Leading the Development of Concepts of Operations for Next-Generation Remotely Piloted Aircraft

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The clear precursor to fundamental changes in tactics, technology, and community norms is the design of new concepts of operations (CONOPS). Development of a CONOPS is a low-cost activity, but it has the power to change the direction of an entire enterprise. The current CONOPS for medium-altitude remotely piloted aircraft (RPA) in which the Air Force is deeply entrenched has

driven budgets, manpower, requirements, and technological development for nearly two decades. To enable progression, the Air Force must reform its philosophy of how it procures RPA technology. Despite a fiscal environment that is prohibitive for development of an entirely new next-generation RPA system, the service can use existing assets to realize a vast improvement in capability through changes in software architecture and digital data-linking of RPAs. An open-architecture RPA system can harness the natural rate of technological progression in industry and reverse the currently defunct RPA acquisition process, wherein new technology drives requirements, back to a state of requirements driving technological development. Only then can the Air Force resume its responsibility to lead industry in the development of RPA technology and break free of a sole-source paradigm.

Definitions

A CONOPS is a written statement or graphical depiction that clearly and concisely expresses what the joint force commander intends to accomplish and how it will be done using available resources.[1] Today's prevalent RPA CONOPS can be defined as *analog control by a pilot and a sensor operator of an armed aircraft for a 24/7 combat air patrol to support combatant commanders with armed reconnaissance of time-sensitive targets*. Remote split operations (RSO) is a subset of this CONOPS, requiring launch-and-recovery and mission-control elements to allow nondeployed personnel to conduct the combat sorties.

Requirements are broadly defined capabilities that must be available to execute the overarching CONOPS. RPAs must provide full motion video and signals intelligence (SIGINT) capabilities to fulfill their intelligence, surveillance, and reconnaissance role for combatant commanders. They have to be armed to react kinetically to fleeting targets, and they must do so 24 hours a day. Thus, requirements start with meeting a needed mission capability, allowing multiple solution options, and potentially capturing the creativity/efficiency of industry and joint partners. Defined requirements are then broken down to second- and third-order parameters and attributes that are the basis for purposefully engineering the system. With the aforementioned requirements, designers of today's RPAs selected high-aspect ratio wings and efficient motors for long endurance, hard points for weapons, and a data bus to integrate a Multi-Spectral Targeting System and other sensors.[2] Theoretically, everything from software to aircraft design to command and control should trace back to, and be justified by, a requirement.

The earliest antecedents of what the Air Force now terms RPAs originated just prior to World War One; however, only in the last 20 years has the RPA's potential in the context of transnational security challenges become readily apparent.[3] The development of RSOs allowed the intelligence community to control reconnaissance platforms in real time anywhere on the globe. These operations, combined with highly fuel-efficient aircraft, offer an unprecedented level of persistence that remains the primary advantage of the RPA. In 2001, when Big Safari—the Air Force's program office charged with rapid development, procurement, and fielding—launched the first Hellfire missile from an MQ-1 Predator, the armed scout CONOPS

was born, shaping the face of the modern RPA enterprise.[4] The emergence of that CONOPS is a brilliant success story in the Air Force's acquisition history. Combatant commanders recognized the necessity of the previously exclusive intelligence, surveillance, and reconnaissance aircraft kinetically reacting to the targets it had located. A shotgun acquisition and capabilities implementation followed, but this success story was the last of its kind for the medium-altitude RPA enterprise.

Paralyzed by Success

The development of RPA CONOPS stagnated in the early 2000s, but the Predator's early triumphs outshined any concern for the need of further evolution. General Atomics Aeronautical Systems Incorporated (GA-ASI) production reached full capacity, combatant commanders had an insatiable demand for this new breed of capability, and phrases like *Pred porn* and *drone strike* became household terms.[5] Cameras improved, a variety of accessories hung from the wings, and the follow-on MQ-9 Reaper emerged to carry even more equipment. For a system at the developmental stage of advanced-technology demonstrator, the Predator was quite possibly the largest and fastest asset acquisition in Air Force history. It seemed to represent a dream come true: the service got a whole fleet of aircraft systems without paying the time or money bills for the laborious and bureaucratic acquisition process. However, the hidden costs and consequences of this approach manifest themselves throughout the asset's service life. The Predator arrived in the active Air Force inventory as a rapidly procured prototype lacking any standing requirements and including its own implicit CONOPS. The early performance of the system led to an explosion in production that the Air Force was then charged with managing. An asset designed with the intention of limited covert use suddenly faced oversight and standards endemic to a multi-billion-dollar military acquisition program.

