

USAWC STRATEGY RESEARCH PROJECT

**MILITARY UNMANNED AIRCRAFT SYSTEMS IN SUPPORT OF HOMELAND  
SECURITY**

by

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## ABSTRACT

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There are a multitude of opportunities for consistent UAS surveillance within the United States. Potential roles would include border patrols, drug interdiction, illegal fishing/whaling, oil spills, disaster relief missions, long-term airborne communications nodes in times of national emergency, search and rescue, as well as many commercial applications. The US Army UAS available after Hurricane Katrina were unable to be used because of airspace and command and control concerns at that time. Flying UAS within National Airspace will require Federal Aviation Administration (FAA) approval for unrestricted flight. Command and control of military assets within the United States is being assessed to ensure we are in compliance with the 'posse comitatus' requirements. There may also be times, such as border patrol or drug interdiction, that armed systems may be of value. While those issues are being addressed it doesn't appear that any organization is focusing on the major issues of bandwidth and airspace management. This paper begins by reviewing UAS history, current use, and regulations. The Department of Defense (DoD) UAS Roadmap and Department of Homeland Security (DHS) potential missions are assessed. Finally, the primary hurdles to expanded military UAS propagation are reviewed and recommendations are offered.



## MILITARY UNMANNED AIRCRAFT SYSTEMS IN SUPPORT OF HOMELAND SECURITY

Unmanned aircraft systems (UAS) consist of unmanned aircraft (UA); sensors, weapons, and communications equipment carried on board the aircraft, known as payloads; and ground control stations that control the flight of the aircraft and receive information collected and transmitted by the payloads.<sup>1</sup> The UAS can provide a level of persistence and stamina that far exceeds a human capacity and removing the human from the aircraft provides options for risk taking and risk avoidance not previously available with a manned platform.<sup>2</sup> This increased potential has great promise for operations inside the United States (US) national borders.

The northern border separating the mainland US and Canada is 3,986 miles long and consists of 430 official and unofficial ports of entry. The southern border separating the United States and Mexico is 1,951 miles long and consists of thirty ports of entry and “innumerable unofficial crossings.” The US also has a total of 12,380 miles of coastline to defend and patrol.<sup>3</sup> The expansive nature and the possibility of entry through unpopulated regions make the border difficult to patrol. Past difficulties in securing the borders in conjunction with fears that terrorists could exploit existing security vulnerabilities by surreptitiously crossing the borders has prompted Congress to call on the Department of Homeland Security (DHS) to examine the potential use of UAS. The use of UAS on the northern and southern borders could potentially act as an important force multiplier by covering previously un-patrolled areas or providing more effective surveillance of areas already patrolled.<sup>4</sup>

UA should be the preferred solution over manned counterparts when the requirements involve the familiar three jobs best left to UA: the dull (long dwell), the dirty (sampling for hazardous materials), and the dangerous (extreme exposure to hostile action).<sup>5</sup> The attributes that make the use of unmanned preferable to manned aircraft in the above three roles are, in the case of the dull, the better sustained alertness of machines over that of humans and, for the dirty and the dangerous, the lower political and human cost if the mission is lost, and greater probability that the mission will be successful. Lower downside risk and higher confidence in mission success are two strong motivators for continued expansion of unmanned aircraft systems.<sup>6</sup>

There are a multitude of opportunities for consistent UAS surveillance within the United States. Potential roles would include border patrols, drug interdiction, illegal fishing/whaling, oil spills, disaster relief missions, long-term airborne communications nodes in times of national emergency, search and rescue, as well as many commercial applications. The US Army UAS available after Hurricane Katrina were unable to be used because of airspace and command

and control concerns at that time. Instead small UA were attached to helicopter skids to provide some limited electronic collection capability.<sup>7</sup> UAS must be seamlessly integrated into the current National Airspace System (NAS) infrastructure while enabling safe, efficient, and effective operations.<sup>8</sup>

Flying UAS within National Airspace will require Federal Aviation Administration (FAA) approval for unrestricted flight. Command and control of military assets within the United States will need to be assessed to ensure we are in compliance with the 'posse comitatus' requirements. There may also be times, such as border patrol or drug interdiction, that armed systems may be of value. This paper begins by reviewing UAS history, current use, and regulations. The Department of Defense (DoD) UAS Roadmap and Department of Homeland Security (DHS) potential missions are assessed. Finally, the primary hurdles to expanded military UAS propagation are reviewed and recommendations are offered.

