AIR WAR COLLEGE

AIR UNIVERSITY

THE PROLIFERATION OF UNMANNED AERIAL VEHICLES AND THE THREAT TO
THE UNITED STATES

By

David C. Lionberger, Lt Col, USAFR

A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements

Advisor: CAPT Randall Lovell

10 February 2016

DISCLAIMER

The views expressed in this academic research paper are those of the author and do not reflect the official policy or position of the US government, the Department of Defense, or Air University.   In accordance with Air Force Instruction 51-303, it is not copyrighted, but is the property of the United States government.

Biography

Lt Col David Lionberger is assigned to the Air War College, Air University, Maxwell AFB, Alabama. Lt Col Lionberger is a career Logistics Readiness Officer with extensive experience at the wing, numbered air force and major command level. In addition, Col Lionberger has almost 10 years in law enforcement where he routinely worked crowd control, event security and VIP protection.

David Lionberger
Seminar 14

Abstract

The proliferation of Unmanned Aerial Vehicles (UAVs) is both a benefit and treat to the security of the United States. The use of UAVs by terrorist poses a serious threat to the American public if left unaddressed. By comparing the capabilities provided by UAV and our current security measures, it is easy to see the gaping holes in our current protection. These gaping holes in our security coupled with the terrorist predisposition to use aerial assets as a primary method to conduct terrorist attacks highlight the urgency of the threat.

Identifying and understanding the threat is just the first part of the problem. The challenge is combating this emerging threat. The rapid proliferation in the public and private sector makes identifying, tracking and disabling UAVs used for terrorist activities extremely difficult. The solution will require a comprehensive approach comprising public education, UAV marking, tracking of key components and changes in current security measures.

Only by acknowledging the threat and implementing significant changes can we hope to avoid another aerial attack on American soil.

The recent terrorist attacks in Paris and around the world highlight the difficulty governments' encounter preventing terrorist from injuring and killing innocent people in public places. These attacks are not a result of weak government or poor security but more the results of determined extremist exploiting vulnerabilities in security measures to inflict harm and cause fear. Protecting the public is a massive responsibility of every government and requires maintaining existing security measures as well as adjusting to new emerging threats. Often these new threats are the result of changes in technology or tactics used by various terrorist organizations. The challenge for the agencies charged with protecting the public is accurately identifying these changes and adapting appropriate countermeasures. This continues to be a struggle for governments around the world. Unfortunately, the future appears more difficult as technology continues to expose new areas for terrorist exploitation.

Today, the challenge for governmental agencies and local law enforcement is the development of the Unmanned Aerial Vehicle (UAV). In the hands of criminals and terrorist, this transformational technology could be devastating. To put it bluntly, the proliferation of UAVs coupled with terrorist characteristics to exploit technology and invoke fear makes the use of UAVs a clear and present threat to the United States. This paper will show the developing UAV technology provides increased opportunities for terrorist to exploit current security vulnerabilities while remaining consistent with established patterns of terrorist behavior. The characteristics of UAVs, not only increase the access to high profile targets, in many cases, it would potentially reduce the risk of apprehension and the associated cost.

We will start with a basic understanding of terrorism and the motives behind most terrorist attacks directed at the United States. Then from that perspective show how the UAV capabilities could easily be used to conduct terrorist attacks in the United States and abroad. For

this, we will focus on the specific element of aerial terrorism, which has been a long held tactic of terrorist. By connecting the intended terrorist goals, the UAV capabilities and the historic tendencies of terrorist organizations, we can project the possible use of UAVs in future attacks. Only then will we be able to look for counter measures to offset the advantages presented by the developing UAV technology.

The relationship between technology and violence is historic. Both have remained constant often feeding off each other. In some cases, violence drives the technology to defeat the threat and in other cases, technology enables the violence. Regardless of the reason, nations invest heavily in research and development to develop new ways of inflicting violence. In many cases, the very technology they develop later becomes a weapon used against them. Just think about the atomic bomb. It played a key role in the end of World War II but was later the weapon of choice for the Soviet Union.

In addition to technology driving violence, it also drives commerce. Many of the technological developments first used to escalate or reduce the violence will find their way into the civilian market place. In many cases, these advances in technology have proved decisive in combat and ultimately profitable in society. However, from the very first crude weapon used to defend a water hole to the complex weapon systems used around the world, these great advances are equally as powerful force for good as evil.