GA-ASI, a fledgling company only a few short years before, had to adhere to government oversight and standards for airworthiness, production, safety, sustainment, software, and training, all of which are substantially time consuming, expensive, and not part of the original contract for the system.[6] The rapid procurement of the Predator and Reaper system led to its classification as experimental in terms of airworthiness, an inefficiency that forced a need for certificates of authorization issued by the Federal Aviation Administration anytime the Air Force wished to transit through the national airspace. This practice limits RPA systems to tight corridors between bases and military operating areas to keep them safely separated from civil aviation. The initial intent of the system for limited covert use in military-controlled airspaces did not require developmental test and evaluation documentation necessary for a Title 10 airworthiness certificate. Now that the Predator and Reaper have moved from covert to more conventional use, the Air Force is facing greater need for standard airworthiness certification. The Predator and Reaper program office has responsibility for future production and retroactive contracts—that is, the service now spends millions of dollars to generate developmental test and evaluation documentation to prove airworthiness for a system with over two million flight hours! Beyond the obvious and seemingly nonsensical insistence from the acquisition

process to document for the sake of documentation, the Predator program had two distinct effects. First, it did succeed in providing weapons, sensors, and a follow-on airframe that significantly improved the utility of the original Predator A and brought the armed scout CONOPS to full maturity. Second, it secured the future of GA-ASI as the Air Force's sole-source provider for manufacturing, sustainment, and future development.

Air Force efforts to write requirements that could evolve the armed scout mission and begin to break free of the sole-source paradigm have been unable to move forward. For example, an operational RPA squadron was tasked to implement a GA-ASI proprietary multiaircraft control system, but its attempts were unsuccessful.[7] The Air Force could not compete the requirement on the open market because of software licensing restrictions, thus forcing the service either to purchase the GA-ASI solution or face the seemingly insurmountable cost of buying out proprietary software rights. The fate of the multiaircraft control system was further exacerbated when it was employed by a squadron in "surge" state. The result was an abbreviated syllabus that did not allow operators to gain enough experience with the system to use it skillfully. Ultimately, the initial cadre of pilots with limited experience abandoned the system because they did not "trust" it and because their burden of operations did not give them the time required to employ it properly.[8] The following analogy best describes the present state and potential future of the medium-altitude RPA enterprise:

> Imagine a group of men cutting their way through a jungle with machetes. They're the producers, the problem solvers. They're cutting their way through the undergrowth, clearing it out. The managers are behind them, sharpening their machetes, writing policy and procedures manuals, holding muscle development programs, bringing in improved technologies and setting up working schedules and compensation programs for machete wielders. One day a man climbs the highest tree, surveys the situation and yells, "Wait! We're in the Wrong Jungle!" But how do the busy efficient producers and managers often respond? "Shut up! We are making progress."[9]

The Air Force worked diligently to meet the ambitious 65 combat air patrol demand set by the secretary of defense.[10] Some of the Air Force's best tacticians have eloquently formulated and distilled stunningly brilliant tactics, techniques, and procedures (TTP) to enable the Predator to perform operational tasks and entire mission sets that the system's designers never imagined. The Predator program office is engineering block upgrades full of improvements, fixes, and new technologies.[11] Several Reserve and Guard units convert from legacy airframes to RPAs every year. The Air Force developed an entirely new pilot training program to teach officers how to fly the Predator and Reaper.[12] An entire career field has been established, centered on the GA-ASI-branded medium-altitude RPA enterprise. But all of these advancements are still just polishing the same two-decades-old CONOPS, feeding the sole-source paradigm, and cutting deeper and deeper into the wrong proverbial jungle.