## History

In the United Kingdom, experiments beginning in 1917 produced unmanned aircraft with newly designed, expendable engines.<sup>9</sup> British Professor Low led the research program to design and develop a true remotely piloted vehicle. Some historians bestowed upon him the title, "Father of the Remotely Piloted Vehicle," for being a pioneer in this field.<sup>10</sup> By November 1917, an "Automatic Airplane" was flown for representatives of the US Army. While the "Automatic Airplane's" revolutionary technology was successful, the war ended before it could be fully developed and deployed.<sup>11</sup>

After the Vietnam War, the United States reduced spending on UAS and defense in general. In the late 1970s and early 1980s, there were practically no major UAS programs. A turning point came in the early 1980s as Israel successfully deployed a number of different unmanned systems that had been developed in the 1970s. The watershed moment came in the Bekaa Valley in Lebanon in 1982. In a carefully planned and coordinated operation, Israeli forces used unmanned systems to provide intelligence, surveillance, and reconnaissance (ISR) and to activate Syrian air defense systems, allowing manned aircraft and surface-to-surface missiles to destroy the air defenses.<sup>12</sup>

UAS did not come into their own until the 1980s when the combination of improved and miniaturized sensors matched the developments in pilotless flight. By 1989, technology had enabled a UAS to perform fully autonomous flight, from takeoff to landing, without human intervention.<sup>13</sup> The early part of the 21st century will likely see even more enhancements in UAS capabilities and sophistication. The ongoing revolution in biological sciences, coupled with

ever-evolving microprocessor capabilities and nano-technology will undoubtedly produce advances in future UAS.

Generally, UAS are directed by an autopilot system with radio control (RC) backup. The autopilot directs the aircraft using sets of waypoints programmed in before takeoff using a map on a workstation; pilots click on the desired map coordinates with a mouse, and then download the program into the UAS.<sup>14</sup> The sensor package selected is based on the mission needs. Mission options within the military have grown and will continue to grow, opening the doors for newer technology and leading to greater opportunity for non-military applications across a wide continuum of emerging opportunities.

The two basic approaches to implementing unmanned flight, autonomy and pilot-in-the-loop, rely predominantly on microprocessor and communication (data link) technology, respectively.<sup>15</sup> While both technologies are used to differing levels in all current UAS, it is these two technologies that compensate for the absence of an onboard pilot and thus enable unmanned flight. Advances in both are driven today by the development of commercial applications, microprocessors for the personal computer industry, and the banking and wireless communication industries for data protection and compression.<sup>16</sup>

Military UAS have historically flown in restricted airspace (over test and training ranges) or war zones, and have thus largely avoided coming into conflict with manned aircraft in civil airspace. In the future the United States NAS must be shared by all aircraft, military and civilian, manned and unmanned, to support national defense, homeland security, and other government and commercial operations.<sup>17</sup> Even paramilitary missions like border patrol require a level of routine access to civil airspace unavailable to UAS today.<sup>18</sup> The current Certificate of Authorization (COA) process allows for DoD UA access to the NAS for events planned well in the future; however, it is insufficient to support unplanned operations. A prime unfortunate example is the lack of authorized DoD UA support for disaster relief in the wake of Hurricane Katrina, even though it was available.

### Current Use

As of December 2006, US Army aircraft have flown over 1.4 million total flying hours in support of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF), over 200,000 of these hours were flown by four different types of unmanned systems.<sup>19</sup> The primary function of a combat UAS is to observe events on a battlefield in real time, orbiting over the battle area and relaying intelligence to a ground control station, where it is used by attack assets to focus increased lethality and persistence on the target area.

The US Army Shadow UAS has flown over 150,000 hours since 2001. It took 4 years for the Shadow program to log the first 50,000 hours, ten months later it logged 100,000, and 7 months later it has now surpassed 150,000 hours. The usage rates for all programs have been growing exponentially, and are now at more than 10 times their original projected usage rate. As of 26 January 2007, the four US Army systems have logged over 245,000 hours; with 189,745 of them in support of combat operations.<sup>20</sup>

American combat troops can't get enough UAS; many of them have been distributed to combat units and commanders who have one or more of them up, keeping a real-time eye on the combat area, when a battle is underway. The primary enthusiasm for UAS is at the bottom and the top of the chain-of-command. UAS give everyone an eye-in-the-sky that is difficult to shoot down, and in many cases works for the guy on the ground exclusively.<sup>21</sup>

