

DRONES IN THE U.S. NATIONAL AIRSPACE SYSTEM: A SAFETY AND SECURITY ASSESSMENT

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INTRODUCTION

Since 9/11, the United States government has made extensive investments to safeguard citizens, cherished monuments, critical infrastructure and key government installations. Unfortunately, many safeguards are easily bypassed by overflight. On January 26, 2015, a [small drone bypassed the fences and radar](#) protecting the White House and crashed unceremoniously onto the south lawn.¹ Back in 2012, Congressman Michael [McCaul](#) stated: “Now is the time to ensure these vulnerabilities are mitigated to protect our aviation system as the use of UAS (unmanned aircraft systems or “drones”) continues to grow.”² Despite his warning, three primary problems exist for UAS as they enter the United States’ national airspace: (1) inadequate safety systems, (2) inadequate statutes, and (3) incomplete threat analyses.

BACKGROUND

The National Airspace System (NAS) is a highly integrated and complex network designed to provide safe and reliable air transportation throughout the United States with an average of [50,000](#) manned flights a day.³ In a single month of 2014, domestic airlines transported more than [66.4](#) million passengers, or one fifth of the U.S. population.⁴ The Federal Aviation Administration (FAA) [estimates](#) that air traffic will increase one percent per year for the next 21 years.⁵

In spite of this modest growth projection, Congress [passed](#) the FAA Modernization and Reform Act of 2012 (henceforth the Reform Act) to “improve aviation safety and capacity.”⁶ While such reforms are laudable, nested within the Reform Act’s 300 pages is a small statutory order that raises major concerns. The Act stipulates that the Secretary of Transportation “shall develop a comprehensive plan to safely accelerate the integration of civil unmanned aircraft systems (UAS) into the national airspace system”⁷ by September 30, 2015.⁸

Presently, drone integration is problematic due to regulatory impediments on their operations and the resultant political climate. All drone operations in the NAS are restricted to below 400 feet above ground level or Special Use Airspaces (SUAs) for government testing and training. Access to airspace and flight corridors outside SUAs is only granted through a special FAA [permit](#) known as a Certificate of Authorization or Waiver (COA).⁹ These operational restrictions exist because of the hazards drones pose to manned aircraft and the public. However, the restrictions also impede many commercial drone applications such as Amazon’s vision for UAS delivery.

Consequently, in 2010, the Association of Unmanned Vehicle Systems International ([AUVSI](#)), a leading robotics industry lobby, published a report^{10, 11} geared toward their legislative [goal](#) of increasing “[a]irspace access . . . to ensure that obstacles to advancing and fielding unmanned systems and robotics are removed.”¹² The report argued that the U.S. economy would benefit enormously if drones had access to the NAS. AUVSI also warned a failure to integrate UAS would impede military readiness by limiting the Department of Defense’s ability to stay at the forefront of new technology, and negatively impact jobs and the aviation industry.¹³ It was a compelling argument that resulted in [bi-partisan support](#) for

integration.¹⁴ Unfortunately, by creating a requirement for drone integration, Congress failed to examine many of the latent safety and security issues surrounding domestic use of UAS.

INADEQUATE SAFETY SYSTEMS

The Reform Act took a bold step in supporting a new aerial robotics industry, but premature integration in the NAS is dangerous. Three technological challenges hamper the UAS industry: sense and avoid systems ([SAA](#)),¹⁵ control and communications (C2) links, and general UAS safety. Manned aircraft implement a concept known as “see and avoid.” However, a remotely piloted aircraft requires an alternative safety system because it cannot always see obstacles. The FAA’s UAS [roadmap](#) anticipates SAA will be ready between 2016 and 2020 and a C2 structure between 2016 and 2017,¹⁶ yet general safety concerns remain.

These systems are under development, but the Department of Transportation ([DOT](#)) Inspector General observed, “[FAA] is behind schedule . . . and the magnitude of unresolved safety and privacy issues will prevent FAA from meeting Congress’ deadline.”¹⁷ In addition, Dr. Mica Endsley, Chief Scientist of the United States Air Force, notes, “Drones have scary implications, but the FAA has developed a plan. They are currently working on ‘sense and avoid’—a new technology that will alert aircraft to the presence of drones.”¹⁸ But Rory Paul, the CEO of Volt Aerial Robotics Company, a firm that produces agricultural drones, fears “There are still key safety components missing. At this time, there is no low-cost sense and avoid system applicable to small UAS and large aircraft”¹⁹

A recent FAA safety report underscores the need for SAA; in 2014 an American Airlines Group regional jet in Florida [nearly collided with a drone](#) at 2,300 feet. This type of UAS is supposed to remain within 400 feet of the surface.²⁰ A collision at 2,300 feet might have ended in tragedy for the 23 passengers and crew. In a similar incident in 2011, an Air Force [C-130 collided with an unmanned aircraft](#) in Afghanistan. Though no one was injured, the incident resulted in costly repairs for the C-130.²¹ The number of accidents involving only military drones makes the need for SAA apparent. According to the *Washington Post* drone crash [database](#), “About one-third of the crashes (since 9/11) occurred in Afghanistan, but nearly one-quarter happened in the United States.”²²

The [DOT](#) Inspector General is also concerned that “FAA is not effectively . . . analyzing UAS safety data . . . [and] has not developed procedures for ensuring that all UAS safety incidents are [shared] with the U.S. Department of Defense (DoD), the largest user of UAS.”²³ Strangely, despite FAA’s overwhelming focus on aviation safety, their regional safety inspectors do not oversee UAS operations in person because inspectors lack the necessary guidance and resources.²⁴ FAA is retooling its process, but the delivery date for new procedures is September 2015—rather late considering the importance of this issue and the congressional deadline.²⁵

While congested airspace will remain problematic for all aircraft, a crowded frequency spectrum is an added issue for unmanned aircraft. In the [2013 UAS Roadmap](#), FAA observed, “government agencies and industry need to investigate link security requirements [e.g. jamming, hacking, and spoofing].”²⁶ However, as of June 2014, a [DOT audit](#) found UAS frequency space remains unreserved and that security vulnerabilities from link interference remain unresolved.²⁷

To address integration problems, FAA established six UAS test sites together with states, universities, and industry. However, research at the various test sites is poorly coordinated. According to the [DOT](#) Inspector General, FAA needs to take a more proactive role in directing research to meet its data collection requirements.²⁸ As a partial remedy, FAA, along with NASA and Air Force Research Lab, is [sponsoring](#) the UAS Airspace Operations Challenge. The event [focuses](#) on developing solutions for SAA and C2 problems. The first phase concluded in September 2014. While this interagency cooperation was encouraging, the Challenge was [cancelled](#) due to technical problems and cost overruns.