The current transfer of technology from the military to the commercial sector is the use of unmanned aerial vehicles (UAVs). What are UAVs? According to the Department of Defense (DOD), they are powered, aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or

recoverable, and can carry lethal or nonlethal payloads.[1] Joint Publication further defines the

entire system involved. According to Joint Publication 3-30, an unmanned aircraft (UA) is an

aircraft that does not carry a human operator and is capable of flight with or without human

remote control. In addition, the Unmanned Aerial System (UAS) is the equipment, network, and

personnel required to control an unmanned aircraft. The USAF refers to some of its larger UAS

as remotely piloted aircraft (RPA) to differentiate its operators who have been trained to similar

standards as manned aircraft pilots.[2] UAVs are also referred to in many ways such as remotely

piloted vehicle (RPV), drones, robot plane, and pilotless aircraft to name a few. For this article,

we will use the term UAVs.

President Bush highlighted the significance of the UAV in changing the very way

American conducts war in a speech to the Citadel in December 2001. President Bush stated,

"The Predator is a good example. This unmanned aerial vehicle is able to circle over enemy

forces, gather intelligence, transmit information instantly back to commanders, and then fire on

targets with extreme accuracy. Before the war, Predator had skeptics, because it did not fit the

old ways. Now it is clear the military does not have enough unmanned vehicles. We're entering

an era in which unmanned vehicles of all kinds will take on greater importance."[3]

The use of UAVs fundamentally changed the way we conduct war. Not only did it give

us the advantage in information and in the element of surprise, it greatly reduced the risk of

United States and coalition causalities; making the idea of waging war much more agreeable to

the American public. Using advanced computer software, analyst are able to map an entire

enemy networks by watching the movements of known members of the organization over time

then link this data with other intel gathered such as e-mails, phone call or text messages to select

the precise place to strike a target. Never before has this level of precision been available.[4]

From that first strike in Feb 2004, the armed UAV program has dramatically increased. As represented on chart 1 below, in 2004 the US conducted one armed UAV strike in Pakistan then increased the number of strikes until reaching the high point of 128 strikes in 2010.[5]
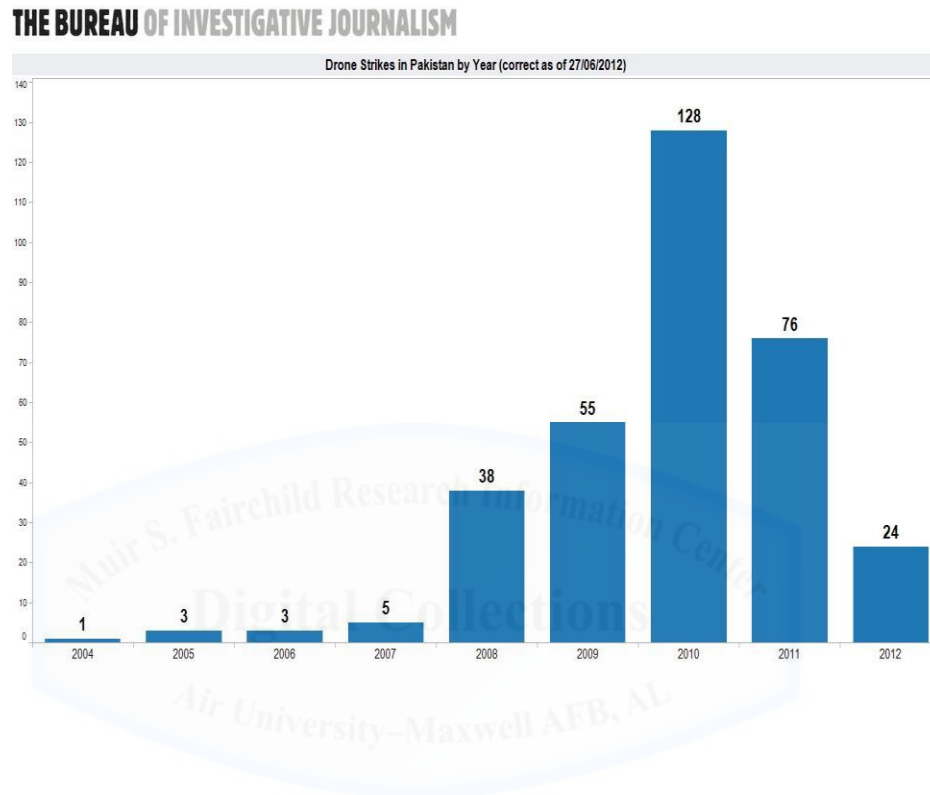
The use of UAVs has given us a great advantage as we conduct combat operations around the world. However, what happens when our enemy begins using the same technology against us? The rapid development in UAV technology has greatly reduced the cost and size of many UAVs allowing almost anyone the ability to purchase and operate it. This proliferation in UAV technology will pose a significant threat to our national security, which must be addressed aggressively.

Just as with computers in the past, the recent advances in UAV technology have dramatically increased the availability to the public by reducing cost and increasing operational

performance. This is great news for hobbyist and commercial interest looking to capitalize on the new opportunity. Unfortunately, the same attributes that make this technology attractive to consumers also makes it attractive to terrorist.