Unmanned aviation has historically been limited to the reconnaissance (Firebee, Global Hawk) and strike (DASH, Predator) missions. Reconnaissance is now a well-established mission for UAS, complementing manned aircraft in this role. Lessons learned from these platforms point the way to concepts of operations (CONOPs) that, to some extent, have already brought advantages to the Services and Combatant Commanders. Aircraft with inhuman endurance bring persistent surveillance at reduced sortie levels. Fewer flight hours are "lost" due to reduced time otherwise needed for transit time in shorter range/endurance aircraft. Fewer take offs and landings mean reduced wear and tear, and exposure to historical risks of mishaps. The ability to operate in distant theaters with ground stations at stateside bases means many crews fly operational missions without deploying forward. This, in turn, reduces forward footprints, support costs, and demands on force-protection authorities. Fewer deployments reduce family stress and mean better retention for highly trained crews reducing pipeline-training costs.<sup>22</sup>

In May 2003, the Secretary of Homeland Security directed a demonstration for evaluating UAS utility in support of border surveillance.<sup>23</sup> DHS also established an internal UAS Working Group under its Border and Transportation Security (BTS) Directorate's Office of Science and Technology in 2003 to explore roles and define requirements that UAS could potentially fulfill throughout DHS.<sup>24</sup> It addressed UAS potential applicability to border security, Coast Guard missions, critical infrastructure security, and monitoring transportation of hazardous materials.

The Custom and Border Protection (CBP) organization has been gaining experience with UA since the 1990s through cooperative use of Navy and Marine Corps Pioneers and Army Hunters. These 2- week-long deployments have occurred one or more times annually to provide added night surveillance capability along the US southern and northern borders. CBP

officers have been integrated into these operations, with a CBP officer sitting in the UA ground control station during missions and directing agents to activities found by the UA's sensors. CBP use of a medium altitude and endurance UA (Hermes 450) during the 2004 Arizona Border Control Initiative (ABCI) proved successful and led to the follow-on use of a similar UA (Hunter) to patrol the southern border at night.<sup>25</sup>

The first Predator B flying south of the Tucson area assisted in nabbing more than 1,000 illegal immigrants and 400 pounds of narcotics in the 2005 fiscal year.<sup>26</sup> A squadron of 16 Predator I-Bs will be based in Texas's Ellington Air Force Base starting sometime next year, Governor Perry said. As commander in chief of the Texas Air National Guard, of which the Predators will be a part, Governor Perry will exercise some control over the deployment of the US Air Force owned planes. While flying unseen and unheard thousands of feet overhead, the Predator can accurately read a license plate or scan the faces of people in a moving crowd. Of note, the original purpose of placing the Predators in Texas was to train US Air Force pilots who will later operate the UA over Afghanistan, Iraq, and other countries.<sup>27</sup>

These demonstrations have served to educate DHS on the strengths and limitations of UA and support its decision to focus efforts on a Homeland Security UAS, a medium/high altitude endurance UA capable of supporting multiple DHS organizations across a variety of applications and environments. Although the concept for its operation is still being developed, the UAS will likely be embedded in one of the aviation-using elements of DHS, who will assume responsibility for operating and maintaining it. The primary aviation-using organizations within DHS are the Coast Guard, Customs and Border Protection, and Counter Narcotics Office, who together currently operate a mixed fleet of some 170 fixed-wing aircraft and 240 helicopters.<sup>28</sup>

### Regulations

One of the 12 Major initiatives in the National Strategy for Homeland Security is to plan for military support to civil authorities.<sup>29</sup> The importance of military support to civil authorities as they respond to threats or acts of terrorism is recognized in Presidential decision directives and legislation. Military support to civil authorities pursuant to a terrorist threat or attack may take the form of providing technical support and assistance to law enforcement; assisting in the restoration of law and order; loaning specialized equipment; and assisting in consequence management.<sup>30</sup>

With the proliferation of UAS it will be essential to open currently controlled airspace to mixed use. The FAA has stated that for UAS to fly regularly in the nation's controlled airspaces, those UAS must meet the same FAA air worthiness standards as manned aircraft. If UA

operators were held rigorously to the see and avoid requirements of Title 14, Code of Federal Regulations (14 CFR) part 91.1131, Right-of-Way Rules, there would be no UA flights in civil airspace.<sup>31</sup> To meet this need, the FAA and DoD have agreed on an incremental approach for currently fielded systems based on regional location, and individual platform capabilities.