The military research and development (R&D) community has danced around the next-generation RPA CONOPS through technology demonstration for several years. Individual programs have developed key enabling technologies such as sense and avoid, automated aerial refueling, man-to-machine interfaces, machine-to-machine

interfaces, multiaircraft control, and autonomy.[13] All are fragments of requirements of a future CONOPS. The key mistake has been to focus on these individual technologies and attempt to apply them to the armed scout CONOPS. Why have all of these technologies not made their way into the Predator or Reaper systems? The sole-source paradigm makes innovation difficult because even when the contractor enjoying the monopoly legitimately offers new functionality, service culture can still reject it without explanation. This practice is a manifestation of the danger of not having a clear CONOPS to drive government requests to the market, instead having the market proffer features and functionality.[14] Specifically, something as straightforward as auto takeoff and land (AT&L) has yet to be implemented on Air Force Predators and Reapers even though the Army has successfully employed AT&L on the GA-ASI-produced Grey Eagle system for years. The RQ-4 Global Hawk almost exclusively utilizes the feature, and the Navy's X-47 is making autonomous landings on aircraft carriers.[15] According to Gen John P Jumper, former Air Force chief of staff,

> We have allowed the pilot culture (fly the vehicle) to dominate what should have evolved into technologies that minimize the need for individual aircraft control. We should be trying to maximize the larger effects of automated flight and sensor functions, allowing the grouping of air vehicles when appropriate, developing more advanced mission planning software and enabling automated mission execution. . . . What has evolved is an RPA world that continues to be overly concerned with input rather than the output, persisting with more-than-necessary man-in-the-loop, and less than necessary integration of sensors and machine-to-machine capabilities automated for mission success. It is only logical that the next generation mission effectiveness will strive to fully develop the spectrum of RPA capabilities most valued by commanders, shift to an output, mission oriented doctrine and allow automation to ease the emerging burden on manpower, training, bandwidth management, etc.[16]

John Boyd warned of the dangers of a culture that clings to an outdated standard. His paper "Creation and Destruction" describes how organizations that adhere to standards and concepts which rule constituent elements will progress to a state of disorder as new elements are added to the domain.[17] In other words, an organization that adheres to one particular CONOPS without the ability and foresight to assess, strategically forecast, select, and formulate an appropriate CONOPS for the situation—and then drive action—will see an increasing level of complexity and confusion in their TTPs as new perceptions and technologies emerge. According to Boyd, the only way to escape this slide toward entropy is to allow the concept to collapse by abandoning the old standard and permitting the emergence of a new domain by finding common attributes and qualities among the constituents of the former standard and creating a new standard. Put concisely, an organization eventually has to abandon the old CONOPS and leverage emerging TTPs and technology to form a new one. The alternative is to face an ever-increasing state of complexity and confusion while trying to integrate new technologies into a construct in which they do not fit.

Casting a Vision

Intuitively, developing a new CONOPS sounds like an investment of years of work and billions of taxpayer dollars, particularly at the mention of a word like *autonomy*—but that is hardly the case. The cost of a CONOPS is critical thinking more than anything else. Such concepts are ways of reasoning to produce guidance that can drive requirements which in turn lead to technological development. Budgets for technology development have already been executed (e.g., AT&L, sense and avoid, etc.), but the concept of how the Air Force employs these technologies (i.e., input over output) is the limiting factor that needs to be reformed.[18] Air Force leadership must turn the RPA enterprise around from contractor-developed technology that drives requirements and CONOPS to having the service lead technology through defined future CONOPS and subsequent forward-looking requirements. The alternative is to remain locked in the sole-source paradigm for the foreseeable future.

As an example of a proper flow from forecasting and strategizing to CONOPS development to technical design, consider autonomous mission planning and execution (AMPLEX). In this notional design, a mission director tells the AMPLEX system a set of objectives, and the system generates a multiaircraft sortie flow with accompanying mission routing for review. The director approves, and the system autonomously executes and adjusts in real time to manage allowable performance deviations. The difference between AMPLEX and today's RPA employment is that the operator is a "human *on* the loop," not a "human *in* the loop." Although this description may appear simplistic, that is precisely the purpose of a CONOPS: to effectively articulate the key facets and avoid becoming entrenched in technical or tactical details. It is the on-ramp back onto the highway of technological progression and the right proverbial jungle to begin cutting through.

A CONOPS like AMPLEX would inform and orient requirements, and requirements would drive technological development, resetting the government-industry relationship to one of government leading industry. The technological pillars of an AMPLEX CONOPS already exist in higher-technology readiness levels than the Predator's systems when it was first deployed; however, adoption of the approach has stagnated because these technologies are difficult to integrate into a proprietary, closed technical ecosystem that dominates the armed scout CONOPS.[19] Initially, AMPLEX can be realized without upgrading any major hardware, without building new aircraft or facilities, and by utilizing the command and control infrastructure already in place. The stumbling block is the sole-source paradigm: monopolistic control of the software architecture and a laborious software update process that would otherwise not survive open-market competition. Software, more specifically ground control station (GCS) software, is pivotal in redefining modern aircraft capabilities, and it is the major element of change that the AMPLEX CONOPS would drive.

