Democratizing Innovation in the Department of Defense: A Model for Improving Innovation in an Era of Fiscal Tightening

by

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Submitted to the System Design and Management Program
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ABSTRACT

Democratized innovation is a paradigm characterized by users moving beyond the traditional construct that portrays them as passive recipients of firm-developed products. This field of research was launched by Professor Eric von Hippel in the 1970s with his landmark study on the scientific instrument industry that identified users as the source for the majority of new products on the market. Following this work, empirical studies have been conducted in countless other fields; however, the existing research regarding user innovation within the military is lacking. This work contributes to the existing literature by investigating user innovation principles within the context of the DoD with a multi-axis study that examines toolkit-related innovation, user-initiated projects, institutional attempts to stimulate user innovation, and the introduction of maker spaces. The exploratory research included here allows us to study patterns and compare internal and external factors in a way that avoids extrapolating overly broad conclusions from a single case. Considered together, the projects yield evidence supporting the existence of user innovation within the Army, Air Force, Navy, and Marines. They are also a mix of software development, hardware modification, and “platforming” initiatives.

Our findings reveal environmental factors that, at times, stunt the naturally occurring user innovation processes and distort the democratized innovation construct formulated by von Hippel and his colleagues. Following the identification of these barriers to user innovation, we suggest ways in which DoD leadership might rebalance the scales between formal R&D units and user-innovators. These proposals consist of catalyzing agents that would serve to counteract DoD-specific barriers to user innovation and allow the military to access previously untapped human capital.

Throughout this work, user innovation is shown to hold significant promise as an additional source of new product concepts for the DoD. The current state of the military acquisitions system, which is beset by aging equipment, a shifting strategic picture, rapid technological change, and declining budgets, demands that this promise be acted upon.

Thesis Supervisor: Dr. Eric von Hippel
Title: Professor of Technological Innovation, Sloan School of Management
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I would also like to thank Mr. Pat Hale, Director of MIT's System Design Management program, for providing me an opportunity to study at a first-class academic institution. The program has provided me with countless lessons and an education that will no doubt stay with me throughout my career.

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DEDICATION

This effort is undoubtedly dedicated to my smart, enthusiastic, beautiful, and loving wife, Alina Myers. She is a one-woman support network without which I simply would not have succeeded in this effort. It has been a challenging two years as we both pursued Master’s degrees in addition to work, but I would not have wanted to share it with anyone else. Adding our little Patrick to the mix halfway through increased the degree of difficulty a bit, but I am so thankful to have our wonderful family. Full credit goes to them for driving me to persevere through life’s little challenges.
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LIST OF ABBREVIATIONS

A4A: Apps for Army
AD: Active Duty
AFMSS: Air Force Mission Support System
AFSOC: Air Force Special Operations Command
ALICE: All-purpose Lightweight Individual Carrying Equipment
ANG: Air National Guard
API: Application Programming Interface
AWE: Aircraft Weapon Electronics
C&A: Certification and Accreditation
CAC: Common Access Card
C2: Command and Control
C2ISR: Command and Control, Intelligence, Surveillance, and Reconnaissance
CFPS: Combat Flight Planning Software
CIO: Chief Information Officer
CISSP: Certified Information Systems Security Professional
CoT: Cursor on Target
CROWS: Common Remote Operating Weapons Station
CSAF: Chief of Staff of the Air Force
CSAR: Combat Search and Rescue
CSDA: Connection Soldiers to Digital Applications
DISA: Defense Information Systems Agency
DoD: Department of Defense
DTC: Data Transfer Cartridges
DTED: Defense Threat Elevation Data
ECA: External Certification Authority
E-CHUM: Electronic Chart Update Manual
ELM: Expeditionary Lab-Mobile
ESC: Electronic Systems Center
FDCE: Federated Development and Certification Environment
FFRDC: Federally Funded Research and Development Center
FFT: Friendly Force Tracking
FOA: Field Operational Assessment
FOB: Forward Operational Base
FOUO: For Official Use Only
FPLAN: Flight Planner
FVCoT: FalconView Cursor-on-Target
GDP: Gross Domestic Product
GPR: Ground-Penetrating Radar
GTRI: Georgia Tech Research Institute
HUD: Heads-up Display
IED: Improvised Explosive Device
ILC: Integrated Lifecycle
ISR: Intelligence, Surveillance, and Reconnaissance
IT: Information Technology
JMPS: Joint Mission Planning System
MOLLE: MOdular, Lightweight Load-carrying Equipment
MPS: Mission Planning System
MPUC: Mission Planning User Conference
MRAP: Mine-Resistant Ambush-Protected
MSS: Mission Support System
NGB: National Guard Bureau
NPD: New Product Development
NSRDEC: Natick Soldier Research, Development, and Engineering Center
NRT: Near Real Time
O&M: Operations and Maintenance
OCI: Opportunities for Consumer Involvement
ODD: Ogden Data Device
OEF: Operation Enduring Freedom
OIF: Operation Iraqi Freedom
OPSEC: Operations Security
PAO: Public Affairs Office
PC: Personal Computer
PEO: Program Executive Office
PFPS: Portable Flight Planning Software
PKI: Public Key Infrastructure
PM: Program Manager
QRC: Quick Reaction Cell
RACE: Rapid Access Computing Environment
RCO: Rapid Capabilities Office
RDECOM: Research, Development, and Engineering Command
RDISS: Rapid Deployable Integrated Security System
REF: Rapid Equipping Force
S&T: Science and Technology
SDK: Software Development Kit
SOA: Service-Oriented Architecture
SOF: Special Operations Forces
TAC: Tactical Air Command
TTP: Tactics, Techniques, and Procedures
UCore: Universal Core
US: United States
W3: What, Where, When
XML: eXtensible Markup Language
Chapter 1 - User Innovation and the Department of Defense

"It’s war: Innovate or die." – Robert Cooper in Product Leadership

Cooper’s words invoke a powerful metaphor that emphasizes the existential significance of a commercial firm’s ability to innovate. However, within the military domain, these words can be interpreted quite literally in light of the central role of technology in modern warfare. The nation that creates technological asymmetries between its own armed forces and those of its enemies enters any conflict in an advantageous position. For the United States Armed Forces, this technological superiority depends on the defense acquisition system’s ability to produce the incremental and breakthrough innovations that bolster the American military’s status as the most advanced fighting force in the world.

Of course, new product development (NPD) is an uncertain exercise that relies upon varying measures of creativity, advances in science, engineering discipline, and quite often, chance. Given the critical nature of innovation in the defense sector and its inherent uncertainty, it follows that defense stakeholders would seek to capitalize on all resources at their disposal and carefully mine all potential sources of innovation. A third environmental factor that further exacerbates the need for the Department of Defense (DoD) to maximize its utilization of all sources of innovation is the 2013 defense budget outlook (See Figure 1). The high tech nature of 21st century militaries, intrinsic difficulties associated with innovation, and ongoing fiscal tightening are realities for a defense leadership that is also faced with shifting its focus from the last decade’s war on terror to rising strategic threats. In order to succeed in the face of this complex and challenging climate, the DoD will be forced to wring out value from all potential innovation channels. This research concentrates on whether and how the defense industry is already extracting value from an oft-ignored source of new technology: innovation from users.

![Figure 1: Fiscal Year (FY) 2013 Budget Outlook & Military Spending as Percentage of U.S. GDP (Masters, 2013)](image-url)
User innovation characterizes both end and intermediate users as more than passive recipients of private industry’s product development process. This field of study, backed by a large (and growing) number of empirical studies in a wide variety of industries, reveals that users are often the sources of new products that are used in-house and ultimately experience commercial success. These user-innovators are empowered by their own robust knowledge of user needs and, in many cases, technical skill in related and sometimes unrelated fields. Additionally, they are supported by vibrant user communities that engage in collaborative development projects and share information freely. Since the turn of the century, user groups have become more powerful and productive. This is due to the fact that the Internet has reduced the costs of communication, and design software has lowered the barriers to professional-caliber toolsets. In response to the increase in number and efficacy of user groups, firms have begun to more actively engage with these communities in an effort to leverage their activities and align them with company goals.

While there is a large body of evidence regarding the type of user innovation described above in the private sector, there is little deliberate study of how military operators engage in these activities. However, anecdotal reports of user innovation have surfaced from high-profile military engagements throughout U.S. history. Examples include continuous aim firing in the 19th century, the Culin Hedgerow Cutter during World War II, and a number of field expedients used to up-armor Humvees in Iraq and Afghanistan (Morison 1966; Lindsay 2010; RobertsArmory.com; Neuhaus 2007). While the user innovation construct has not been applied to the study of these examples, they do offer evidence that user innovation is not solely a private sector phenomenon.

The goal of this research is to contribute to the existing body of user innovation literature by conducting an exploratory study using six case studies within the national defense sector. Before delving into the case examples, Chapter 2 provides a review of the literature currently in circulation is highlighted to establish a foundation from which user innovation in the military can be explored. Chapter 3 follows by highlighting the interview- and literature-based case studies. Chapter 4 details the analyses of the various cases grounded in the principles discussed in Chapter 2 and the writer’s own familiarity with the defense acquisitions system and related literature. The discussion contained in Chapter 4 reveals peculiarities in the defense industry that are driven by environmental factors distorting the classic user innovation paradigm. Building on
the case studies and subsequent analysis, Chapter 5 suggests a vision for change that serves as a backdrop for practical initiatives that DoD leadership might pursue in order to more effectively support and encourage users participating in product development. Chapter 6 closes with final thoughts on user innovation within the DoD, arguing that there is reason for hope that this fertile breeding ground will begin to produce value for the U.S. military in its search to maintain poll position as the world’s dominant fighting force.
Chapter 2 - Literature Review

2.1 - User Innovation in the Private Sector

According to traditional theories regarding the innovation process, new products are brought to users by producers that conduct market research, identify consumer needs, and subsequently develop an end item to fill that need. However, as innovation-related research has evolved during the 20th and early 21st centuries, this traditional construct has evolved to reflect additional sources of innovation. Perhaps one of the most interesting variations of the traditional paradigm of producer-dominated product development is the theory of user innovation. While at first glance appearing somewhat counter-intuitive, this methodology involves consumers fulfilling their own needs by assuming the development roles originally believed to be reserved for manufacturers. The existence of this innovation phenomenon has been confirmed in multiple case studies. These studies encompass a diverse set of industries and products, including oil refining innovations (Enos, 1962), chemical production processes (Freeman, 1968), scientific instruments, semiconductor processing (von Hippel, 1988), sports equipment (Shah 2000), medical equipment (von Hippel and Finkelstein, 1979), library information systems (Morrison et al, 2000), printed circuit CAD software (Urban and von Hippel, 1988), and commercial banking (Oliveira and von Hippel, 2009). While this is not an exhaustive list, it does capture the ubiquity of user innovation during the last 30 to 40 years. Given the growing body of evidence that user innovation exists, research on the nature of this paradigm, the costs and benefits involved, and the ways in which firms interact with this type of product development has accelerated during the last decade. What follows is a review of the literature related to user innovation to date.

Before delving into the literature itself, it is important to highlight what is being conveyed by the term user in this context. In this context, users are the consumers, whether firms or individuals, that have a reasonable expectation of benefitting from using a product, service, or process. On the other hand, the goal of manufacturers is to benefit by selling a product or service, generally for a given profit (von Hippel, 2005). The difference is highlighted here because the research on user innovation describes both end users, or consumers, and intermediate users, or user firms (Bogers et al, 2010). To illustrate, von Hippel cites the example of Boeing, a company that is a user (i.e. intermediate user) when new metal forming technologies are involved and a manufacturer when it seeks to sell aircraft to airline companies (von Hippel,
2005). With a clear understanding of what constitutes a user in this study, we can proceed with reviewing prior research.

2.1.1 - Empirical Studies on User Innovation

Users have been singled out as contributors to the innovation process since the 1960s as the aforementioned case studies demonstrate. In Freeman’s study of the chemical industry in 1968, he reported that user firms were responsible for 70% of major process innovations (Bogers et al, 2010). Building on this research, Professor Eric von Hippel of the Massachusetts Institute of Technology (MIT) was responsible for truly establishing user innovation as a field of research worthy of more deliberate exploration. His investigation of scientific instrument innovation became a seminal study in the birth of user innovation research. During his analyses of scientific instruments and semiconductor and electronic subassembly manufacturing equipment, he identified users as the developers of 82% and 63%, respectively, of all commercialized products studied. These findings led von Hippel to propose a methodology he called the “customer-active paradigm” (CAP) (von Hippel, 1976; 1977). CAP turned the traditional “manufacturer-active paradigm” on its head and stimulated a large body of research that explored consumers’ motivations and capabilities to take a more central role in the innovation process.

2.1.2 - The Lead User Concept

Following these initial discoveries, the literature expanded from simply identifying that users were, in fact, active in the innovation process to identifying specific characteristics about those active users. Von Hippel’s revelation that users make up what he calls an “invisible front end” of many product development curves demonstrated that user-innovators are distinct from so-called early adopters (von Hippel, 2013; 2002). Figure 2 illustrates lead users contributions in terms of the well-established innovation curve. The term “lead users” became popular to describe users exhibiting certain characteristics that make them more likely than average users to take innovation into their own hands. These characteristics consist of (1) experiencing needs months and sometimes years before the majority of the market does and (2) being positioned to “benefit significantly by obtaining a solution to those [advanced] needs” (Urban and von Hippel, 1988).
During their research on medical equipment technology, Lettl, Hienert, and Gemuenden (2009) characterized lead users as true experts in their field with an ability to study technologies from an unrelated industry (e.g. nuclear technology) and apply it to their development. This “interdisciplinary know-how” can spark a lead user’s creativity and sometimes lead to radical innovation. Urban and Von Hippel’s (1988) research on printed circuit board computer aided design (PC-CAD) proved that lead user analysis could improve NPD productivity and should, at a minimum, be used to augment traditional market research methods. In essence, due to the fact that they experience needs ahead of the general market, lead users represent a sort of “need-forecast laboratory for marketing research” and have often already produced preliminary designs and prototypes, all of which provide firms with a potential competitive advantage over firms not examining lead user activities (von Hippel, 1986).

Later research found that lead user innovations often entail product concepts and designs that later experience commercial success. In the words of Franke, von Hippel, and Schreier (2005), “the ‘high expected benefits’ [dimension] predicts innovation likelihood and...the ‘ahead of the trend’ [dimension] predicts both the commercial attractiveness of a given set of user-developed innovations and innovation likelihood.” While this may seem obvious in hindsight, the needs of lead users had not always been considered representative of the rest of the market since these users seemed to be unique, both with respect to their advanced nature and their technical abilities. These findings added more weight to the idea that firms should pay close attention to user-innovators’ activities.
In addition, Morrison, Robert, and Midgley (2004) added to lead user research by introducing the concept of Leading Edge Status (LES), which seeks to quantify the degree to which users exhibit lead user characteristics. LES was built on the two aforementioned traits of lead users, as well as a third trait. They considered a user's ability to innovate an important factor in LES. Their work illustrated that classification of users into two categories (lead users and not lead users) was overly reductive, instead suggesting that a continuous distribution was a more valid approach.

Further, follow-on studies identified that lead users “[demonstrate] a ‘high degree of centrality’ within low density and low interconnectedness user innovation networks (Lettl et al, 2009). This is largely due to their leadership position within user innovation collaboratives, a subject that will be discussed later in this research. Jeppesen and Fredericksen (2006) went on to cite lead users’ potential value to firms as opinion leaders (Morrison et al, 2004), early adopters and willing diffusers of new products, knowledge, and practices, and critical actors in the “contagion process (assisting others in the adoption process).” These works added weight to the lead user concept and strengthened the case for firms to pay greater attention to these users’ activities.

2.1.3 - User-Innovation Incentive Structures

Following the identification of the lead user concept, researchers began to focus on further examining the incentive structures for user-innovators. Von Hippel again used the example of the scientific instrument industry to identify the types of innovation produced by users and manufacturers. In this study, users were shown to be responsible for new functional capabilities that advance their scientific research and win them recognition in their field. On the other hand, manufacturers tend to create innovations with commercial appeal, such as reliability or convenience improvements, that lead to increased profits (Riggs and von Hippel, 1992). In innovation parlance, manufacturers often produce dimension-of-merit improvements while users create functionally novel products. As another example, von Hippel highlights the creation of the heart-lung machine by a user-surgeon, John Heysham Gibbon, and the subsequent manufacturer-provided improvements in efficiency (von Hippel, 2012). This dynamic often takes shape due to the fact that firms prefer to wait until market uncertainty is largely negated by
a lead user that develops a new product, begins to use it, shares it with other like-minded users, and proves that others share a similar need (Liettl et al, 2009).

Another driver of user innovation lies in the transaction costs associated with firms conducting market research, identifying a need, and collecting enough information about the need and the environment in which it occurs. Von Hippel (1994) called this difficult-to-reach information “sticky,” and defined the stickiness of a given unit of information “as the incremental expenditure required to transfer it to a specified locus in a form useable by a given information seeker. When this cost is low, information stickiness is low; when it is high, stickiness is high.” In this context, both the need-related information that users possess and the solution-intensive information that producers more often possess can be sticky (Lüthje et al, 2006). With respect to what determines the degree of stickiness, von Hippel cites the nature of the information itself, the amount of information that must be transferred, and the attributes of the seekers and providers of that information. Empirical studies have shown that information transfer costs between parties can be significant, sometimes driven by “repeated shifts in the locus of technical problem-solving activities” (Teece, 1977; Tyre and von Hippel, 1993). Figure 3 provides a representation of the information transfer patterns observed by von Hippel (2005).

![Diagram of information transfer patterns](image)

**Figure 3: A Pattern of Problem Solving often Encountered in Product Development (von Hippel, 2005)**
In contrast, user innovators are often able to innovate using only “local” need and solution information. This situation constitutes a “low-cost innovation niche relative to others who must import sticky information to develop those same innovations” (Lüthje et al, 2006). It is extremely difficult for manufacturers to access this local information because “learning by doing,” the purest method of learning, can only truly be accomplished when operating within the use environment (von Hippel and Tyre, 1995).