Terrorism

Terrorism lacks a universal definition but most experts agree terrorism is the use of or threat to use violence against a civilian population for political goals. Terrorist use indiscriminate violence for several key reasons: such as gaining recognition for their cause, discrediting or destabilizing the government, influencing governmental decisions or retaliating for perceived injustices.[6] There are definitions that are far more complex but for the purpose of this discussion, this should be sufficient. It is important to remember terrorism is not a new threat faced by nations; unfortunately, terrorism has existed for almost as long as civilization. The first documented use of terrorism came in the first century when a Jewish group called the Sicarii used violence against Roman soldiers and any Jews they believed helped the Romans to oust the Romans from Judea.[7]

For terrorism to work, the world must know about it. A primary goal of any type terrorist attack is media attention. Without it, they fail to gain any attention for their cause and are ineffective at forcing any other demands. Therefore, to ensure mass media attention, the terrorist seek targets based on the publicity expected from a successful attack. For our purposes, we will refer to these as high value targets. For planning and risk assessment, high value targets are broken into three categories by law enforcement. They are high payoff targets, high-risk personnel and high-risk events.

Targeting

A high payoff target is any target that would generate a great deal of media attention because of the symbolic nature of the target. The September 11 attack is an example of a high payoff target. A second type high value target is key figures in society such as elected official or other people of status. This includes assassination and the 1972 attack on the Israeli Olympic team in Munich, Germany. The third type high value target is a high-risk event; any large gathering of people that would cause a large number of causalities and generate mass media attention. Aircraft hijackings or the Boston Marathon Bombing are examples.

Knowing terrorist seek to use violence against high value targets gives our first insight as to why UAV technology might be appealing. The current UAV technology provides increased access to high value targets without forcing significant adjustments in the terrorist patterns of behavior. Terrorist have successfully used the airline industry repeatedly as a tool of terror for almost 50 years creating the sub-category aerial terrorism. Aviation terrorism is a violent act, aimed at a civilian aviation carrier, the crew or the passengers aboard to promote general political objectives. The type incidents include hijacking, kidnapping, in-flight assassinations, sabotage, destroying the aircraft, downing the aircraft or flying the aircraft into a specific target.[8] The first documented case of aerial terrorism occurred on July 22, 1968 on an El Al Boeing 707 flying from Rome to Tel Aviv.[9] An important note of distinction is this is not the first case of criminal activity involving the airline industry. Numerous other bombing, hijackings and incidents of sabotage occurred before this event. The 1968 event was the first time the perpetrator issued political demands. Previous incidents were suicides, insurance claims and disgruntled employees.

The rapid proliferation of UAV technology exposes gaping holes in current security measures exposing high value targets to increased risk. The reduced cost and increased operational capabilities allow almost anyone the ability to purchase and operate the device. This will fuel increased development resulting in many more UAVs with greatly enhanced capabilities. This creates a twofold problem for government agencies responsible for protection of high value targets. First, as UAVs become more common, it will draw less attention by the public and blend into the background allowing terrorist and criminal's greater access to use the UAVs without unwanted attention. Second, it will make tracking all the UAVs almost impossible.

The use of UAVs expands the tools available to terrorist conducting aerial attacks against targets in the United States and around the world. Their size makes them hard to detect and they are controlled from a safe distance. A prime example is the attack planned by Rezwan Ferdaus in September 2011. Fortunately, he was arrested by the FBI and convicted in federal court for plotting to fly remotely controlled airplanes filled with explosives into the Pentagon and US Capitol. The planes would be guided by GPS and contain five pounds of plastic explosives.[10]

UAVs provide several characteristics appealing to terrorist. First, UAVs provide increased range and mobility for terrorist to operate. This greatly increases access to numerous high profile targets previous protected with walls, fences and security guards. UAVs also provide terrorist the ability to operate from a distance thus reducing the probability of apprehension. Finally, the use of UAVs as terrorist weapons would produce a strong psychological effect.

A key consideration for terrorist is the ability to access the target, the probability of success and the impact of the attack. Previously, terrorist focused on less protected or soft targets

because the security in place at hard targets limited their effectiveness. By adding an addition

dimension to their arsenal, they increase the opportunity to strike higher valued targets without

additional risk. A high value target is a target that an attack results in the death of key figures,

attacks critical infrastructure, destroys culturally significant landmarks and gains mass media

attention.