At this point, a delay in the Reform Act's ordered integration is unavoidable. According to the DOT Inspector General, [embracing](#) this delay will afford relevant agencies much needed time to re-establish priorities and conduct further research.²⁹ After all, it's better to have fewer UAS operating while preparations are underway than thousands of UAS integrated under poorly conceived policy. The Reform Act serves as a worthwhile first step to support a burgeoning industry, but Congress should not demand integration before the necessary technology is ready.

INADEQUATE STATUTES AND REGULATIONS

In addition to inadequate safety systems, current civil, criminal, and FAA rules are insufficient for regulating the increasing interest in hobby (or model) aircraft. In May 2014, a cheap (\$2,000), hobby drone was discovered crashed on a skyscraper in down town St. Louis. Hobby aircraft can be legally flown below 400 feet and within sight of the operator; however, "the drone that [crashed](#) [in St. Louis] hit the 30th floor of the 593-foot-tall building."³⁰ FAA rules do not provide adequate deterrence against reckless or criminal behavior—indeed it [minimally](#) regulates model aircraft.³¹

While drones pose a substantial risk to buildings and other infrastructure, perhaps the greatest threat they pose is to people concentrated in open venues such as sporting events. The U.S. Department of Interior recently [banned](#) the use of airborne drones in all national parks due in part to this type of hazard.³² When Mr. Paul, CEO of Volt Aerial Robotics was asked about the potential hazards to crowds at outdoor venues he noted: "Looking down the road at these kinds of scenarios, all we need is one UAS to hit a person on the ground then it's all over [the industry will be hit hard]."³³

Moreover, legal ambiguity and outdated regulations could favor defendants, thereby undermining the deterrent effect of criminal prosecution. Where the U.S. criminal code concerns aviation, there are concrete penalties for certain disruptive acts. For instance, [49 U.S.C.](#) covers air piracy, interference with crewmembers, and destruction of aircraft.³⁴ Federal law also establishes a special jurisdiction for aircraft *in flight*. According to [49 U.S.C.](#) § 46501, "An aircraft is 'in flight' from the moment when all external doors are closed following embarkation until the moment when one such door is opened."³⁵ Legal descriptions such as this afford federal prosecutors the ability to criminally charge individuals in a uniform way when certain defined acts are committed. However, in the case of drones, potentially criminal acts have to be "construed" to fit existing laws. As a result, defendants must be tried based on precedents focusing on manned aircraft or other unrelated cases.

Although the Reform Act requires the FAA to develop rules and regulations pertaining to drones, the FAA's administrative nature makes this requirement problematic. As an administrative agency, the FAA may only levy fines or revoke credentials. In the case of responsible, credentialed aircraft operators, administrative actions help deter unsafe acts. However, since drone operators—particularly model aircraft operators—do not require credentials, they may not be deterred by administrative action. Thus, there is presently little incentive for drone operators to follow rules. Since drone proliferation will doubtless continue and lone actors may continue operating them as a public hazard or to commit crimes, Congress should also pass laws that carry criminal penalties to deter these acts.

Legislators should also explore point-of-sale limitations on UAS components including licensing, certification, and background checks as part of a comprehensive approach. Similar policies have produced positive results in other industries. For example, the Department of Justice, via the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) restricts the availability of explosives to individuals or enterprises with a legitimate need. While explosives are obviously dangerous, the ATF [acknowledges](#) their many legitimate uses in mining, petroleum exploration, air bags, and special effects but levies fines and prison sentences against unlicensed users.³⁶

The drone industry, like the explosives industry, can also benefit society, but certain controls are needed due to their capacity to do harm and violate privacy. The [FAA UAS roadmap](#) acknowledges the need for “security and vetting requirements;”³⁷ one method to accomplish this is through point-of-sale restrictions.

A common argument against point-of-sale restrictions is that drones are easy to manufacture and build at home. Others argue there are so many drones already available that limiting certain technologies would be pointless. However, in the past, high explosives were also readily available until legislation was enacted. Once regulations were established in 1970³⁸, the old inventory was depleted leaving only licensed explosives. A similar outcome is likely with UAS.

Hobby aircraft rules and the Reform Act provide a giant loophole for irresponsible individuals to fly through. For less than \$2,000 anyone can purchase a fully operational drone kit equipped with remote control, GPS, gyro stabilization, and a Wi-Fi controlled payload—typically a camera. These aircraft are small and are easy to purchase, modify, and operate. FAA rules and criminal codes must account for these changes in aviation technology and their potential for misuse.

INADEQUATE THREAT ANALYSES

Negligent or criminal behavior is inevitable, but it is also important to consider the threats from a security standpoint. There is mounting evidence that both domestic and international terror networks desire to utilize drones. As UAS proliferate, our government should anticipate a rise in the types and number of such threats and prepare to respond in kind.

In September 2011, the [FBI stopped a plot](#) by Rezwan Ferdaus to use drones to ferry explosives into the U.S. Capitol and the Pentagon.³⁹ In another example, [Hamas launched three drones](#) against Israel in July 2014.⁴⁰ According to one media report, “[this] strike against Israel introduce[d] the use of drones with an offensive capacity [by terrorist groups], which could potentially inflict significant casualties.”⁴¹ In light of these and other plots, concern in the drone community is mounting.