2.1.4 - Examining User Innovation Networks

The next step in researching user innovation consisted of moving beyond individual users and further examining the existence of user networks. Multiple studies identify vibrant user communities that materialize around various products, including outdoor sports equipment (Franke and Shah, 2003), automobiles, consumer products (Fuller et al, 2006), open source software (von Hippel and von Krogh, 2003), online music composition tools (Jeppesen and Fredericksen, 2006), and many more. Individuals in these communities typically participate in mutually beneficial activities, such as sharing information on their use and modification of existing products, assisting each other in extending functionality, providing feedback on new ideas, and testing and evaluating prototypes. Franke and Shah (2003) refer to these networks as “community-based innovation systems” and contend that innovators enjoy “clear and tangible benefits in obtaining quality innovation-related assistance...from other innovative individuals.” This intuitively makes sense, as the efficiency of design search is scalable, as compared to an individual searching in isolation and when each of the searchers is essentially working for free (Baldwin et al, 2006). Figure 4 outlines conditions that determine the ease with which users within these communities are able to pursue innovation (Raasch et al, 2008).
2.1.4.1: Free Revealing within User Communities

A key enabler in the success of these communities is the degree of "free revealing" that occurs amongst its members. Free revealing consists of users developing products, features, and processes and subsequently making that innovation available as a public good (von Hippel, 2002). A number of cases have been cited to prove the existence of this concept that appears, at first glance, to be somewhat irrational. Von Hippel (2002) cites the prevalence of free revealing in clinical chemistry analyzer equipment, copper interconnect semiconductor processes, furnace design information, and open source software projects. To economists, free revealing can be a surprising revelation due to the fact that it runs counter to a key principle of the economic theory of innovation. This principle states that “appropriating returns to innovation requires agents to keep the knowledge underlying an innovation secret or to protect it by patents (or other means).” According to this theory, free revealing is “non-compensated information spillover” by another name and should be avoided by innovators (Harhoff et al, 2003).

However, upon further examination, free revealing is quite often a calculated move by user community participants seeking to extract returns from the revealing activity. The catalysts of this behavior can stem from internal factors, such as intrinsic motivation, altruistic inclinations, or community identification needs. External rewards can also incentivize free
revealing through expectations of future returns, investments in personal human capital, self-marketing goals, or peer recognition needs (Hars and Ou, 2002). Active contributors to user community progress stand to extract reputational benefits, have the potential to shape environmental factors to their advantage, and also profit from complementary innovation from other community members (von Hippel, 2002). With these motivations in mind, the concept of free revealing becomes an entirely rational behavior, through which users actively participate in a collaborative venture for any number of personally-defined rewards.

Having observed that free revealing regularly occurs within user communities, interesting questions arise regarding traditional notions about the societal need for property rights as they pertain to innovation. It is commonly accepted that property rights were established in order to encourage prospective innovators by allowing them to protect their invention from others seeking to profit from or use the idea. Effective protection of an innovator’s intellectual property would then allow the inventor the option to extract rents from others seeking to use the idea or product. However, research tangentially related to user innovation has found this protection, (1) ineffectual in motivating firms to innovate; and (2) unsuccessful in combating information spillover to other parties. In 1973, an exploratory study revealed that “24 of 32 responding firms said that 5% or less of recent [research and development (R&D)] expenditures would not have been undertaken if patent protection had not been available” (Taylor and Silbertson from Harhoff et al, 2003). Additionally, Levin et al. (1987) reported that a survey of 650 R&D executives in 130 different industries indicated that all respondents except those from the chemical and pharmaceutical industries believed patents to be “relatively ineffective” (from Harhoff et al, 2003).

The time period during which these protections counteract spillover is also deemed to be somewhat insignificant. Mansfield (1985) reported that development decision information is typically known by competitors within 12 to 18 months and detailed information regarding product or process operations is generally leaked within a year. In aggregate, these findings seem to indicate that innovators are really only faced with a “choice between voluntary free revealing now [or] involuntary free revealing later” (von Hippel, 2002). While some may make the rational decision to keep the information secret for as long as possible in order to gain first-mover advantages, Harhoff et al. (2000) highlight reasons to consider revealing as an attractive
alternative. These reasons include the potential to induce improvement by others, establish an advantageous standard for the innovating user, and extract reciprocity and reputation benefits (from Franke and Shah, 2003). A case study of IBM illustrates the motivation for established firms to reveal. In this case, IBM shared a “process to manufacture semiconductors that incorporated copper-interconnections among circuit elements instead of the traditionally used aluminum ones.” In this situation, IBM was motivated by a need to secure equipment from suppliers in order to implement the process on a production scale. In revealing this innovation to suppliers and others, IBM ensured that their process would become the industry standard and also locked in economic order quantities when other firms adopted the process (Harhoff, 1996; Lim, 2000 from Harhoff, 2003).

While the majority of this research acknowledges that free revealing is more prevalent within low rivalry situations, it has also been shown to take place in very competitive sporting industries, (Raasch et al, 2008). Fauchart and von Hippel (2008) have also identified competitive situations, such as French cuisine, in which free revealing takes place under norms-based social structures that ensure innovators’ ideas are protected. Other research in this area consists of computer simulations that suggest innovation productivity and social utility are relatively higher under liability rule regimes than property rule regimes (Torrance and Tomlinson, 2011).

Essentially, the debate regarding the need for intellectual property protection and other safeguards is a polarizing topic as many believe that patent protection remains a key incentive for innovators. However, user innovators continue to eschew securing intellectual property protection for their ideas in favor of freely revealing to collaborative user communities. The situation has created a new “private-collective” hybrid construct that compounds the private investment and collective action models. This model consists of users investing private resources (e.g. time, expertise, and other resources) to develop products that subsequently become public goods (von Hippel and von Krogh, 2003). While the most obvious example of the private-collective construct is open source software, a number of user innovation communities embrace the model. This model has gained enough traction to necessitate that rights be established to ensure that open projects are protected as a public good. One example is the General Public License (GPL), or “copyleft,” developed by Richard Stallman, founder of the
Considering and sometimes in spite of the intellectual property protection regimes enacted by government, user innovation communities acting within the private-collective construct remain prevalent through many industries. Further, a growing number of researchers argue that these networks are becoming increasingly active and powerful. These networks are stimulating a shift from producer innovation to user innovation, as new technological enablers continue to emerge. Baldwin and von Hippel (2009) hold that “the transition to increasingly digitized and modularized design and production practices, coupled with the availability of very low-cost, Internet-based communication” will only serve to increase the momentum of this shift.

In the case of open source software, networks are able to unilaterally proceed through the entire innovation process (i.e. from development to distribution). Von Hippel (2001) calls these groups, “full-function,” and points out that these communities are only able to compete with commercial firms when their manufacturing and distribution capabilities are competitive. This is clearly the case with software (where free distribution is possible); however, hardware may often require commercial firms to take over when cost effective production and distribution involves considerable economies of scale (from von Hippel and von Krogh, 2003). This holds true in the case of the windsurfing industry research by Shah (2000, from von Hippel, 2002), but more research is needed to generalize the interaction between users and manufacturers during the production and manufacturing phases. At the very least, user networks are diffusion catalysts, serving as “a bridging link to the general mass market...[convincing] customers in the early majority segment to adopt the lead users innovation” which reduces uncertainty for the market at large and encourages more widespread adoption (Hienerth and Lettl, 2011).

2.1.5 - Firm Engagement with User Innovation Collaboratives

Given the prevalence and apparent success of many user networks, firms have increasingly begun to ask themselves how they can proactively engage with user communities in a way that facilitates user group activities while also ensuring their results align with the firm’s overall strategy. One way in which firms are cooperating with their user communities is by outsourcing important innovation tasks that necessitate need-related information knowledge to the users themselves. This outsourcing is made possible when firms provide so-called “toolkits
for user innovation” (von Hippel and Katz, 2002). These toolkits are not an entirely new idea. The concept was first seen in the 1980s, although not in the robust form we see today. Custom integrated circuit design and manufacturing stakeholders adopted the toolkit approach in order to avoid costly mistakes associated with not understanding user needs well enough (von Hippel and Katz, 2002). In 2000, Thomke and von Hippel (2002) valued sales associated with user-designed chips by semiconductor manufacturers at $15 billion (from von Hippel and Katz, 2002).

In their study of Apache Security Software, Franke and von Hippel (2003) identified four critical capabilities of successful software toolkits. First, they facilitate complete cycles of experimentation and learning during design. Second, they are user-friendly in terms of leveraging users’ existing skills or customary design language. Third, they contain libraries of useful component and module designs that users can integrate into their new product concepts. This allows users to focus on the novel elements of their design. Lastly, they account for the limitations of the manufacturing processes that firms will use during production. While these capabilities were outlined in a software case study, they can reasonably be assumed to hold for other product types. As an example, von Hippel (2001) outlined a case study in which Nestle provided a toolkit to Mexican chefs that allowed them to create recipes and communicate those recipes to the factories in terms easily translatable to mass production (from Jeppesen, 2005).

Jeppesen (2005) extended toolkit-related research by identifying re-emergent costs associated with increasing opportunities for consumer involvement (OCI). In his study, these re-emergent costs were observed when firms saved on initial development due to a concerted toolkit-enabled outsourcing strategy but were then forced to invest more in customer support as users encountered issues while using the toolkit provided. While these re-emergent costs provide cause for thoughtful consideration of a toolkit-based strategy, Jeppesen also went on to cite the cost neutralizing effect of consumer-to-consumer support within the user communities surrounding toolkit products. This type of support proved very effective during his study of a software gaming company, Westwood Studios. Westwood’s concerted attempts to foster an active user group were rewarded through offsets to customer support that might otherwise have been necessary if consumer support networks had not otherwise filled the need.
While toolkits provide firms with one means of integrating users into new product development, subsequent research has provided increased insight into how firms should engage user communities themselves. Fuller et al. (2006) provide insight into how firms should handle engaging with existing communities, standing up new user networks, and sponsoring community activities. Audi is highlighted as an exemplar of extracting value-added contributions from user communities through meaningful investment in community platforms. The company’s development of a Virtual Lab capability that allowed users to contribute to the design of the next Infotainment system was a successful instance of engaging existing user groups and recruiting potential new participants for a company-sponsored user innovation project. Other examples from the auto industry including BMW and Peugeot are cited for their design tools, competitions, and virtual lab capabilities. Each of these firm-sponsored initiatives can serve as an effective means of soliciting customer input for new products.

Other consumer products companies, such as Procter and Gamble, have instantiated user advisory boards that participate in the design, testing, and launch of new products. As Jeppesen and Fredericksen (2006) found, users are often highly motivated by the promise of firm recognition (and the peer recognition that follows) to engage in company-sponsored communities. Fuller et al (2006) provide a conceptualized model of when users can be expected to be engaged in a three-stage product development cycle (Figure 5). These studies are highlighted as evidence that successful firms are moving far beyond voice-of-the-customer market research and attempting to truly integrate users into their innovation process.
Various paradigms have been suggested to guide companies in user community engagement. Dahlander and Magnusson (2008) suggest a methodology grounded in three themes: "(1) Accessing the communities to extend the resource base, (2) Aligning the firm's strategy with that of the community, and (3) Assimilating the work developed within communities in order to integrate and share results." This three-pronged approach requires firms to accomplish the difficult tasks of influencing the direction of user development activities and filtering through the potentially large amount of data to evaluate and select the most promising ideas and concepts. Fuchs and Schreier (2010) suggest a construct characterized by empowering users with two functions: (1) empowerment to create and (2) empowerment to select. While the first reflects classical user innovation, the second function is more analogous to mass customization. To some extent, the degree to which users will innovate is locked in early in the process of manufacturer-dominant development. The architectural decisions involving the openness of the design, the degree of modularization pursued, and the complexity of the technologies involved all contribute to downstream user involvement (Jeppesen, 2004 from Baldwin and von Hippel, 2009).
2.1.6 - Firm-Sponsored Engagement with Users and the Concept of “Partial Openness”

A new line of research seeks to systematically assess how users will react to “partial openness” on the part of producers (Balka et al, 2013). Partial openness is characterized by a mix of closed, proprietary design information and freely revealed information. On the surface, “producer-imposed gradations in openness” seem to be anathema to the principles of the open source movement, but research has found that user communities are not rigidly opposed to the concept. Users acknowledge the need for firms to keep some innovations close-hold in order to make a profit (Balka et al, 2013). However, firms wishing to pursue a strategy of “partial openness” must tread carefully. A proprietary software company named Xara provides a cautionary tale concerning the risks of partial openness. During product rollout, Xara provided 90% of its vector graphics engine software as open source, leaving the remaining 10% as proprietary code. The resulting backlash soured users on the company and its product, as the user community believed the 10% of the code that was not opened was a critical piece of the software. The resulting user backlash stemmed from the company’s inability to effectively balance user preference for openness with its desire for some measure of control (Asay, 2007).

Ultimately, firms that choose to engage with user innovation communities must exploit the tools at their disposal. Raasch (2011) suggests a number of “strategic instruments” available to firms in their attempts to influence the costs and benefits of user innovation. Figure 6 outlines the levers at a firm’s disposal. Her research provides companies with practical means of affecting users’ propensity to join firm-sponsored user communities, tinker with products, and then reveal the results of their work. These levers include enhancing brand attractiveness, increasing firm-to-user information sharing, deliberately facilitating user modification of existing equipment, and providing a platform to ease community forming and discussion. While Raasch clearly advocates for firms sponsoring user innovation, these levers are also made available for firms wishing to discourage or more selectively promote user-led design and development.
As the collection of literature related to user innovation has continued to expand, one thing remains clear. User innovation and the research exploring its practice have only accelerated since the turn of the century, a trend that is likely to persist as user toolsets continue to improve, advancing communication methods increasingly enhance the effortlessness of Internet-based collaboration, and firms come to view engagement with user communities as an opportunity that must be exploited to establish market dominance.

2.2 - User Innovation in the U.S. Military

To date, research on user innovation within the military is largely a collection of anecdotal reports on field expedients that have been observed when troops faced an urgent need during a conflict. Examples range from soldiers adapting beach obstacles as hedgerow cutters on Sherman tanks during World War II to Signal Corps units deploying blimps to raise antennae in order to overcome terrain-related communications limitations in Vietnam (Lindsay 2010; Durish 2012). More recently, troops have been observed in Iraq and Afghanistan devising creative ways to up-armor Humvees (Neuhaus, 2007). Despite this evidence of military operators innovating in response to emerging battlefield requirements, very few systematic studies of user innovation within the Department of Defense have been conducted through the prism of von Hippel’s democratized innovation model. Jon Lindsay (2010) provided one such study when he investigated the history of users developing a mission planning application named FalconView.
This prior research will be leveraged later in this investigation in order to compare with other user innovation projects that are highlighted here. In general, the literature related to user innovation in the military domain is immature and should be expanded before drawing more general conclusions.

2.3 - The DoD’s Formal Acquisitions System

Any discussion of user innovation within the DoD is not complete without juxtaposing the distributed product development with the DoD’s Integrated Lifecycle (ILC) Acquisitions System. Figure 7 illustrates the system’s processes and procedures for those unfamiliar with its characteristics. It is a system defined by a deliberate, standardized progression through exhaustive documentation activities, in-depth review cycles, extensive stakeholder coordination practices, and complex planning, programming, and budgeting procedures. Each process shown in Figure 7 can be traced to well-intentioned initiatives aimed at safeguarding taxpayer money and maintaining insight into defense industry activities; however, the bureaucratic nature of the surrounding environment has eroded the productivity of acquisitions units and increased costs to the detriment of end users.

The level of complexity involved in the current system has tended to dilute user involvement in product development and created acquisition personnel skilled at navigating the process but lacking an intimate understanding of user needs. Defense leadership have continually voiced displeasure with the system itself. As recently as 2009, Secretary of Defense Robert Gates called for “a fundamental overhaul of our approach to procurement, acquisition, and contracting” (DefenseLink 2009 from Kotzian, 2010). Many leaders have made similar calls-to-action with reform efforts facing stiff resistance due to the extent of entrenched interests from defense industry, political, and military leaders. While this research is not an examination of the long list of failed reform efforts or the acquisition system itself, it is important to understand the setting in which military user-innovators are operating.
Figure 7: Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System (Source: Defense Acquisition University)
Chapter 3 - Evidence of User Innovation in the Department of Defense

3.1 - Introduction to the Case Studies

The following case studies form the backbone of this exploratory study and comprise a representative sample from which conclusions are drawn regarding user innovation in the military. While there are undoubtedly other cases of user innovation taking place, the following cases were selected in order to investigate various concepts of user innovation that are targeted in this study while also implicating multiple branches of the Armed Forces. The studies also comprise a collection of efforts that experienced varying degrees of success, increasing the potential to identify success/failure criteria. An assortment of online periodicals, prior research, and defense literature provided reference material in addition to the interviews that were conducted to support this research.

3.2 - Cursor-on-Target (CoT): Democratizing a Data Standard

3.2.1 - A Data Standard for the People by the People

CoT is a terse eXtensible Markup Language (XML) schema (see Figure 8) used to exchange situational awareness (SA) data consisting of what, when, and where (W3) information. Developed by MITRE, a federally funded research and development center (FFRDC), in concert with lead users in the Special Operations community, the schema is used to enable machine to machine communication, typically in bandwidth-constrained environments. The CoT suite consists of the basic message schema, 14 subschema, and a set of small software applets that allow users to quickly “CoT-enable” their systems at low cost. The subschemas allow users to expand upon the basic message set of the base schema with additional information such as flow tags that display what systems have processed the CoT message, engagement details (e.g. weapon/target pairings), links that are used to link one CoT message to another, free text remarks, and many others. The basic software suite consists of:

- The CoT Message Router: provides rule-based routing of CoT Messages in one-to-one or one-to-many networks
- The CoT Debug Toolkit: a small software application designed to facilitate users in experimenting with and prototyping CoT implementations
- FVCoT: a software plug-in for the most widely used digital mapping application in the DoD, FalconView, which is highlighted later in this research. The plug-in allows users to display CoT messages on the map in order to track friendly locations, targeting information, or their current position.

```xml
<?xml version='1.0' standalone='yes'?>
<event version="2.0"
    uid="J-01334"
    type="a-h-A-M-F-U-M"
    time="2005-04-05T11:43:38.072"
    start="2005-04-05T11:43:38.072"
    stale="2005-04-05T11:45:38.072">
  <detail>
    <point lat="30.0090027" lon="-85.9578735" ca="45.3"
          hae="-42.6" le="99.5" />
  </detail>
</event>
```

Figure 8: Basic CoT XML Message (Kristan et al, 2009)

The CoT strategy is oriented around the goal of establishing a common language that facilitates machine-to-machine data exchange between disparate Command and Control systems, thus eliminating human-in-the-loop communications that are often error prone and time intensive. The CoT philosophy consists of concentrating on where information needs intersect and maintaining what the DoD terms as a “net-centric” approach (i.e. developing systems that add value to the broader network). Object-oriented decomposition is used to ensure object types are universally understood and units of measurement are consistently applied to ensure all systems properly digest and display CoT messages. The extensibility of CoT allows users to exchange as little (e.g. base W3 schema) or as much (additional subschema) as they prefer.