For example, currently a UAV armed with a bomb or other weapon could easily bypass

the current levels of security for many of our outdoor events such as football game. On any given

Saturday during the college football season, stadiums across this country are packed to capacity

with cheering fans completely unaware of the possible threat. Unregulated air space near

stadiums and other outdoor venues exposes innocent spectators to potential attack. Just such an

event happened at the University of Texas at Austin during the Longhorns home opener against

the University of North Texas. A small UAV was spotted hovering over the packed Darrell K

Royal–Texas Memorial Stadium during the second half of the game. According to Todd

Humphreys, a professor of aerospace engineering at the school "the drone was apparently piloted

by a hobbyist, but it delivered a wake-up call. Police can protect every side of the stadium but

not the top."[11] Imagine the shock and fear if several UAVs armed with explosives or chemicals

struck multiple large football stadiums on Saturday afternoon. The destruction would be caught

on live TV with little anyone could do to stop it. Consider stadiums such as Michigan Stadium,

Darrell K Royal–Texas Memorial Stadium and Bryant–Denny Stadium, all hold over 100,000

people.

Other examples of UAVs entering restricted areas include at least three UA incidents

near the White House in Washington DC in 2015. The first incident occurred on January 26,

2015 when a small UAV crashed into a tree on the White House grounds.[12] The second incident

occurred on May 15, 2015 when someone was spotted flying a UAV over the White House

fence.[13] The third reported incident occurred on October 9, 2015 when a small UAV crashed on

the Ellipse near the White House.[14] Despite some of the most sophisticated security in the world,

all three reported incidents were discovered after the UAV had entered the perimeter of the

White House. How many others have successfully penetrated this airspace without detection?

What would happen if explosives were attached to the UAV when it crashed?

     A more chilling example occurred in September 2013 when a UAV flew within a few

feet of German Chancellor Angela Merkel before crashing on stage during a campaign event.

Activists from Germany's Pirate Party claimed responsibility for the incident. They said they

were protesting the EUs use of drones.[15] Just imagine the challenge protecting our elected

officials as they campaign across the nation.

     Other high profile targets easily assessable with UAVs include bridges, nuclear reactors

and airports. One such event occurred on July 22, 2014; the pilot of an Airbus A320 reported a

drone flying at about 700 feet near the Heathrow Airport. The official investigation conducted by

the UK Airprox Board (Ukab) found the drone flew within 20 feet of the Airbus A320 as it

landed at the Airport. The investigation discovered the UA was never tracked on radar and the

owner was never identified.[16] The ability to fly UAs near congested airspace such as airports

exposes several risks. First UAs could target the engines on an aircraft during takeoff with the

intent to cause multiple engine failure. We all remember US Airways Flight 1549 piloted by

Captain Chelsey "Sully" Sullenberger bound for Charlotte North Carolina. The aircraft struck a

flock of Canadian geese causing both engines to lose power as it left LaGuardia Airport in New York forcing the pilot to land the aircraft in the Hudson River.[17]

If birds can accidently cause this type event, what is the likelihood a group of motivated terrorist could do the same thing. Alternatively, they could simply attached explosives to the UA and fly it into the side of the aircraft with devastating effects; or just a tactic of swarms of UAs to shut down all air traffic at several key hubs during the holidays.

Just one example of bridges is the Golden Gate Bridge. The Golden Gate Transportation District has requested help from federal government to help control the rising number of UAs flying near the bridge. According to the Denis Mulligan, Golden Gate Transportation District General manager, the UAVs pose a safety and security threats to the bridge by flying past security fences and sensors into areas where photography is prohibited.[18]

The French nuclear operator EDF reported 13 drone incidents in October 2013 at just one facility, but the Guardian has learned that other nuclear facilities have been targeted for surveillance by the drones.[19]

Cost is a major consideration for terrorist. As governments around the world continue to interrupt and prevent cash flows the terrorist will seek less expensive ways to use terrorism. Not only are the UAVs getting less expensive, they are becoming more reliable and easier to use. Reduced cost for GPS and auto pilot systems and free online training greatly reduces any barriers the terrorist faced using this technology. To put it in perspective, the UN estimates the 2002 bombing of a Bali nightclub that killed 202 people cost about $50,000 and took 10 months to plan.[20] A single UAV hitting a major sporting event as described previously could kill and injure many more people for a fraction of the cost.

In many cases, UAVs could achieve the same if not greater impact than the tactic of placing bombs or using suicide bombing without all the risk. The UA would fly above the traffic bypassing potential checkpoints en-route to the location. Once the UA is launched, a separate operator could actually control the UA with a cell phone or over the internet form anywhere on earth. This concept was tested by Boeing Research and Technology division and students at the Massachusetts Institute of Technology's Humans and Automation Lab, in August 2011 in an experiment called the Micro Aerial Vehicle Visualization of Unexplored Environments (MAV VUE). Operators in Seattle Washington successfully controlled a UAV in an open field in Cambridge, Massachusetts using an iPhone connected to the internet via a wireless hotspot. The UAV was also able to communicate with a separate ground station also connected by a wireless hotspot.[21] The ability to use readily available technology such as cell phones and hotspots provides an addition layer of protection to the extremist. By using a disposable cell phone and a random hotspot, the terrorist can operate with almost complete secrecy.