The National Priorities Project [found](#) that “the United States has spent \$635.9 billion [inflation adjusted] on homeland security since FY2001.”⁴² Much of this investment has been focused on shoring up critical infrastructure and countering conventional threats, yet drones can easily bypass many of the security measures implemented since 9/11. Even more troubling, the availability of off-the-shelf technology already presents a tangible threat, regardless of whether the Reform Act’s integration provisions were postponed or reversed.

With the advent of widespread UAS, the United States must reframe its planning process for national security, air defense, and domain awareness. According to Dr. Endsley, Chief Scientist of the USAF, “The Scientific Advisory Board began looking at this [threat] between 2005 and 2006. The threats were approached in phases . . . [eventually] it did cover defense against UAS. These [drones] are a very real and credible threat.”⁴³ Air Force Major Michael [last name withheld], Chief of Global Intelligence, Surveillance, and Reconnaissance Operations at U.S. Central Command also “Expect[s] the enemy is going to fly these [drones].”⁴⁴ [FAA](#) agrees, “integrating public and civil UAS into the NAS carries certain national security implications, including security vetting.”⁴⁵

Noting the importance of future security implications of drone operations in the NAS, Rory Paul of Volt Aerial Robotics stated, “[r]ecently Hezbollah and the Iranians attempted to fly a drone over a nuclear reactor in Israel. It went for the reactor in one of the most secure airspace systems in the world.”⁴⁶ According to Israeli officials, “[the Iranian drone] . . . was [shot down](#) in an area near the Dimona nuclear reactor.”⁴⁷ Mr. Paul further explained, “Today, I could shut down Saint Louis Lambert International Airport from my basement; all I would have to do is fly up and down the runway. No one would know who was controlling it or from where.”⁴⁸ Mr. Paul’s example makes it clear that even non-military UAS can pose a threat.

Lt. Col. (Ret.) Mitchell [last name withheld], former Chief of MQ-1 Training for a USAF Special Operations Squadron agrees, “It is a very naive approach not to worry about non-weaponized drones . . . you can put a small amount of chemical in a[n] . . . RC [remote controlled] plane, [find] coordinates with an iPhone GPS, then 24-hours later, launch an RPA [Remotely Piloted Aircraft] from the parking lot into a full stadium using those coordinates.”⁴⁹ This scenario provides a glimpse of what might be possible and, in fact, was already tried. In April of 2014, the [FBI foiled a terror plot](#) involving an attack that would use toy planes loaded with explosives against a school and a Connecticut Federal Building.⁵⁰

Despite these security risks, there is still debate on how much of a threat small drones truly pose. Thus, it is essential to conduct a credible impact assessment. Lt. Col. (Ret.) Mitchell suggests, “a study should be considered where they hire someone and say – ‘Go buy one [a drone] and see what you can do.’ This kind of practical study will fill in gray areas very quickly.”⁵¹

Lt. Col. (Ret.) Mitchell’s comments underscore that many of the assumptions we are operating under could be wrong. According to a congressional aide, “DHS (Department of Homeland Security) did collaborate with the FAA on the privacy issues where test sites were concerned, but as far as any spoofing or hacking is concerned the DHS has yet to take any serious action. There should be more of a sense of urgency surrounding this issue.”⁵² A University of Texas at Austin study proved that civilian unmanned aerial systems can be hacked into and hijacked with a relatively small investment suggesting a “gaping hole in the security of using UAS domestically,” according to Congressman [McCaul](#).⁵³

Presently, the USAF position on small drones, according to Dr. Endsley, is that if they are not designed to carry weapons, they are not a concern.⁵⁴ Thus, while the Air Force focuses on drones designed to carry weapons and DHS focuses on ground threats—the FAA, a regulatory agency of the DOT, is left to fill the void. But the FAA is not equipped to safeguard our nation from this burgeoning threat. In fact, security is entirely incongruent with the FAA’s mission, role, and resources. Consequently, America is becoming increasingly vulnerable to the whims of those who seek to do harm with an effective, anonymous, and easily acquired airborne delivery system.

With the advent of widespread UAS, the United States must reframe its air defense posture. Some government leaders are taking notice. In recognition of the changes in UAS technology, 43 states introduced [130 pieces of legislation](#) concerning privacy, law enforcement, and research, among other issues.⁵⁵ Recently [Congressman Michael McCaul](#), Chairman of the House Subcommittee on Oversight, Investigation, and Management made the following indictment,

The Department of Homeland Security mission is to protect the homeland. Unfortunately, DHS seems either disinterested or unprepared to step up to the plate to address the proliferation of UAS in U.S. air space, the potential threats they pose to our national security, and the concerns of our citizens of how drones flying over our cities will be used, including protecting civil liberties of individuals under the Constitution.⁵⁶

NEXT GENERATION SECURITY SOLUTIONS

Once the security gaps are understood, solutions are needed. One possibility is an air defense system specifically designed for small aircraft. Major Michael proffered, “[w]e need to think along the lines of a ‘kill switch’ that could just turn [drones] off. Another aspect would be bi-state radar, lasers, etc. Bi-state radar can see something as small as a bird flying.”⁵⁷ Lt. Col. (Ret.) Mitchell agreed, “Directed kill switches might be a good answer to this A deployable asset . . . would [have a] high cost, but reasonable if portable [for] big events. Such technology could play a very important part in the future of an integrated homeland defense.”⁵⁸ Dr. Wetham, of the UK Defense Academy at Kings College, similarly suggested: “The idea of deployable anti-drone countermeasures has got to be taken seriously There are technologies already developed that could be . . . fairly easily adapted.”⁵⁹ He postulated that

the Phalanx system, a radar guided anti-aircraft system, could do the job.⁶⁰ While civil air defense is complex, these experts agree it presents a viable approach.

