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Cursor on Target

Inspiring Innovation to Revolutionize Air Force Command and Control

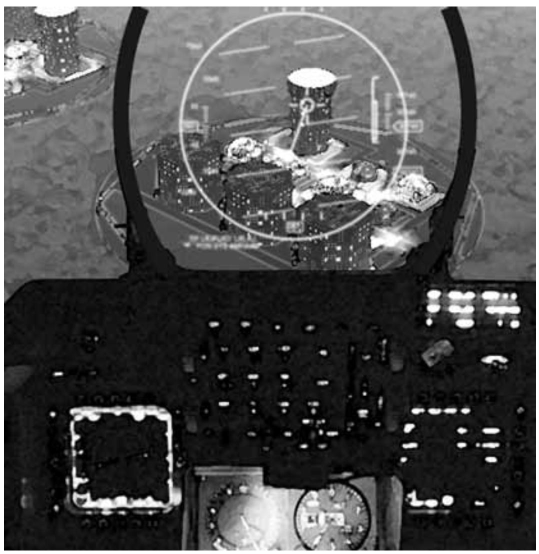
Dr. Raymond A. Shulstad, Brigadier General, USAF, Retired

In this article, Ray Shulstad tells a compelling story of the power of technology inspired by a concept of operations that puts technology to work directly for commanders—no endless list of requirements, no overreach for impossible technology. Using a simple organizing principle of "cursor on target" allowed everyone to visualize the same goal and focus on a comprehensive solution. There is no better example of engineers, industry, operators, and commanders being on the same page and delivering technology that has saved many lives on the battlefield. We need more of the same!

—Gen John P. Jumper, USAF, Retired

Because innovation is the key to increasing organizational effectiveness, improving efficiency to reduce cost, and applying technology that leads to new products, increased revenue, and profit, all leaders have a responsibility to inspire innovation within their organization. Leaders like Microsoft's Bill Gates and Apple's the late Steve Jobs have spoken extensively about inspiring innovation as the key to the success their companies have enjoyed. Gates clearly recognizes the tremendous potential of information technology, noting that "never before in history has innovation offered the promise of so much to so many in so short a time." And Jobs indicated how strongly he felt about a leader's responsibility in this area: "Innovation distinguishes between a leader and a follower." Some leaders, such as these two individuals, can inspire simply by coupling their vision with comprehensive knowledge of the technology and driving the organization toward that vision. Others, like General Jumper, inspire by coupling their vision with passionate demands that the organization respond by bringing that vision alive.

This responsibility to inspire innovation becomes especially important if the organi-



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zation's mission focuses on research and development. I understood that fact firsthand from my experience in the Air Force, where I led engineering organizations and commanded a major research laboratory. From May 2001 to April 2006, I applied that experience numerous times to the benefit of the service as the senior vice president and general manager of the MITRE Corporation's Air Force Command and Control Center.[1] At that time, my center was one of three in MITRE's Department of Defense (DOD) Command, Control, Communications, and Intelligence (C3I) Federally Funded Research and Development Center, charged with providing systems engineering to the government's programs to modernize its C3I capabilities.

This article offers one specific example of how inspiring innovation revolutionized the Air Force's command and control (C2) capabilities. It reveals how General Jumper, as chief of staff of the Air Force, inspired a revolution with his vision of an automated and integrated C2 system capable of significantly reducing targeting-cycle timelines and friendly-fire casualties. Furthermore, the article shows how I responded to General Jumper's challenge by driving MITRE's Air Force Center, in collaboration with the service's acquisition and operational communities, to bring such a system alive by using rapid prototyping and information technology to deliver machine-to-machine targeting.

Background

When I took over the Air Force Center in May 2001, I found that I had about 1,000 engineers deployed across hundreds of programs. My predecessor, Dr. Hal Sorenson, a former chief scientist of the Air Force, recognized that the legacy C3I systems had major interoperability problems and that the information technology revolution offered the promise of automating and integrating the DOD's C3I systems in ways that could solve these problems. To do so, Hal had launched an architecture-based technical strategy that would use standards like Internet protocol (IP) communications and extensible markup language (XML) to tag and share data. With the support and encouragement of Lt Gen Leslie Kenne, then the commander of the Electronic Systems Center (ESC) and our largest Air Force customer, I drove the Air Force Center to bring the strategy to maturity and begin implementing it across ESC's C3I programs. Although we made progress, the initial pace was slow and evolutionary.