There are a multitude of self-inflicted barriers to this level of innovation, including RPA community perceptions, disconnects between operational and R&D entity efforts, and subtle incentives for leaders within the community to maintain the status quo rather than foster a culture of innovation. The tendency among experienced RPA operators is to quickly reject the prospect of autonomy. A standard concern is that

the crew will become overly dependent on autonomous aids that in turn will lead to poor preparation to execute complex mission sets if the autonomous features ever become unavailable. This argument communicates a valid concern from a near-term point of view, but from a mid-to-long-term perspective, it is historically accurate to say that reliance on technology for enhanced mission success is a gradual process of rejection, caution, acceptance, and, eventually, dependence. Currently, while performing cognitively demanding maneuvers, aircrews are utterly dependent on autopilot functions such as the stability augmentation system and autopilot hold modes. Stakes would have to be very high to consider an RPA for continuous use in collection or weapons employment while autopilot functions were malfunctioning, yet people who fear more advanced automation ignore the reality of their present dependence. Similarly, the community utilizes a host of supporting software that practitioners deem vital for flight safety, mission management, and validation of the weapon employment zone. Aircrews are allowed to depend on autopilot and peripheral tools because they have proven highly reliable over a large swath of the system's more than two million flight hours and greatly aid effective accomplishment of the RPA mission.

The vision and achievements of the R&D community have advanced so far beyond current operational capabilities that crews get discouraged when they become aware of the wonderful options that already exist but are not available on their aircraft.[20] Such disparity leaves the impression that they will never employ technologies such as autonomous teaming, multiaircraft control, artificial logic and decision making, and so forth. It is important to understand the need for tailorable autonomy levels to afford the opportunity to build operational trust in new automated functions cautiously.[21] All of these features are technically mature but require giant leaps forward in RPA CONOPS and TTPs to bring them into operational use.[22] Missing is a bridge between the current set of TTPs, accepted norms, training, and technology and the ever-evolving state of the art.

The New Domain

Unbeknownst to some community leaders, its members have already begun building such a bridge! Through auditing and processing of the Predator and Reaper systems' exploitation support data (real-time aircraft and sensor payload telemetry) and digital terrain elevation data (database of terrain and elevation values used by the system), some astute operators have constructed a series of basic piloting aids—the first steps to trusting autonomy. Initially, these tools were a quick reference for aircraft-sensor look angles as well as flight data such as airspeed, heading, and altitude. Additionally, the tools supplied data such as target coordinates, elevation, and aircraft height above target. Not only was the tool capable of supplying pilots with these data sets for their own aircraft but also they could select other aircraft in the network and pull their data as well. Next, the exploitation support data was used to derive tailored two-dimensional visual representations of relevant elements of the tactical situation, continuously updated based upon aircraft altitude and bank angle. Currently, these tools have been programmed to provide predictive position points

based upon aircraft turning radius and current winds to aid pilots in more precise attack positioning.[23] The tool has been accepted with open arms in the pilot community as a situational awareness asset that will lighten a pilot's cognitive load during complex maneuvers. However, the community at large does not see past using these tools as visual aids and quick references for data. Pilots and operational leadership argue ad nauseam about button positioning and functionality, color coding, and optimal tool positioning for pilot cross-check. They fail to recognize that it would be advantageous to abandon such tedious and time-consuming exercises and instead envision the revolutionary capabilities that expanding upon tools like these could provide in the near term.

An intuitive next step is to visually represent a continuously updating "predictive" flight path arc based upon current winds and commanded bank angle in two dimensions. A further progression would overlay a three-dimensional steering line on the video feed of the pilot's head-up display (HUD) that would indicate turning cues and finite steering paths for optimal positioning. The pilot's current cross-check of *eight* monitors would be virtually eliminated by something as simple as enabling the primary HUD screen to have a selectable overlay source input or utilization of a tool like Google Glass that would permit the selection and display of third-party overlay software of the kind proposed here.[24] On the sensor-operator side of the GCS, a similar overlay capability on that station's HUD might include a pointer to another payload's target. For example, having an arrow pointing in the direction of where another aircraft is looking with its sensor and then including a floating box on the sensor's screen that hovers over a vehicle that the other aircraft was following would make the tactical task of passing custody of a target infinitely easier. Additionally, the software can and should allow manipulation by targeting officers. They should be able to drop target coordinates in the system; assign collection goals such as desired look angle, standoff distance, and camera type; and then assign specific aircraft to these targets based upon load-out (of ammunition), unique capabilities, and availability with respect to maintenance status. The system would then visually represent the target and collection parameters and notify the selected aircraft of the new target. This capability is a fundamental shift in the norms of RPA collection from considering what the aircraft and aircrew can provide to what the supported unit wants from a target. It is a perspective change that shifts the focus from crew input to desired customer output.