Developing air defense technologies suitable for domestic use will require a high degree of interagency cooperation. Congress established the Joint Planning and Development Office (JPDO), an office comprised of members of the DoD, NASA, FAA, DOT, and DHS for similar purposes relating to UAS integration. However, the JPDO was defunded by Congress in 2014. Nevertheless, the FAA understood the value of cooperation and [reestablished](#) the JPDO as the Interagency Planning Office. Under the present or a modified framework, DoD should work with DHS and FAA immediately to begin outlining research requirements and seek support to develop drone defense technologies.⁶¹

CONCLUDING REMARKS

The question before us is not *if* drones will be a part of the NAS, but *how*? Will integration unfold in a safe and reasonable manner, or will we repeat mistakes from history? DOT testified to the House Transportation aviation subcommittee that [FAA would miss the deadline](#) due to significant technological and safety concerns.⁶² From a historical perspective, this is not surprising. The current NAS took years to develop. It resulted from reactive legislation following numerous accidents. Conversely, safe UAS integration will require proactive resolution of many regulatory, legislative, and technological issues.⁶³ However, the most significant of these are: (1) inadequate safety systems (2) inadequate statutes, and (3) incomplete threat analyses.

The first problem is the technology required to safely implement FAA's UAS roadmap. According to a [DOT audit](#), "Significant technological, regulatory, and management barriers exist to safely integrat[ing] UAS . . . Following many years of working with industry, FAA has not reached consensus on standards for technology that would enable UAS to detect and avoid other aircraft and ensure reliable data links between ground stations and the unmanned aircraft they control."⁶⁴ To resolve this, FAA, along with its interagency partners must lead and expand research and development at UAS test sites. Competitive design challenges may also provide FAA with a viable option to accelerate technological problem solving.

In addition to the technological issues, current criminal, civil, and regulatory provisions are inadequate for deterring hazardous use of drones. It's also vital to address [Congressman McCaul's warning](#), "that these aerial vehicles could be modified and used to attack key assets and critical infrastructure in the United States."⁶⁵ Additional threat analysis and research on drone capabilities and prospective defense measures is needed. According to Lt. Col. (Ret.) Mitchell, drones "will be one of the worst security . . . issues that we have."⁶⁶

These latent problems will continue to delay the safe and useful integration of UAS. According to [DOT](#), "Integrating UAS into the complicated U.S. airspace requires an incremental approach, and one that will allow the NAS processes currently in place, as well as those under development, to effectively ensure safety both in the air and on the ground."⁶⁷ While delays may hinder a growing UAS industry and draw unwanted attention to FAA, they will also provide vital time for research, threat assessment, and the implementation of practical solutions.

¹ Schmidt, Michael and Shear, Mishael. "A Drone, Too Small for Radar to Detect, Rattles the White House," *New York Times*, January 26, 2015, http://www.nytimes.com/2015/01/27/us/white-house-drone.html?_r=0 (accessed February 18, 2015). ("A White House radar system designed to detect flying objects like planes, missiles and large drones failed to pick up a small drone that crashed into a tree on the South Lawn early Monday morning, according to law enforcement officials. The crash raised questions about whether the Secret Service could bring down a similar object if it endangered President Obama.")

² McCaul, Michael. "Using Unmanned Aerial Systems Within the Homeland: Security Game Changer?" Address, Statement of Chairman Subcommittee on Oversight, Investigations, and Management, Washington, D.C., July 19, 2012. Available at <http://homeland.house.gov/sites/homeland.house.gov/files/07-19-12%20McCaul%20Open.pdf>

³ Jones, Tammy, and Paul Takemoto. "Fact Sheet." http://www.faa.gov/news/press_releases/news_story.cfm?newsId=12903 (accessed June 28, 2014).

⁴ U.S. Department of Transportation. "March 2014 U.S. Airline Traffic Data | Bureau of Transportation Statistics." March 2014 U.S. Airline Traffic Data | Bureau of Transportation Statistics. http://www.rita.dot.gov/bts/press_releases/bts028_14 (accessed June 28, 2014). ("15,461 air traffic controllers handle 50,000 flights a day.")

⁵ Price, Henry. "Fact Sheet – FAA Forecast–Fiscal Years 2014-34." http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=15934 (accessed June 28, 2014).

⁶ "Integration of Civil Unmanned Aircraft Systems." In FAA Modernization and Reform Act of 2012. ed. Washington D.C. : Government Publication Office, 2012. Available at <http://www.gpo.gov/fdsys/pkg/CRPT-112hrpt381/pdf/CRPT-112hrpt381.pdf> ("The committee of conference on the disagreeing votes of the two Houses on the amendment of the Senate to the bill (H.R. 658), to amend title 49, United States Code, to authorize appropriations for the Federal Aviation Administration for fiscal years 2011 through 2014, to streamline programs, create efficiencies, reduce waste, and improve aviation safety and capacity...")

⁷ Ibid. Comprehensive Plan. ("Not later than 270 days after the date of enactment of this Act, the Secretary of Transportation, in consultation with representatives of the aviation industry, Federal agencies that employ unmanned aircraft systems technology in the national airspace system, and the unmanned aircraft systems industry, shall develop a comprehensive plan to safely accelerate the integration of civil unmanned aircraft systems into the national airspace system.")

⁸ Ibid. Deadline. ("The plan required under paragraph (1) shall provide for the safe integration of civil unmanned aircraft systems into the national airspace system as soon as practicable, but not later than September 30, 2015.")

⁹ Federal Aviation Administration. "Certificates of Waiver or Authorization (COA)." Unmanned Aircraft Systems (UAS). http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/aaim/organizations/uas/coa/ (accessed July 12, 2014). ("COA is an authorization issued by the Air Traffic Organization to a public operator for a specific UA activity. After a complete application is submitted, FAA conducts a comprehensive operational and technical review. If necessary, provisions or limitations may be imposed as part of the approval to ensure the UA[V]s can operate safely with other airspace users.")