CoT is currently employed throughout the spectrum of military operations in time sensitive targeting, blue force tracking, intelligence, surveillance, and reconnaissance (ISR), unmanned aerial vehicle missions, and many other scenarios. This is accomplished by installing small CoT software applets that speak the CoT language (i.e. schema) into operational systems. Figure 2 shows one such scenario where CoT functionality is integrated into the systems used to prosecute a target identified by a Special Operator and attacked by an F-15 fighter aircraft. While the systems and acronyms may not be familiar to the reader, the example is shown here to demonstrate the lightweight nature of integrating a small CoT software add-on (i.e. maybe a few hundred lines of code) to the machine input/output ports that allow these systems to publish and
subscribe to the data (Shulstad 2011). This construct allows previously “stove-piped” systems to become interoperable and facilitate improved communication.

3.2.2 - Why CoT?

In essence, the question of why CoT was created should be decomposed into two sub-questions: 1) What led to the creation of the CoT data exchange philosophy in a MITRE lab?, and 2) Once the basic CoT schema and software had been developed, why did lead users engage so willingly to push CoT to what we now know as the full suite of schema, subschema, and applications? The reason for this distinction lies in the fact that CoT, as it is known today, would not exist without the involvement of lead users in its early stages. To answer the first question, it must first be said that, in a broad sense, CoT was developed to answer a challenge from the Chief of Staff of the Air Force (CSAF) in 2001. General John P. Jumper had tired of the lack of automation in processing ISR data and transmitting it to decision makers. He pointed to his experience as an F-15 pilot when he was able to designate a target, feed the information to the avionics and weapon systems, and then simply allow the system to handle the rest. Gen Jumper wanted a similar level of automation present in command and control (C2) systems in order to
drive down the mistakes and latency inherent in the current system. To him, “the sum of all wisdom [was] a cursor over the target” (Shulstad 2011).

This challenge, which he delivered at the 2002 C2ISR Conference held by the Air Force’s Electronic Systems Center (ESC), led to a rapid prototyping initiative within MITRE. The initiative was established to “deliver automated, integrated C2 capabilities to warfighters” (Shulstad, 2011). It was led by two of the top engineers in MITRE’s Air Force C2 Center, Mike Butler and Doug Robbins. Mike Butler, known to be an innovative thinker within the organization, had experienced firsthand the frustrations of not being able to share situational awareness information and pass data between C2 systems during time spent assisting the recovery effort at Ground Zero after 9/11 and working intimately with Special Operations Forces (SOF). So, while not an operational user in the tactical sense, Butler was keenly aware of the challenges faced by users and had devoted time to thinking about solving the machine-to-machine communications challenge during his involvement in operational scenarios. As a result, he knew the Air Force had constructed “communications silos” where vertical integration was possible, but horizontal integration was extremely difficult (Butler 2013).

More than simply knowing that these silos existed, Butler had experienced them firsthand at Ground Zero, where he had walked around with maps attempting to annotate where recovery efforts were concentrated, where supplies were being stored, and which units were assigned to various tasks (Butler 2013). Relegated to marking up hard-copy maps, Butler found the task of sharing situational awareness information with a wide variety of mission participants nearly impossible. He designed CoT as a tool to address the “shared situational awareness” problem. One example of the type of integration CoT made possible, which Butler used as the first demonstration of CoT technology, involved a laser range finder designating a target, which was then passed to a targeteer’s system for processing, and automatically transmitted to the heads-up display (HUD) of an F-15 fighter aircraft. While this was merely a lab scenario, it clearly demonstrated the value of machine-to-machine data exchange technologies.

Butler also had the insight to see that systems attempting to develop message formats that encompassed all data types and message sets for each and every mission thread were problematic due to their complexity, which made them hard to manage, difficult to implement, and costly to integrate. As a result, he studied the types of messages that were being used during operations.
(rather than all of the possible types of messages that *might* be used). With his eye firmly on current user needs, he made a key discovery. Despite the thousands of pages that made up existing message formats, such as Link-16, users were typically utilizing a small subset of the available messages. In total, 85% of the messages being used could be boiled down to object type (what), time (when), or location (where) information.

![Link-16 Message Usage](image)

Figure 9: Link-16 Message Usage (Niessen, 2004)

It is important to note here that Link-16 is an extremely successful and useful message format for many defense users. But Butler knew that many users existed in bandwidth-constrained, non-standard environments where Link-16 failed to deliver the needed capability. Capitalizing on his W3 findings, Butler developed the basic CoT schema which provided this core set of data, knowing that if users needed additional information, they would be able to develop subschema and applets for their individual mission needs. To ensure this user-developed standard would be possible, CoT was developed to be a widely disseminated, open data standard with an emphasis on simplicity, low-cost, and publicly releasable documentation and software. After the rapid prototyping effort was complete, Butler and his team conducted multiple demonstrations for Air Force leadership and after seeing the interoperability advantages of CoT, Gen Jumper directed the use of CoT for data exchange at the tactical edge of the battlefield.

3.2.3 - Transitioning to User-Driven Development

'The CoT rapid prototyping effort served as a way of showing the data exchange possibilities to the warfighter. It then became a community effort to make those possibilities a
reality. In his words, Butler (2013) intentionally “drove the CoT initiative underground” after discovering how easily developers understood the value of the technology and, by contrast, how difficult he found it to convince managers that CoT would make their systems more successful. A user community composed of forward thinking lead users quickly mobilized and built on the momentum generated by Butler and his team. While MITRE engineers had developed a baseline capability, it would be up to the users to generate the necessary momentum for this data standard to become a true interoperability enabler within the Air Force and defense community, at large.

Before outlining the story further, it is important to note a few key characteristics of CoT that paved the way for a community development model. First, unlike many defense technologies that are highly complex, proprietary, and closed to user innovation, CoT was simple, low-cost, publicly available, and completely open to user development. Had MITRE been a privately-held defense contractor, CoT might have been protected as a proprietary technology. However, in this case, the company’s FFRDC status naturally motivated (and required) it to share the development with the government and its partners. User innovation was also made possible by the fact that Butler’s team developed an open, flexible schema but also took the vital step of making the rules that governed data exchange using the schema extremely rigid (e.g. location data could only be passed using latitude/longitude, distances were only measured in meters, height above ellipsoid was always used for altitude designation, etc.). The rigidity of these rules was critical for enabling machine-to-machine communication due to the fact that users could integrate CoT into new and existing systems (and develop new subschema) knowing exactly what type of data would need to be transmitted and/or received.

Additionally, the first adopters, or lead users, of CoT were Air Force Special Operations Command (AFSOC) personnel. These operators existed at the edge of standard missions, consistently testing the limits of Air Force capabilities. They faced a continuously evolving enemy and had a pressing need for technologies that could facilitate a wide variety of operations with an array of military organizations. CoT’s simple, flexible, low-cost nature fit their profile, and AFSOC became a champion of CoT-enabled interoperability. Due to their involvement with a broad swath of conventional and unconventional military organizations and those organizations’ motivation to integrate with tip-of-the-spear special operators, AFSOC’s use of CoT naturally exposed others to the advantages of the technology and drove them to integrate CoT into their systems. Butler (2013) also points to the relative autonomy enjoyed by AFSOC
organizations in the early 2000s, as a catalyst for CoT deployment. This autonomy allowed AFSOC to skirt much of the standard acquisitions processes that plague defense programs and slow development. Butler’s AFSOC partners, known affectionately as “The Quiet Professionals,” had the ability to quickly procure operational equipment for rapid prototyping and test activities. The AFSOC mentality of “just make it work,” provided fertile ground for CoT development and deployment.

The exposure to other organizations through AFSOC highlights a third key trait of CoT that led to community development: its exponential value growth as network effects emerged within a continuously growing user community. Due to this value proposition and the fact that AFSOC employment led to wider adoption, users were naturally motivated to broadcast their use of CoT and bring the functionality to other systems. This motivation was compounded by the military’s growing emphasis on network-centric technologies and led to the sort of collective action necessary to make democratized innovation a viable development paradigm for the DoD. This led to a grassroots movement as the advantages became clear to a growing number of users, and key lead user groups within each domain pushed CoT integration as a starting point for interoperability.

The last enabler of community development was, in fact, an exogenous factor and not at all a trait of CoT: timing. The wars in Iraq and Afghanistan forced the military to conduct an unprecedented level of interoperable, near real time (NRT) operations that necessitated machine-to-machine communications. This sense of urgency paired with the degree of highly integrated, cross-service teaming inherent in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) produced a hospitable environment for an interoperability facilitator like CoT that allowed users to remain agile in developing systems that responded to the threat of the day.

While each of these traits was important to CoT’s emergence as a community developed technology, AFSOC’s willingness to champion the cause and push integration on all of its partners and customers was perhaps most critical to gaining the necessary momentum for the grassroots movement to take shape. Specifically, an AFSOC Master Sergeant engaged as a critical user-developer. His involvement added credibility to the CoT user group and his innovative, lean-forward nature further advanced CoT technology and increased its usefulness to operators in the field. The Master Sergeant’s exposure to CoT followed a friendly fire incident...
in which he was injured, a situation that might have been avoided with more interoperable communications (Butler 2013). Undoubtedly motivated to fix the problem before other accidents occurred, he pushed for additional subschema to fill other mission needs and set off to make CoT the backbone of AFSOC communications. As is typical of a lead user, this individual was extremely motivated to expand on CoT’s initial success, had the personal experience to access sticky need information, and anticipated the significant benefits that CoT-enabled interoperability would yield for AFSOC. As such, he would continue to stay at the forefront of interoperability trends and be a crucial proponent of CoT employment within the DoD.

With user support and development continuing to grow, a small office was created at the Air Force’s ESC to oversee the user community and provide for the care and feeding of CoT. This office consulted with new and existing users trying to expand CoT functionality, advocated for the CoT philosophy within the C2 community, managed the CoT toolkit (schema, subschema, and software), and tracked the user community’s needs and direction. In general, the CoT program office sought to advocate for the user group and enable continued CoT development by its members. The former was typically accomplished by broadcasting CoT users’ successes to key Air Force leadership, and the latter was largely facilitated by the user group itself. The program office, one of the smallest (and cheapest) groups at ESC, worked to keep the cost of CoT design and prototyping very low with a basic software development kit and freely available documentation, schema, and consulting services. Funding was typically procured through applying for end-of-year fallout, or excess, funds within the acquisition community or appealing for user-provided funding, which lead users were sometimes able to find in their own budgets.

What allowed this low-cost service to continue was the degree of free revealing that existed within the CoT community. While instances of proprietary subschema and software were known, many users also provided software and subschema to others hoping that their expanded use would accelerate the proliferation of CoT technology within the defense community. Further, knowing that they could continue to tinker with their CoT implementations, users found it valuable to show others what they had developed, seek advice, and look for opportunities where others might respond in kind with their own technologies. This free revealing was often extended to the program office and many users allowed their subschemas to be included in the starter kit that was freely available to the community at large.
As this toolkit was made more useful and robust for the CoT community, it proved to be a key factor in boosting the volume of CoT adoption and innovation. As support for CoT strengthened, the program office worked to keep the software kit current, assist user-developers where needed, and fight the bureaucratic battles within the DoD to ensure operators enjoyed uninterrupted use of CoT. An annual conference was also held to bring together users from across various government agencies. Users hosted live demonstrations, gave briefings on their CoT employment strategies, and interfaced with other like-minded community members. As CoT continues to grow as of the time of this research, the user community remains central to the development approach and user group meetings are held on a yearly basis.

3.2.4 - Continued Success in the Face of Systemic Resistance

As the popularity of CoT became impossible to ignore, DoD leadership decided to pursue a more ambitious data standard that would provide CoT-like functionality to an expanded set of users. In essence, Universal Core (UCore) was designed to replace CoT within the C2 community and also provide a common data standard for the intelligence community, among others. What resulted was a data standard weighed down by an ever-increasing set of requirements that hindered deployment of an operational capability. Six years after the release of UCore v1.0, the CoT user community continues to expand as its intended replacement has encountered problems. Ultimately, UCore struggles due to its development model being driven by requirements personnel from a vast array of organizations. Despite pressure to support the rollout of UCore, the CoT user community continues to thrive because the technology “just works,” and it empowers them to unilaterally develop solutions unburdened by time- and resource-intensive acquisition processes.

3.3 - FalconView: Operator-led Development in the World of Mission Planning

The FalconView story provides insight into a project that launched from a user innovation, transitioned to operator-led development, and continued to evolve through the efforts of a large and vibrant user community. What follows is a summary of Jon Lindsay’s (2010) influential work “War Upon the Map,” which covered user innovation in the automated mission planning domain, supplemented by a first-hand working knowledge of the software and its development.
3.3.1 - What is FalconView?

In the same way the Cursor-on-Target approach facilitates user involvement and empowers operators to assertively direct defense contractor development, the mission planning and geospatial visualization tool FalconView also succeeded due to operator-led innovation. FalconView, first released in the early 1990s, "emerged through user efforts to develop automated planning tools within the U.S. Air National Guard F-16 community" and quickly became the most widely used digital mapping tool within DoD and a host of other government agencies (Lindsay, 2010). Due to its popularity and continued success in the face of formal acquisitions programs designed to supplant it, FalconView developed a strong following, and a tightly knit user community materialized. This user community would further the FalconView cause with continued development, tailoring, and expansion of the already valuable functionality provided by the core components of the software. At its core, FalconView is a PC-based automated mission planning tool that was conceived and developed by lead users with the help of Georgia Tech Research Institute (GTRI) engineers in order to fill a need for crews preparing for increasingly complex mission profiles. While originally developed for a specific community, FalconView became the de facto standard for mission planning within the Air Force, Navy, Special Operations, and many other communities.

3.3.2 - The Benefits of a FalconView-like Approach

Prior to the creation of FalconView, mission planning involved a painstaking process that included manually plotting flight routes on paper charts, annotating navigation aids and obstructions with pencil, and measuring distances by pulling strings across charts. In general, these activities represented wasted time spent on manual tasks that could more effectively be accomplished by reliable software tools. While this may sound like a scenario based in the 1960s, some of the practices could be found in flying squadrons into the mid-1990s. However, as early as the late 1970s, aviators began to experiment with emerging microcomputers and engineering calculators to automate these well-standardized mission planning practices. The value added was clear. Operators were able to reduce effort spent on manipulating manual tools and, as a result, increase time devoted to focusing on the mission and accounting for less well-defined variables such as enemy responses to flight profiles and potential mission contingencies. The software also provided mission execution tools such as a real time moving map display and
an interface with tactical radio feeds to display intelligence data and friendly force tracking (FFT) capability (Lindsay, 2010).

As software and processing power improved throughout the 1990s and into the 2000s, FalconView functionality continued to expand with the growth of a diverse user group consistently bringing new requirements and features into the fold. These feature additions included capabilities such as automated integration of Electronic Chart Update Manuals (ECHUM), incorporation of tower displays, visualization of Defense Threat Elevation Data (DTED), depiction of sensor footprints, and the ability to import intelligence and threat data. These incremental improvements, funded and often developed by distributed users, fueled continued expansion of FalconView functionality, only serving to improve the flexibility of the product and, necessarily, its value to additional users (Lindsay, 2010).

Beyond the capabilities developed by the original lead user group and their GTRI counterparts, the aforementioned user-developed capabilities were encouraged by the adoption of a third-party development approach that exponentially increased FalconView feature expansion. The decision to expose Application Programming Interfaces (API) and eventually create a full-fledged Software Development Kit (SDK) to foster the third party development that was already taking place eased the burden on users to expand functionality and became the type of market-generating product feature that has proved successful in the commercial market (Lindsay, 2010).

3.3.3 - The Critical Role of the Lead User in Mission Planning Capability Development

Since FalconView development was largely run by users (as opposed to a formal acquisition program office), the user reaction to the system is woven throughout the story from the inception of the software. In 1981, two A-10 Warthog pilots, Captain Jake Thorn and Captain Jerry Fleming, based in South Carolina began writing very basic software to aid them in their mission planning. A chance encounter with Gen Wilbur Creech, then commander of Air Force Tactical Air Command (TAC), led to a demonstration for a group of Air Force generals who quickly made microcomputers available for all flying squadrons to encourage the type of computer-assisted mission planning that had proven helpful to these two enterprising young pilots from the A-10 community (Lindsay, 2010).

While limited in proliferation (typically 1 per squadron), the provisioning of these microcomputers led to a number of aviator-developed mission planning tools, with a system called
Flight Planner (FPLAN) eventually emerging as the dominant design. Concurrently, and incidentally at the same base from which FPLAN originated, a formal program designated Mission Support System (MSS-1) was in development. In general, MSS-1, a UNIX-based solution, was considered to be less user friendly, leading to a complete software overhaul in 1983. The follow-on system, MSS-II, was extremely bulky and still lacked the user-friendly aspects of FPLAN, although it did provide a solution for digital map displays and Data Transfer Cartridges (DTC), which were used to load mission plans onto aircraft. As the Air National Guard (ANG), traditionally a more resource-constrained organization than the Active Duty (AD) Air Force, lacked the mobility assets and resources to carry a MSS-II on deployments and exercises, two aviators, Major Walter Sobczyk and Major Robert Sandford, were determined to build a PC-based solution that would mimic MSS-II functionality on a more portable hardware solution. The resulting product, called the Ogden Data Device (ODD), paired with a PC running FPLAN to effectively replace MSS-II for ANG units, and ultimately began to spread into AD squadrons. By 1989, TAC, initially frustrated by the ODD/FPLAN solution’s popularity in AD squadrons in the face of the sponsored MSS-II product, mandated that MSS-II emulate the FPLAN interface and also directed follow-on MSS-II programs to provide both UNIX and PC solutions (Lindsay, 2010).

In 1991, the Gulf War underlined the usefulness of automated mission planning, providing evidence of the value of digital mapping and imagery, but also highlighting the insufficient number of MSS-II systems. In response, the Air Force’s ESC, the formal acquisition arm for C2 systems and Information Technology (IT) programs, established the AF Mission Support System (AFMSS) program office to develop the Mission Planning System (MPS). The scope of MPS, which was more wide ranging than MSS-II, quickly mired the program in bureaucracy and led Maj Sandford, assigned to the National Guard Bureau headquarters in 1992, to acquire end-of-year fallout funds to develop a solution that could function on a single laptop. In 1993, he capitalized on an existing contract vehicle teaming with GTRI to release the first tested version of FalconView in less than 9 months. Maj Sandford was intimately involved in the architecture and interface discussions during development, and as a lead user, “sometimes even [coded] software to convey a concept” to GTRI engineers (Lindsay, 2010). His direct involvement made the user interface a priority (e.g. the Microsoft Office style of the software, familiar to many aviators) and emphasized usability (e.g. map overlays could be saved and
shared as small files). This initial capability was entirely focused on the F-16 community. FalconView’s user community would quickly expand from these initially humble beginnings (Lindsay, 2010).