Everything discussed thus far constitutes a basic exercise of graphical user interface and information networking. If handled by the right contractor, it represents fewer than six months of work to build, test, and implement. The system currently used by the operational community was developed by a single pilot in his spare time on his home computer over several months.[25] The giant leap forward in RPA capability and TTPs is closer than most operators realize. For example, one could amend the hypothetical software package's requirements (that have thus far been extremely simple) to include the ability to assign a continuously updating series of Global Positioning System coordinates and waypoints to its predictive flight paths and payload cues. These cues create holding patterns based upon customer-desired collection parameters such as look angle, standoff distance, and SIGINT effects. Starting at the customer's list of prioritized targets (with desired collection-parameter

information), the system builds the optimal orbits and recommended aircraft capabilities and load-outs. It then generates transit missions to and from a home airfield to the target, utilizing knowledge from the air tasking order or along air traffic control preassigned common routes while continually monitoring the fuel needed for the return trip. Lost-link contingency routes (a series of autopilot waypoints that pilots currently set by hand for the aircraft to follow to return to base in the event of the total failure of satellite links) would automatically follow the aircraft from target to target and maintain a safe routing to the recovering base. Its data sources would include weather, restricted operating zones, and air traffic control activity, eliminating the need for the pilot to continuously update the routing. In today's configurations, the only thing separating the system from direct control of the aircraft is the pilot. The missing link is the ability of the third-party software to interface bidirectionally with the present GCS software. If the Air Force were to order a software update that allowed the GCS to accept console commands from a securely authenticated alternate source other than the stick, rudder, and throttle, the aircraft could follow third-party system cues, sidestepping the proprietary portions of the system and unlocking the RPA's true potential.

Thus begins the process of rejection, caution, acceptance, and dependence on new technology. Initially, the system will produce flight paths for pilots to review and either accept or reject. The pilot would choose whether or not to allow the system to generate operational and contingency routing and upload them to the GCS. During the period of caution, features (perhaps best thought of as "apps") could be added to the systems' "playbook"—such as specific collection maneuvers, optimal SIGINT collection orbits, or even time-on-target maneuvering for weapons employment (with respect to aircraft positioning only, not actual weapons release). The level of automated functions should be tailorable—an autonomy "dial" that lets operators choose how much or how little to be involved in the direct control of the system. After a period of time, caution will evolve into acceptance, community norms will direct pilots to use the system, and it would be taught to new pilots as the primary approach to mission management. Eventually, the community would become dependent on the AMPLEX system for most of the dull, tedious mission sets. The days of manually entering waypoints to build erratically behaving navigational routes using original proprietary software would become a distant memory.

The third-party system described is an open-architecture software construct that will not only allow for monumental leaps forward in autonomous functions but also lead to rapid integration of new capabilities. The first and most important capability it can facilitate is the integration of Link 16 (tactical digital information link [TADIL-J]) or other air/ground-to-air data links to the RPA community. The limiting factor, once again, is the ability of the third-party system to take command of the aircraft and sensor payload. Aircraft equipped with Link 16 have the option of slaving their sensor payloads to Link 16 coordinates and autoslew to view or mark a target. The same function is needed on board the RPA lest the almost instantaneous process of machine-to-machine cueing between Link 16 and targeting pods be bogged down by machine-to-human-to-machine interfacing and manual input of target coordinates. Similarly, ground-based customers able to view the video feed via the remotely operated video enhanced receiver (ROVER) could hypothetically take control of the

payload to quickly gain situational awareness of their surroundings as well as personally verify locations of friendly and enemy forces. This CONOPS would replace the current practice of Army, Marine, and special forces customers having to verbally "talk-on" sensor operators to targets.

