Innovation Is Ugly: Managing Change in Operational Training Environments

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ABSTRACT

Innovation is the buzzword of the day. Innovation conjures images of bright new ideas and sleek technology. In most cases, though, innovation is ugly. Innovation results in a minimum viable product (MVP) held together with duct tape and baling wire. It does not work consistently and certainly does not scale. However, innovative ideas do not have to live in skunkworks labs and garages. Properly applied, even the ugliest of innovations serve tangible and valuable purposes in real-world, operational systems. Implementing innovations into operational environments in their "ugly" MVP states almost certainly accelerates their adoption or disposal; the latter is just as valuable as the former. During the past three years, applying these types of innovation resulted in faster training times, reduced instructor to student ratios, and improved student engagement within US Air Force and US Army undergraduate aviation training programs. This paper describes the program management strategies, ranging from stakeholder management, procurement, subcontracting, staffing, and communications, used to incorporate innovative technologies and methodologies into these programs. The paper also discusses insights about sustaining innovation within institutional environments.

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BACKGROUND

Nearly 20 years ago, SAIC began applying commercial entertainment gaming technologies and methodologies to training and education for programs such as America's Army. That work organically led to increased use of extended reality (XR) and, in particular, its use in military aviation training. For the past three years, we supported innovation programs focused on military aviation training for the US Army, Navy, and Air Force, as well as the US Air Force Academy (USAFA). The global pilot shortage, which at its peak left more than 2,000 operational pilot spots unfilled in the USAF alone, created a national security risk that enabled decision-makers to accept the risk that comes with making significant, immediate, and out-of-the-box changes to their training programs.

The USAF Air Education Training Command (AETC) led the charge, seeking revolutionary innovation in an experimental Undergraduate Pilot Training (UPT) program called Pilot Training Next (PTN). PTN used immersive training devices (ITDs) built with commercially-available, virtual reality (VR) gaming technology as the basis of a comprehensive training reboot that graduated 70% of their first-class and 80% of their second class after six months of training, less than half the time required for traditional UPT (Lewis and Livingston, 2018). The US Army Aviation Center of Excellence (USAACE) accepted PTN's hypothesis that VR is a best-value training approach and developed a Design of Experiments (DoE) that aimed to quantify the return on investment (ROI) of using ITDs in lieu of live flight hours. In its first year, the Aviator Training Next (ATN) program graduated more than 200 Initial Entry Rotary Wing (IERW) students while providing valuable training data and consistent training. ATN evidenced this consistency through decreased standard deviations in student's grades as compared to traditional training methods. USAFA conducted ITD-based programs and curriculum with more than 300 JROTC and USAFA cadets to encourage student interest in pilot training. Feedback from the program was overwhelmingly positive, resulting in student pilots who were able to take off and land without instructor intervention during their first flight in the live aircraft.

In each of these cases, the programs achieved significant and rapid changes to the way students trained by taking advantage of small, experimental groups to test their innovative approaches. PTN used a divergent mindset to identify and evaluate a rapid succession of innovative products and processes, some of which the program selected for additional investment. General Electric used a similar methodology to give specific ideas more time and space to prove their worth after they passed through an initial stage of rigorous testing. This "pivot-or-preserve" mindset allowed GE to function more like a start-up. (Govindarajan, 2017). As early as 2002, Defense Secretary Donald Rumsfeld encouraged a culture of risk-taking and entrepreneurship in the Department of Defense (DoD) and the armed forces (Rumsfeld, 2002). His encouragement was valuable because research indicates that high performing organizations employ a top-down focus on innovation that allows them to pioneer innovation in products and processes (Barsh and Capozzi, 2008). Other studies show that entrepreneurial organizations tend to encourage calculated risk-taking and are tolerant of failure (Wood, 2004; Jennings and Lumpkin, 1989). However, nearly two decades later, the Air Force still maintains a culture that rewards risk-taking only if the risk works out (Brees, 2019).

Even though the PTN and ATN programs have successful results to share, the programs each took risks along the way that did not work out and suffered technical, contractual, and procedural setbacks that created doubt about whether innovation deserves a place in institutional training environments. At times, these seemingly minor setbacks created doubt about the overall value of the program and its supporting teams.