Inspiration

That situation changed, and the evolution became a revolution when General Jumper became chief of staff of the Air Force in September 2001. He was already well known for inspiring innovation in the service. As commander of Air Combat Command in 2000, he had challenged Air Force acquisition "to demonstrate a weaponized [remotely piloted vehicle (RPV)] with the ability to find a target [and] then eliminate it," which led to the fielding of a Predator RPV armed with two air-to-ground Hellfire missiles in less than a year.[2] In a well-publicized story, the acquisition community responded to General Jumper's challenge with a "business as usual" approach requiring five years and $15 million. He gave them $3 million and three months. Sixty-one days and $2.9 million later, a Predator fired Hellfire missiles in a flight test on 21 February 2001, and in September of that year, the Predator/Hellfire weapon system deployed to support Operation Enduring Freedom in Afghanistan.

General Jumper understood the force-multiplying advantages of information superiority and the fact that integrating and automating the C2 system to take advantage of that superiority was the key to shrinking the timeline for attacking time-critical targets. Therefore, he spoke widely and passionately of that vision, demanding that industry as well as government acquisition organizations like ESC and MITRE change the paradigm and start applying information technologies to attain the necessary automation and integration.

At the Command, Control, Intelligence, Surveillance, and Reconnaissance (C2ISR) Summit hosted by General Kenne and ESC in April 2002, General Jumper and his 12 four-star commanders made an impassioned plea to horizontally integrate C2ISR machines (i.e., sensors, air and space operations center [AOC] targeting systems, and shooters) to allow them to talk to each other and thus eliminate the time-consuming, error-prone manual translations by humans. To make sure everyone understood the degree of integration he sought, the general gave a specific example based on his experience as an F-15 fighter pilot. He told the audience of using his combat flying skills to position his aircraft behind the enemy fighter and then put his targeting cursor on it. That done, the machines took over. The aircraft avionics locked on the target, shared target information with the air-to-air missile's avionics, and readied the missile for launch automatically. When ready, the system gave him visual and audio commands to fire, after which he was completely certain the missile would fly to and destroy the target without any further help from him. He closed that presentation and many others with a reminder that for warriors, "the sum of all wisdom is a cursor over the target."[3]

Listen and Respond

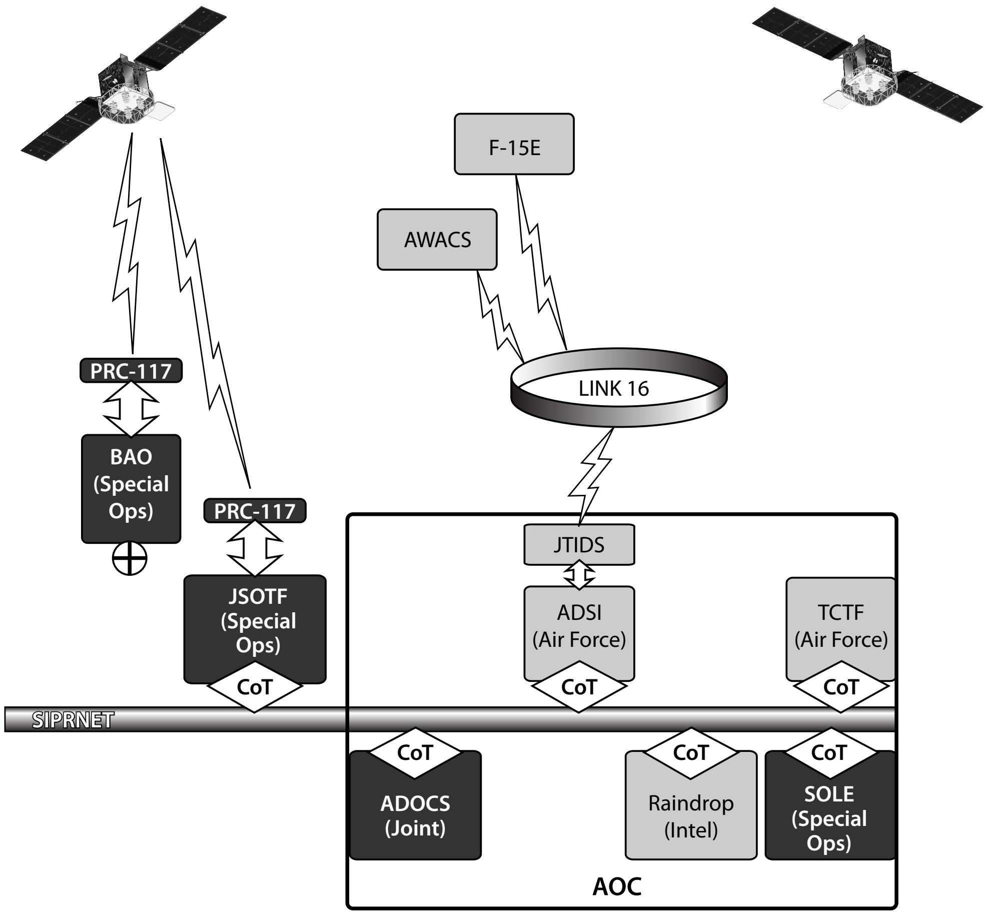
Shortly after the summit, I held a management off-site with the leadership of the Air Force Center. I told my executive directors that after listening to General Jumper and the other Air Force four-stars, we had an important responsibility to respond to their challenges and demands. I made sure they understood that business as usual was not a sufficient response. Over a two-day period, we embraced the integrated C2 system as our vision and put several teams together to spearhead progress. One team would finalize the technical strategy and obtain support from the ESC program offices to fully deploy it across all new C2ISR programs as well as to upgrades of legacy systems. A second team would define a system-of-systems or enterprise engineering process. A third team would reinvigorate MITRE's rapid-prototyping capabilities and define specific opportunities to use that capability and information technology to demonstrate and quickly transition automated, integrated C2 capabilities to war fighters.