Retaliation is also a strong motive of terrorist organizations. The United States has successfully used UAV technology to track terrorist networks, disrupt terrorist operations and kill known terrorist. The use of UAVs in Afghanistan has taken the reconnaissance technology first used widely in the Vietnam War and refined it into a lethal killing platform. The continued development and use of UAVs by the US against terrorist organizations demonstrates the power and effectiveness they provide. The US has conducted 595 confirmed UAV strikes in Afghanistan and Pakistan since 2004 killing as many as 5,120 and injuring as many as 1875 people. Of the people killed, it is estimated as many as 228 of those were children.[22]

Finally, the UAV gives the terrorist a tool capable of producing a strong psychological effect. Just the idea of a UAV with nuclear, biological or chemical weapons flying into a

crowded area could invoke fear in large segments of our population. Imagine the mass confusion

created if UAVs began flying close to crowds at various events. Just the stampede generated

would result in injury and possible death. Not to mention the impact it could have on the

commerce associated with such events.

<div align="center">**Recommendations to Mitigate the Risk**</div>

UAVs use by terrorists' organizations presents two distinct challenges. First the ability to

detect and track UAVs and second, what to do if a potential dangerous UAV is detected. The

first challenge is a result of the size and range of current UAVs. According to an Army Research

Laboratory report, a remote control aircraft roughly the size of the average hobbyist UAV has an

average radar cross section (RCS) of 14.55 decibels referenced to a square meter (dBsm), which

is a measure of how much a particular object will reflect radar energy.[23] Which is just a little

smaller than the RCS of a large bird (20 dBsm).[24] The radar technology exists to track objects

with a small RCS but then the radar operator must be able to distinguish the difference between a

UAV and a bird. As you can imagine, the number of UAVs and birds flying in given areas such

as public parks is a staggering number. Radar tracking of every UAV would require a substantial

investment in new equipment and personnel to keep pace with the growing demand.

To help with the detection of UAVs, the federal government could work with the UAV

industry to track the sale of UAVs with specific capabilities such as large payloads and specific

components such as the autopilot. By tracking the sales of specific UAVs and the autopilot

components, the government could compare the purchaser information with names on terrorist

watch list.

In addition, the state and local governments could pass legislation to regulate the use of UAVs to include standard markings similar to privately owned aircraft, establish required training to operate UAVs in public to educate the public about the safe operation of UAVs and the potential restricted air space. This could include large public gatherings, national monuments, nuclear reactors, airports and high profile political events. The Federal Aviation Administration or other agency may also require UAV operators to check the Notices To Airmen (NOTAM) before operating their UAVs.

Jamming is a viable option for most non-commercial grade UAVs because the Federal Communications Commission regulates the control frequencies of UAVs purchased at local stores or off the internet because these UAVs will only operate in a pre-defined frequency range. By jamming theses frequencies, the operator would be unable to control the UAV. Jamming works by interrupting the signal between the controller and the UAV. The primary reason jamming could be effective against UAVs is because of the path loss or loss of power that occurs as radio waves travel over a distance. The primary factor in path loss is the decrease in signal strength over distance of the radio waves themselves. Radio waves follow an inverse square law for power density: the power density is proportional to the inverse square of the distance. Every time you double the distance, you receive only one-fourth the power.[25] As the UAV flew toward the intended target, the control signal would continue to get weaker as it traveled away from the operator and closer to the target. By placing the jammer near the high value target, the jammer signal would gain strength as the UAV approached until the communication between the operator and UAV was severed. This would be an effective counter measure for high vale personnel and possibly large outdoor events but jamming does have a downside. The jamming

also interrupts many other devices such as Bluetooth devices, cordless phones, wireless internet

protocol networks, and even microwave ovens.[26]

To counter jammers, terrorist would have to make technical adjustments to the

transmitter and receiver to change the frequencies or change the output power of the transmitter.

Both require a detailed understanding of electrical and radio frequency engineering. Another

option would be for the operator to be closer to the intended target but that might expose the

operator to detection by security. Both counter measures increase the complexity of using UAVs

to attack the target.

As difficult as detecting potential dangerous UAVs seems, once detected, the choices

become more difficult. Depending on the location, the ability to take kinetic action against the

UAV may be limited. In crowded areas, the potential collateral damage may prevent destroying

the UAV as it approaches the target. Currently there is some research and development in using

lasers to destroy UAVs. This is an area that will require immediate attention to prevent a

successful terrorist attack the United States using UAVs in the future.

