of the new requirements and to determine high value and user prioritization. The application of the agile development is recommended.

The systems program office, must complete an 804 Middle Tier of Acquisition, the Rapid Prototyping Plan and gain approval from the acquisition executive. Modernization or replacement of legacy components should be incremental. To address multiple modernization issues, it is recommended to start small and scale. An iterative process is recommended to develop increments, allow user to assess, update based on feedback from the customers and then field new components. Since AFMSTT is a currently fielded system, it is recommended that the least controversial or contentious modification to all the users be considered. One might consider what issue provides the biggest heart burn for the users and tackle this one first. One might also consider the modification that will be considered the highest value to the community.

It is equally important to identify a location where deliveries of capability are tested and evaluated by a small section of the user base before the products are fielded. Even though there are multiple users and sites for AFMSTT, a designated simulation center with a user force to test, evaluate and provide feedback before software is released is recommended. Release of the product to a centralized server can offer many benefits to making the applications available to the cloud and ease of updates or maintenance. To streamline the information technology, Modular Open System Architecture (MOSA) with common services on the cloud should be considered. Users may access as needed from their locations. The future capability will have to integrate with various federation environments, not owned or controlled by the Air Force. Since this could delay delivery of new Air Force capabilities, strategies for test, and

integration and deployment with other federation owners must be explored. Considerations as to how Air Force capabilities are presented singularly to multiple federations without the need for various configurations must be examined.

The program office should consider innovative contracting strategies and other transactional authorities to assemble the innovative team and infrastructure that is required to build the new system capabilities. The program office will have to consider the need to sustain the existing system as they modernize and deliver new components. It is important to reduce the amount of work that is required on the legacy system and this contract may be kept separate from the modernization contracts. It is important to note that some activities will still how to occur to support existing training exercises, mission rehearsal, experimentation and the integration to other command and control systems and joint service capabilities.

Availability of funding as always must be considered. The funding for maintenance should be kept separate from the funding for modernization. It is recommended that the advocate for the user community fight for the resources that are needed to modernize focusing on the value to the warfighter and future reduction of sustainment costs.

The program office must consider the culture of the user workforce throughout the modernization phases. There will be reluctance for some users to move from the old to the new as some may even experience job security issues. An emphasis should be placed on the value of the new system, the value input that users will have in shaping the future system and the opportunities it will provide. When addressing new automation techniques and modernization, stress to the user force how the enhanced capabilities will contribute to the overall effectiveness and productivity without threats to job security

Taking full advantage of the KREL lessons learned is critical. Innovative techniques were used that allowed the program office to obtain the necessary talent to complete major milestones. The use of metrics and the technique for cybersecurity authorization to operate may be exploited.

CONCLUSION

The Air Force Agency for Modeling and Simulation had the opportunity to visit the Kessel Run facility in October of 2018 and May 2019. During the visits, we were able to receive detailed information from the Kessel Run team on their approaches to agile development and the experience with the Air Combat Command (ACC), a customer of the AOC products that are fielded. Success is realized. Their innovative approaches may serve as a template for other organizations that are struggling with creating new products or modernization of existing capabilities that are delayed due to traditional software development approaches.

Based on industry and government reporting, agile development is a way to meet customer needs more rapidly. Since AFAMS and AFLCMC/HB are responsible for the modernization of legacy modeling and simulation capabilities, and the incorporation of new capabilities in support of the AOC, the approach to agile software development of Kessel Run Experimentation Lab is recommended for future efforts.

ACKNOWLEDGEMENTS

We recognize the input and insight from AFLCMC AOC Program Office as well as the staff of the Kessel Run Experimentation Lab in Boston, Massachusetts. We also recognize support and leadership from Lt Col Jerold Scott, Dyke, USAF, Chief, and AOC Modernization Branch Air Combat Command. The contributions of the employees of the Air Force Agency for Modeling and Simulation are certainly recognized.

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