Moreover in May 2002, shortly after the summit, Lt Gen Bill Looney assumed command of ESC, and Lieutenant General Kenne went to the Pentagon to stand up the Deputy Chief of Staff for Warfighter Integration, a new staff organization charged with attaining the integrated C2 system. After my off-site, I briefed both General Kenne and General Looney on MITRE's strategy for realizing General Jumper's vision via an architecture-based technical strategy, enterprise engineering, and rapid prototyping. Both gave me their enthusiastic pledges of support.

I put Jason Providakes and Rich Byrne, two of my brightest and most creative executive directors, in charge of the rapid-prototyping team.[4] Though small, Rich's team included several of the best engineers in the center, including Mike Butler and Doug Robbins. After two days of brainstorming, they told me at the off-site outbrief that they would initially concentrate on automating the targeting cycle via machine-to-machine interaction, an effort that Mike would lead. Since that proposal clearly addressed one of General Jumper's top priorities, I gave Mike a budget (less than $100,000) to get started. The team gave me a progress report about every two weeks and briefed me in early June on a specific concept and the prototype demonstration plan.

Innovation

Their idea involved automating a very real-world-like concept of operations for engaging time-critical targets. As depicted in figure 1, a Battlefield Airman would use a laser range finder, the Global Positioning System (GPS), and a compass to obtain the target coordinates and send them over the PRC-117 radio to the Joint Special Operations Task Force (JSOTF), which would manually send the target and its coordinates over the Secret Internet Protocol Router Network (SIPRNET) into the AOC. There, the intel cell would prosecute it, using tools such as Raindrop, as would the planning cells, using tools like the Automated Deep Operations Coordination Sys-



ADOCS = Automated Deep Operations Coordination System
ADSI = Air Defense Systems Integrator
AOC = Air and Space Operations Center
AWACS = Airborne Warning and Control System
BAO = Battlefield Air Operations
JSOTF = Joint Special Operations Task Force
JTIDS = Joint Tactical Information Distribution System
SIPRNET = Secret Internet Protocol Router Network
SOLE = Special Operations Liaison Element
TCTF = Time-Critical Targeting Functionality

Figure 1. Machine-to-machine targeting using the cursor-on-target XML schema (special tactics to F-15E). (From Rich Byrne, briefing to the MITRE Board of Trustees, subject: Making a Difference to the War Fighters, 1 October 2003, chart no. 20.)

tem (ADOCS) and the Special Operations Liaison Element (SOLE). After approval, the AOC would manually transmit the target coordinates using Link 16 to the Airborne Warning and Control System (AWACS) and F-15, which would then attack the target. The process at that time involved many lengthy voice or typing transactions that, despite verification and reverification, still remained prone to errors. For example, in one tragic friendly-fire accident, the coordinates of the Battlefield Airman rather than those of the target were sent to the F-15.