To date, UAS have been confined to segregated airspace as the regulatory authorities remain to be convinced that they are yet mature and safe enough to be allowed wider access. However, UAS are increasingly ranging outside restricted military airspace as demand for a persistent airborne presence grows. The formal launch of a project to enable routine flights in US civil airspace has begun and a joint research agreement between National Aeronautics and Space Administration (NASA) and the UAS National Industry Team (UNITE) has received formal legal clearance. The resultant Access 5 program was developed to focus on gaining routine airspace access for high altitude, long endurance UAS within five years.<sup>32</sup>

The Office of the Secretary of Defense (OSD) has issued the following guidance on the domestic use of UAS effective 28 Sep 2006: The Department requires rapid progress on DoD technology issues, as well as the resolution of new regulatory restrictions recently issued by the FAA on DoD UAS use. UAS use is encouraged in support of appropriate domestic mission sets, including homeland defense and defense support of civil authorities. Consistent with Executive order 12333 and DoD Directive 5240.1, DoD Intelligence Activities, DoD UAS operations, exercises, and training missions shall not conduct surveillance on specifically identified United States persons, unless expressly approved by the Secretary of Defense, consistent with US law and regulations. Civil Law enforcement agencies such as the Customs and Border Patrol, FBI, US Immigration and Customs Enforcement, and the US Coast Guard will handle any data collected. Governors in States where DoD UAS assets are assigned to the State's National Guard may use DoD UAS assets with the expressed approval of the Secretary of Defense. Use of armed UAS for domestic operations is not authorized.<sup>33</sup>

DoD Directive 5240.1-R defines the term "United States person" as: A United States citizen; or an alien known by the DoD intelligence component concerned to be a permanent resident alien. A person or organization outside the United States shall be presumed not to be a United States person unless specific information to the contrary is obtained. An alien in the United States shall be presumed not to be a United States person unless specific information to the contrary is obtained.<sup>34</sup>

The underlying requirement not to conduct surveillance on specifically identified US persons comes from what is referred to as the Posse Comitatus Act (PCA). Section 1385 of Title 18, United States Code (USC), states: "Whoever, except in cases and under

circumstances expressly authorized by the Constitution or Act of Congress, willfully uses any part of the Army or Air Force as a posse comitatus or otherwise to execute the laws shall be fined under this title or imprisoned not more than two years, or both.”<sup>35</sup>

The PCA does not apply to the US Coast Guard in peacetime or to the National Guard in Title 32 or State Active Duty status. The substantive prohibitions of the Posse Comitatus Act were extended to all the services with the enactment of Title 10 USC, Section 375. As required by Title 10 USC, Section 375 the Secretary of Defense issued DoD Directive 5525.5, which precludes members of the Army, Navy, Air Force, or Marine Corps from direct participation in a search, seizure, arrest, or other similar activity unless participation in such activity by such member is otherwise authorized by law.<sup>36</sup>

The PCA generally prohibits US military personnel from direct participation in law enforcement activities. Some of those law enforcement activities would include interdicting vehicles, vessels, and aircraft; conducting surveillance, searches, pursuit and seizures; or making arrests on behalf of civilian law enforcement authorities. Prohibiting direct military involvement in law enforcement is in keeping with long-standing US law and policy limiting the military's role in domestic affairs.<sup>37</sup> However, the threat of catastrophic terrorism requires a thorough review of the laws permitting the military to act within the United States in order to determine whether domestic preparedness and response efforts would benefit from greater involvement of military personnel.<sup>38</sup>

The United States Congress has enacted a number of exceptions to the PCA that allow the military, in certain situations, to assist civilian law enforcement agencies in enforcing the laws of the US. The most common example is counter-drug assistance (Title 10 USC, Sections 371-381). Other examples include The Insurrection Act (Title 10 USC, Sections 331-335). This act allows the President to use US military personnel at the request of a state legislature or governor to suppress insurrections. It also allows the President to use federal troops to enforce federal laws when rebellion against the authority of the US makes it impracticable to enforce the laws of the US; and emergency situations involving chemical or biological weapons of mass destruction (Title 10 USC, Section 382). Accordingly, when the Attorney General and the Secretary of Defense jointly determine that an emergency situation exists that poses a serious threat to US interests and is beyond the capability of civilian law enforcement agencies, DoD personnel may assist the Justice Department in enforcing prohibitions regarding biological or chemical weapons of mass destruction.<sup>39</sup>

DoD intelligence components are authorized to cooperate with law enforcement authorities for the purpose of investigating or preventing clandestine intelligence activities by

foreign powers, international narcotics activities or international terrorist activities. Specialized equipment and facilities may also be provided to federal law enforcement authorities, and, when lives are endangered, to state and local law enforcement authorities, provided such assistance has been approved by the Secretary of Defense or the Deputy Secretary of Defense per DoD Directive 5525.5.<sup>40</sup>

Agencies within the intelligence community are authorized to collect, retain or share information concerning United States persons only in accordance with procedures established by the head of the agency concerned and approved by the US Attorney General. Those procedures permit collection, retention and dissemination of information acquired by overhead reconnaissance not directed at specific United States persons. Incidentally obtained information that may indicate involvement in activities that may violate federal, state, local or foreign laws is included in this authorization.<sup>41</sup>