¹⁰ AUVSI. "About Us." - Association for Unmanned Vehicle Systems International. <http://www.auvsi.org/home/aboutus> (accessed July 10, 2014). ("The Association for Unmanned Vehicle Systems International is the world's largest non-profit organization devoted exclusively to advancing the unmanned systems and robotics community. Serving more than 7,500 members from government organizations, industry and academia, AUVSI is committed to fostering, developing, and promoting unmanned systems and robotic technologies.") Author's note: link updated to <http://www.auvsi.org/about> (23 Feb, 2014)

¹¹ AUVSI. "Unmanned Aerial Vehicle Integration into the National Air Space System: An Assessment of the Impact of Job Creation in the Aerospace Industry." <http://rmgsc.cr.usgs.gov/uas/pdf/AUVSI/0510JobsReport.pdf> (accessed July 8, 2014). Author's note: this document is no longer available at the USGS website (23 Feb, 2014)

¹² AUVSI. "Advocacy." Association for Unmanned Vehicle Systems International. <http://www.auvsi.org/advocacy> (accessed July 10, 2014). ("On behalf of our membership we are committed to shaping global policy by advocating on behalf of the unmanned systems and robotics community, monitoring legislation and assessing the global impact of the industry to ensure that obstacles to advancing and fielding unmanned systems and robotics are removed. AUVSI's current legislative initiatives include: Airspace Access.")

¹³ AUVSI. "Unmanned Aerial Vehicle Integration in the National Air Space System: An Assessment of the Impact of Job Creation in the Aerospace Industry." <http://rmgsc.cr.usgs.gov/uas/pdf/AUVSI/0510JobsReport.pdf> (accessed July 8, 2014). ("The economic impact analysis outlined in this report assumes a steady progression in UAS access to unrestricted airspace. If UAS integration efforts result in the uninhibited operation of all classes of UAS in the NAS over the next 5 years, positive economic

benefits will result and UAS employment opportunities will develop sooner than expected. Alternatively, if efforts to integrate UAS into the NAS are stalled, serious repercussions will result, the following: Smaller, UAS-centric companies will struggle to stay in business; end users, especially those in the public safety field, will miss the opportunity to employ a technology with proven life-saving benefits; the military will be challenged to maintain the readiness levels of UAS operators; the U.S. will risk being surpassed in the global UAS space in terms of technology development; and the U.S. aerospace industry will miss an opportunity for economic growth at a time when many sectors are declining. New job growth will be stifled and current jobs in the UAS industry could be lost. The repercussions associated with failed UAS integration efforts will negatively impact the UAS community for years to come.”) Author’s note: this document is no longer available at the USGS website (23 Feb, 2014)

¹⁴ US Congress. H.R.658 - FAA Modernization and Reform Act of 2012. 112th Congress (2011-2012). <https://www.congress.gov/bill/112th-congress/house-bill/658/actions>. (accessed February 20, 2015).

¹⁵ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. (“Experts we interviewed stated that “detect and avoid” is the most pressing technical challenge to integration.”)

¹⁶ Federal Aviation Administration. "Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap." http://www.faa.gov/about/initiatives/uas/media/UAS_Roadmap_2013.pdf (accessed July 7, 2014). (“FAA’s initial regulations and guidance material (such as TSOs and Advisory Circulars) to enable the production, sale, installation, and maintenance of FAA-certified systems and services used in providing radio LOS C2 capabilities for civil UAS published by 2016–2017.” And “Goal 1: Initial FAA certification of ABSAA that facilitates UAS operations without the requirement for a visual observer by 2016–2020.”) Available at http://www.faa.gov/uas/media/uas_roadmap_2013.pdf (22 Jan, 2014)

¹⁷ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. (“the Agency is behind schedule on most of the act’s UAS provisions, and the magnitude of unresolved safety and privacy issues will prevent FAA from meeting Congress’ September 2015 deadline for UAS integration.”)

¹⁸ Endsely, Mica. Phone interview conducted by author at 12:47 CT, July 8, 2014.

¹⁹ Paul, Rory. Phone interview conducted by author at 18:33 CT, June 26, 2014.

²⁰ Nicas, Jack. "FAA: U.S. Airliner Nearly Collided With Drone in March: Incident Appears to be First Case of a Big U.S. Airliner Nearly Colliding With an Airborne Drone." *The Wall Street Journal*. <http://online.wsj.com/articles/faa-u-s-airliner-nearly-collided-with-drone-in-march-1399659956> (accessed July 7, 2014). (“A U.S. airliner nearly collided with a drone over Florida earlier this year, a federal official said, a near miss that highlights risks posed by the proliferation of unmanned aircraft in U.S. skies. A pilot of an American Airlines Group regional jet told officials that on March 22 he came dangerously close to a “small remotely piloted aircraft” about 2,300 feet above the ground near Tallahassee Regional Airport in Florida, said Jim Williams, head of the unmanned-aircraft office at the Federal Aviation Administration. Mr. Williams disclosed the incident publicly for the first time at a drone conference in San Francisco on Thursday.”)

²¹ Whitlock, Craig. "When Drones Fall From the Sky." *The Washington Post*. <http://www.washingtonpost.com/wp-srv/special/national/drone-crashes/database/> (accessed July 7, 2014) (accessed July 17, 2014). (“Air Force leaders circulated briefing materials that quoted an unnamed general as saying, ‘What I worry about is the day I have a C-130 with a cargo-load of soldiers, and a [drone] comes right through the cockpit window.’ The general’s worries were well founded. On Aug. 15, 2011, a C-130 Hercules weighing about 145,000 pounds was descending toward Forward Operating Base Sharana, in eastern Afghanistan. Suddenly, a quarter-mile above the ground, the huge Air Force plane collided with a 375-pound flying object. ‘Holy shit!’ yelled the Hercules’s navigator, according to a transcript of the cockpit voice recorder. ‘We got hit by a UAV! Hit by a UAV!’”) Author’s Note: link updated to <http://www.washingtonpost.com/sf/investigative/2014/06/20/when-drones-fall-from-the-sky/> (22 Jan, 2014)

²² Ibid. "Drone crashes database: 194 of the worst drone accidents since 9/11." *The Washington Post*. <http://www.washingtonpost.com/wp-srv/special/national/drone-crashes/database/> (accessed July 7, 2014). (“About one-third of the crashes occurred in Afghanistan, but nearly one-quarter happened in the United States during test and training flights. As the Pentagon deploys drones away from traditional combat zones, more accidents are occurring in Africa and other locations. The annual number of crashes has risen over the past decade as the military has expanded the frequency of drone missions. The Pentagon says most drone types have become more reliable over time and that the number of crashes per flight hour has steadily decreased.”)