By this point, Maj Sandford was leading the grassroots FalconView development while Maj Thorn had progressed to become the manager for the formal program, still focused on developing the MPS. While friction existed between the more popular FalconView product and the formal program, Maj Sandford continued to push forward. He recognized the need to replace FPLAN and was able to team with the formal AFMSS office to procure funding for Combat Flight Planning Software (CFPS), which would update the flight planning capabilities for FalconView’s display. Capitalizing on Maj Thorn’s realistic view that a stop gap was needed until MPS could be made operational, the formal support for CFPS also added the critical Aircraft Weapon Electronics (AWE) capability to CFPS, providing for platform-specific cartridge loading (Lindsay, 2010). With FalconView, CFPS, and AWE integrated under the Portable Flight Planning System (PFPS), AFMSS became concerned with the extremely capable informal system that was progressing quickly in contrast to MPS, which was facing negative feedback and familiar acquisitions problems. PFPS pushed forward in the face of AFMSS-instigated resistance. With a stop gap still necessary and political protection provided by ANG and Air Force Reserve sponsorship, FalconView 2.0 was released in 1996. With the unfortunate crash of a CT-43 transporting the US Commerce Secretary in April 1996 and the ensuing investigation that asserted FalconView moving map displays could have helped the aircrew avoid the crash, the Air Force made use of FalconView mandatory on all aircraft transporting senior leadership (Lindsay, 2010).

By 1997, the FalconView community had expanded to over 13,000 end users. With the undeniable popularity of the grassroots solution, the crash that highlighted the value of the software, and the continued problems with MPS, the AFMSS Program Manager (PM) was fired and the program office was directed to officially incorporate PFPS into the formal product in development. With this level of endorsement, funding also came to the FalconView developers and version 3.0 was released later that year. The Mission Planning User Conference (MPUC) organized by about 12 users in 1993 had expanded to 1,100 attendees in 2000 and an informal newsletter had begun circulation from the National Guard Bureau (NGB) headquarters as free revealing of FalconView employment profiles continued to flow through the mission planning
community. The Navy had also joined the PFPS revolution in 1998, approving its distribution through NAVMPS, then its formal automated mission planning program. User contributions (typically no more than $200K), had continued to fuel feature additions with users tightly collaborating with engineering teams. User involvement had expanded with the promotion of third party development by GTRI, as the team had released a SDK in 2002. Underlining the popularity of the capability, the Air Force, Navy, and Special Operations communities were employing PFPS as their primary automated mission planning tool (Lindsay, 2010).

In essence, the user reaction to mission planning development was to support the grassroots FalconView with funding and operational employment, while formal acquisitions designed to replace the user-driven solution continued to struggle under difficult acquisition processes and shifting requirements for panacea solutions. These parallel developments highlighted the ineffectiveness of the acquisition system in getting capability fielded and made FalconView the de facto standard in the operational community. As is often observed within motivated user communities led by proficient, power users, “operational users drove FalconView development and diffusion far beyond its initial scope as an F-16 mission planner, resulting in a versatile platform for networked planning and operations, all for a total cost of about $20M” (Lindsay, 2010).

3.4.3 - Integration of FalconView into a Formal Acquisition Effort

Perhaps unsurprisingly in Lindsay’s historical account of Mission Planning, the acquisition community’s response to the wildly popular FalconView/PFPS suite was to establish a program office to design its replacement, beginning in 1998. While admirable in its goal to provide a joint-approved solution for all services, the Joint Mission Planning System (JMPS) experienced many of the problems that plagued its predecessors. The program was created in response to a USAF-funded Carnegie-Mellon study that recommended the USAF move away from the rebellious FalconView, which was deemed too personality dependent due to its user-driven development. The goal was to establish a common, PC-based MPS with the initial scope centering on PFPS functionality. With the ambitious scope of providing every service with a mission planning system, JMPS suffered from continued requirements evolution and the service in-fighting that is common in joint programs. In the meantime, FalconView continued to field operational versions of the software through 2006 as, once again, a stop-gap to a formal program.
struggling to deliver. All told, one quote of the two programs stated that FalconView cost $20M between 1993 and 2006, while JMPS was project to exceed $1B in its first decade. Ultimately, JMPS was fielded but only after GTRI was contracted to adapt the FalconView mapping engine for inclusion in JMPS (Lindsay, 2010). Use of FalconView remains prevalent throughout DoD through 2013, while JMPS continues to be fielded throughout operational communities.

3.4 - Ironman and the Fight for Agile Acquisition of a Field Expedient

3.4.1 - The Evolution of the Crew-Served Weapon

Another example of user innovation occurred in the mountains of Afghanistan during OEF. The shifting tactics employed by insurgent forces during OEF necessitated rapid adaptation of American tactics in order to gain the upper hand in engagements with the enemy. This naturally resulted in the type of field expedients that U.S. forces have been known to produce when formal acquisitions processes simply fail to generate the needed capabilities. An auto-feeding ammunition system for crew-served weapons that came to be known as Ironman was one such field expedient developed by dismounted infantry soldiers serving in Afghanistan. The term “crew-served” applies to weapons that are operated by at least 2 soldiers, usually because more ammunition or equipment (e.g. tripods or bases) is required during employment. The original Ironman system consisted of a jury-rigged combination of welded ammunition cans strapped to an old all-purpose lightweight individual carrying equipment (ALICE) frame with an added modular, lightweight load-carrying equipment (MOLLE) pouch for holding other equipment (Reinert, 2011). A feed chute assembly from a vehicle Common Remote Operating Weapons Station (CROWS) was incorporated to complete the Ironman kit. It was originally designed as a complement to the Mk-48 7.62mm machine gun, a weapon employed by many deployed troops during the wars in Iraq and Afghanistan.

3.4.2 - The Value of Ironman

The system was designed to allow a single gunner to carry 500 rounds of ammunition unassisted with an auto-feeding mechanism, eliminating the need to frequently reload shortened ammunition belts (Tarantola, 2011). In other words, Ironman allowed a 2- to 3-man crew-served weapon to be operated by one soldier. In Afghanistan, this was especially important for units operating in mountainous terrain during long firefights with the enemy, as weapons teams found it difficult to stay together and inefficient to use the shortened ammunition belts. Ironman
provided the capability to carry the ammunition with a combat load (i.e. 43 pounds with 500 rounds) and still have 17 pounds remaining for additional equipment without operating outside of Army specifications. While the combat load was undoubtedly burdensome for the machine gunner, the benefits to the collective squad of freeing up one to two soldiers to focus solely on the firefight were immense. With the auto-fed system in place, continuous reloading eliminated the lulls in fire many squads experienced due to reloading and also alleviated additional, cumbersome equipment (e.g. the ammunition sacks that came with the Mk-48) that troops found difficult to bring on patrols (Reinert, 2011).

3.4.3 - Drawing Inspiration from Jesse Ventura: How Users Developed the Ironman System

In this case, the true breakthrough innovation was indeed driven by end users. The Iowa National Guard, known as Task Force Ironman, drove the design and initial prototyping of the system after experiencing difficulty employing the Mk-48 machine guns they were issued upon arrival in theater. They were especially troubled by the ammunition belts during foot patrols in the extremely difficult terrain in Eastern Afghanistan. Their initial solution was to divide the belts into 50-round segments, but this proved ineffective for maintaining fire, most notably during a heavy engagement with insurgents that lasted 2.5 hours (Tarantola, 2011). Recalling the actor Jesse Ventura’s auto-fed mini-gun in the movie Predator, the soldiers wondered why a similar capability was lacking in the Army inventory. Inspired by the image of a fictional commando eviscerating jungle foliage with sustained fire from an auto-fed mini-gun, the guardsmen set out to create a similar capability.

After four months of operating in Afghanistan, Staff Sergeant Vincent Winkowski led the development of the initial prototype Ironman system with the aforementioned crude combination of ammunition cans, an ALICE frame, a MOLLE pouch, and a feed chute assembly. With his in-depth knowledge of both dismounted operations and the Army inventory, Staff Sgt. Winkowski had been able to imagine an auto-fed solution for dismounted patrols that was similar to the feeding assemblies onboard some Army vehicle turrets. With the assistance of his squad’s Mk-48 gunners, Specialists Derick Morgan and Aaron McNew, Winkowski assembled the crude prototype, added a simple block of wood to the ammunition cans to prevent rounds from falling in on each other, and quickly tested the solution at the shooting range. On February 26, 2011, Ironman was employed during an engagement with the enemy and performed well enough for
the soldiers to elevate the design to leadership for consideration as a candidate for further development. While the prototype undoubtedly had its shortcomings resulting from the nature of a field expedient, it improved upon Task Force Ironman’s current tactics, techniques, and procedures (TTP), aided the unit during real-world firefights, and eventually won the award for soldier’s greatest invention in 2011 (Hsu, 2012).

3.4.4 - The Fight to Support a Field Expedient

When the operators took the critical step of bringing their innovation forward to Army leadership in theater, science advisors recognized the system as a valuable capability that needed further refinement. These science advisors were deployed to Afghanistan to provide a catalyst for rapid requirements development for the service’s Research, Development, and Engineering Command (RDECOM). RDECOM quickly delegated the project to Natick Soldier RDEC (NSRDEC), with responsibility eventually falling to the Quick Reaction Cell (QRC). NSRDEC is a science and technology (S&T) lab that often pursues development in support of programs that are eventually transitioned to Program Executive Office Soldier (PEO-Soldier) for formal test and evaluation and initial procurement. David Roy, a NSRDEC current operations analyst, received the tasking in April 2011 (Roy, 2013). Recognizing the need for expediency as soldiers awaited a refined solution in the field, Roy moved quickly to carry out the Quick Reaction Cell’s mission of rapid prototyping and equipping to demonstrate technology with deployed troops (McGuiness, 2011).

After pulling in subject matter experts skilled in prototyping, load carriage, machining, and fabrication, Roy’s team released the first prototype to users for a Field Operational Assessment (FOA) in May 2011 (Reinert, 2011). In only 48 days, the development team had essentially reverse engineered the field design and substituted the crudely assembled parts for a repeatable design (e.g. the ammo compartment used polycarbonate plastic rather than the modified ammo cans). The prototype was released for evaluation by 13 deployed soldiers who, in turn, validated that the design met general requirements and also suggested improvements. These suggested improvements ranged from tweaks to the feed chute assembly’s placement to simple requests such as including a handle on the top to ease transportation of the pack (Roy, 2013). Following the initial round of feedback in May, Roy’s team responded to the direct user feedback by improving the design and releasing a second prototype within 45 days. The second
round consisted of providing 5 prototypes to the field. As these prototypes were seen in theater, RDEC’s Science Advisors were quickly approached by other users requesting the new capability. These approaches included requests that the system be compatible with the 7.62mm M-240B machine gun and another one to look into creating an Ironman for weapons that used 5.56mm ammunition (Reinert, 2013).

As a prototyping shop, the NSRDEC Quick Reaction Cell lacked the manufacturing capability to fill every user request for an Ironman system. This highlighted the need to transition the project to PEO-Soldier for formal acquisition and distribution to a large number of squads in Afghanistan. In an attempt to increase the stability of the effort, Roy’s group approached PEO-Soldier to review the status of the program and look into transitioning the effort to the office responsible for soldier-carried equipment. While the initial rapid fielding of Ironman had been an example of cross-organization coordination and collaboration between PEO-Soldier, Warfighting Protection and Aerial Delivery Directorate, Armament Research Development and Engineering Center, Tactical Communication Integrated Logistics Support Center, and the Army’s T&E Command, the transition effort met stiff resistance from acquisitions managers that wanted a formal requirement and requirements personnel that refused to recognize Ironman as an enduring capability (Foran, 2011; Roy, 2013). Even as additional requests from the field flooded into NSRDEC, Ironman remained in limbo. Fortunately, Roy had established a work-around in the event PEO-Soldier proved difficult to convince. The Rapid Equipping Force (REF), a group established to flatten the requirements process and speed the fielding of urgent operational needs during OEF and OIF, was able to quickly validate user requests from the field for Ironman systems with a requirements process that was parallel to the formal procedures (Roy, 2013). These REF-generated requirements, called 10-liners, provided NSRDEC with the necessary tasking (read: cover) to continue to produce the Ironman for users clamoring for the system. With the support of the REF, NSRDEC continued to manufacture Ironman, with up to 175 systems projected to be in the field in 2013.

According to Roy, the Quick Reaction Cell has largely been dissolved as the Army prepares for the conclusion of operations in Afghanistan, and the Army acquisition centers appear to be allowing Ironman to “die on the vine” as troops begin to return home and requests to the REF cease to be generated (Roy, 2013). With these developments, Ironman will likely be relegated to history with 175 systems remaining in the Army inventory, unrecognized as an
enduring capability by requirements managers and unsupported by an active program office. The true irony in the Army’s failure to recognize Ironman as an enduring capability is that Roy’s review of the history of the Vietnam War revealed the existence of an earlier weapon nicknamed the “Death Machine.” It was a very Ironman-like belt-fed machine gun system that “connected an aircraft-type flexible feed belt to a 1,000 round backpack drum” (Plaster, 2000). This historical context seriously calls into question the Army requirements community’s assessment that the Ironman requirement did not represent an enduring capability.

3.5 - Apps for the Army: An Experiment in Emulating Commercial Development Practices

3.5.1 - There’s an (Army) App for That

In 2009, the Army set up a challenge in the hopes of testing out a fast-tracked software acquisition process and stimulating direct user involvement from soldiers and civilians with the technical expertise and motivation to write mobile device applications. This competition, branded as the “Apps for Army” (A4A) challenge, provided a test bed for a type of development that Army leadership saw as prevalent in the private sector and worthy of emulation within DoD. A4A came on the heels of the Apps for Democracy challenge, a similar effort that had taken place in Washington, D.C. urging developers to create apps that would use government-provided information to improve life in the city (Overly, 2010).

Being realistic about the dissimilarities that existed between military and commercial sector development, the Army decided that A4A would provide a worthwhile proving ground for agile, crowd-sourced software development. In essence, the idea was based on the assumptions that: (1) the Army could eventually provide a marketplace similar to Apple’s App Store that would facilitate publishing of user-developed apps for mass distribution to other like-minded users, (2) there were a significant number of soldiers or government civilians with the technical expertise to write an application, (3) a streamlined develop-test-certify-publish process could be attained within the DoD environment (and this less cumbersome process would incentivize users to develops apps in their spare time), and (4) users possessed need-related information that was difficult for formal developers to access and would make a user-developed apps model valuable for the Army at large.
3.5.2 - The A4A Sandbox

Basically, the intent of the A4A challenge was two-fold: (1) the Army would showcase soldier-programmers' skills in developing mobile applications, and (2) the Army would pilot a streamlined software acquisition process. The former would be motivated by cash prizes and the latter would be tested in a time-constrained challenge format. For the Army, the true focus was on testing a rapid certification and accreditation (C&A) and publishing process that was being pushed by the Army’s Chief Information Officer (CIO), Lieutenant General Susan Lawrence. The hope was that the “new submission and approval processes [would] eventually enable Army members, organizations, and third-party developers to release applications for Army-wide distribution” (Office of the Army CIO, 2012). However, the search for soldier-developers that was implicit in the challenge provided an excellent breeding ground for user innovation within the Army.

At the time that the idea for the A4A challenge took shape within the CIO’s office, the Apple App Store had been in existence for approximately one year with 100,000 apps already being distributed on the wildly successful platform. Army leadership saw this commercial example and believed that their service was composed of the type of tech-savvy soldiers that would be able to make an Army marketplace successful in delivering the type of user-specific apps that were not being generated by the acquisitions community (Motes, 2013). As a result, the A4A challenge was set up with a variety of services provided to create an environment that would help developers rapidly develop and deploy their applications. These resources included: (1) The Rapid Access Computing Environment (RACE), “a multi-platform, cloud-based, secure development environment, hosted by the Defense Information Systems Agency (DISA), that offers access to on-demand virtual Windows and Red Hat Linux development environments for Android, BlackBerry, SharePoint, LAMP, and ASP.net platforms,” (2) Forge.mil, discussed later in this chapter, for access to a collaborative software repository, and (3) milBook, the Army’s internal Facebook solution, in lieu of email (DON CIO, 2013). The developers received prioritized access to security certification resources and authorities, and after certification, the apps were judged in five categories, consisting of Information Access, Location Aware, Training, Warfighting/Mission Specific, and MWR/other.

The contest attracted 140 participants that were able to develop 53 applications over the 75-day challenge. Of the 53 applications, 25 apps met Army certification standards and 15 were
selected for cash prizes (Overly, 2010). The applications were distributed through the public-facing iTunes App Store, with hundreds of thousands of downloads as of the writing of this study.

3.5.3 - User Engagement in App Development

One such participant, LtCol Gregory Motes, was uniquely positioned to play an instrumental role in the A4A challenge. Stationed at Ft. Gordon, then-Major Motes had been tasked to head up the implementation of a program called Connecting Soldiers to Digital Applications (CSDA) within the Army’s training bases. This assignment had come after Lieutenant General Mark Hertling had made a request to the 15th Signal Brigade Commander, Colonel Mark Horoho, asking him to find a sharp officer to “push the envelope” on the use of mobile apps within Army training (Motes, 2011). Motes fit the bill and was quickly identified to lead the effort, which dovetailed nicely with the issuance of the A4A challenge at roughly the same time in March of 2010. In Motes, Army leadership had selected a true lead user with a background as an armor officer and scout as well as experience in writing applications and certification as a Certified Information Systems Security Professional (CISSP). His position as Chief, Information Dissemination Management Division at the Army’s School of Information Technology provided him with access to soldiers with similar backgrounds in order to build a small development team. After selecting two such students, the team quickly built on their development backgrounds with mobile app-specific training from iTunes U.

Motes’ team quickly began developing four applications. These included apps called Mobile Learn, which allowed students to import instructor-generated quizzes during coursework, Ft. Gordon 411, which provided a detailed map of on-post locations, PRT, a physical readiness training app, and SIGACTS, a more provocative app in that it was designed to ingest tactical data and display where significant activity was taking place on the battlefield. As a way of testing the cradle-to-grave process involved with app development, Motes also created a very simple app named Army Creeds that provided various Army mottos and quotes that soldiers may need to memorize during their career and published it to the App Store and Android Market in mid-April. By the completion of the A4A challenge, Motes and his team had published 20 apps in 17 weeks to either Android or iPhone and had already garnered over 40,000 downloads. The PRT app won its category and Ft. Gordon 411 and SIGACTS earned second place in their categories.
Among others, developers also earned recognition for a Movement Projection app that allowed soldiers to input obstacles and threats into road navigation plans to determine the fastest route and a Disaster Relief Operations app that provided a data survey, dissemination, and analysis tool that interfaces with Google Earth and Google Maps (DON CIO, 2013).