Under guidance established by the Military Departments and the Defense Agencies concerned, the planning and execution of compatible military training and operations may take into account the needs of civilian law enforcement officials for information when the collection of the information is an incidental aspect of training performed for a military purpose. In this regard, the needs of civilian law enforcement officials may be considered when scheduling routine training missions. This does not permit the planning or creation of missions or training for the primary purpose of aiding civilian law enforcement officials, and it does not permit conducting training or missions for the purpose of routinely collecting information about US citizens. Local law enforcement agents may also accompany routinely scheduled training flights as observers for the purpose of collecting law enforcement information.<sup>42</sup>

### Roadmap

The Army's current transformation initiative envisions each Brigade Combat Team having a reconnaissance, surveillance and target acquisition squadron equipped with UAS, reflecting the initiative's emphasis on reducing weight, increasing agility, and integrating robotics in future forces. Current programs are the RQ-5A (Hunter B) UAS for Division/Corps commanders and the RQ-7B (Shadow) and the Class IV (Fire Scout) UAS for Brigade commanders. Other programs include the Extended Range/Multi-Purpose (Warrior) UAS for the Division/Corps and the Company Level (Raven B) and the Class I (MAV) UAS for the dismounted soldier.<sup>43</sup>

The DoD Road Map provides a comprehensive outline of potential applications for military operations in the future as technology continues to improve. The development of new technologies provides new opportunities to transfer military developed technology to civilian

roles. Utilizing this new technology, expanded use of UAS for missions outside strict military operations is now possible, opening doors of opportunity for supporting civilian missions such as border security, pipeline patrol and homeland defense. In order to take advantage of these opportunities, UAS need formal acceptance in the US National Airspace System.<sup>44</sup>

The head of the US Army's UAS project management office, Colonel Don Hazelwood is calling for a more phased approach to the development of UAS access to US NAS, warning that the current focus on Class A and B airspace by the UAS lobby is limiting near term opportunities for use of military systems in civil support roles. "All of our systems have entered the airworthiness release process. By 2011 the US Army expects to be fielding some 230 UAS company's, operating more than 10,000 individual aircraft."<sup>45</sup>

The Army is using an approved airworthiness process, which is based on years of experience that has already integrated many improvements in aviation technology. The Army Aviation Engineering Directorate is developing and testing an equivalent level of safety standard to ensure that UAS can operate safely in the NAS, just as they are in combat today. For military operations, UAS will operate with manned aircraft in and around airfields using concepts of operation that make distinctions transparent to air traffic control authorities and FAA regulators. A combination of recommendations may accelerate the current timeline of UAS integration into the NAS and assist in overcoming the political and cultural barriers with this developing form of aviation.<sup>46</sup>

DHS and NORTHCOM have identified unmanned aircraft as high interest enablers for homeland security and law enforcement functions. Significant efforts in education, standardization, potential policy changes, and additional technology integration are needed to transition the existing unmanned aircraft to full integration.<sup>47</sup> Critical actions to initiate the policy changes have started with the establishment of FAA UAS Project Management Office, an FAA office fully focused on integrating UASs into the NAS.<sup>48</sup> In conjunction with this effort, the US Army, Navy, and the Air Force, along with the FAA, Department of Homeland Security, and US Customs and Border Protection have established a Joint Integrated Product Team (JIPT) to answer many of these concerns. This working group continues to address the technical issues of see and avoid, lost link command and control, safety and training, as well as methods to overcome cultural bias.

Particular emphasis on establishing operating policies and procedures rather than regulating vehicle technologies needs to be diligently worked. The US plan is ambitious, with the ultimate goal of gaining airspace rights identical to piloted aircraft for UAS providing safety performance equivalent to piloted aircraft. The plan involves the Department of Defense (DoD)

and US Federal Aviation Administration as well as NASA. Planners have laid out a four-step process to achieve routine airspace access. As envisaged, the four steps will take six years to complete at a total cost of around \$360M.<sup>49</sup>

The UNITE alliance was formed in 2002 with Boeing, Lockheed Martin and Northrop Grumman along with General Atomics, AeroVironment and Aurora Flight Sciences. Their goal is to demonstrate routine UAS operations in the NAS for high altitude long endurance UAS by 2010. The alliance is calling for the launch of a new UAS airspace integration study.<sup>50</sup> This could assist the European process and, if successful, it is estimated that integration could be achieved in Europe by 2012. There are three major obstacles impeding the wider deployment of UAS systems. These are the problem of integrating routine UAS operations within the Air Traffic Management environment, the lack of agreed certification standards, and adequate funding to address both.<sup>51</sup>