At the same time, PTN's first visit from the AETC commander, Lt Gen Steve Kwast, resulted in high praise for the sheets of cardboard duct-taped to the ceiling to prevent infrared (IR) interference (Figure 1) and for the ITD not starting up the first time he tried to log in. Kwast motivated the team, saying that innovation is ugly – that if it looked good or worked right every time, we weren't pushing hard enough.

With this type of conflicting culture and guidance, how should a program manager proceed when supporting DoD programs focused on innovation? This paper discusses the day-to-day strategies and procedures that helped us move fast and stay compliant, specifically with regard to stakeholder management, procurement, subcontracting, staffing, and communications. This paper also discusses insights for sustaining innovation within institutional environments, a concept not often considered at the beginning of an "innovation journey."

Figure 1. PTN used cardboard and duct tape to prevent IR interference from multiple VR headsets

INNOVATION IN ACTION

From the beginning, the PTN program presented a problem statement (the pilot shortage), a hypothesis statement (emerging game technologies accelerate learning at the individual and institutional level), and the freedom to explore options – even if that freedom did not end in success. These ingredients created a recipe ripe for an Agile project management approach. This approach provides structure to fast-paced, innovative programs. It also allows the team to "fail fast" by giving a specific amount of time, known as a sprint, for the team to try out ideas and technologies that might otherwise introduce unacceptable risk. Rather than summarize the terminology, benefits, and risks of Agile project management, which many publications such as the Agile Manifesto (Beck, 2001) document, this section discusses our adapted implementation of Agile, including what worked and what we learned.

Stakeholder Management & The Holy Grail

In an Agile methodology, the Product Owner owns the vision for the solution to the stated problem while the Team owns how they approach the solution (Sliger, 2011). The vision and approach, however, is naturally impeded by constraints known to the Product Owner and the Team. For example, Product Owners who are operational SMEs can articulate problems; however, their very intimacy with the operational environment can spoil creativity in determining a new set of capabilities in a solution. Their knowledge of policy, operational, fiscal, time, political, cultural, and other institutional constraints immediately begins to bound the solution and the definition of done. To avoid this issue, we built a shared understanding of desired capabilities unbounded by time, space, money, and physics. We broke down the elements of training into discrete lines of operation: training content, simulators, grading, instructors, and recruiting. For each line of operation, we understood from the stakeholders how a perfect, unconstrained solution looks. This unconstrained perfect end state, or Holy Grail, gave us intentionally unattainable goals, which oriented disparate groups of users, SMEs, engineers, and managers in the same direction without inhibiting the team's unified understanding due to nuances of operations and engineering.

These Holy Grail statements also provide an orienting objective to help direct complex or broadly-scoped innovation projects. Typically, a given sprint sets the momentum and vector of the successive sprint. We may set out on a

generally "true" direction but go off-vector to capitalize on low hanging fruit or to address critical items not tied to our stated problem (see Figure 2). In past projects, our team observed that over time, we drift significantly from the originally intended vector due to the lure of achieving short-term solutions that are not proximately related to the stated problem.
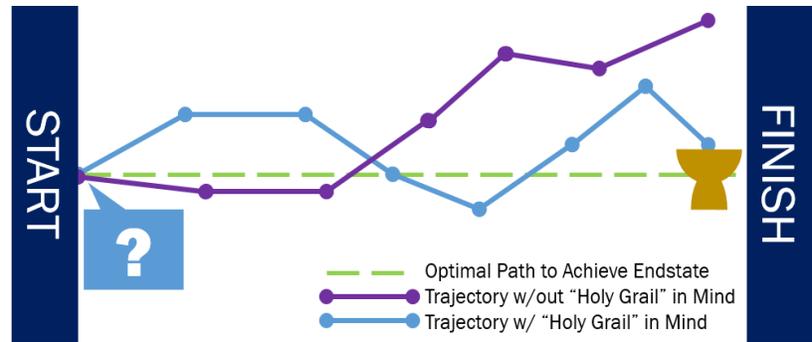
On the contrary, with a defined Holy Grail, we can begin with the end in mind. Because the Holy

Figure 2. PTN used Holy Grail discussions to determine high-level orienting objectives

Grail is intentionally unattainable, it serves as an immutable orienting objective to keep the team on track no matter how wildly successful we are, or how short we may fall, in any given sprint's direction. Engineers can now enumerate the major muscle movements within broad timeframes and then decompose those into work packages and backlog items. Along the way, stakeholders remain confident that engineers are pointed in the right direction but never confuse the Holy Grail with deliverables since it is so wildly unfathomable (for now). For instance, a PTN Holy Grail is to create flight simulations that are indistinguishable from the real aircraft, such that every hour a student spends in VR is equivalent to an hour in flight, to include stress loads, smell, g-forces, and emotions. Another example is to define and quantify all characteristics of a pilot candidate that guarantee he becomes a successful fighter pilot.