Summarizing the activities of Motes and his team ignores many of the challenges the team faced in generating these relatively simple mobile applications. In spite of the Army’s support for the A4A challenge and the base commander’s interest in the project, Motes recalls encountering significant pushback from many middle managers that did not like the idea of providing Army-related information on public-facing app stores. In fact, at the time of Motes’ activities, his work aligned with two of the six top priorities for the commanding general at Ft. Gordon, including the pursuance of mobile apps for Army end users and the education of Army soldiers and civilians in app development. However, the development team was small, approximately 3-5 personnel, and to many, the effort was a pet project for a commanding general that was not involved in their daily activities.

Motes earned most of the resistance to his development activities due to his conscious effort to push the envelope with Army app development. Though many of the apps being submitted to A4A simply repackaged information provided in regulations and well-known procedures, Motes intentionally pursued the SIGACTS and Ft. Gordon 411 apps as a way of testing the limits of what could be distributed on public app stores and eventually, the Army Marketplace. Both apps displayed potentially sensitive information, as Ft. Gordon 411 annotated detailed layouts of the base that some considered a violation of operations security (OPSEC) policies, and SIGACTS was designed to display activity reports that are often classified. After being told that Ft. Gordon 411 would never be approved by the local base webmaster, Motes pursued approval through the Public Affairs Office (PAO), and with agreement from the PAO and some study of applicable regulations, Motes moved forward with submitting the app. As a workaround for SIGACTS, Motes and his team developed the infrastructure to display For Official Use Only (FOUO) and classified activity reports but instead used WWII data to prove the concept worked. Ultimately, Motes and his team developed apps that highlighted a major shortfall of the A4A challenge. The competitors were essentially being constrained to developing apps that displayed completely unclassified information and were unable to distribute apps that dealt with FOUO information, much less classified material (Motes, 2013).
Motes experienced other problems that, at first glance, should have been relatively low hanging fruit for an effort with 3-star support. Many very basic and more practical obstacles hindered the team’s activities. One example was Motes’ inability to establish an Apple developer account under his Army organization until 14 months after the initial request. This was due to local policies and legal procedures that required approval by multiple echelons of management. To solve this, Motes had obtained a personal account to move forward with development long before the Army was able to work through the bottleneck. Motes also ran into issues more familiar to commercial developers, such as a trademark dispute when a company named Blackboard notified the Army that they had the rights to the “MobileLearn” name that Motes had chosen for the quizzing application. The app was subsequently removed due to the fact that it was not in wide use and Motes lacked the legal support to fight the company.

While this is certainly not an exhaustive list, many other participants in A4A faced similar challenges. However, the applications that were developed, certified, and loaded to public-facing app stores proved that Army soldiers and civilians have the expertise to develop applications. While the number of participants may not have met the Army’s expectations, a small cadre of tech savvy personnel undoubtedly exists. Additionally, the Army was able to prove out a method of development that, according to then-CIO Lieutenant General Jeff Sorenson, “[eliminated] the need for writing a requirements document, doing a request for proposal, and doing all the ‘bureaucratic acquisition process that…slows [the Army] down in trying to deliver a capability” (Lopez, 2010).

3.5.4 - Difficulties in Building on A4A-Generated Momentum

After the A4A challenge, the students comprising Motes’ team moved on to continue their schooling and Motes himself eventually moved to another assignment, where he now serves as an Information Assurance division chief. The Mobile Applications Branch that he headed after his strong performance in A4A has since been dissolved. However, the CSDA initiative, now in Ft. Leavenworth, Kansas, is still being funded and supported by Army leadership.

While there were many challenges associated with participation in A4A, Motes regards the effort as a mix of successes and failures. Publicly, the Army advertised the program as highly successful, in that it provided a proving ground for a faster acquisition process and generated enough user interest to produce 53 app submissions. However, the result is more
complicated when you consider that only government personnel participated in the program, which removed much of the complexity introduced by third parties. Further, the unclassified-only apps that were developed were loaded to commercial app stores, rather than an Army Marketplace available to soldiers and civilians.

Three years after the effort, the distribution platform solution remains elusive. Motes contends that the Army has solved the technical aspects of the Army Marketplace, but with the move to DISA enterprise services, the Army has resisted moving forward with a service-specific solution (Motes, 2013). With respect to the specific apps that Motes and his team developed, many remain on the iTunes store, registered under his name rather than sponsored and supported by the Army. He continues to receive approximately four to five emails per week from Army users but lacks the time to make all of the updates and fixes that are requested.

The Army had plans to sponsor a second A4A open to the public and commercial developers but appears to have put the program on the backburner while the enterprise-wide distribution platform is developed. Establishing an app marketplace remains a priority for the service, but at the time of this research, figuring out a platform that will be useful to each of the services, formulating an approach to involve third party developers, and addressing security concerns remain troublesome problem sets.

3.6 - Forge.mil: A DoD-Sponsored Platform for User Innovation

3.6.1 - An Online Host for User Innovation Communities

As the DoD searches to establish environments that are conducive to user innovation, projects like Forge.mil have been instantiated to create collection points for those users and developers who seek to collaborate with like-minded innovators that might be pursuing similar efforts. In its most basic form, Forge.mil is a website that provides an online code repository to the DoD community at large and allows users to form collaboration communities working on defense-related software projects (Perera, 2012). In many cases, this basic construct is extended to provide an online development environment for coders working with open source and DoD community source software (Forge.mil Homepage). In other words, this project represents a best effort to design a sanctioned home for an online community of DoD users in need of functionality similar to SourceForge or Github but unable to leverage open sites due to security requirements.
To be frank, the site is functionally equivalent to SourceForge.net with the major
distinction being that it lies within the DoD firewall. Forge.mil offers DoD projects free hosting
capabilities for open source projects and fee-for-service offerings for those projects with greater
access control requirements. The Forge.mil domain is divided into three subsections: (1)
SoftwareForge is designed for projects pursuing open source and DoD community source
development projects, (2) ProjectForge houses projects requiring the same functionality as
SoftwareForge with the added constraint of increased security requirements that preclude the
ability to pursue open- and community source-development, and (3) Forge.mil Community is
intended to provide an open collaboration forum for developers pursuing DoD-related
development that may apply to multiple projects.

Prior to Forge.mil, DoD development only existed in a world of closed development
environments and private enclaves. These were hosted in the labs of private contractors and
government-run facilities. What prompted the growth of Forge.mil was an Army-run initiative
designated Federated Development and Certification Environment (FDCE) for service-oriented
architecture (SOA). FDCE was a smaller scale effort to emulate SourceForge.net within the
C2 community. As senior leadership recognized the value of collaborative software development on
a small scale, the desire to create an enterprise solution became a high priority. This push by
senior leadership, a key enabler for many user-driven projects, eventually extended to the Vice
Chairman, Joint Chiefs of Staff, General James Cartwright, whose support ensured that the
Forge.mil vision would become a reality. As the team attempted to emulate open projects like
SourceForge.net, DoD-specific requirements for increased security were recognized upfront and
integrated as part of the core system requirements (Grosenheider, 2013). While this was
immediately acknowledged as an undesired constraint for a project hoping to imitate open source
innovation domains, the Forge.mil team considered it an unfortunate reality within the DoD
ecosystem.

The nuts and bolts of the Forge.mil environment are the Subversion version control
system and CollabNet TeamForge application life cycle management tool (Forge.mil FAQ). The
Drupal open source content management system powers the Forge.mil Community functionality
with respect to the social collaboration tools. This tool suite includes discussion threads, blogs,
group polling features, document management, and idea forums. The aggregate of these tools
was designed to stimulate an active user base motivated to self organize, discover commonality, and effectively pursue distributed development.

3.6.2 - The Value of Forge.mil

Administered by DISA, Forge.mil was created in 2009 to finally provide a home for open source software coders within the defense community. In an industry where stove-piped development was, and still is, identified as a common source of redundancy and inefficiency, Forge.mil was designed to allow for code re-use and cross-program collaboration. DISA advertises the service as “a family of enterprise services provided to support the DoD's technology community [by facilitating] collaborative development and IT project management through the full application lifecycle” (DISA Homepage). Many of the services represent open source best practices, including “software version control, bug tracking, requirements management, and release packaging along with collaboration tools such as wikis, discussion forums, and document repositories to enable collaborative development amongst distributed developers” (Forge.mil FAQ).

Part of DISA’s original charter for Forge.mil was to allow for increased speed in software development projects by improving the environment for interactions between geographically dispersed teams that also may be able to leverage an existing code base. At the macro level, the version control, bug tracking, and rapid delivery methods provided by Forge.mil were intended to increase speed-to-market and reduce development costs. One DISA estimate indicated that savings ranging from $18,000 per project for small teams (i.e. 1-15 developers) and $1.2 million per project for enterprise groups (i.e 300-2,000 developers) have proven realistic within the Forge.mil domain (IDC Customer Spotlight, 2013). As compared to previous environments that were typically project-specific, Forge.mil filled a void within the DoD for functionality that had long since been proven outside of the defense industry.

3.6.3 - User Engagement with the Project

When Forge.mil went operational, users quickly recognized the value of an enterprise service that provided the tools for community-driven projects. By mid-2013, adoption across DoD expanded to 24,000 registered users, 900 projects, 200 active groups within the Forge.mil Community, over 2,900 applications, and over 150,000 downloads of software, source code, and documentation (IDC Customer Spotlight, 2013). This growth was generally aided by word-of-
mouth and, more importantly, DISA team members called community managers who met with users, managed requests from projects for information about standing up Forge implementations, and led evangelism efforts to promote rapid adoption of Forge.mil tools and principles.

Susan Grosenheider (2013), a retired Army Lieutenant Colonel who worked on FDCE and current Forge.mil community manager, estimates that 80% of users are initially attracted to the site by Forge.mil’s Subversion version control system capabilities. This use case appears to constitute the most common scenario for projects on Forge.mil, closely followed by employment of the tools to distribute source code, software, and documentation. From a purist’s perspective, simple employment of tools for configuration management and software delivery represent the use of a program management toolset. However, the availability of this infrastructure on an enterprise-wide basis constitutes a significant step in the DoD’s conflicted pursuit of the benefits of distributed innovation.

Typical criticisms of Forge.mil follow a familiar path for critiques of military-led development. True acolytes of open source philosophy and methodologies lead these criticisms which focus on the relatively closed nature of the Forge community as compared to SourceForge.net and GitHub. The aforementioned security requirements that are currently a reality of participation in the DoD community entail a noteworthy barrier to entry. To become a registered member of the Forge.mil community, developers must gain access to a Common Access Card (CAC) or External Certification Authority (ECA) certificate. With either of these two credentials, users are able to clear the Public Key Infrastructure (PKI) based restrictions to enter the Forge.mil environment. While this seems to be a relatively basic requirement, open source innovation projects typically work to create little to no barriers to entry in order to generate pain-free adoption. As opposed to GitHub, which takes seconds to create an account and log on, obtaining a CAC or ECA for access to Forge.mil may take weeks.

The classical open source philosophy also runs counter to the ProjectForge construct, which paves the way for military users to default toward a more restrictive approach. In order to mitigate these well-founded criticisms, Forge.mil and the projects that embrace the Forge.mil philosophy attempt to encourage increased buy-in from users to engage more actively with the social networking and collaboration tools, as yet under-utilized aspects of Forge.mil.
While these open source enthusiasts exist within the DoD, a larger problem exists with private contractors that are incentivized to limit government rights to software and its source code. Even as the DoD continues to emphasize unlimited rights to software produced for the government, contractors advocate closed development environments in private labs, as a means of maintaining control and optimizing development environments. Though more prevalent within defense contractors, the preference for a closed environment extends even to some government personnel, influenced by an overly conservative acquisition community (Grosenheider, 2013).

In spite of these criticisms, Forge.mil has built up an extensive user base, including projects leveraging the environment to maintain their source code, collect trouble tickets from far-reaching user communities in the field, and generate and track their requirements. Forge.mil management is also beginning to see the community answer questions posed by other users, an encouraging development on the path toward a self-sustaining user base. From a broad view, DISA has seen encouraging adoption numbers as it searches for a happy medium between open and secure (Grosenheider, 2013).

3.6.4 - A Balancing Act Between Lowering Barriers for User Participation and Security Needs

While Forge.mil’s vision is to “improve DoD’s ability to rapidly deliver dependable software, services and systems,” the ultimate objective of the broader effort is to facilitate a cultural shift within the DoD to embrace open source and community development principles (Martin and Lippold, 2011). In this effort, the project has experienced mixed success. Many of the exogenous factors (e.g. security considerations, intensive testing requirements, lack of motivation from defense industry partners to buy in, DoD firewalls, etc.) associated with pursuing open source in the DoD environment are to blame for this muted endorsement. That is to say that the product itself goes far in emulating wildly popular open source community sites freely available on the internet (SourceForge.net, GitHub, etc.), but the difficulties in stimulating the grassroots engagement that is critical to truly valuable community innovation are clear within the DoD environment.

In spite of the many barriers, the Forge.mil management team is pressing on with the effort to evangelize open development and looking to expand the environment to include an increasing number of lifecycle management tools. This effort will be encompassed in an
initiative designated MilCloud, which will include testing, certification, and accreditation capabilities to build on the development tools already incorporated into forge.mil (Gahafer, 2013).

Plans are in place to integrate functionality to accept DoD-interoperable PKI certificates issued by other government agencies and industry partners, allow CAC/PKI-enabled client access to integrated Git repositories, and become part of DISA’s emerging cloud environment (IDC Customer Spotlight, 2013). In general, DISA is looking to expand upon its well-established foothold within a development environment that is often more fractured than one might expect. Senior leadership continues to support the project’s admirable goals and perceives the value of finding the right balance between the crowd-sourcing that has generated so much excitement in the commercial sector and the security requirements that are an absolute within defense. DISA leadership is pushing for an expanded development environment that includes more robust collaboration and testing capabilities in the hopes of finally achieving the goal of providing an online replacement for closed development environments and government labs.

3.7 - Expeditionary Lab-Mobile: Alleviating Development Project Transfer Costs between Stateside and In-Theater stakeholders during Conflicts

3.7.1 - A Maker Space for Soldiers

One of the benefits of user innovation is often the reduction or altogether elimination of transaction costs associated with transmitting need-related information, or requirements, to developers in far-removed laboratories and testing centers. One way in which the Army has attempted to target the non-value added costs associated with the requirements process is by creating deployable labs through the Expeditionary Lab-Mobile (ELM) program. The labs are the result of visionary thinking by Colonel Peter Newell, former director of the REF, as his team searched for a “platform of the future” that would continue the REF’s mission after OEF and OIF concluded (Cox, 2012). Part of the “Connecting Soldiers to Scientists” initiative, the labs were designed as a means of embedding developers and rapid prototyping equipment with deployed troops in order to facilitate direct information exchange between operators and engineers.

The labs themselves consist of two roll-out modularized carts that can be customized based on a given operating environment and the associated needs. The modules comprise an advanced workshop designed to flatten the requirements process and ensure fast delivery of
needed capability. The labs are, in essence, 20-foot shipping containers filled with “3D printers, computer-assisted milling machines, and laser, plasma, and water cutters, along with common tools like saws and welding gear” (Hill, 2013). This equipment allows for quick generation of parts made of plastic, steel, and aluminum. In addition to the tooling described above, the labs arrive with satellite communications to allow engineers to communicate with development teams in the United States. Altogether, the ELMs are quoted to be $2.8 million and weigh approximately 10-tons. The size of the labs was intentionally limited to make these maker-spaces easily deployed by trucks and Chinook helicopters. As of the writing of this document, two of the labs were located in undisclosed locations in Afghanistan and a third was being assembled (ELM Video, 2012).

3.7.2 - Empowering the User

In their most basic form, the labs are intended to co-locate experts on solution-related tasks with the source of requirements: soldiers. As a digital fabrication workshop, the lab was created by the REF to provide soldiers with on-the-spot delivery of capability gaps. This convenience lies in stark contrast to the process of submitting requirements to distant staff officers for eventual consideration by bureaucratic review boards that determine whether or not a request will be forwarded to the acquisition community. Many users are disillusioned by this process, and still others that go to the trouble of submitting requirements find that solutions do not arrive quickly enough to answer an urgent need. Colonel Newell’s REF was designed to address exactly those urgent needs, and as he sought to streamline the delivery of solutions, the ELM concept seemed to be a natural fit for the unit.

The ELM model encourages soldiers returning to forward operational bases (FOB) from patrols to communicate any problems or issues they are encountering during missions directly to embedded engineers. These problems may highlight issues with existing equipment or completely new requirements that current inventory items simply do not fulfill. With fresh, need-related information, the ELM developers are then able to use the wide array of rapid prototyping equipment to quickly fabricate equipment, collaborating with users to brainstorm potential solutions, immediately test prototypes, and collect instant feedback. This rapid prototyping process is designed to result in short-term solutions that fill an urgent need, rather than mass-produced equipment for the Army at large. However, the prototypes that succeed in
successfully fulfilling operator needs represent valuable test cases for potential Army-wide solutions for a fraction of the cost associated with requirements generation and research and development at home station.

3.7.3 - User Participation in the ELM Project

A few examples of the utility of the ELMs have emerged from operations in Afghanistan. To demonstrate the detailed understanding developers gain from being embedded with operators, the ELM team points to a solution that, while basic, proves the value of directly interfacing with soldiers. In this case, troops were encountering difficulty with a raised power button on a flashlight that was often inadvertently being activated. This worried soldiers due to the potential of giving away positions if the light was visible or not having a working flashlight if the equipment had been turned on inside a bag without the soldier's knowledge. Soldiers were skeptical that the Army would respond to such a simple requirement due to the cost associated with decommissioning and replacing a sanctioned inventory item. In response, the soldiers worked with the ELM team to fabricate a very basic plastic clip-on guard for the end of the flashlight. The solution was quickly generated and in use by the troops, totally bypassing the costly processes highlighted above (Hill, 2013). The joint ELM-soldier teams have also developed the Rapid Deployable Integrated Security System (RDISS), a surveillance system tailored to user needs in Afghanistan, and a more user-friendly mount for the Ground Penetrating Radar (GPR) used with armored vehicles to detect improvised explosive devices ("Expeditionary Lab-Mobile" Video, 2012).