Sense and avoid systems and the actions of the UAS while in data link lost status are the primary focus areas. Technical efforts to date have shown particular emphasis on collision avoidance. Also, the procedures developed must be aligned with normal civilian flight rules, vice the current operations which are centered on combat operations. A step-by-step approach needs to be adopted now to introduce UAS into a mixed peacetime manned and unmanned airspace, with progressive removal of the overly restrictive limitations that currently apply to their operation. Some of this, however, will depend on achieving agreements at the international level.<sup>52</sup> There are at least 32 nations developing or manufacturing more than 250 models of UA; 41 countries operate more than 80 types of UA, primarily for reconnaissance.<sup>53</sup> There is also a proliferation of unmanned assets within police departments, universities, and fire departments which recently can afford them and want to fly them.

### Potential

The number of government agencies and commercial entities that want to use UAS in support of their mandate is increasing. In addition to the DoD and DHS, the Department of Interior (DOI), the National Oceanic and Atmospheric Administration (NOAA), and state and local governments are all interested in increasing their use of UAS for a range of very different purposes.<sup>54</sup> The head of the US Army's unmanned air system acquisition program office, Colonel Don Hazelwood, said "Last night on the news there was a missing person, a child missing. Could we not put up UAS to go out on search missions?"<sup>55</sup>

The Bureau of Land Management is considering using unmanned surveillance planes to help oversee remote areas of eastern Idaho to monitor vegetation and streams in areas used

largely for grazing and recreation. Officials said unmanned planes also could prove valuable for assessing wildfires without endangering people.<sup>56</sup>

Future uses under development in the US include border and customs surveillance for the US Coast Guard and anti-terrorism intelligence for the DHS and local police authorities.<sup>57</sup> DHS has identified four major UAS missions. They are border protection (UAS are patrolling the southern US border), infrastructure support (including protection of pipelines, key electrical nodes, and nuclear facilities), transportation security (such as railways, tunnels, and bridges), and maritime support (including port security and drug interdiction).<sup>58</sup>

House lawmakers have also prodded Pentagon and homeland security officials to make wider use of the military's UAS to tighten security along the US southern border. Rep Jeff Miller (R-FL) called for more UAS along the border. "I can't believe we don't have 24-7 surveillance over the border," Miller said. Paul McHale, Assistant Secretary of Defense for Homeland Security, said DoD has given DHS access to UAS along the southern border and would continue to do so.<sup>59</sup> The task of patrolling America's borders and protecting its critical infrastructure is too immense to be accomplished without their use.<sup>60</sup>

UAS have also been used in domestic settings. The NASA-sponsored Environmental Research Aircraft and Sensor Technology (ERAST) program has produced civilian UAS to monitor pollution and measure ozone levels. Academia has also been active in exploring civilian uses for UAS. The Massachusetts Institute of Technology (MIT) is involved in developing Global Positioning Systems (GPS) and video camera guidance for locating and identifying toxic substances. The Department of Energy recently announced that it will test UAS outfitted with radiation sensors to detect potential nuclear reactor accidents.<sup>61</sup>

This attention on the US homeland security market drives companies to larger investments of UAS. Beyond homeland security, the leap to commercial use is visible on the horizon. The evolving abilities of UAS are capturing attention in the civilian field, potentially opening a new and lucrative market. UAS have potential use as communication nodes, such as temporary cell towers, during times of disaster and as news media platforms for long term persistent events and for monitoring transportation of hazardous material and logistical supplies. They can also be used to search for missing persons or fugitives, pipeline surveillance, snow and fire patrols, and even dropping first aid or communication supplies to stranded people in a desperate situation.

According to Forecast International unmanned vehicles analyst Larry Dickerson, the global war on terrorism has prompted the United States to pump significant amounts of money into its UAS programs. The Market for UAS, including air vehicles, ground control equipment

and payloads, is expected to be worth \$13.6 billion through 2014. More than 9,000 UAS are expected to be purchased over the next 10 years by countries in every region of the world.<sup>62</sup>

Airspace coordination is haphazard even among the military within a theater of war. The USAF Predator and Global Hawk, for example, are controlled by a Coalition Force Air Component Commander (CFACC), as are manned aircraft. However, the Army UAS, which directly support ground units, are controlled by the land commander, not the CFACC. With so many aircraft in the theater, the skies are crowded, and some pilots are concerned about sharing airspace with the UA. There have been at least two collisions and several near misses.<sup>63</sup> This lack of coordination will only be magnified within the US NAS with additional organizations involved and even less prospective for direct command and control.