²³ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. (“FAA is not effectively collecting and analyzing UAS

safety data to identify risks. This is because FAA has not developed procedures for ensuring that all UAS safety incidents are reported and tracked or a process for sharing UAS safety data with the U.S. Department of Defense (DoD), the largest user of UAS.”)

²⁴ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. (“Further, regional UAS safety inspectors do not conduct onsite inspections of UAS operations for various reasons, such as resource constraints and unclear guidance regarding oversight authority. While FAA issued guidance in January 2013 that provides necessary policies for evaluating proposed UAS operations and describes the details a COA applicant should have in place, the guidance does not clearly detail what actions an inspector should take in overseeing a UAS operator.”)

²⁵ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. (“In addition, FAA has not reached agreement with DoD on exchanging the most useful data. For example, FAA’s Office of Accident Investigation and Prevention receives annual UAS mishap data from DoD under a Memorandum of Agreement. However, FAA’s UAS integration staff told us they do not find these data useful because they lack detail. Although DoD has a wealth of other operational data, such as airworthiness data, FAA has been unable to obtain the data, despite requesting it nearly 2 years ago. DoD has been reluctant to provide some data to FAA due to concerns regarding the release of sensitive information and uncertainty over who would bear the cost of retrieving the information. FAA has now formed a data-sharing team with DoD representatives to resolve this issue. In June 2013, FAA began a series of meetings with DoD representatives to discuss obtaining pertinent DoD operational data, such as pilot training standards and air traffic control lessons learned. In addition, recognizing that the Agency needs a better data management strategy, FAA tasked MITRE21 to develop a system to collect and better analyze UAS safety data. According to FAA, it expects MITRE to complete this initiative in September 2015.”)

²⁶ Federal Aviation Administration. "Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap." http://www.faa.gov/about/initiatives/uas/media/UAS_Roadmap_2013.pdf (accessed July 7, 2014). (“Government agencies and industry need to investigate link security requirements, such as protection against intended and unintended jamming, RF interference, unauthorized link takeover, and spoofing”)

²⁷ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. (“A related unresolved issue is securing adequate radio frequencies for UAS operations. While some UAS-specific radio frequencies exist, it is uncertain how many are needed and whether there will be licensing, control and communications standards, and security vulnerabilities. FAA is currently working with industry to develop standards for UAS radio frequencies and to determine how these issues will be addressed.”)

²⁸ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. (“Determine the specific types of data and information needed from each of the six planned test ranges to facilitate safe integration of UAS into the NAS. For recommendation 9, FAA stated that the Agency is working with each test site to understand planned research activities. Additionally, FAA stated that if the research is applicable and available, the Agency will determine what data should be collected and request results of studies and relevant data from the test sites. FAA stated this would be an ongoing activity and the results would be available by December 31, 2017. However, our recommendation was specifically aimed at encouraging FAA to determine the data it needs early in the process so it can more effectively use the test sites to identify and reduce UAS integration risks. Therefore, we request the Agency provide information on actions it will take to more timely identify the specific types of data and information needed from each of the six test sites, as we recommended.”)

²⁹ Jansen, Bart. "Watchdogs: FAA won't meet 2015 deadline for drone safety." USA Today. <http://www.usatoday.com/story/news/nation/2014/02/05/faa-drones-inspector-general-gao/5226427/> (accessed July 7, 2014). (“The agency will not meet the September 2015 deadline for safe (drone) integration and it is uncertain when this will be achieved,” Calvin Scovel III, the Transportation Department’s inspector general, told the House Transportation subcommittee on aviation. Scovel cited ‘significant technological barriers,’ such as having drones detect and avoid other aircraft, and remaining linked to their remote pilots. He also said that air-traffic controllers contend that existing automation can’t handle drone flight plans.”)

³⁰ Piper, Brandie, and Elizabeth Matthews. "Drone crashes into Met Square building downtown. Drone crashes into Met Square building downtown." <http://www.ksdk.com/story/news/local/2014/05/07/drone-crash-metropolitan-square-building/8828895/> (accessed July 7, 2014). (“Schron Jackson, a spokesperson for the St. Louis Metropolitan Police Department, says Bike Unit officers responded to the Metropolitan Square building in the 200 block of North Broadway around 4 p.m. Monday after security officers called about a recovered article from a 30th floor balcony. Jackson says the article is a DJI Phantom II Quadcopter, controlled through WiFi. It crashed into the building and landed on the balcony. Pieces of the drone were broken from the crash. Police are now looking for the owner of the drone. According to the FAA, ‘civilians can have and operate drones, if you maintain

a visual while flying and keep it under 400 feet above ground.’ The drone that crashed Monday hit the 30th floor of the 593-foot-tall building. It crashed into a floor that houses a law firm. Witnesses tell NewsChannel 5 an employee of the firm found the drone and called security.”)

³¹ Federal Aviation Administration. “14 CFR Part 91: Interpretation of the Special Rule for Model Aircraft.” 6 & 16. http://www.faa.gov/uas/media/model_aircraft_spec_rule.pdf (Accessed August 21, 2014). (“Section 336 also prohibits the FAA from promulgating “any rule or regulation regarding a model aircraft, or an aircraft being developed as a model aircraft” if the following statutory requirements are met:

- the aircraft is flown strictly for hobby or recreational use;
- the aircraft is operated in accordance with a community-based set of safety guidelines and within the programming of a nationwide community-based organization;
- the aircraft is limited to not more than 55 pounds unless otherwise certified through a design, construction, inspection, flight test, and operational safety program administered by a community-based organization;
- the aircraft is operated in a manner that does not interfere with and gives way to any manned aircraft; and
- when flown within 5 miles of an airport, the operator of the aircraft provides the airport operator and the airport air traffic control tower ... with prior notice of the operation....”

And “Rules addressing operation of the aircraft may include prohibitions on careless or reckless operation and dropping objects so as to create a hazard to persons or property.”)

³² Berman, Mark. "National Park Service bans drone use in all national parks." *The Washington Post*. <http://www.washingtonpost.com/news/post-nation/wp/2014/06/20/national-park-service-bans-drone-use-in-all-national-parks/> (accessed July 10, 2014).