Conclusion

The proliferation of UAV technology promises to be a blessing and a curse. The

increased opportunity for amateur operators to enjoy afternoons at the park interacting with other

enthusiast; the ability to incorporate UAV technology into law enforcement and natural disaster

relief and the prospect of commercial applications are all welcomed developments. However,

this proliferation also exposes gaping holes in our current security measures. Left unchecked, the

proliferation of UAVs poses a real threat to US security.

Terrorist use violence or the threat of violence to generate fear in the civilian population to gain recognition for their cause, discredit or de-stable the government, influence governmental decisions or in retaliation. These underlying motives fit nicely with the capabilities inherent in current UAV technology. UAVs provide increased mobility, increased range and reduced cost. The increased mobility and range exposes targets previously protected with walls and security.

UAVs are also consistent with previous types of terror using airborne assets, known as aerial terrorism. The continued growth of the UAV industry will continue to improve performance and reduce cost. This will increase the use by industry and the American public drastically increasing the number of UAVs operating in our airspace. This proliferation also greatly increases the probability of terrorist using UAVs to strike at high value targets. The increased range and mobility provides an opportunity to strike targets once too difficult to reach while potently reducing cost and risk.

To expect our government to detect and track all UAVs is unrealistic. The sheer number of UAVs operating in our airspace would overwhelm our current capacity and require additional equipment and personnel. In addition, the size and characteristics of UAVs make them hard to distinguish from large birds. Detection and tracking will have to be area specific and will require increased cooperation between the government and the UAV industry to facilitate tracking of specific type UAVs and critical components. In addition, it will require increased regulation to ensure UAV operators are trained in the legal use of UAVs to limit the flights into restricted airspace.

Jamming is a possible solution for specific type events because it provides the ability to disrupt the operator's control of the UAV. It is possible to counter jamming but would require

additional training, increase cost and increase the chance of capture. However, jamming does have some drawbacks; primarily it interferes with other devices in the immediate area.

The challenge is what to do once rouge UAVs are detected. Currently the range of options are limited. We have the ability to jam the radio frequency in limited air space but that is not 100%. The option to shot down the UAV is hampered by the possibility of collateral damage and the characteristics of the UAV. Most are lightweight and difficult to destroy with a single shot. The real issue is to acknowledge the risk of UAVs as terrorist weapons and allocate adequate resources to develop new security measures to limit the chance of success for the terrorist. Failure to fully recognize the threat and develop effective countermeasures will leave America vulnerable to another devastating aerial attack on American soil.

If a significant attack using UAVs were to occur on American soil, the public would demand our government take action. This action would result in greatly restricting the use of UAVs or eliminating the use by private citizens. Basically, UAVs would become so regulated, only select users would be able to comply. For this reason, it is imperative the UAV community comes together to self-regulate UAV use and impede the potential use by terrorist.

NOTES

1. Elizabeth Bone and Christopher Bolkcom, *Unmanned Aerial Vehicles: Background and Issues for Congress*, Congressional Research Service Report for Congress (Washington DC, 25 April 2003)

2. Joint Publication 3-30, Command and Control of Joint Air Operations, 10 February 2014, GL-7

3. President George W. Bush, President of the United States (address The Citadel, Charleston, South Carolina, 11 December 2001)

4. Mark Bowden, "How the Predator Drone Changed the Character of War," Smithsonian Magazine November 2013, http://www.smithsonianmag.com/history/how-the-predator-drone-changed-the-character-of-war-3794671/#iHkmYPCTf6IkATB3.99

5. Chris Woods, Alice Ross and Jack Serle, "October 2012 update: US covert actions in Pakistan, Yemen and Somalia" The Bureau of Investigative Journalism, November 2012, https://www.thebureauinvestigates.com/2012/11/01/october-2012-update-us-covert-actions-in-pakistan-yemen-and-somalia/

6. International Terrorism and Security Research, *Terrorism Research, Goals and Motivations of Terrorists*, http://www.terrorism-research.com/goals/

7. Reich, Walter, Origins of Terrorism: Psychologies, Ideologies, Theologies, States of Mind, Woodrow Wilson Center Press, September 18, 1998

8. Ajay Lele and Archana Mishra "Aerial Terrorism and the Threat from Unmanned Aerial Vehicles" Journal of Defense Studies, Vol 3. July 2009, p 54-65

9. Hillel Avihai, *Aviation Terrorism: Evolution, Motivation and Escalation* (Saarbrucken, Germany: VDM Verlag October 2009)