Mike's team proposed automating this entire process by putting the target's "what (type), where (coordinates), and when (time)" into an XML data schema and transmitting the data directly, machine to machine, without human involvement other than decision making. This concept offers a good example of an enterprise data strategy whereby various users (e.g., the intelligence cell, planning cell, and attack fighter) subscribe to data published in XML. Each small diamond in figure 1 labeled CoT (cursor on target) represents a few hundred lines of software at machine input and output ports that can publish or subscribe to the targeting data. The final step called for automating transmission of the target data with a CoT publisher over the air defense system integrator (ADSI)—the AOC's interface with Link 16 to the F-15.

After hearing the concept and plan, I gave the team members approval to proceed. In early July, they asked me to come to a MITRE laboratory for a prototype demonstration that included using a laser range finder, the GPS, a compass, and a laptop computer to obtain the target coordinates. Using CoT, the laptop published the coordinates directly onto a Raindrop display map where, after the Raindrop operator clicked on the target on the map, the coordinates were sent directly over a laboratory Link 16, showing up automatically on an F-15's head-up display in the laboratory. It truly was one of the most amazing things I had ever seen in the more than 35 years of my professional career.

Operationalizing and Deploying

Innovation by definition will not be accepted at first. It takes repeated attempts, endless demonstrations, and monotonous rehearsals before innovation can be accepted and internalized by an organization. This requires "courageous patience."

—Warren Bennis

During July 2002, we showed the laboratory demonstration to most of the senior leadership at ESC, including its new commander—General Looney—and John Gilligan, the Air Force's chief information officer, both of whom were very impressed and excited about what the capability could do to automate and integrate Air Force C2. General Looney again pledged his enthusiastic support for rapid prototyping in general and to CoT specifically. When he returned to the Pentagon, John sent a note about the accomplishment and its potential to General Jumper. In late August, we performed the laboratory demonstration for Secretary of the Air Force James Roche, who urged quick fielding of the capability.

In November 1982, a variant of the prototype underwent testing with F-15Es at Nellis AFB, Nevada, in a live-fly exercise. In March 2003, with strong support from the secretary and Air Force Special Operations Command, ESC stood up a program office and formalized a machine-to-machine targeting program. During that same month, an enhanced variant of the prototype went through accelerated operational test and evaluation at Hurlburt Field, Florida. The results were spectacular—a threefold reduction in targeting timelines with a significant increase in accuracy! In July 2003, ESC and MITRE mobilized the prototype and, with General Kenne's sponsorship, took it to the Pentagon to present to General Jumper. Needless to say, he was impressed and ecstatic. A freeze on AOC software at the beginning of Operation Iraqi Freedom delayed deployment until September 2003. Nevertheless, moving from a laboratory prototype to fielding an operational capability in only 14 months equates to speed of light for the acquisition process!

This accomplishment involved overcoming a number of barriers, none of them technical in nature. Organizations that had not responded aggressively to General Jumper's challenge were somewhat embarrassed and exhibited the "not invented here" syndrome by trying to slow down the initiative with "better" ideas of their own, including some that were proprietary and not net-centric. Others expressed concern over their false perception that machine-to-machine targeting would eliminate humans from the targeting cycle. As mentioned earlier, although CoT eliminated manual transactions, humans remained involved in each step of the decision process to attack the target. Others cited the lack of a validated requirement and the fact that the Air Force program objective memorandum had no budget for CoT. In fact, formally documented requirements to automate the AOC targeting cycle did exist, and CoT simply represented a solution to those requirements. Moreover, war fighters were more than willing to pay for the extremely small funding associated with the capability. Others objected to fielding prototypes directly instead of following the formal acquisition process, which would have taken years. Still others wanted the XML schema to cover all militarily useful information rather than just "what, when, and where," which would have added significant complexity and demanded prohibitive bandwidth. Finally, some objected to combining developmental test and evaluation and operational test and evaluation, which also became a nonissue because of the simplicity and low risk of the concept and because war fighters supported this approach to accelerate fielding of the concept.