Interlinking RPAs and enabling target coordinates to flow quickly between air and ground assets, in addition to utilizing open-architecture GCS mission software, will allow the RPA to become much more useful for combatant commanders. The same process of integrating Link 16 on the Predator/Reaper can be used to integrate air-to-air or new air-to-ground weapons. Third-party software can transpose real-time aircraft telemetry data into weapons-employment-zone validation programs and project the zone on the customized HUD, ensuring that pilots can quickly release weapons on cross-cued targets within valid employment parameters. Interlinking also offers a backup to loss of satellite data links. The aircraft could still retain a level of autonomous functionality for full motion video or SIGINT collection, shift transmission to theater nodes, and continue to slave the payloads to cues given by joint partners in-theater.

Embracing Leadership in Innovation

The AMPLEX example may seem ambitious—all of the "what ifs" inherent to implementing autonomy in a weapon system create a general perception among operators that this kind of CONOPS is unachievable. However, the responsibility of creating technological solutions to enable a CONOPS is not the concern of operational squadron, group, and wing leaders. They have a blank check limited only by their imaginations when influencing a new CONOPS and should state the *normative*, optimal way of things rather than agonize over every detail of how other units and agencies in the Air Force and how industry will attain it. With a clearly defined CONOPS, the Air Force can begin writing forward-looking requirements, and industry will answer the call under normal market mechanics. This flow is how large steps in technological progression occur: not by looking at what is currently on the shelf or waiting on a salesman to present a new capability and figuring out a way to stitch it on an airplane, but by conceptualizing to bridge notional applications of technology to enable tactics that will vastly improve and perhaps completely change the way the Air Force does business.

Cost-effective and dramatic improvement in capability through software architecture changes and digital data-linking of RPAs with theater assets are all technologies ready for near-term transition. An open-architecture RPA system can harness the rate of technological progression and reverse the current acquisition practices: technology must not drive requirements—the opposite should be true. The benefits of such a program not only will reap manpower savings through automation of dull mission sets but will do so while concurrently multiplying operational capability. To date, the current emphasis on the "culture of innovation" in the Air Force has manifested as improvements to menial processes. Reorganizing a maintenance shop to reduce an Airman's travel between stations, claiming hundreds of man-hours saved 30 seconds at a time, or streamlining taxi procedures saving a minute

or two of fuel per T-38 sortie are smart moves but hardly innovative. An AMPLEX program will present a substantial step forward in TTPs and operational capability, not through employing an entirely new aircraft acquisition but through releasing the current sole-source systems to an open-software architecture. Only when Air Force leadership truly enculturates innovation by developing forward-looking CONOPS can the service resume its responsibility to lead industry in the development of RPA technology and break free of the sole-source paradigm. ✪

Notes

1. Joint Publication 5-0, *Joint Operation Planning*, 11 August 2011, I-5.

2. "MQ-9A Reaper," fact sheet, US Air Force, 23 September 2015, http://www.af.mil/AboutUs/Fact Sheets/Display/tabid/224/Article/104470/mq-9-reaper.aspx.

3. Thomas P. Ehrhard, *Air Force UAVs: The Secret History,* Historical Study (Arlington, VA: Mitchell Institute for Airpower Studies, 2010), http://www.dtic.mil/get-tr-doc/pdf?AD = ADA525674.

4. Richard Whittle, "Hellfire Meets Predator," *Air & Space Magazine,* March 2015, http://www.air spacemag.com/flight-today/hellfire-meets-predator-180953940/?no-ist.

5. The Air Force received nearly 300 MQ-1B Predators between program inception and 2011. "Air Force Accepts Delivery of Last Predator," GA-ASI press release, 7 March 2011, http://www.ga-asi.com /air-force-accepts-delivery-of-last-predator.

6. John Pike, "RQ-1 Predator MAE UAV," FAS Intelligence Resource Program, 6 November 2002, http://fas.org/irp/program/collect/predator.htm.

7. The multiaircraft control station allowed one pilot to distribute control of up to four aircraft to sensor operators by drawing constrained airspace containers called sensor operator containers. Once the aircraft was within the container, the sensor operator could command aircraft positioning through point click loiters. Employed by the 15th Reconnaissance Squadron, this capability was eventually abandoned under the premise that pilots could not cognitively handle multiple aircraft in the event of simultaneous, attention-demanding maneuvers such as emergency procedures, entry into restricted operation zones, or attacks.

8. Lt Col Jerry Brown, multiaircraft control system instructor, personal communication with the author, 3 October 2015.

9. Stephen R. Covey, *The 7 Habits of Highly Effective People: Restoring the Character Ethic* (New York: Free Press, 2003), 101.