³³ Paul, Rory. Phone interview conducted by author at 18:33 CT, June 26, 2014.

³⁴ U.S. Department of Justice. "Criminal Resource Manual 1405 Special Aircraft Jurisdiction of the U.S.." Criminal Resource Manual 1405 Special Aircraft Jurisdiction of the U.S.. http://www.justice.gov/usao/eousa/foia_reading_room/usam/title9/crm01405.htm (accessed July 15, 2014).

³⁵ U.S. Department of Justice. "Criminal Resource Manual 1405 Special Aircraft Jurisdiction of the U.S.." Criminal Resource Manual 1405 Special Aircraft Jurisdiction of the U.S.. http://www.justice.gov/usao/eousa/foia_reading_room/usam/title9/crm01405.htm (accessed July 15, 2014). (“An aircraft is ‘in flight’ from the moment when all external doors are closed following embarkation until the moment when one such door is opened for disembarkation, or in the case of a forced landing, until competent authorities take responsibility for the aircraft. 49 U.S.C. § 46501(1)”)

³⁶ Department of Justice: Bureau of Alcohol, Tobacco, Firearms and Explosives. "Explosives Industry." Home. <https://www.atf.gov/content/Explosives/explosives-industry> (accessed July 13, 2014). (“Explosives industry members play an integral role in maintaining and improving our quality of life in the United States and work to bring countless benefits to our everyday lives in areas such as mining, oil and gas exploration; demolition; avalanche control; and the use of explosives in special industrial tools, fire extinguishers, air bag inflators, fireworks; and special effects in the entertainment industry. However, because of the potential misuse of explosive materials, ATF’s role plays a vital role in regulating and educating the explosives industry and in protecting the public from inadequate storage and security.”)

³⁷ Federal Aviation Administration. "Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap." http://www.faa.gov/about/initiatives/uas/media/UAS_Roadmap_2013.pdf (accessed July 7, 2014). (“UAS training standards will mirror manned aircraft training standards to the maximum extent possible, including appropriate security and vetting requirements, and will account for all roles involved in UAS operation. This may include the pilot, required crew members such as visual observers or launch and recovery specialists, instructors, inspectors, maintenance personnel, and air traffic controllers.”)

³⁸ Department of Justice: Bureau of Alcohol, Tobacco, Firearms and Explosives. "ATF: Federal Explosives Law and Regulations." Home. <http://www.atf.gov/files/publications/download/p/atf-p-5400-7.pdf> (accessed February 18, 2015). (“Public law 91-452 (approved October 15, 1970) The Congress hereby declares that the purpose of this title is to protect interstate and foreign commerce against interference and interruption by reducing the hazard to persons and property arising from misuse and unsafe or insecure storage of explosive materials. It is not the purpose of this title to place any undue or unnecessary Federal restrictions or burdens on law-abiding citizens with respect to the acquisition, possession, storage, or use of explosive materials for industrial, mining, agricultural, or other lawful purposes, or to provide for the imposition by Federal regulations of any procedures or requirements other than those reasonably necessary to implement and effectuate the provisions of this title.”)

³⁹ U.S. Department of Justice: U.S. Attorney's Office. "USDOJ: US Attorney's Office - District of Massachusetts." USDOJ: US Attorney's Office - District of Massachusetts. <http://www.justice.gov/usao/ma/news/2012/July/FerdausRezwanPlea.html> (accessed July 10, 2014). (*"On Sept. 28, 2011, Ferdaus requested and instructed the undercover FBI employees (UCE) to deliver explosives and firearms (material represented to Ferdaus to contain 25 pounds of C-4 explosives, including approximately 1.25 pounds of actual C-4 explosives, three grenades, and six fully automatic AK-47 assault rifles) for his attack plan. While inspecting the explosives and firearms in the UCEs' vehicle and inside his storage unit, Ferdaus placed some of the explosives inside a remote controlled aircraft that he had ordered and obtained for his attack plan. Ferdaus then locked the explosives and firearms in his storage unit at which time he was placed under arrest."*)

Author's Note: link updated to: <http://www.justice.gov/archive/usao/ma/news/2012/July/FerdausRezwanPlea.html> (23 Jan, 2014)

⁴⁰ FOX News Network. "Israel military says it has shot down drone along southern coastline." Fox News. <http://www.foxnews.com/world/2014/07/14/israel-military-says-it-has-shot-down-drone-along-southern-coastline/> (accessed July 17, 2014).

⁴¹ Ibid.

⁴² "U.S. Security Spending Since 9/11." National Priorities Project. <https://www.nationalpriorities.org/analysis/2011/us-security-spending-since-911/> (accessed July 7, 2014). (*"Funding for homeland security has risen from \$16 billion in FY2001 to \$71.6 billion requested for FY2012. Adjusted for inflation, the United States has spent \$635.9 billion on homeland security since FY2001 [as of 2012]. Of this \$163.8 billion has been funded within the Pentagon's annual budget. The remaining \$472.1 billion has been funded through other federal agencies. For full details of the FY2012 homeland security request, see the "Homeland Security Mission Funding by Agency and Budget Account" appendix to the FY2012 budget."*)

⁴³ Endsely, Mica. Phone interview conducted by author at 12:47 CT, July 8, 2014.

⁴⁴ N., Michael. Phone interview conducted by author at 13:35 CT, June 30, 2014.

⁴⁵ Federal Aviation Administration. "Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap." http://www.faa.gov/about/initiatives/uas/media/UAS_Roadmap_2013.pdf (accessed July 7, 2014). (*"Integrating public and civil UAS into the NAS carries certain national security implications, including security vetting for certification and training of UAS-related personnel, addressing cyber and communications vulnerabilities, and maintaining/enhancing air defense and air domain awareness capabilities in an increasingly complex and crowded airspace."*)

⁴⁶ Paul, Rory. Phone interview conducted by author at 18:33 CT, June 26, 2014.