We overcame all of these obstacles due to the support we had from the top leadership of the Air Force, including not only General Jumper, our champion, but also the senior leadership of the acquisition and operational commands. At the working level, we worked collaboratively as a team with personnel from the ESC acquisition office, Air Force Special Operations Command, the operational test and evaluation agency, and industry. That teamwork was also a critical factor in keeping the initiative on track in spite of the barriers.

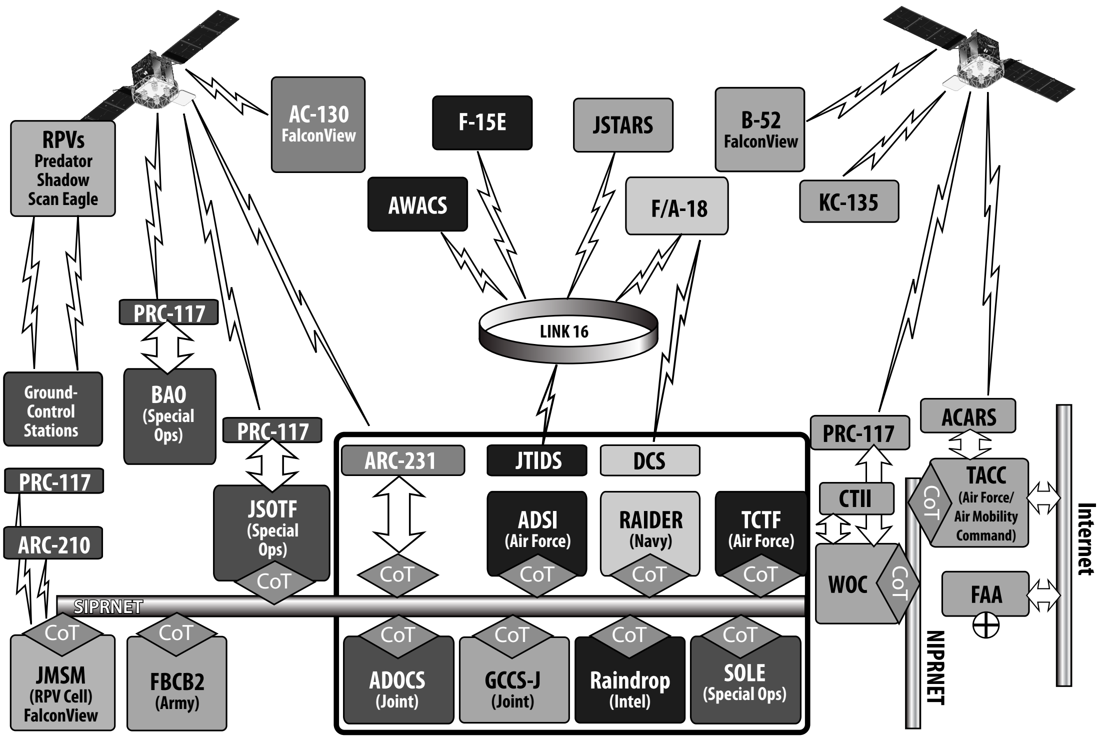
Expansion to the C2ISR Enterprise

Word quickly spread around the Air Force and DOD about the powerful CoT data exchanges of "what, when, and where" information. The DOD adopted the CoT XML schema as a data standard for sharing militarily significant "what, when, and where" information.[5] Additionally, Mike's team continued to expand and help others extend the applications to such capabilities as conducting blue force tracking; overlaying blue force, RPVs, and enemy positions on common operational picture displays such as FalconView; synchronizing global combat and refueling missions; and bringing Link 16 displays on board C-130 gunships that lacked Link 16 capability. Today, over 100 C2ISR systems (i.e., sensors, AOC targeting system tools, and shooters) have incorporated CoT at an average cost of about $100,000 per system. Figure 2 shows a small subset of these systems that, by means of CoT, are providing revolutionary, net-centric capabilities to our war fighters. The fielding of CoT dramatically illustrates the power of a common, net-centric, information-sharing strategy.