10. SSgt Adawn Kelsey, "RPA Community Launches 65th CAP, Meets SecDef Initiative," Creech AFB press release, 10 June 2014, http://www.acc.af.mil/news/story.asp?id = 123413492.

11. John Keller, "General Atomics to Build 24 MQ-9 Block 5 Reaper Attack Drones in $279.1 Million Air Force Contract," Military and Aerospace Electronics, 5 February 2015, http://www.militaryaerospace .com/articles/2015/02/reaper-drone-order.html.

12. Hoffman, "UAV Pilot Career Field Could Save $1.5B," *Air Force Times,* 1 March 2009.

13. Sam LaGrone, "Navy Conducts Successful Test of Aerial Refueling with X-47B, UCAS-D Program Ending," USNI News, 22 April 2015, http://news.usni.org/2015/04/22/navy-conducts-successful-test -of-aerial-refueling-on-x-47b-ucas-d-program-ending.

14. John Reed, "USAF Says Adios to MQ-X," DoD Buzz, 15 February 2012, http://www.dodbuzz .com/2012/02/15/usaf-says-adios-to-mq-x/.

15. John D. Gresham, "Details of the X-47B's First Autonomous Carrier Landing," Defense Media Network, 11 July 2013, http://www.defensemedianetwork.com/stories/details-of-the-x-47bs-first-auto mated-carrier-landing/.

16. John P. Jumper, "RPA CONOPS Effects Scenarios," limited circulation white paper, 14 March 2011, 1.

17. John R. Boyd, "Destruction and Creation," 3 September 1976, http://www.goalsys.com/books /documents/DESTRUCTION_AND_CREATION.pdf.

18. Caroline Rees, "Predator B Demonstrates Automatic Takeoff and Landing Capability," Unmanned Systems Technology, 25 September 2012, http://www.unmannedsystemstechnology .com/2012/09/predator-b-demonstrates-automatic-takeoff-and-landing-capability/.

19. "Gray Eagle UAS Achieves 10,000 Automated Takeoffs and Landings," fact sheet, GA-ASI, 25 July 2012, http://www.ga-asi.com/gray-eagle-uas-achieves-10000-automated-takeoffs-and-landings.

20. "AFRL UAS Roadmap," Air Force Research Laboratory / XP limited circulation publicly released presentation, March 2010.

21. Jeffrey Eggers, "A Future Vision for Unmanned Systems Operation within NATO: Leveraging Autonomous Behaviors to Manage Complex Systems," AF/A2Q submission to NATO/OTAN, 1 May 2013, 5.

22. Currently the MissionX client is taught as part of the 732nd Operations Group squadron's advanced tactics course as a viable tool for advanced multiship tactics. Additionally, FocusedX, a derivative of MissionX, is used daily by aircrews for quick reference of standoff and depression.

23. MissionX client was developed by Capt Brandon Magnuson. FocusedX is a derivative of MissionX (later adapted as a plug-in for Raytheon-Solipsys's "Zeus" software, developed by Focused Support LLC).

24. Google Glass is an optical head-mounted display that can project opaque digital data into the user's field of view.

25. The MissionX client was developed entirely in Captain Magnuson's spare time and transferred between his personal and government computers throughout several iterations until his time of departure from Creech AFB, NV.

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Captain Wilson (BS, Auburn University; MAS, Embry-Riddle Aeronautical University) is a dual-qualified MQ-1B and MQ-9A mission control element flight evaluator, MQ-9 launch recovery element pilot, mission commander, and chief of weapons for the 556th Test and Evaluation Squadron, Creech AFB, Nevada. Formerly, he served as branch chief of MQ-1 weapons for the 867th Reconnaissance Squadron, where he logged over 2,000 hours executing diverse mission sets in the Predator and Reaper systems. Before volunteering as one of the first individuals for 18X Undergraduate Remotely Piloted Aircraft Training, Captain Wilson served at Wright-Patterson AFB, Ohio, as the Air Force Research Laboratory (AFRL) / XP unmanned systems portfolio manager, integrating research and development efforts concerning unmanned aircraft systems across the AFRL, Office of the Secretary of Defense, and NATO partners. He also served as the Block 5 Reaper Systems engineer in the MQ-9A system program office, where he led developmental efforts such as auto takeoff and land, sense and avoid, airworthiness certification, and special programs. Captain Wilson offers a rare fusion of insight from acquisition, engineering, test, and operational experiences.

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