3.7.4 - ELM-Generated User Innovation

The labs are still co-located with deployed troops in Afghanistan, and the REF has plans for the ELM after the conclusion of OEF. To date, the labs have been responsible for innovations that include IED jammer emplacement systems, improved valve stem covers for mine-resistant ambush protected (MRAP) vehicles experiencing problems with flat tires, novel surveillance systems, weather protection for deployed equipment, and new gear for combat search and rescue (CSAR) forces. Each of these innovations was directly requested by soldiers in-theater, developed in close coordination with the user, and costs little to nothing beyond what is contained in the ELM. Given its early successes, the Army sees utility in continuing the ELM
program in order to maintain the capability for potential disaster relief operations and future engagements.
Chapter 4 - Discussion

While the cases included in this study are certainly not an exhaustive list of user innovation within the military, they constitute a representative sample of the type of user-led development that occurs regularly in the DoD. These cases are often widely publicized and highlighted by senior leadership as evidence of the ingenuity of soldiers, sailors, and airmen. However, as we have observed in the case studies above, user innovations predominantly exist on the outskirts of the established acquisition process. Further, they are frequently in direct competition with program office-led R&D efforts that are sometimes initiated in spite of the existence of already popular grassroots developments.

Formal efforts exist along a spectrum from current products viewed as inadequate by users to development projects established to replace user innovations that are considered ungainly field expedients begging for a more refined solution that only R&D professionals can provide. Regardless of whether or not a competing project exists, user innovations regularly fly in the face of the acquisition community’s policies and procedures. As a result, they are often resisted by the very acquisition personnel that are supposed to be in the business of supporting the unsatisfied user. Despite resistance from a firmly entrenched bureaucracy, user innovations are able to achieve varying measures of success, as illustrated by select case studies. Von Hippel’s research shows that this is not an unfamiliar pattern.

So, what can we learn from the case studies recounted above? With a detailed examination, it is possible to glean lessons learned from each of these unique cases. Their stories shed light on different classes of user innovation as well as efforts by the military to more effectively recognize and facilitate operator-led development, regardless of the formal acquisition system’s apparent distaste for it. For example, the Expeditionary Lab-Mobile (ELM) project represents a bold attempt to penetrate the barrier that divides users and developers. To reduce the transaction costs that exist when requirements are flowed to the R&D community, the ELM projects seeks to co-locate need-related and solution-specific information to stimulate direct interface between user-innovators and development personnel able to provide the engineering perspective users sometimes lack. This effort to capture users’ ideas at the source and stimulate participation in the development process by operators that may be jaded by
previous experiences with unresponsive capabilities is a compelling attempt to catalyze user innovation.

In addition, Cursor-on-Target (CoT) and FalconView constitute software projects designed by users for users. Both systems are impressive in their acknowledgement of the power of third party development and have largely succeeded because of the ease with which users can integrate the capability and incrementally improve upon existing functionality. Further, Forge.mil and A4A seek to establish platforms intended to serve as focal points around which user communities can form, share ideas, and develop mutually beneficial products. Finally, Ironman exists as evidence of textbook user innovation, a system that was developed unilaterally by a user seeking to improve an existing product that failed to provide the needed capability. Ironman is also intriguing in the Natick Quick Reaction Cell’s involvement as an organization designed to respond to user needs that have gone unrecognized by the formal acquisition community.

As noted above, each of these efforts experienced varying degrees of success and provides an interesting study in the challenges and benefits associated with user innovation within the DoD environment. This chapter will delve into further detail on each of the cases in an attempt to identify lessons learned and analyze how these types of development projects might be more effectively harnessed and exploited by the military. These lessons learned will serve as a foundation from which areas for improvement and potential solutions can be formulated.

4.1 - Lessons Learned from CoT

The CoT story is one of innovation fueled by a strong user community motivated to engage with development of an expanding data standard and software suite in order to leverage potential network effects. In this case, the innovator, Mike Butler, was not a military end user in the traditional sense, but a federally-funded developer that had serendipitously experienced first-hand user pain points while in the field. Once he began development of CoT, his personal experience with users’ needs and close coordination with operators led to an end product that responded effectively to warfighter requirements and allowed for further extension. Butler was perceptive enough to know that he was simply unable to predict all use cases for CoT and
allowing for user development would ensure that the data standard and software would remain tightly aligned with the future evolution of the CoT community.

Knowing this, he was also realistic in acknowledging that a general rule set was needed to make certain that true interoperability could be achieved through CoT employment. Butler possessed the technological expertise to carefully define a rulebook that strictly governs how users are allowed to define their data sets in such a way that avoids restricting the types of use cases in which CoT can be employed. In other words, Butler was able to cultivate a development space where coders can expand on CoT capability and know that others are pursuing similar efforts in a way that precludes incompatibilities amongst disparate systems. In fostering this sort of environment, Butler instigated a sort of well-managed chaos that continues to yield improvements on the core capability through the first decade of CoT’s existence. Extrapolating from this case, the establishment of a framework in which users can operate often facilitates increased user involvement as the community becomes comfortable with the reality that each incremental innovation will complement, not break, existing functionality.

Other characteristics of CoT that mobilized an active user base were its low-cost, lightweight implementation and accessibility. Users’ ability to quickly implement CoT with no requirement for significant funding or personnel resources allowed for rapid prototyping and swift realization of the software’s value. Its existence as a public release technology further lowered the barriers to entry and naturally expanded a user base hungry for more interoperable technologies. If CoT had developed as a privately held, pay-for-play system, these benefits would likely have been overshadowed by a business case that mandated tighter control. This reflects a more short-term mentality that demands immediate profits often at the expense of more widespread adoption by a vibrant user community.

The vitality of the CoT community was often spurred by the free-revealing that von Hippel and others have repeatedly identified in user innovation groups. The military, perhaps, further galvanizes free revealing amongst users that are engaged in combat, often relying on other users to provide cover during battlefield operations. In this way, military operators are more incentivized than commercial actors to assist other users. For military users, sharing innovations with mission partners improves collective capabilities. In many cases, this is enough
to overcome military organizations' penchant for exclusivity, which is driven by classification levels and perceptions regarding outsiders' need-to-know.

Another lesson of the CoT case, and others within this study, is the need for a champion. In this case, the product champion faces the demanding task of supporting the user innovation to senior leadership, providing top cover for users facing resistance from middle management, and encouraging users diverted by their primary duties. For CoT, the champion was a general officer equivalent within the Intelligence arm of Air Force Headquarters. In this case, the champion evangelized the CoT cause with other senior leaders, provided funding to the office watching over the user community, and pressed users to expand CoT functionality. Whether the champion is the user-innovator, an executive supporting that user innovator, or a combination of the two, he or she plays a key role in seeing user innovation communities succeed.

Within the acquisitions community, the gravity of a procurement system expending billions of dollars in federal funding, permeated by political and economic interests, and built on bureaucratic, deliberate procedures is often simply too much for small user-led efforts to resist. Thus, a small program office within that acquisitions system is often a boon for small user communities pursuing unsanctioned development efforts. These program offices, when properly focused, act as shepherds and can improve outcomes from a user-led innovation group, especially within the military where funding and policy-making can often modify the natural trajectory of technology trends. While the office will face an uphill battle for legitimacy within the acquisition community, it can provide real value in overseeing user group activities, linking various users pursuing similar efforts, advertising successes to senior leadership sponsors, and providing a focal point for user community issues.

Finally, the CoT case demonstrates that strong user groups brought together by a viral technology have the ability to face down military leadership that sometimes favors a more legitimately sponsored (read: top-down) technology. In this case, leadership established a direct competitor to replace CoT. However, UCore's shortcomings and leadership's unwillingness to mandate curtailment of fielded, CoT-enabled technologies led to continued expansion of the user base. This user base, fueled by the viral nature of CoT, continued to integrate the technology into operational systems in the face of bureaucratic organizations denouncing CoT as a rogue data standard and software suite. The fact was, CoT "just worked" and the value to users was
obvious. In a hierarchical organization like the military, the willingness of the CoT user community to operate outside of formal policy direction is significant. However, it is difficult to determine whether or not this is a lesson that can be applied to more community-led efforts. Additionally, the user community in this case was likely emboldened by the fact that the leadership personnel that refused to formally sanction CoT were not required for access to funding and resources to develop the capability. A user innovation that requires significant upfront capital investment may produce a different result where leadership holds a position of more leverage.

In the end, the CoT lessons seem to constitute a familiar story of successful community development with a few military-specific insights. The benefits of lowering barriers to entry, building in third party development capabilities, and intrinsically motivated free revealing are not groundbreaking observations. But the value of a user community shepherd, the need for championing within senior leadership, and the inertia associated with user innovations integrated into operational systems shed light on the intricacies of user innovation within the DoD. Whether this is an isolated case within the Air Force or a representative instance that can be more broadly applied to the DoD environment remains to be seen, but at the very least, CoT illustrates that user-driven development can work within the military. However, just as in commercial industries, "governmental policy and legislation sometimes preferentially support innovation by manufacturers," hence the need for an organization like the CoT program office to protect users' interests within the DoD community (von Hippel, 2005).

4.2 - Drawing Conclusion from the History of FalconView

Many of the lessons learned from evaluating the CoT story are also revealed by an analysis of the FalconView case. While FalconView itself was not wholly developed by a pilot, the precursors to the software resulted from an informal development community consisting of aircrew members that were unsatisfied with mission planning capabilities at the time. Using the initial user-developed capability as a spring board, a particularly savvy flyer capitalized on an opportunity to work with a small cadre of professional developers that were able to refine what was, in essence, a field expedient. Maj Sandford’s technical expertise and firsthand knowledge of user needs resulted in a FalconView system that repeatedly outperformed formally developed systems. The tradition of user involvement in development activities that was initiated by
FPLAN developers and enhanced by Maj Sandford’s actions was further expanded by the creation of the third party development capabilities that paved the way for continual extension of FalconView capability. This development arc was defined by user involvement and ensured FalconView, like CoT, constituted a more responsive capability than formal acquisition programs designed to supplant it.

At a basic level, FalconView’s success can be attributed to its usability. As Lindsay pointed out in his revealing account of the system’s development, Maj Sandford and his team members’ focus on creating a system characterized by a user-friendly interface and features resulted in a product that users were eager to integrate into operations, expand with value-added extensions, and share with other aircrew members participating in similar activities. In many ways, this focus on usability is enabled by user-developers’ inherent familiarity with system requirements. Due to this familiarity, lead users save time that acquisition professionals spend attempting to understand and fulfill operator requirements. This time saved is then devoted to developing a capability that users will find intuitive and easily integrated into existing systems.

Said another way, users are naturally motivated and uniquely positioned to build in usability due to the fact that they will ultimately be consumers of the technologies they develop. Acquisition teams are simply unable to duplicate this dynamic, which leads to a focus on sell-off of formal requirements that is sometimes detrimental to creating a responsive capability (i.e. usability requirements are often much more difficult to articulate than more straightforward performance requirements). This dynamic was in evidence during FalconView development when contractor-led efforts produced UNIX-based solutions hosted on extremely large form-factor hardware while FalconView reflected a more familiar Windows-like interface on a simple laptop. As Lindsay rightly points out, this sort of responsiveness to user needs ensured FalconView’s continued survival in the face of tough resistance from the acquisitions community (Lindsay 2010).

FalconView’s success was also facilitated by personnel realities, within both the formal acquisition units and the informal user community. As with any innovation, the team developing the capability is a key determinant in the success of the project. FalconView was fortunate in the involvement of true power users like Maj Sandford who possessed firsthand knowledge of user needs, in-depth software expertise, the charisma to mobilize a user group, and the necessary
degree of irreverence for a formal effort that enjoyed massive funding and personnel advantages. As with CoT, where Special Forces-sponsors of the technology were uniquely postured to support a development effort outside the acquisitions community, FalconView was also supported by unique organizations.

The Air National Guard and Air Force Reserve units that led FalconView development were motivated by their relative lack of resources to produce an alternative to the bulky, expensive active duty-sponsored systems. And their existence outside of formal active duty Air Force channels allowed them to support development of FalconView regardless of sponsorship by the acquisitions community. These organizations also enjoyed the luxury of maintaining personnel at the same locations and jobs for long periods, which lies in sharp contrast to the formal acquisition units where military officers move every two years. This continuity is a significant advantage compared to active duty organizations that experience a revolving door of military program managers and engineers. Overall, the existence of power users able to remain in the same job for long periods while pushing FalconView development from an organization with some measure of autonomy from the formal acquisitions system provided a leg up for the upstart development project.

Another key decision that fueled FalconView’s continued survival and eventual prosperity was the choice to develop a toolkit-based approach that mobilized third party participation in FalconView feature extension. As with CoT, third party development allowed the program office sponsoring development to remain small and capitalize on a distributed team of developers essentially working for free. These toolkits are market-generating features that encourage more widespread adoption and increase the chances that systems will evolve alongside the user base. Difficult for many government program offices to stomach, toolkits require acquisitions personnel to be comfortable with a degree of operator autonomy that necessarily cedes power to the user community. As users develop functionality that meets their changing and sometimes unique needs, feature additions constitute a majority of the work. On the other hand, the deep re-architecting that is often needed as the ecosystem in which the system operates changes will not typically be accomplished by users in the DoD environment, which provides fertile ground for program office shepherds to step in and ensure the quality of the foundation upon which user participation is built (Lindsay, 2010).
FalconView is another interesting study in the shifting dynamics of military innovation spurred by increased reliance on software for virtually every aspect of military operations. As software has become increasingly integrated into weapons systems, the resources required by users to tailor formally developed products have decreased. While this assumes a certain amount of technical expertise on the part of the user-innovator, it is also a reflection of the nature of software development, which often allows for rapid prototyping and widespread distribution of applets or programs at little to no cost. Specifically for FalconView, once a software development kit was created, users invested further in the technology and increased the value to the user community as a whole.

The continued responsiveness of FalconView through a 15-year span characterized by a changing operational landscape proves the value of this development paradigm and serves as a wake-up call for government program offices instinctively interested in tightly controlling all aspects of a technology in the name of configuration management, system commonality, and acquisition discipline. CoT and FalconView form powerful arguments for user empowerment through toolkit-based approaches built on rule-based participation in extension of existing functionality.

4.3 - Ironman and the Difficulties of Integrating User Innovation with Formal Acquisition

The story of Ironman begins with textbook user innovation, continues with initial support from an acquisitions organization, and yet ultimately concludes with rejection by the program office designed to produce such capability. In this case, the initial support stemmed from a somewhat maverick acquisitions unit in Natick designed to quickly identify and support unmet user needs during wartime. While the Natick Lab QRC’s existence represents a step in the right direction for supporting this type of innovation, it also highlights a lack of support from the more formal program offices. The transition between upstart organizations like the QRC and the more properly resourced and established acquisitions units is not well-managed and typically leaves field innovations unsupported.

The genesis of Ironman as a classic user innovation produced by operators experiencing difficulties with existing products is interesting in that it confirms von Hippel’s democratized innovation model does, in fact, occur in the military. However, this section focuses more on the
military’s reaction to that user innovation to examine whether or not the Ironman story reveals insights into how the process might be better managed in the future. In this case, the Army had established a community of first responders to field expedients and urgent needs. These actors comprised a support network that encouraged and facilitated user innovation in a way that is typically lacking within the DoD. Forward deployed science advisors were tasked with identifying capability gaps, current operations analysts within QRCs at labs like Natick were trusted with rapidly evaluating and developing capability, and the REF was designed to supplement rapid responses to requirements with management, engineering, and funding resources.

This ecosystem constitutes the encouraging success of the Ironman case. It provided the innovator, SSgt Winkowski, with the needed support to refine a field expedient from a collection of cannibalized parts to a repeatable, reliable design. While the end product was a joint effort by users in the field and stateside lab engineers, the initial concept and prototyping were sourced from the user. As the lab took a more active role in refining the field innovation, the rapid prototyping and FOA process ensured the product remained tightly aligned with the user’s original intent. This process resulted in capability in users’ hands along an extremely accelerated timeline. In the end, the Ironman story suggests that parallel acquisitions processes such as those supported by the REF can benefit users innovating in the field. Unburdened by the exhaustive documentation, approval processes, and stakeholder coordination that plagues standard acquisitions efforts, rapid response units optimize development and delivery of capability encouraging users to identify unmet needs and, in some cases, innovate on their own.

This is not to diminish the rigor with which organizations like the REF pursue development, but instead to highlight their focus on value-added processes that result in delivering reliable capability to users. The Ironman case also emphasizes the valuable role users can play in designing initial prototypes and field expedients even if the same user does not end up conducting the refinement of the end product. This is where von Hippel’s manufacturer-innovators can enter the fray with the necessary degree of solution-related information. If managed properly, the synergy achieved by an acquisitions unit closely interfacing with a user-innovator can result in a truly valuable product. Unfortunately, formal R&D organizations often ignore this lesson.
In this case, we also observed the acquisitions community’s capacity to ignore users’ innovations. Along the timeline of Ironman’s development, a missed opportunity occurred as the demand for the system outgrew the Natick lab’s manufacturing capacity. While organizations like the QRC are able to support user innovations with continued rapid prototyping and small scale manufacturing, the need for a formal program office, in this case PEO-Soldier, to step in and assume control of the program becomes a critical step to success. While Natick lab personnel worked hard to ensure this transition would happen, resistance strengthened and the program office refused to support the effort.

Much of this can be attributed to the fact that these program offices are not designed to assume control of these types of projects. When programs do not follow the standard “requirements generation-formal competition-deliberate development” paths that make up the DoD’s Integrated Lifecycle system, it becomes very difficult for program offices to assume control of the project. In this case, the requirements organizations became a stumbling block, as they refused to recognize the system as an enduring capability. While their refusal flew in the face of a history of field requirements for Ironman-like systems during war, it ultimately signaled the end of Ironman production. Without a vetted requirement, PEO-Soldier was simply unable to justify funding and other resources to support the program. This illustrates the lengths that vestiges of the establishment often go in resisting user innovations, even when it becomes an apparently illogical decision. Obviously, this is a source of some disillusionment amongst military users and those who attempt to support their innovations.

In the end, the Ironman story begs the question of what will happen to user innovations after the conflicts in the Middle East come to a close. Will the ecosystem that has developed to support field expediency (i.e. QRCs, science advisors, and current operations analysts within labs) during OIF and OEF be allowed to wither on the vine, or will the military learn the lessons of projects like Ironman? The inability to duplicate the urgency of wartime, within both users and R&D organizations, and the continued tightening of fiscal belts following a long period of conflict suggest the former. However, the REF’s plan to continue projects developed during wartime do provide hope that the military will build on some of the movement toward more meaningful support of operators and their innovations.
4.4 - Reducing Transaction Costs by Empowering Users with ELM

One such effort that will continue after the close of operations in Afghanistan is the ELM. This project is interesting in its attempt to directly address the transaction costs stemming from the user-manufacturer boundary that von Hippel highlights in Democratizing Innovation (2005). These labs were designed to address the geographic gap between engineers and users and therefore stimulate increased interaction and teaming.