Procurement and Subcontracting

Understanding the orienting objective of an innovative project is critical to project success. However, understanding the procurement and subcontracting processes that support the project team is foundational to success as well. While the project teams conducted Holy Grail discussions, the team's deputy program manager (PM) led Rehearsal of Concepts (ROC) drills with functional staff. These ROC drills mapped out the end-to-end processes for delivering contractual products, identifying appropriate time boxes for each step, and the accountable person for each step or process. With these mapped-out processes, the functional staff can adequately decompose complex actions into manageable, sequence-able, and estimate-able tasks for a program management backlog. The deputy PM serves as the product owner to functional staff, where the products are purchase orders, subcontractor agreements, contract modifications, and financial reports. In addition, we established a single POC from the procurement team and the subcontracting team and made them part of our project scrum teams. With a shared understanding of their practices, we can now develop a scrum battle rhythm to suit the project and functional teams' needs.

A risk in executing innovative tasks is a lack of accountability in vendor performance due to a lack of concrete requirements. Involving procurement and subcontractors in, at a minimum, sprint reviews, sprint planning, and financial review sessions allows them to gain and maintain a firm understanding of the problem statement (instead of delivery requirements) and to work with vendors appropriately. In many cases, innovative solutions involve the efforts from start-ups, very small businesses, or commercially oriented businesses equally unfamiliar with DoD contracting practices. In this case, we work with our subcontracting POC to assign a subcontracts administrator who emphasizes consistent communication and dialogue, rather than the passing of contractual artifacts and other documentation. This approach allows our subcontracts administrators and buyers to serve as mentors to these businesses, which allows them to move fast and stay agile, all with a shared understanding of the problem statement in mind.

Integrated Functional Staff

Functional support organizations traditionally focus on internal review and delivery of legal and contractual documentation. Each draft document typically requires three levels of review before delivering a package to a vendor. Then, the team must re-draft and review those documents for any renegotiation—hardly an established framework that is congruent with an Agile philosophy. Part of the mitigation strategy to overcome the existing culture was inclusion. We recognized that functional staff tends to see their products as configuration management codes, version numbers, and purchase order tickets. They do not have an opportunity to witness the innovative impact of the products they support. We now implement a best practice of involving functional staff in technology demonstrations, making them "owners" of the product. Last year, the project staff took a road trip to procurement office headquarters to conduct

a half-day, hands-on demonstration of each of the products we had delivered over the previous six months. This excursion from the daily grind paid dividends due to the buy-in and common understanding gained. As part of this best practice, we also discovered and addressed communications and procedural challenges that often oppose innovation-focused, Agile projects. For example, innovation projects tend to pivot from one idea to another as the team proves or disproves project hypotheses. This tendency creates risk for contractual actions, which tend to proceed through more rigid and extensive processes. For contractual actions to keep pace with developmental changes, the team often labeled every contractual action as a high priority. However, if everything is a high priority, nothing is a high priority. The team overcame this risk through the mutual understanding of project intent, which allowed functional staff to think creatively about how to accelerate procurement and subcontracting actions while staying aligned to intent.

Diversified Technical Staff

Functional staff is just one type of a diverse mix of resources we used to staff our innovative programs. Project teams consist of a variety of subject matter experts, "jack of all trades" technical staff, and junior-level engineers, providing the opportunity to combine existing ideas in individual domains in new and novel ways. Research supports this approach, indicating that both breadth and depth of expertise are required to bring value from innovations (Boh et al, 2014) and that teams that integrate diverse individual expertise tend to perform better (Tiwana and McLean, 2005). However, a more diverse staffing mix can introduce significant communication challenges, as discussed in the Communication section.