Benefits

Unlike Microsoft and Apple, MITRE and our government sponsor—ESC—were not driven by the promise of increased revenue and profit. Nevertheless, we reaped many benefits from the CoT rapid-prototyping effort. The MITRE team and its ESC partners have won numerous awards, including a highly coveted Armed Forces Communications and Electronics

Net-Centric Approach Dramatically Expands Possible Concept of Operations



ACARS = Aircraft Communications Addressing and Reporting System
ADOCS = Automated Deep Operations Coordination System
ADSI = Air Defense Systems Integrator
AWACS = Airborne Warning and Control System
BAO = Battlefield Air Operations
CTII = Combat Track II
DCS = Defense Communications System
FAA = Federal Aviation Administration
FBCB2 = Force XXI Battle Command Brigade and Below
GCCS-J = Global Command and Control System-Joint
JMSM = Joint Mission Support Module
JSOTF = Joint Special Operations Task Force
JSTARS = Joint Surveillance Target Attack Radar System
JTIDS = Joint Tactical Information Distribution System
NIPRNET = Nonsecure Internet Protocol Router Network
RAIDER = Rapid Attack Information Dissemination Execution Relay
RPV = Remotely Piloted Vehicle
SIPRNET = Secret Internet Protocol Router Network
SOLE = Special Operations Liaison Element
TACC = Tactical Air Control Center
TCTF = Time-Critical Targeting Functionality
WOC = Wing Operations Center

Figure 2. Expansion of the CoT application. (From Rich Byrne, briefing to the MITRE Board of Trustees, subject: Making a Difference to the War Fighters, 1 October 2003, chart no. 22.)

Association Golden Link Award in 2004 recognizing innovative applications of technology in government operations. Many articles on the achievement have appeared in technical journals.[6] From a business standpoint, MITRE and ESC's image with war fighters and customer-satisfaction ratings soared to new heights. Furthermore, MITRE's stature within the technical community grew significantly. Finally and most importantly, our initiative gave our war fighters improved operational capabilities that reduced the targeting-cycle timeline enabling attacks on time-critical targets and diminished the potential of casualties from friendly fire.

Additional Spin-Off Benefits

At least as significant as these direct benefits is the fact that the CoT initiative led to reinvigorating MITRE's rapid-prototyping capability and to ESC's embracing rapid prototyping as a key part of its acquisition strategies.[7] With Rich's leadership and support, more than 50 other rapid prototypes were developed and demonstrated in ESC programs. For example, we showed how easily we could use legacy radios to bring IP communications and the Internet onto platforms like the Joint Surveillance Target Attack Radar System (Joint STARS). In another case, we automated production of the air tasking order briefing and reduced the time required from more than 12 hours to just a few hours. An additional rapid-prototyping effort with industry demonstrated a way of synchronizing force-level and unit-level planning.

By means of rapid prototyping, we showed the possibilities to war fighters and a means of lessening the fielding risk. The urgent needs of war fighters directly drove the swift fielding of prototypes like CoT; others transitioned into upgrade plans for the systems of record and were fielded as part of the upgrades. Some did not receive war-fighter support and were not fielded, but in these cases, we refocused our efforts after a few months without expending much money or time—something quite different on both accounts from the normal acquisition process.

Keys to Success

As I look back on the CoT rapid-prototyping initiative, I see that a number of keys proved important to its success—keys that have wide-ranging applicability to other innovation initiatives. First, inspiring innovation allows us to derive tremendous benefits at relatively little cost. Having a champion like General Jumper who has an important, urgent need and who demands innovation probably represents the most critical element for this inspiration. My role as leader of an engineering organization was also significant, starting with my insistence that the organization not simply listen to the passionate demands of champions like the general but respond to those demands with innovative solutions.

I also take credit for putting a small but world-class team on the project and giving it very talented and creative leaders like Jason Providakes, Rich Byrne, and Mike Butler. Additionally, empowering the team and providing it with resources to be successful proved important. Initial laboratory demonstrations of the prototype, from working levels to senior levels of the government acquisition and operational user communities, played an essential role in obtaining their support and shaping the prototype prior to operational testing. Because engineers tend to want to tinker with prototypes in the laboratory and not show them to anyone until they are perfect, such early demonstrations are something of an unnatural act for them; however, user exposure and feedback at the beginning is invaluable to prototyping initiatives. As I mentioned earlier, collaborative teamwork with the acquisition, operational and test communities, and industry proved instrumental in overcoming a number of barriers.