ELMs built on the foundation established by labs the Army operated at Bagram and Kandahar, two hubs for military operations in Afghanistan. The intriguing aspect of the REF’s decision to further extend laboratory capabilities within the country is that the organization was finding that even in-country labs at headquarters locations were suffering from the difficulties associated with being separated from the user. In other words, the user-manufacturer boundary was apparently so pronounced that establishing major lab capabilities in deployed locations had not gone far enough to address the gap. Valuable capabilities had undoubtedly been developed by the labs in Afghanistan (e.g. an improved battery for hand-held ground-penetrating radar devices), but there was still a lack of understanding between users and engineers even when the engineers were deployed to the theater of operations. As a result, REF leadership decided to establish a mobile capability that was able to travel to remote forward operating bases and embed the labs as close to the source of the requirement as possible. The REF hoped this change in location would improve the gain-loss factor in requirements transmission and reduce development timelines (Cox, 2012). Short of sending mobile labs out on patrols with soldiers, the ELM is as close as possible to the source of Army requirements.

With the labs positioned in high foot traffic locations at forward bases, the initial results have been encouraging. A number of small-scale prototyping efforts have succeeded in delivering on-the-spot capability by teaming soldiers and scientists (Asclpiadis, 2013). Beyond the successes, the ELM project shows a true commitment to serving the user. Thinking of the ELM and the assigned development personnel as a tool which users can employ to develop capability, the project is a promising model for moving toward a democratized innovation model.
4.5 - Forge.mil, Apps for the Army, and the DoD’s Attempts to Emulate Revolutionary Civilian Software Development Projects

In the final case studies that were included in the previous chapter, Forge.mil and A4A provided distinct examples of deliberate attempts by DoD organizations to stimulate an active user innovation community. These cases are compelling in that they offer unique variations on the popular narrative that typically outlines a story of inevitable innovation by lead users, often in spite of professional R&D organizations. With Forge.mil and A4A, military leadership recognized the value of operator-led innovation and pursued calculated initiatives to create platforms around which users could congregate and construct communities of like-minded thinkers. This sort of premeditated effort to incite and foster user innovation communities is a somewhat new phenomenon within DoD, largely attributable to the successes within the civilian sector that military leadership has observed and, in some cases, worked to emulate. Both Forge.mil and A4A represent encouraging movements within some pockets of DoD; however, they have also exposed the shortcomings of the current defense acquisitions environment in facilitating the success of user innovation, especially in the software space.

As a concluded project, A4A provides a somewhat cleaner case by which to judge ultimate successes and failures. Most sources referenced during this study agreed that A4A was worthwhile as a test bed for the streamlined software testing and certification procedures that were used as a way of minimizing the overhead imposed on individual user-developers. It also proved the hypothesis that operators with the skills to develop software did exist within DoD and their contributions could add value to existing mobile application offerings. Coming on the heels of the breakout success of Apple’s App Store, Army leadership hoped to establish an equivalent platform that would offer the same testing, certification, and distribution capabilities that attracted so many outside developers to Apple’s mobile applications home. In the end, the effort to stand up an Army App Store failed to materialize. While a solution was developed, a DISA attempt to build an enterprise-wide storefront for all services was preferred by DoD leadership. This DISA App Store effort remains in development. Without a platform to post applications, A4A was always destined to be somewhat limited in its success.

A4A participants and analysts also experienced difficulties with the toolset that was provided for entrants’ development activities. This highlighted a divergence in civilian and military app development. While the civilian world allowed for developers to choose their own
development environment, A4A mandated use of the aforementioned DISA RACE environment, Forge.mil, and other sponsored capabilities. While enthusiastic about A4A’s goals, Gunnar Hellekson (2010), Chief Technology Strategist for Redhat’s U.S. Public Sector Group and co-chair of Open Source for America, considered the mandatory use of these tools problematic as inevitable barriers to entry. His position centered around the idea that software projects like A4A survive on large, active communities, which are nurtured through lower barriers to entry and increased transparency.

Based on Hellekson’s perspective, the prescriptive and somewhat closed nature of A4A hindered the formation of a larger, more vibrant community of participants. Ultimately, the military culture will always drive development projects to gravitate toward more regulated environments, but this tendency must be resisted for efforts like A4A to thrive. As ever, users like LtCol Motes proved able to produce value-added capability in spite of the handicaps inherent in the system. However, user communities for projects like A4A must expand beyond the small number of lead users like Motes in order to bear a strong resemblance to their civilian equivalents.

On the other hand, Forge.mil, as an ongoing effort, continues to move toward its goal of establishing a robust collaboration community for open source and DoD community source software. The number of users engaged in the online community is encouraging, and DISA’s attempts to emulate the capabilities of SourceForge and GitHub represent a good faith effort by the DoD to provide tools previously unavailable within the defense acquisitions environment. In essence, Forge.mil has established a foundation from which a truly lively, collaborative user community might emerge.

To date, groups using the environment to jointly develop open source code for the good of a larger community have been limited. One of the lessons learned from this effort is the ability for very small barriers to entry to have apparently disproportionate negative impacts on user participation. For Forge.mil, the requirement for users to obtain formal certificates through an approval process is a reality of existence within the DoD environment but also creates barriers that are simply not there for commercial collaboration environments like GitHub. While this may be a seemingly insignificant hurdle to participation in the defense community, it is an obstacle to participation that most users will experience as their first impression of the
community. As a result, it leaves users familiar with civilian online collaboration forums justifiably skeptical about DoD’s effort to emulate proven communities’ capabilities. This initial uncertainty can then be exacerbated upon entry when open development enthusiasts are unable to access the more closed, tightly controlled Project Forge community.

Aside from the barriers to entry for participating in Forge.mil, the activity of the current user base must be assessed to judge the value of the effort from a user innovation perspective. DISA has attracted a large number of users employing the toolset to share code and maintain configuration control amongst distributed teams, promote communication between other users and developers, and track requirements generation. The degree of true open source, community development is difficult to track, but DISA’s Forge.mil community managers have seen self-organizing user communities, an active user base that maintains a dialogue shared via the Forge.mil Community site, and frequent accessing of the source code repository by some of the more IT-savvy users.

While an impressive number of participants have engaged with the online community, users familiar with non-DoD forums continue to push for more access and increased capabilities. DISA’s plans to deploy a virtual resource pool for cloud-based testing within the milCloud tool represent continued efforts to attract users with a robust toolkit. In the end, the success of Forge.mil will be determined by whether or not user communities are able to build on the foundation that has been established to pursue more far-reaching, collaborative open source development projects. This will ultimately require a shift from the DoD culture of locked-down, closed development to practices that balance the need for control with the value of open source initiatives.

As progressive projects that push the boundaries of current defense acquisitions policies and procedures, Forge.mil and A4A have required the participation of avant-garde operators with the technical knowledge to be comfortable operating outside of DoD development norms and the willingness to push the envelope. This often puts lead users in conflict with middle managers grappling with forward-thinking initiatives sponsored by senior leadership but unsupported by traditional acquisition practices. In other words, building a platform from which user-innovators can build communities and access toolkits does not provide a panacea within a DoD community built on restrictive policies and procedures. The policies governing the use of the platform and
the culture in which the platform's users operate are exogenous factors that can hinder the success of users in a restrictive climate. Further, DoD leadership has been hesitant to stand up these platforms, a situation that restricted the success of A4A when the Army App Store solution was shelved in lieu of the as-yet unreleased enterprise-wide DoD storefront. While the effort to establish a common solution can be readily justified, it often preempts the instantiation of a "good-enough" solution that would provide real value to a user base in need. Platforms like A4A also highlight the bureaucracy involved in DoD work, as Peter Corbett, founder of iStrategyLabs, pointed out when he noted that Apps for Democracy, a similar effort established by the Washington, D.C. local government took roughly 7% of the time to launch as compared to A4A (Corbett, 2010). The increased technical and legal overhead is emblematic of these efforts that are attempting to establish more open development practices that involve users within the DoD.

Upon final consideration, each of these efforts should be considered steps in the right direction by DoD. The deliberate attempts to foster lively user communities and develop tools designed to catalyze user-innovators' efforts are relatively new and encouraging. The DoD's efforts in this area are aided by the advancement in technology that is allowing an ever-increasing population of users to access and become proficient with software development tools. With this access, the online collaboration forums that have also developed and been established by civilians have created a model for the DoD to follow. While this model is often degraded by DoD security requirements and a tendency to prefer more control, it is becoming increasingly clear to the Services' CIOs and other senior leadership personnel that the DoD must find a way to harness the power of this development paradigm or risk becoming a technologically inferior military. Ultimately, the military has a long way to go in establishing an infrastructure that encourages user innovation, but A4A and Forge.mil have made strides in setting a course toward that end.

4.6 - The Barriers to User Innovation in the Department of Defense

While the cases researched for this study are certainly not an exhaustive list of recent user innovation projects, they provide a reasonable representation of the type of efforts pursued by military operators within DoD. Considered together, the projects yield evidence supporting user innovation within the Army, Air Force, Navy, and Marines. They are also a mix of software
development, hardware modification, and “platforming” initiatives. Given the sample’s representative nature, it is possible to identify barriers that stand as obstacles to user innovation within the military. While these efforts each succeeded to varying degrees, there were undoubtedly systemic hurdles that were overcome during the process.

4.6.1 - Military Culture as a Barrier to User Innovation

As a point of departure, it is important to note the culture that pervades the DoD and military as an organization. The foundation of the armed forces is a hierarchical structure that relies on an individuals’ obedience to superiors within his or her chain of command. This culture is designed to create efficient fighting forces often faced with a great deal of uncertainty. When comparing military user innovation with von Hippel’s theories, this rank structure must be acknowledged as a factor in how innovation is pursued and the extent to which users feel comfortable developing new capability. In a deadly environment filled with uncertainty, leadership within a user’s chain of command often favors tested, certified, and formally sponsored solutions in lieu of a soldier’s makeshift invention. An emphasis on system safety in this environment, by all accounts a justified concern, compounds this tendency toward conservatism.

While leadership in all industries may favor less risky solutions, this is perhaps even more important within the military, where management is more empowered to control the actions of their subordinates. This decreases both the likelihood that a soldier will innovate and that soldier’s sense of freedom to tinker with existing solutions that he or she may feel could be improved. As we have seen with the case studies, this is not to say that soldiers, sailors, and airman are mindless automatons, but it does produce an environment that tends toward strict compliance with the operating manuals and technical orders of certified solutions generated by formal acquisition channels. For the same reasons, this culture also drives program offices away from the development of toolkits designed to assist lead users in extending product line functionality on their own.

4.6.2 - How Security Considerations Impact User Empowerment

Those interviewed for this research also cited challenges stemming from security considerations that non-military users often do not face. While other industries undoubtedly prioritize secure systems and control of sensitive information, the need is rarely as pronounced as
in the military setting where breaches can directly lead to loss of life. The clear need for tightly controlled systems and secure facilities makes life more difficult for lead users attempting to tinker with existing technologies. This is most evident with systems that deal with classified information, where interfaces tend to be locked down, certification and accreditation processes are exhaustive, and the stakes of a potentially unsecured user expedient are highest.

Fully aware of these realities, commanders tend to discourage subordinates that seek to stray from formally recognized procedures and capabilities. For users that pursue innovation in spite of these challenges, a complicated bureaucracy awaits that often drives development timelines far beyond what is feasible for an operator attempting to develop new solutions in addition to his or her primary duties. These barriers accentuate the need in the military for true power users, like LtCol Motes, that are experts in their field, technically capable, forward thinking, and educated in fields like information security.

4.6.3 - Resource Constraints in the Military User Setting

Beyond the tightly controlled environment in which military users operate, operators are also disadvantaged by a lack of development resources. While labs and R&D centers within the acquisitions community often feature state-of-the-art capital equipment, users are faced with tight operations and maintenance (O&M) budgets, a general lack of prototyping equipment, and innovation processes that often involve jury-rigging cannibalized parts. The fact that disadvantaged users still prove capable of innovating is a testament to von Hippel’s notion of the lead user whose technical capability and need-related knowledge are powerful enough to overcome these obstacles.

This uneven playing field makes innovations like Ironman interesting in their confirmation of the existence of traditional user innovation in the military. It also makes efforts like the Expeditionary Lab-Mobile compelling as a way of resourcing user-innovators with development lab quality capabilities. While non-military user innovation also typically stems from relatively disadvantaged (i.e. undercapitalized) sources, the command relationship distinguishes military innovators from their civilian counterparts. While non-military users have been shown to innovate at their own risk, military operators are further restricted in that user-level resources are controlled by commanders that are typically risk-averse for the
aforementioned reasons. In the current environment, this often limits users to low-cost innovation niches (Lindsay, 2010).

4.6.4 - Systemic Barriers from the DoD Acquisitions Community

While many of the previously outlined barriers create obstacles for users to initiate independent development activities, the DoD acquisitions climate continues to challenge users following the creation of a usable end item. While operators may begin to form free-revealing user innovation communities, there is a point at which the acquisitions community will inevitably begin to act upon the development of a user-generated product. If a popular field expedient begins to proliferate, bureaucratic actors will influence the continued success of the product through the application of governance documents, testing requirements, political maneuvering, and the potential introduction of competitor products.

While these actors may be hard-pressed to stamp out grassroots movements they refuse to endorse, the systemic support for these individuals and organizations can serve to limit the success of a user-developed product even when that product is a scalable, reliable, and valuable military capability. As with many of the barriers discussed above, these actors can be defended for their reasonable concern regarding enterprise-wide needs, cost savings and risk reduction through standardization, and strict governance of products designed to inflict harm on others. However, the inertia created by these institutional forces often wipes out even those non-standard innovations that represent real value to warfighters the bureaucracy is supposed to serve.

Beyond the above barriers, other considerations such as personnel turnover, a shifting tactical picture, the military’s preference for formally vetted requirements documents, and politicians’ involvement with defense acquisitions further stack the deck against soldier-innovators. An important note in this discussion of the barriers to operator-led innovation in the military is an acknowledgement that user innovators in the civilian world also face significant hurdles to success. Despite these challenges, users continue to achieve successes in their pursuit of improved capabilities. This reality begs the question of how the military can better facilitate this type of innovation and encourage others that may be deterred by the current environment to actively engage in improving existing capabilities.
4.7 - Final Thoughts on the Cases

As mentioned above, these cases appear to provide a suitable representation of recent user innovation efforts in the military. While FalconView, Cursor-on-Target (CoT), and Ironman provide evidence for the existence of user innovation within the military domain, ELM, Forge.mil, and A4A represent an encouraging movement afoot to support operator-led innovation. The successes of FalconView, CoT, Ironman, Forge.mil, ELM, and A4A suggest that user innovation in the military will continue to occur. However, the challenges experienced by these programs also underline the need for the military to make a conscious decision to provide assistance for user-innovators. The case for improving systemic support to user-innovators is even more compelling considering the potential for capturing value from users essentially working for free. For an acquisitions community beset by continued programmatic challenges, an aging inventory, an elevated threat picture, and a declining budget, the opportunity is simply to promising to ignore. Ultimately, this will require a fundamental change in the way military leadership and the acquisitions community think about how innovation should be pursued. The case studies discussed here provide support for pursuing such a strategic shift.
Chapter 5 - Opportunities for Improvement

In addition to discussions of a fundamental shift in how DoD acquisitions are conducted, this research also works to outline immediately actionable options for military leadership searching to better equip users for independent innovation.

The cases included in this study have proven the existence of user innovators within DoD and demonstrated the value the resulting products might provide to a user community that is not always equipped with highly responsive systems. So with the existence of lead user-innovators proven and the technical ability of those same users adequate for producing value-added products, why has the military fallen short in encouraging and fostering these initiatives? To a large degree, this failure seems to be attributable to uncertainty from those governing the formal development community regarding how to respond to unplanned operator innovation and unanticipated field expedients. Resistance to user, field-developed innovations is a general phenomenon. Recall von Hippel’s research that points to the familiar responses of organizations evaluating user initiatives (i.e. develop a direct competitor, discredit the innovation, steal the idea and claim credit for it, or ignore the product altogether).

The case studies suggest that grassroots user innovation communities comprised of lead users engaged in free revealing and continuous improvement of existing products will eventually come into direct confrontation with the acquisition community. Despite the success of initiatives like FalconView and CoT, it is undoubtedly true that this direct confrontation disadvantages user innovations and, absent a large degree of good fortune, will continually counteract the progression of these initiatives. The gravity of the formal acquisitions framework, strengthened by immense budgets, potent regulatory forces, and a large cadre of general officers, is simply overpowering in most cases. The previously mentioned authoritative nature of the military hierarchy and insufficient resourcing of end users distorts von Hippel’s model of democratized innovation in the private sector due to military users’ existence in a more effectively controlled environment.

This degree of control within DoD lies in stark contrast to the commercial world where, for example, Microsoft was unable to prevent users from adapting its Kinect hardware to their own, non-gaming needs, and Apple was frustrated in its attempts to prevent the popular “jail breaking” of its devices. The military hierarchy provides a means by which leadership can
achieve the sort of reach and control over users that Microsoft and Apple might seek given the same authoritative capacities. This stunts the natural process that occurs in the civilian world as classification restrictions constrain the development of user innovation communities and block free revealing, well-meaning safety procedures discourage users from tinkering with existing products, and state-of-the-art technology often prices users out of the innovation market.

However, within the military, there is a chance to emulate the streamlined processes developed during periods of exceptional need to effectively incubate and protect operator-developed technologies through the entirely viable and often abundantly fruitful side streets of the acquisitions system. What follows is a framework in which the DoD might be able to more effectively encourage and cultivate this obviously important source of technology development.

5.1 - Codifying a Vision

At the most basic level, the key to improving user innovation outcomes is to strengthen the operator’s position within the acquisition and procurement community. Given the current situation in DoD acquisitions, where user innovation faces stiff resistance from a collection of well-resourced individuals and organizations, broad transformation is needed in order to rebalance the scales between users and formal R&D units. While this may seem obvious, it requires conscious encouragement and support of user collaboratives working to promote field-developed solutions.