Despite the diverse skillsets across the team, we maintained a lean staffing plan to stay agile, flexible, and innovative. In some cases, the team relied on just one or two people with expertise in a particular area, which made the team susceptible to single points of failure. However, the team worked continuously to address these areas of concern, e.g., changing the software technology stack to accommodate the team's current skillset better and creating a deputy system to ensure a trained backup was available for all critical and desired tasks in the program timeline. The team also actively communicated the areas in which they wanted to grow and assigned mentors to guide this growth. Over time, software engineers brought up training and human performance risks, while trainers developed database administration skills. These same growth opportunities also arose on the customer side. The Air Force, in particular, expected instructor pilots to serve as full-time instructors and full-time innovators. This approach resulted in pilots becoming product owners for solutions with which they had limited technical or training expertise. Although this situation could have negative consequences, in our case, it was a favorable situation, forcing the types of clear and open communication that can help teams integrate their expertise as well as growing individuals' understanding and skillsets.

Finally, to support multiple innovation programs simultaneously, we implemented a matrix model for functional staffing. Each program maintained its customer-focused program manager and program lead engineer. At the same time, functional staff supported all programs in focus areas such as training, software development, immersive content, data analysis, and human performance, resulting in synergies and efficiencies. However, functional resource prioritization between programs was a primary concern for the team. While many matrix models rely on pre-defined work shares, e.g., 25% on one task and 75% on another, our goal was to allow team members to flex between programs as program requirements demanded. Each program conducted its sprint planning sessions as defined by their sprint cycles. The team then addressed portfolio-level resource prioritization conflicts and roadblocks at weekly meetings, including the portfolio manager, program managers, program lead engineers, and functional lead engineers. Asking team members to attend multiple project and portfolio level meetings often resulted in expressions of frustration, especially among the lead engineers who had many demanding technical tasks to complete as well. However, when surveyed to assess team communications, team members consistently indicated that the number of meetings was adequate but not burdensome. They also indicated that leadership heard and valued their opinions, even during periods of heavy workload and project stress.

Communication

Our diverse staffing mix introduced significant communication challenges for the team. For example, an information technology (IT) expert and a pilot have two completely different understandings of the acronym IP – internet protocol or instructor pilot. Acronyms are an easily identifiable source of misunderstanding, which we resolved by posting a data dictionary accessible by the entire team that highlights confusing or over-used acronyms and terminology. Other misunderstandings are harder to identify and resolve, including topics as fundamental as what people in other jobs do. A software engineer may not understand the nuance associated with a graphic content developer's job, assuming

taking a photo is as simple as pointing and clicking an iPhone. More importantly, the software engineer may not understand second and third-order effects about the quality of the resultant photo that affects his job. If he does not understand these, he cannot adequately identify or communicate risks and opportunities to his program manager. Although sometimes challenging to implement, an effective way to resolve this type of misunderstanding is analogies. Comparing the tasks to an everyday or straightforward occurrence helps the entire team understand relationships and outcomes. In one particularly useful analogy, we compared pilot training to learning to make a peanut butter and jelly sandwich. Comparing a pilot's underlying knowledge of aerodynamics to knowing in which drawer we keep the knives brought a laugh and helped convey complex instructional design concepts, such as Bloom's Taxonomy.

A diverse staffing mix also makes it more challenging to ensure the entire technical staff understands the big picture of the solution the team is developing. Like an artist who is painting one tile in what will become a mosaic, team members may feel isolated or unsure how their contribution affects the system, especially in large, distributed projects. To resolve this, we used regular all-hands and leadership calls to communicate early and often what the vision, mission, and goals of the program were as well as the technical approach the team was implementing to meet those goals. In each call, the team reviewed the program's mission statement, a technique borrowed from the Army's Battle Update Brief (BUB). This step helps team members remove themselves from in-the-weeds activities to remember what the overall objective is. This step not only ensures that everyone is acting with a good understanding of mission intent, but it also is a significant morale boost. No longer are team members spending the day installing operating system patches; they are helping to revolutionize warfighter training.