Safety isn't the only problem. The radio frequency bandwidths are already congested, with the current level of systems. General Jumper told the Heritage group that, with so many operators using the same radio frequencies, "we're jamming each other."<sup>64</sup> UAS are inherently dependent on communications and bandwidth for control of the aircraft and for transmission of collected data to other networked vehicles, ground facilities, and commanders. Essential electronic surveillance systems may be too sensitive or overwhelmed by the density of emitter traffic to be useful in the electronically polluted environment of Baghdad. "Right now we get into situations where we jam against improvised explosive devices and it corrupts our radio traffic and some line-of-sight UAS operations" says the Air Component Command Chief, GEN Ronald Keys.<sup>65</sup> These problems would grow exponentially should an enemy ever challenge US dominance. Following the current approaches, large fleets of UAS will challenge the amount of bandwidth available to send control signals to the vehicles and receive and distribute their sensor findings.

A critical technology enabling capability for unmanned systems is agile frequency spectrum management. As UAS proliferate within a given theater of operations, agile management of the frequency spectrum would maximize operations within the limits of any frequency band. Traditional frequency spectrum management relies on static or ground-mobile transmitters and receivers and frequency assignments are made to specific systems with few changes over time. In an environment with highly-mobile UAS, frequency spectrum management must cover a wider range of dynamic capabilities. This spectrum allocation process must allow flexible frequency reassignments between organizations and Services in a joint environment. Such a capability will provide leadership a means to ensure frequency supportability to the assets with the highest priority missions.<sup>66</sup>

New generations of sensors and sensor platforms will improve threat awareness by helping to close current gaps over much of the maritime domain and in domestic airspace, particularly at low altitudes. Shared sensor technology could also play an important role in improving border surveillance by civilian agencies. The placement of sensors on high altitude platforms, including new generations of unmanned aerial vehicles, satellites, and aerostats, could allow sustained surveillance of wide areas of the earth's surface. These sensors could also strengthen defenses against low flying cruise missiles.<sup>67</sup>

New Mexico State University's Physical Science Laboratory has successfully completed the first round of test flights for a collision-avoidance system that promises to be a key to safe operation of unmanned aircraft in civilian airspace. Automated sense-and-avoid systems are the key technical hurdle that must be overcome for UAS to fly safely in the National Airspace System controlled by the Federal Aviation Administration.<sup>68</sup>

### Conclusions

UAS are here to stay, and they should be, they are doing great things. However, we are on a collision course with potentially high cost and safety issues if a global systems view isn't developed and fostered soon. The two primary technical issues are insufficient bandwidth to meet the projected growth and safely managing airspace with manned and a multitude of unmanned systems sharing that airspace. The services and programs are each developing systems that meet their desired requirements. However, these various programs will come into greater and greater conflict with each other as systems propagate. It is this author's opinion that an executive agent with both the responsibility and authority to enforce decisions is necessary. The technology and systems are advancing too quickly for a team to develop a set of control documents that all programs could manage to. The documents would be irrelevant by the time they are complete and would never keep up with the technology refresh cycle. This can only be accomplished through active management participation.

Given that UAS are available and bring added capabilities; what are the best missions for them and who is best suited to do them? UAS are primarily suited for the 'dull, dirty, and dangerous' missions; all of which are potential missions within Homeland Security. Border security alone, with 5,936 miles of border and 12,380 miles of coastline, is a monumental task. DHS currently doesn't have the resources or the infrastructure in place to handle this. DoD does have resources and infrastructure and can use their UAS resources to support DHS. Military UAS can be used for border surveillance and fully comply with the posse comitatus act as long as the focus of the surveillance is on illegal aliens and terrorists and not on US persons.

The Development of two Military Training Airspace Zones (T-51 and T-52) along the southern border, stretching from California to Louisiana also supports the President's Secure Border Initiative and augments military UAS surveillance along the southern border.<sup>69</sup>

Multiple versions of UAS are being used in both Iraq and Afghanistan and the soldiers are finding more and more methods to employ them. UAS will provide an even larger capability jump to DHS than they currently are for DoD. The soldiers are also developing standard operating procedures that will be very valuable when used for DHS support. Just as there is a broad range of UA, there will be a broad range of ways to safely provide them access. Senior Air Force Northern Command and Federal Aviation Administration officials have hammered out a pact that will allow the service to deploy UAS over the continental United States during major disasters, according to the AFNORTH commander. "I'm positive that we have an agreement now," said Major General Scott Mayes. "If a national disaster is declared, we will be able to use UAS such as Predator and Global Hawk over a disaster area."<sup>70</sup> Having the preponderance of policy and regulation issues worked through, the next major hurdle will be how we manage the 'system'. Will we continue to herd the individual pieces and patch them as they come on line or will we take a centralized focus for the limiting factors that are common to all UAS programs?