10. Brian Ballou, "Rezwan Ferdaus of Ashland sentenced to 17 years in terror plot; plotted to blow up Pentagon, Capitol" Boston Globe Media, 1 November 2012, http://www.boston.com/metrodesk/2012/11/01/rezwan-ferdaus-ashland-sentenced-years-terror-plot/KKvy6D6n2PfXfbEfA4iMwJ/story.html)

11. CBS 11 Local News, "Police Detain UT Student For Flying Drone Over Longhorns, UNT Game" September 1, 2014, http://dfw.cbslocal.com/2014/09/01/police-arrest-ut-student-for-flying-drone-over-longhorns-unt-game/

12. Michael D. Shear and Michael S. Schmidt, "White House Drone Crash Described as a U.S. Worker's Drunken Lark", New York Times, 28 January 2015, http://www.nytimes.com /2015/01/28/us/white-house-drone.html?_r=0

13. Michael S. Schmidt, "Secret Service Arrests Man After Drone Flies Near White House", 14 May 2015, http://www.nytimes.com/2015/05/15/us/white-house-drone-secret-service.html

14. Bart Jansen, "Small drone crashes near White House despite ban against flights in D.C.", 9 October 2015, USA Today, http://www.usatoday.com/story/news/2015/10/09/drone-crash-white-house-ellipse-us-park-police-federal-aviation-administration/73641812

15. Jason Bittel, "German Pirate Party Uses Drone to Crash Angela Merkel Event", 18 September 2013, http://www.slate.com/blogs/future_tense/2013/09/18/german_pirate_party_uses_drone_to_crash_event_with_chancellor_angela_merkel.html

16. Robert Pigott, "Heathrow plane in near miss with drone", BBC News, 7 December 2014, http://www.bbc.com/news/uk-30369701

17. NBC News, "N.Y. jet crash called miracle on the Hudson", 15 January 2009, http://www.nbcnews.com/id/28678669/ns/us_news-life/t/ny-jet-crash-called-miracle-hudson

18. CBS News SF Bay Area, "Drone Swarm Plagues Golden Gate Bridge; Officials Asking For Restrictions" 26 April 2015, http://sanfrancisco.cbslocal.com/2015/04/26/golden-gate-bridge-officials-ask-sen-feinstein-for-help-restricting-drones/Ref

19. Arthur Nelson, "Three arrests fail to staunch mystery of drones flying over French nuclear plants", Guardian News 6 November 2014, http://www.theguardian.com/environment/2014/nov/06/arrests-myster-drones-flying-french-nuclear-plants

20. Eben Kaplan, "Tracking Down Terrorist Financing" Council on Foreign Relations, 4 April 2006, http://www.cfr.org/terrorist-financing/tracking-down-terrorist-financing/p10356

21. MIT Humans and Automation Lab, "MAV-VUE - Micro Aerial Vehicle Visualization of Unexplored Environments" retrieved 6 November 2015, http://web.mit.edu/aeroastro/labs/halab/collaboration.shtml

22. Alice K Ross and Jack Serle, "Get the data: Drone wars", The Bureau of Investigative Journalism, 23 May 2014, https://www.thebureauinvestigates.com/category/projects/drones/drones-graphs/

23. Thomas J. Pizzillo, *RCS Measurements of a PT40 Remote Control Plane at Ka-Band* Army Research Laboratory, March 2005

24. J. A. Spruyt and Ph van Dorp, *Detection of Birds by Rada*r, Netherlands Organization for Applied Research, August 1996.

25. Chris Downey, "Understanding Wireless Range Calculations" ElectronicDesign.com, 3 April 2013, http://electronicdesign.com/communications/understanding-wireless-range-calculations

26. Bryan Card, *The Commercialization of UAVs: How Terrorist Will Be Able To Utilize UAVs to Attack The United States*, 12 November 2014.

Bibliography

Avihai, Hillel. Aviation Terrorism: Evolution, Motivation and Escalation Saarbrucken,
　　　　Germany: VDM Verlag October 2009.

Ballou, Brian. "Rezwan Ferdaus of Ashland sentenced to 17 years in terror plot; plotted
　　　　to blow up Pentagon, Capitol" Boston Globe Media, 1 November 2012,
　　　　http://www.boston.com/metrodesk/2012/11/01/rezwan-ferdaus-ashland-sentenced-years-
　　　　terror-plot/KKvy6D6n2PfXfbEfA4iMwJ/story.html.

Bittel, Jason. "German Pirate Party Uses Drone to Crash Angela Merkel Event", 18
　　　　September 2013, http://www.slate.com/blogs/future_tense/2013/09/18/german_pirate_
　　　　party_uses_drone_to_crash_event_with_chancellor_angela_merkel.html.