In addition to policy and organizational maneuvering, military leadership must work to establish tangible assets for these user groups. One such asset with the potential to positively impact users is a platform upon which grassroots level initiatives can be launched with the support of others in similar fields. It is possible to imagine a future where users exert a sustained influence on acquisitions units. It is a future built upon platforms and toolkits through which users maintain an active voice in the development of technologies intended for their eventual use. This voice consists of contribution through more effective sharing of tacit, sticky need-related information, pursuit of break through innovations, and incremental improvement of delivered technologies using third party development toolkits. It is also a voice strengthened by easy access to other users working to improve fielded capabilities, accelerating user group growth and facilitating collaboration.
There are many examples found in the existing research of companies with the foresight to pursue this same vision for the future, including Ford, Xerox, and Lego just to name a few. And, as we have seen in the cases included in this study, the military has made attempts to mimic commercial examples with projects like Forge.mil and Apps for the Army. In addition to these platform-centric efforts, projects like CoT and FalconView developed end items in a way that encouraged user innovation without providing a platform that facilitated free revealing, collaborative user development, and other user community infrastructure. For CoT and FalconView, the user communities developed organically in much the same way von Hippel has identified in prior research. While this organic growth is a well-established phenomenon, there are undoubtedly DoD-specific obstacles that hinder the success of naturally occurring user groups. It is when these obstructions are removed from the outset by formal R&D units that the true power of user communities can be harnessed. Deliberate reinforcement of user-innovators’ activities with platforming initiatives and development toolkits represents a win-win scenario in which users are empowered and R&D units are able to access previously untapped human capital.

These platforms provide a central hub around which users can congregate, whether they are new to a product or looking to expand upon existing technology. As we have seen with the Xerox Eureka case, the platform can simply be a shared database where users are able to log new ideas, have them validated, and also access other user’s ideas to help with their own work. In a similar way, Forge.mil seeks to provide an online home for shared code repositories, best practices, and open source products, all backed by far-reaching user groups with an interest in building upon existing capability. However, the military must continue to broaden its efforts to establish user development platforms that essentially provide an ecosystem in which user-innovators can thrive. Existing capabilities are undermined by their exclusivity and relative lack of user-friendly features. The benefits of more robust platforms lie in lowered barriers to operator participation in development activities, synergies to be captured through increased user collaboration, and reductions in duplicative efforts due to community-wide sharing.

Beyond the benefits of creating more opportunities for Defense Department users to innovate, these platforms also improve the odds for an effort to succeed. This research has pointed to a spectrum along which user innovation projects tend to fall. The spectrum proceeds from efforts that fail to clear the initial hurdle of successfully developing a product to
innovations that gain broad adoption and support. Of particular interest here are projects along the continuum that fail due to an inability to overcome the institutional resistance that has been identified throughout the acquisition community. In these efforts, a platform upon which users can self-organize, share information, and reinforce each other’s confidence in a particular technology might serve to improve the outcome.

The most powerful user innovations are the projects backed by a determined, capable user group that is able to generate enough support at the grassroots and senior leadership levels to surmount the bureaucratic obstacles throughout the DoD acquisitions community. While there is no data to support a minimum user population required for success, there does seem to be a critical mass at which communities become strong enough to convince leadership that operator-led efforts must, at a minimum, be left alone. CoT and FalconView secured the necessary user adoption, while Ironman failed to generate enough support despite its obvious value. Platforms provide the foundation for achieving this critical mass, accelerating development, and enabling operators to pursue innovation backed by sometimes hundreds of like-minded end users.

The case for more deliberate, formal support to user innovation communities through the establishment of platforms and provision of third party development toolkits is clear. Leadership need only look to the projected decline in budgetary resources as conflicts in the Middle East draw down to see that more effective utilization of the military’s human capital is required. The lead users able to push continued innovation must be aided in their efforts if the U.S. military is to maintain its technological superiority. Platform- and toolkit-based approaches represent an ideal opportunity to access a too often ignored source of development within the Department of Defense, while strengthening both user activities and the acquisitions organizations needed to underwrite and formalize proliferation of user innovations throughout the military.

5.2 - Outlining Near-Term Opportunities

Any discussion that provides suggestions for formalizing the process of user innovation must tread lightly due to the risk of unintended consequences. The inevitability and spontaneity of user innovation are perhaps two of the most important attributes of this type of development paradigm. As a result, any attempt to systematize user innovation must be outlined in a way that avoids extinguishing the inherent enthusiasm and creativity involved with developing products outside of the accepted protocols and procedures. Instead of codifying a process that inevitably
leads to bureaucratic controls unnecessarily governing already productive user innovation sources, the DoD must focus on instantiating catalyzing agents that empower users. The goal should consist of an array of resources to assist users during the innovation process, rather than micro-managing and controlling these efforts. Drawing on the successes of the case studies, tacit knowledge of the acquisitions community, and the broad vision highlighted above, the following suggestions begin to outline a more specific framework that would serve to fulfill these needs.

The framework I propose below is intended to actualize a user innovation ecology that is more hospitable to user-innovators than the current environment (TED, 2013). In doing so, the framework constitutes a bilateral initiative with user-facing and acquisitions community-directed facets. The user-facing proposals are intended to encourage users to engage in development, equip them with tools that will assist in the innovation process, and support products once they have been realized. On the other hand, the concepts posited for implementation within the formal development community are intended to incentivize acquisitions professionals to assist user-led efforts. They are also oriented toward providing support to program offices that find it difficult to engage with atypical innovation sources. These proposals assume the continued existence of lead users seeking to innovate and suggest that additional users would engage in development given improved resources and a more welcoming climate.

5.2.1 - User-Facing Initiatives

These user-facing initiatives are intended to improve the frequency user innovations are brought forward, diversify the sources producing new technologies, and improve the quality of resulting products. Drawing on the previous assessment that military users are typically ill-equipped to pursue development activities, the following proposals are designed to address this shortfall.

5.2.1.1 - Support and Enhance Mobile Labs Programs

Mobile labs, as demonstrated by the ELM project, are powerful in their capacity to attract lead users and provide a toolkit with which to realize product improvements and new development at the point of need. Given the confluence of solution- and need-related expertise elicited by this type of lab capability, the potential to immediately address needs while also reducing the transaction and principal-agent costs that plague traditional development suggests a promising model for the future of user innovation in the military. The Army has articulated this
in the “Connecting Soldiers to Scientists” mantra for which the ELM is a key program. The low cost of these mobile labs also lends credence to the idea that more such maker-spaces should be proliferated throughout both austere and in-garrison locations. The value-added innovations that ELM has already produced in spite of soldiers’ relative lack of awareness and experience with this type of capability suggests that increasing the regularity with which military operators interact with a mobile lab environment will yield advancements in user innovation. If the use of science advisors in the field is continued beyond the conflicts in Iraq and Afghanistan and mobile labs are proliferated throughout the services, users would enjoy a powerful combination of advisors linking them to the formal development community and lab environments enabling onsite innovation.

5.2.1.2 - Provide Small Budgets for Small-Scale Development Projects at Operational Bases

Beyond the provisioning of mobile labs, there is an opportunity to provide operational commanders with small budgets for small-scale development projects at operational bases. Given the realities of military appropriations and restrictions regarding how different types of funding can be expended, this budget would be dedicated to innovation projects within operational units. The funding would be devoted to the purchase of prototyping equipment, procurement of development tools, and the conduct of innovation activities. Follow-on funding in subsequent fiscal years would be tied to demonstrating achievements in improving existing functionality.

If unit commanders failed to effectively capitalize on seed funding, the budget would be reallocated at the end of the year to formal acquisition units always in need of fallout funding. Given existing funding shortages, money could initially be allocated to the high-performance units most likely to contain lead users. It is also important to note the continuously decreasing costs and shrinking barriers to innovation with capabilities like 3-D printing and fabrication tools becoming more available. Ultimately, this proposal would address the lack of funding that often costs users out of the innovation space and would imply leadership’s endorsement of low-level innovation by operational commanders often hesitant to modify formally certified equipment. This model expands on techniques that have been employed with some success in the Special Operations community.
5.2.1.3 - Deploy 3rd Party Development Toolkits

Any discussion of better equipping users to pursue innovation should also include recognition of the value of third party development toolkits. Given formal program office’s preference for greater control and straightforward configuration management, these toolkits are not common in formally delivered products. However, the CoT and FalconView cases demonstrate the value of empowering users to extend product line functionality to suit their situated needs. The logic of capitalizing on an entire user community of developers in addition to the handful of program office engineers is inescapable. Whether this consists of exposing APIs to software users or providing modification kits for customizable hardware, military users will increasingly expect these capabilities as commercial technologies continue to provide this type of functionality. Ultimately, program offices sacrifice little to integrate a toolkit capability into systems in terms of cost and schedule, and the need for greater control must be superseded by the potential to provide more responsive products.

5.2.1.4 - Adapt Safety and Security Policies to Reduce Collateral Damage to User Innovation

The user-facing recommendations above must also be accompanied by a more balanced approach to safety and security policies and procedures. Too often, the fear of security breaches and headline-grabbing accidents overshadows a common sense, nuanced approach to safety and security. There are undoubtedly good reasons for protecting systems from unauthorized access and minimizing accidents, but military operators entrusted with the application of deadly force must also be considered responsible enough to search for ways to improve the technologies used to pursue that mission. Simply put, blanket policies throw the baby out with the bathwater and create an atmosphere that forces users to hesitate even when a viable product improvement is possible.

5.2.2 - Acquisitions Community-Facing Initiatives

In tandem with initiatives that directly impact user innovation at the source, the cases included in this research suggest that adjustments to supply side (i.e. acquisitions system) policies, procedures, and infrastructure would also contribute to building a more hospitable environment for user-innovators. At a high level, existing policies must be fine-tuned to further incentivize and enable formal program offices to support user innovations following initial successes and formation of self-reinforcing user communities.
5.2.2.1 - Empower Program Offices to Respond More Quickly and Flexibly to Unexpected Needs

This involves empowering program offices with increased flexibility to endorse a demonstrated capability that responds to unexpected needs. The deliberate nature of formal acquisitions has been intentionally cultivated by military leadership in order to tightly manage the expenditure of taxpayer dollars and decrease the risk of programs deviating from senior leaders’ priorities and strategy. However, the difficulties experienced by programs with a rigid program management structure often prevent well-meaning acquisitions personnel from supporting validated user innovations. This can occur, as we saw with Ironman, because of the lack of a formally vetted and recognized requirement that might otherwise provide justification for program managers to fund further development of user innovations. It might also occur due to inflexible agreements with defense contractor-led development programs or the unresponsive budgetary process. These are long term problems that must be solved by forward thinking program managers, contracting officers, and financial management personnel supported by senior leadership.

5.2.2.2 - Establish an Organization Specifically Tasked to Support User Innovation

Perhaps the most straightforward initiative the acquisitions community might pursue to establish structural aids for user innovation is the formation of a unique organization to identify and support user innovation. While this suggestion may cause concern for user advocates that worry about the application of bureaucratic forces to operator innovations, the examples of the Army’s REF and the Air Force’s Rapid Capabilities Office (RCO) provide reason for optimism. These organizations were constructed as deliberately small units with special privileges to pursue projects without applying the full complement of acquisitions regulations to their activities.

It is important to note that these organizations do not operate with a limitless budget and total lack of program management. Instead, they prioritize speed and capability delivery in lieu of the formal acquisitions system’s preference for oversight and control. In this model, the military has discovered a way to propagate the activities of the formal acquisitions community while also maintaining a parallel system that can more effectively respond to non-standard development needs. User-innovation, within the current environment, undoubtedly constitutes one such non-standard development source. As such it would benefit from a unit designed to collect data from the field, identify lead users pursuing development projects, and proactively
engage with those users to anticipate and prepare for their inevitable intersection with the acquisitions community.

With a declining budget in mind, this organization would minimize infrastructure costs with a small cadre of acquisitions personnel and users. The unit’s mission would consist of more effectively identifying potential user innovation projects (already often highly publicized) and helping users to overcome the institutional resistance that is often prevalent. With this mandate, the implied endorsement by senior leadership would lend weight to the organization and assist with bringing formal program offices to the table to discuss integrating user-developed products into formal capabilities. The unit would also be tasked with ensuring redundant development efforts, often considered a potential risk for more actively sponsoring distributed innovation, are minimized.

A final facet of the organization’s existence would be an acknowledgement that the value of user innovation does not disappear with the cessation of hostilities. As an enduring unit, personnel would be able to capture lessons learned from contingencies that provided fertile ground for user innovation and ensure that user innovation continues to be supported during peacetime. The potential also exists for an organization like this to host competitions like A4A that seek user involvement in short-duration development activities and rally senior leadership support for democratized innovation. In essence, the office would exist as a go-between for the acquisitions community and users and work to build momentum for viable user-generated product ideas.

5.2.2.3 - Launch Small Program Offices Charged with Shepherding User Innovations

In addition to this high-level office that would exist at service headquarters, a more concerted effort must be made to establish and properly resource program offices assigned to watch over specific user innovations. As demonstrated by the CoT case, the creation of program offices that act as shepherds for user communities can greatly assist in opposing institutional resistance to grassroots efforts. At less than 1% of the cost of a single F-35 aircraft, the annual budget of such a program office is put to good use in providing a central hub for user community activity, advocating for the effort in acquisition circles, fighting policies that disadvantage the community, and connecting like-minded users together that might be pursuing similar efforts. Within the military community, there is often even a need for the program office to promote free
revealing between disparate sub-groups still stuck in old patterns of greater control and exclusivity. In this shepherd role, the program office avoids disrupting user activities, and instead works to assist wherever possible to help operators continue development of a shared capability.

5.2.2.4 - Amend Acquisition Policy to Encourage Development of User Innovation Aids

Finally, an effort must be made to examine policies that might assist with and enforce a movement toward developing capabilities that set the stage for user extension. It is possible to envision the creation of a regulation that requires program offices to build systems with third party development support included from the beginning. While this is easier for software-intensive programs, options for facilitating hardware customization are also viable alternatives to locked down systems that discourage user tinkering. This requirement might be governed by the previously suggested headquarters-level user innovation office and become part of enterprise-wide requirements documents, like existing mandates for system characteristics such as net-centricity. In light of the previous blanket policies that have been disparaged in this research, this requirement would need to be targeted in its application and waivers granted where applicable. In the end, increased support for third party development capabilities would represent inherent endorsement for user extension of delivered capabilities and continue to promote a culture where users feel comfortable making modifications to inventory items.

5.2.3 - Recognizing the Need for Continuous Improvement in Support of User Innovation

In the lead up to these recommendations, it was acknowledged that any discussion of cultural transformation and fundamental reform must be strengthened by discrete, actionable suggestions. This objective was set in order to promote near-term possibilities and highlight the potential for enacting immediately feasible initiatives to benefit user innovation within the DoD. The cases, considered representative of user innovation in the military, suggested both user-facing and acquisitions system-centric improvements that might engender a more hospitable breeding ground for user innovation. These recommendations assume that the organizational resistance resulting from the entrenched interests of acquisitions community actors is unavoidable and often a formidable impediment to user success.

Given this assumption, the recommendations attempt to generate catalyzing agents and effective support networks for grassroots innovation efforts. At first glance, some of these
recommendations may seem anathema to user innovation that is often strengthened by its spontaneity and naturally resistant to management. However, the military provides a somewhat unique case in that users are a captive audience bound by a strict, rank-based hierarchy. In addition, the acquisitions system constitutes a heavily resourced competitor to user-innovators that resists independent efforts with the support of enormous budgets and strong political backing. For these reasons, recommendations centered on establishing entities able to assist users in overcoming institutional hurdles represent realistic change agents.

The problem will not be easily solved. The pitfalls of the military acquisitions process are almost universally recognized as sources of resistance to agile, responsive development programs. And the resource-intensive, bureaucratic processes are commonly believed to distance acquisitions personnel from the warfighters they are intended to serve. However, reform efforts expected to address well-known deficiencies have largely been unsuccessful. In their excellent article “The More Things Change, Acquisition Reform Remains the Same,” Col Peter K. Eide and Col Charles D. Allen (Ret.) point to 60 years of DoD reform efforts that “have not consistently yielded a process [or] system that delivers products faster, better, or cheaper.” In 2009, Senator John McCain drew on President Dwight D. Eisenhower’s famous military-industrial complex speech to highlight the current “military-industrial-congressional complex” that preserves entrenched political, economic, and defense interests and resists fundamental change in the acquisitions system.

The recommendations made above seek to draw on the urgency created by current military contingencies and bypass the cluttered graveyard of previous acquisition reform efforts intended to reinvent Pentagon-led procurement. These proposals draw on the successes experienced by those involved with the parallel acquisitions processes and streamlined methods recently employed during more than a decade of combat operations.

The need for more rapid technology procurement processes has become clear throughout recent U.S. military history from the Korean and Vietnam wars to OIF and OEF. The intentionally deliberate, often plodding defense acquisitions system is simply unable to deliver capabilities within the tight timelines demanded by unanticipated tactical situations that develop during new contingencies. Parallel procurement methods have also been formulated in response to the unique needs of programs requiring greater degrees of secrecy, Special Forces efforts, and
exceptionally high visibility initiatives (e.g. short-notice congressional mandates). The general success and productivity of these alternative processes begs the question of why user innovation has failed to attract the same type of attention.

Despite the inertia of the acquisitions system, it is still possible to move the DoD toward establishing a user innovation ecology that encourages operators to come forward with new technologies while also allowing formal acquisitions programs to continue unabated. While advocates of user innovation may be encouraged by the fact that user-innovators are an undeniable reality even within industries where institutions actively resist them, the idea of these institutions actively working to collaborate on and leverage user innovations is a compelling vision for the future. It is an even more alluring image for DoD users working to improve technologies that may be the difference between life and death.
Chapter 6 - Conclusions

The case studies and discussion included in this research are a small step in the study of how users innovate and acquisitions community stakeholders respond to that innovation within the defense industry. More empirical studies are needed from which to draw more general lessons. However, the existence of this promising type of innovation can no longer be disputed. With DoD budgets declining and threats to the U.S. military growing, the acquisitions community can no longer afford to ignore the promising operator-developed products that are undoubtedly emerging from soldiers, sailors, airman, and marines. Efforts are being made in isolated pockets to harness and promote user innovation, but more must be done.

The environmental forces at play within the DoD acquisitions community increase the difficulties operators face relative to their civilian counterparts. As a result, procurement organizations cannot afford to stand by and passively await user breakthroughs. Proactive efforts, like the deployable labs discussed earlier, are a must within this domain. By instantiating catalyzing agents to assist users and increasing awareness and incentives for acquisitions personnel regarding user community activities, the military stands to realize significant opportunities in the search to better serve the end user. “Serving the needs of the warfighter” is a popular motto for acquisitions units, but these words ring hollow without concrete actions directed toward living them out. There is perhaps no better way to show commitment to the warfighter than by moving beyond traditional top-down development to engage with the type of distributed user innovation that holds so much promise.
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