### Recommendations

A number of methods can be used to reduce bandwidth requirements. Studies have shown that these methods can reduce the amount of bandwidth needed by several orders of magnitude. First, some analysis of the raw data gathered by the platform sensors can be performed on-board the vehicle with only the most pertinent data or target information disseminated to other entities on the network. The DoD Roadmap states that "Eventually, onboard processing power will outstrip data link capabilities and allow UAS to relay the results of their data to the ground for decision-making. At that point, the requirement for data link rates in certain applications, particularly imagery collection, should drop significantly."<sup>71</sup> Second, through the use of automatic target recognition and data bundling, UAS can transmit a compact list of coordinates and/or probable target classifications rather than large imagery files. Finally, when it is necessary to transmit large volumes of data, advanced data compression can be used to reduce bandwidth requirements.<sup>72</sup>

Two major 'families of missions,' one emphasizing payload capacity and persistence and the other autonomy, survivability, and weapons employment, need to drive UAS design and development over the next 25 years. The first family of missions employs endurance UAS as communication relays, Intelligence Surveillance and Reconnaissance (ISR) collectors, tankers,

maritime patrol aircraft, and eventually airlift systems. The second family of missions for future UAS employs them in weapon delivery roles, graduating from electronic warfare to long-range deep strike system and ultimately to air-to-air combat.<sup>73</sup>

There is a need for a concerted, focused effort on the long-term operational use of UAS. Standards and guidelines need to be set, while allowing the technological envelope to be expanded with multiple versions of UAS being developed. Currently each program is focused on solving a specific problem and they are doing great things in solving them. However, few are looking at how they are affecting the 'big picture.' This big picture focus (airspace and bandwidth management) needs to be developed and then shared with all organizations involved. No individual service or program can address and manage these issues on their own. Creating a steering group, consisting of, as a minimum, the military services and DHS, or assigning an executive agent responsible for addressing the airspace and bandwidth issues is required to get control of these issues that transcend individual programs. Great things are being done and greater things can be with a synergistic approach that treats the aggregate UAS as a system and not strictly attentive to each individual UAS as the ends. These problems are not beyond coping with; they just need a leader focused on organizing a coherent plan.

In the Air Force's view, creating an executive agent for UAS would streamline the way UAS are acquired and managed, unifying and thus strengthening the whole apparatus. The Army, Navy, and Marine Corps believe that more coordination is necessary but they see no valid need for an executive agent. They are worried that USAF, if given such a specific legal role, would exercise undue power over their system requirements, funding, and technologies.<sup>74</sup> The problem is clearly growing and needs to be addressed. A joint office managing UAS will be able to tackle these problems while also alleviating the service concerns of undue influence.

It is recommended that a single proponent be assigned with authority to manage broad UAS issues including airspace and bandwidth. This can either be through a combined group (including DHS) in the pattern of a Joint Task Force or by assigning a single service lead to be responsible for integrating all DoD acquisition with the authority to negotiate directly with DHS. It is agreed that creating an executive agent for UAS would streamline the way UAS are acquired and managed, unifying and thus strengthening the whole apparatus. It would also foster common operational concepts and procedures.

Although this paper is specifically focused on the DoD and DHS UAS development and fielding efforts, a much larger outlook is emerging requiring a guiding document similar to the UAS Roadmap. This larger perspective needs to encompass all unmanned systems; UA, Unmanned Ground Vehicles (UGVs), and Unmanned Marine Vehicles (UMVs). This family of

emerging technology and capability shares many similar attributes and will in all likelihood operate in close coordination, and even as teams. Many of the efforts within the UA realm have equal interest and application for other unmanned systems.<sup>75</sup>

The requirement for interoperability between UAS and manned systems is as important as between UAS and other unmanned system types. The need for an UAS to communicate and interact with a UGV is not far off. The Army's Future Combat System program is exploring such concepts. It is very probable future UGVs and UUVs will themselves deploy UA to extend their capabilities and improve overall system performance. Very small UA that afterward convert to unattended ground sensors will also obscure the distinction between the classes of unmanned systems. These simple examples argue that a common unmanned vehicle interface should be investigated for applicability to other unmanned systems. The ultimate goal is the seamless integration of manned and unmanned systems.<sup>76</sup>

## Endnotes

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