Bone, Elizabeth and Christopher Bolkcom. *Unmanned Aerial Vehicles: Background and Issues
　　　　for Congress*, Congressional Research Service Report for Congress, Washington DC, 25
　　　　April 2003.

Bowden, Mark. "How the Predator Drone Changed the Character of War," Smithsonian
　　　　Magazine November 2013, http://www.smithsonianmag.com/history/how-the-predator-
　　　　drone-changed-the-character-of-war-3794671/#iHkmYPCTf6IkATB3.99

Bush, President George W., President of the United States. Address. The Citadel, Charleston,
　　　　South Carolina, 11 December 2001.

Card, Bryan. The Commercialization of UAVs: How Terrorist Will Be Able To Utilize UAVs to
　　　　Attack The United States, 12 November 2014.

CBS 11 Local News, "Police Detain UT Student For Flying Drone Over Longhorns, UNT
　　　　Game" September 1, 2014, http://dfw.cbslocal.com/2014/09/01/police-arrest-ut-student-
　　　　for-flying-drone-over-longhorns-unt-game/.

CBS News SF Bay Area, "Drone Swarm Plagues Golden Gate Bridge; Officials Asking For
　　　　Restrictions" 26 April 2015, http://sanfrancisco.cbslocal.com/2015/04/26/golden-gate-
　　　　bridge-officials-ask-sen-feinstein-for-help-restricting-drones.

Downey, Chris. "Understanding Wireless Range Calculations" ElectronicDesign.com, 3 April
　　　　2013, http://electronicdesign.com/communications/understanding-wireless-range-
　　　　calculations.

International Terrorism and Security Research, Terrorism Research, Goals and Motivations of
　　　　Terrorists, http://www.terrorism-research.com/goals.

Jansen, Bart. "Small drone crashes near White House despite ban against flights in D.C.", 9
　　　　October 2015, USA Today, http://www.usatoday.com/story/news/2015/10/09/drone-
　　　　crash-white-house-ellipse-us-park-police-federal-aviation-administration/73641812.

Joint Publication 3-30, Command and Control of Joint Air Operations, 10 February 2014, GL-7.

Kaplan, Eben. "Tracking Down Terrorist Financing" Council on Foreign Relations, 4 April
　　　　2006, http://www.cfr.org/terrorist-financing/tracking-down-terrorist-financing/p10356

Lele, Ajay and Archana Mishra "Aerial Terrorism and the Threat from Unmanned Aerial
　　　　Vehicles." Journal of Defence Studies, Vol 3. July 2009, p 54-65.

MIT Humans and Automation Lab, "MAV-VUE - Micro Aerial Vehicle Visualization of
Unexplored Environments" retrieved 6 November 2015,
http://web.mit.edu/aeroastro/labs/halab/collaboration.shtml.

NBC News, "N.Y. jet crash called miracle on the Hudson", 15 January 2009,
http://www.nbcnews.com/id/28678669/ns/us_news-life/t/ny-jet-crash-called-miracle-
hudson.

Nelson, Arthur. "Three arrests fail to staunch mystery of drones flying over French nuclear
plants", Guardian News 6 November 2014, http://www.theguardian.com/
environment/2014/nov/06/arrests-myster-drones-flying-french-nuclear-plants.

Pigott, Robert. "Heathrow plane in near miss with drone", BBC News, 7 December 2014,
http://www.bbc.com/news/uk-30369701.

Pizzillo, Thomas J. RCS Measurements of a PT40 Remote Control Plane at Ka-Band Army
Research Laboratory, March 2005.

Reich, Walter. Origins of Terrorism: Psychologies, Ideologies, Theologies, States of Mind,
Woodrow Wilson Center Press, September 18, 1998

Ross, Alice K and Jack Serle. "Get the data: Drone wars", The Bureau of Investigative
Journalism, 23 May 2014.
https://www.thebureauinvestigates.com/category/projects/drones/drones-graphs/

Schmidt, Michael S., "Secret Service Arrests Man After Drone Flies Near White House", 14
May 2015, http://www.nytimes.com/2015/05/15/us/white-house-drone-secret-
service.html.

Shear, Michael D. and Michael S. Schmidt, "White House Drone Crash Described as a U.S.
Worker's Drunken Lark", New York Times, 28 January 2015, http://www.nytimes.com
/2015/01/28/us/white-house-drone.html?_r=0.

Spruyt, J. A. and Ph van Dorp. Detection of Birds by Radar, Netherlands Organization for
Applied Research, August 1996.

Woods, Chris, Alice Ross and Jack Serle. "October 2012 update: US covert actions in Pakistan,
Yemen and Somalia" The Bureau of Investigative Journalism, November 2012,
https://www.thebureauinvestigates.com/2012/11/01/october-2012-update-us-covert-
actions-in-pakistan-yemen-and-somalia.