Golden Nuggets

The keys to the success of the CoT initiative in generic form have broad applicability to inspiring innovation in general. Other leaders can use the following "golden nuggets" or takeaways to inspire innovation in their organizations:

1. Find a champion with a pressing, important need.
2. Demand that the organization respond to the champion with innovation.

3. Establish, empower, and support a talented, creative team to develop the innovation.
4. Demonstrate the innovation to capture advocacy.
5. Anticipate and eliminate obstacles.
6. Operationalize the innovation in a collaborative team effort with acquirers, users, testers, and industry.
7. Transition the innovation into products, services, or capabilities
8. Seek opportunities to expand and apply the innovation to other needs.

Summary

This article has examined how a senior leader's vision and demand for innovation can inspire his organization and others to respond to that vision with innovative solutions. It used a specific example involving the use of rapid prototyping and information technology to automate and integrate the Air Force's C2 system. However, the approach and strategy as embodied in the "golden nugget" takeaways have broad applicability to inspire innovation of other types and in other organizations. Therefore, I hope that future leaders will find this article useful in meeting one of their basic responsibilities—inspiring innovation! ✪

Notes

1. MITRE is a nonprofit company that manages federally funded research and development centers for the government.

2. "Predator Hellfire Missile Tests 'Totally Successful,'" *CheckPoint*, 12 May 2001, http://www.checkpoint-online.ch/CheckPoint/J4/J4-0003-PredatorHellfireMissileTests.html.

3. "Cursor on Target: The 'Sum of All Wisdom' Comes of Age," *MITRE Digest*, December 2010, [1], http://www.mitre.org/news/digest/pdf/MITRE_Digest_10_4266.pdf.

4. At that time, Jason was my executive director for Air Force communication programs, and Rich was my executive director for human resources and for our research program. Today Jason is the senior vice president and general manager of MITRE's Center for Connected Government, and Rich is the senior vice president and general manager for MITRE's Command and Control Center.

5. For the DOD CoT data standard reference, see the Defense Information Technology Standards Registry at https://disronline.csd@disa.mil. (Access to this site requires a government common access card [CAC].)

6. See Rich Byrne, "The What Where and When of Making Net-Centric Warfare Real Today," MITRE Corporation, n.d., http://www.mitre.org/work/tech_papers/tech_papers_05/03_0948/03_0948.pdf; Byrne, "Cursor on Target: A Case Study on Deploying What, When and Where in the Battlefield," MITRE Corporation, December 2004; Byrne, "A Few Choice Words Can Make Network Centric Warfare a Reality Today," *Signal Connections: AFCEA's Official E-Newsletter* 1, no. 4 (15 January 2004), http://www.imakenews.com/signal/e_article000214973.cfm; Byrne, "'Cursor on Target' Improves Efficiency," *Edge: MITRE's Advanced Technology Newsletter* 8, no. 2 (Fall 2004), http://www.mitre.org/news/the_edge/fall_04/byrne.html; Byrne, "Managing Complexity: An Approach to Net-Centric Ops," Association of Old Crows Symposium, Burlington, MA, 26 September 2005, https://www.myaoc.org/EWEB/images/aoc_library/patriotsroost/AOC_Briefs/Managing_Complexity_An_Approach_to_Netcentric_Ops_Rich_Byrne.pdf; Elizabeth Harding, Leo Obrst, and Arnon Rosenthal, "Creating Standards for Multiway Data Sharing," *Edge: MITRE's Advanced Technology Newsletter* 8, no. 1 (Summer 2004): 16–17, 20, http://www.mitre.org/news/the_edge/summer_04/edge_summer_04.pdf; and Dino Konstantopoulos and Jeffery Johnston, "Data Schemas for Net-Centric Situational Awareness" (presentation at the 2006 Command and Control Research and Technology Symposium, San Diego, CA, June 2006), http://www.dodccrp.org/events/2006_CCRTS/html/papers/073.pdf?q=cot.

7. Although this point is not related to our rapid-prototyping initiative, it is interesting to note that DOD Instruction 5000.02, *Operation of the Defense Acquisition System*, 8 December 2008, http://www.dtic.mil/whs/directives/corres/pdf/500002p.pdf, now mandates competitive prototyping to demonstrate technology readiness before entering engineering development.

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