⁴⁷ Karouny, Mariam. "Hezbollah confirms it sent drone downed over Israel." Reuters. <http://www.reuters.com/article/2012/10/11/us-lebanon-israel-drone-idUSBRE89A19J20121011> (accessed July 7, 2014). (*"Seeking to underline that Hezbollah was capable of reaching targets well inside Israel, Nasrallah said the drone "flew over sensitive installations inside southern Palestine and was shot down in an area near the Dimona nuclear reactor."*)

⁴⁸ Paul, Rory. Phone interview conducted by author at 18:33 CT, June 26, 2014.

⁴⁹ W., Mitchell. Phone interview conducted by author at 17:10 CT, July 7, 2014.

⁵⁰ Mayco, Michael. "FBI: Drone-like toy planes in bomb plot." *Connecticut Post*. <http://www.ctpost.com/local/article/FBI-Drone-like-toy-planes-in-bomb-plot-5383658.php> (accessed July 15, 2014). (*"A Moroccan national who allegedly plotted to turn a radio-controlled model airplane into a drone-like flying bomb and crash it into a school and a Connecticut federal building was arrested Monday by FBI agents. Wires and tools were found in the High Ridge Drive apartment where El Mehdi Semlali Fahti, 27, had been living since January with an individual he met while incarcerated in Virginia, according to the FBI. It was not known if any explosives were found."*)

⁵¹ W., Mitchell. Phone interview conducted by author at 17:10 CT, July 7, 2014.

⁵² Homeland Security Committee Aide. Phone interview conducted by author at 09:30 CT, July 8, 2014.

⁵³ McCaul, Michael. "Using Unmanned Aerial Systems Within the Homeland: Security Game Changer?" Address, Statement of Chairman Subcommittee on Oversight, Investigations, and Management, Washington, D.C., July 19, 2012. Available at: <http://homeland.house.gov/sites/homeland.house.gov/files/07-19-12%20McCaul%20Open.pdf>

⁵⁴ Endsely, Mica. Phone interview conducted by author at 12:47 CT, July 8, 2014.

⁵⁵ National Conference of State Legislators. "2013 Unmanned Aircraft Systems (UAS) Legislation." 2013 State Unmanned Aircraft Systems (UAS) Legislation. <http://www.ncsl.org/research/civil-and-criminal-justice/unmanned-aerial-vehicles.aspx> (accessed July 10, 2014). ("In 2013, 43 states introduced 130 bills and resolutions addressing UAS issues. At the end of the year, 13 states had enacted 16 new laws and 11 states had adopted 16 resolutions.")

⁵⁶ McCaul, Michael. "Using Unmanned Aerial Systems Within the Homeland: Security Game Changer?" Address, Statement of Chairman Subcommittee on Oversight, Investigations, and Management, Washington, D.C., July 19, 2012. Available at: <http://homeland.house.gov/sites/homeland.house.gov/files/07-19-12%20McCaul%20Open.pdf>

⁵⁷ N., Michael. Phone interview conducted by author at 13:35 CT, June 30, 2014.

⁵⁸ W., Mitchell. Phone interview conducted by author at 17:10 CT, July 7, 2014.

⁵⁹ Wetham, David, Phone interview conducted by author at 10:00 CT, July 8, 2014.

⁶⁰ Ibid.

⁶¹ Carey, Bill. "FAA's New Interagency Planning Office Replaces JPDO." Aviation International News, <http://www.ainonline.com/aviation-news/air-transport/2014-05-27/faas-new-interagency-planning-office-replaces-jpdo> (accessed Dec 20, 2014).

⁶² Jansen, Bart. "Watchdogs: FAA won't meet 2015 deadline for drone safety." *USA Today*. <http://www.usatoday.com/story/news/nation/2014/02/05/faa-drones-inspector-general-gao/5226427/> (accessed July 7, 2014). ("The agency will not meet the September 2015 deadline for safe (drone) integration and it is uncertain when this will be achieved," Calvin Scovel III, the Transportation Department's inspector general, told the House Transportation subcommittee on aviation. Scovel cited 'significant technological barriers,' such as having drones detect and avoid other aircraft, and remaining linked to their remote pilots. He also said that air-traffic controllers contend that existing automation can't handle drone flight plans.")

⁶³ Dulo, Dana. "UAS In the National Airspace: Aerial Goldmine or Legal Landmine." *Unmanned Systems: Association of Unmanned Vehicle Systems International* Volume 32 No. 6: 14-17. ("[I]t wasn't until the Federal Aviation Act of 1958, enacted after a series of catastrophic airliner accidents, that the predecessor of the FAA was established to fully regulate the skies to create and enforce safety regulations as a unified government enforcement body. Even after the creation of the FAA, laws in manned aviation had a propensity to change or to be conceived after major incidents or mishaps. A survey of the many major airliner catastrophes of the 1970s through 1990s bears witness to this unfortunate fact. This reactive legislative posture can therefore be expected as a proverbial repetition of aviation history in the unmanned aviation domain. UAS integration into the national airspace opens up a variety of legal issues that must be addressed in light of the plethora of UAS airframe and payload technologies.")

⁶⁴ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. ("Significant technological, regulatory, and management barriers exist to safely integrate UAS into the NAS. First, following many years of working with industry, FAA has not reached consensus on standards for technology that would enable UAS to detect and avoid other aircraft and ensure reliable data links between ground stations and the unmanned aircraft they control.")

⁶⁵ McCaul, Michael. "Using Unmanned Aerial Systems Within the Homeland: Security Game Changer?" Address, Statement of Chairman Subcommittee on Oversight, Investigations, and Management, Washington, D.C., July 19, 2012. Available at: <http://homeland.house.gov/sites/homeland.house.gov/files/07-19-12%20McCaul%20Open.pdf>

⁶⁶ W., Mitchell. Phone interview conducted by author at 17:10 CT, July 7, 2014.

⁶⁷ US Department of Transportation. *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*. Report Number: AV-2014-061, 26 Jun 2014. ("Finally, it is important to note that the Act requires safe – not full – integration of UAS into the NAS by September 2015. Integrating UAS into the complicated U.S. airspace requires an incremental approach, and one that will allow the NAS processes currently in place, as well as those under development, to effectively ensure safety both in the air and on the ground.")

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