In addition to diverse teams, distributed teams require special communication considerations, such as access to reliable telecommunications and secure videoconferencing. The teams supporting PTN, ATN, and USAFA are located in eight different cities across the United States, the result of aggressive program schedules that needed resources at the right time more than in the right place. While the overall team is distributed, several groups of co-located personnel exist in locations such as Huntsville, AL, and Seattle, WA. Managing these co-located personnel in terms of the overall distributed team created additional challenges because co-located personnel tend to have spontaneous conversations that do not involve the rest of the team. These conversations have negative consequences, such as individuals making decisions without group consensus or simply less transparency and understanding in the project. Again, the solution we identified was frequent communication with the entire team. While this leads to more scheduled meetings, we structured these meetings to encourage open and honest feedback; specifically, we asked all participants to keep a running list of issues they might discuss with a close colleague or supervisor in a private setting. Regularly, small groups of team members decided how to phrase these issues for discussion in an open setting. Time and time again, the issues to discuss in private focused on feelings, such as one team member feeling less important than another, while issues reframed for discussion in public focused on facts, such as the team member receiving less time to use a limited resource. Helping the team understand how to frame concerns in a factual manner is especially important when asking the team to use distributed project communication tools, such as Confluence, Slack, or Discord, where their comments are viewable publicly.

SUSTAINING INNOVATION

Sustaining innovation could be considered an oxymoron. Yet, creating a sustainable culture for innovation, as well as sustaining specific innovative products, is the ultimate goal of many organizations. When PTN first started, AETC was actively looking for duct tape and baling wire style innovation. The leaders, instructors, and students of the 2018 class had a good idea of what they were getting into. They were willing to work with the project team through and around technical issues ranging from a broken power button on the simulator to a complex set of interdependencies causing intermittent real-time feedback audio cues. They did this consistently, on a daily or even hourly basis. Their persistence and motivation paid off, with ATEC dubbing the program a success in reimagining flight training (Pons, 2018).

An organization can only maintain that level of persistence for so long, though. During 2019, PTN struggled to maintain a divergent attitude toward innovation, one that encourages many "fail fast" attempts at finding improved solutions, while also stabilizing the environment enough to allow for long-term training and evaluation. A critical factor in balancing these approaches was setting up development, test, and production environments. Getting all the stakeholders to follow the agreed-upon software release plan was a struggle. Differing interests sometimes prevailed over a controlled software test in the development environment, and the release of partially tested software was

detrimental to the confidence in the stabilized environment. Balancing the needs of all the stakeholders while protecting the system proved to be essential in maintaining stability, although it slowed down innovation.

With a stable environment in place (see Figure 3), the team could re-evaluate tools, techniques, and technologies. Revisiting and updating the team's analysis of alternatives on VR headsets kept the system on the latest and best solution. The ITDs initially used the HTC Vive Pro while students use the untethered Oculus Quest to perform aircraft walkaround lessons. The latest round of analysis added more companies and headset capabilities as hardware improves yearly with each new release. Hardware refresh can be done in a controlled fashion evaluating the effects, positive and negative, to the objectives.

Even with a stable environment and robust communications in place, sustaining innovations can still instill frustration in a project because innovation is not a linear process. Innovation can require 10 steps back to get 11 steps forward. PTN's decision to move to a new aircraft model caused the training team to stop and take a few steps back to build content for the new aircraft before

Figure 3. PTN's current classes are sustaining innovation

pushing forward with the fun innovating tasks. This back and forth innovation process complicates the already complex sprint vectoring process, described above, to achieve the Holy Grail. For example, while the team was both developing a MVP for automated maneuver detection and stabilizing the data analysis pipeline, the team addressed a critical need to support the new end of course standards in the web-based grade book. This change required a redesign of the stabilized data analysis pipeline and forced a step back in machine learning-oriented innovation. Most significantly, it affected our ability to compare PTN student grades to traditional UPT students, which was a critical first milestone to meet our Holy Grail of identifying characteristics of an ideal pilot candidate.

CONCLUSION

This paper discussed many strategies SAIC used when managing innovative DoD projects. However, the single biggest takeaway the authors can provide is to "fail fast." The director of operations for the first PTN class often said, "Failure is not an option; it's a mandate." At the same time, AETC advocated a fluid approach for sustaining transformational innovation (Kwast, 2018). These philosophies permeated our approaches and set us up for success by quickly identifying the limits of what is possible programmatically, technically, and culturally and then iteratively applying that knowledge in search of revolutionary change.

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