Chapter 18: C-UAS and Large Scale Threats

Chapter 18 will introduce developing trends for countering illegal / rogue drone use within the United States using counter-UAS (C-UAS) technology and systems.

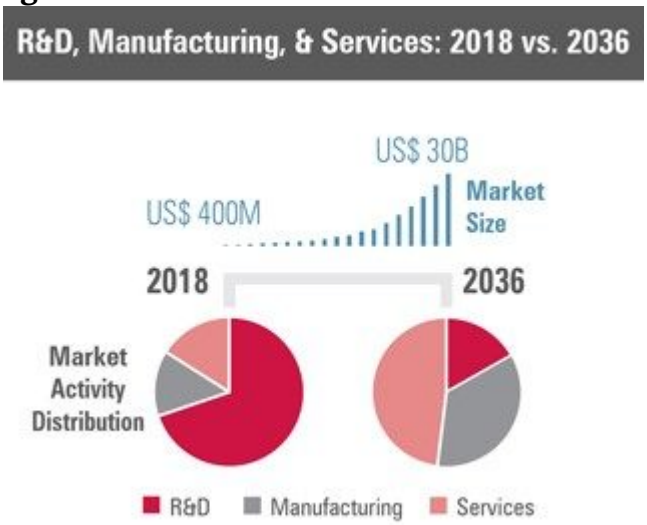
Student Learning Objectives. Upon completion of this chapter, students should be able to:

- Further understand what Counter-UAS (C-UAS) technology is
- What civil restrictions are currently in place and what agencies can use C-UAS
- How the government is attempting to ease restrictions for C-UAS use
- How Congress through HR302 plays a role in easing restrictions for C-UAS
- How and why government agencies use C-UAS
- What types of threats currently exist?
- The growing potential for countering large UAS

Countering Emerging Unmanned Air System Threats

The FAA has forecasted that the unmanned air systems market will see exponential growth over the next 20 years. Commercial 'hobbyist' drones are expected to double from 1.1 million to 2.4 million systems. The larger sized commercial UAS fleet will grow from 111,000 in 2017 to roughly 452,000 by 2022 with the number of registered pilots climbing from 74,000 to over 300,000 by 2022 (Miller, 2018). With this accelerated growth, (Figure 18-1) there have been -numerous incidents around the world involving safety and privacy issues. These incidents have ranged from intruding on personal property to the complete shutdown of major international airports. (Perez-Pena, 2018) These incidents stemmed from UAS being in either the wrong place at the wrong time or the systems were intentionally violating airspace for reasons unknown. The purpose of this study is to examine the current and future methods that are and will be used to safely identify, counter and intercept potentially hazardous drones and to review national policy regarding counter UAS (C-UAS) practices and procedures.

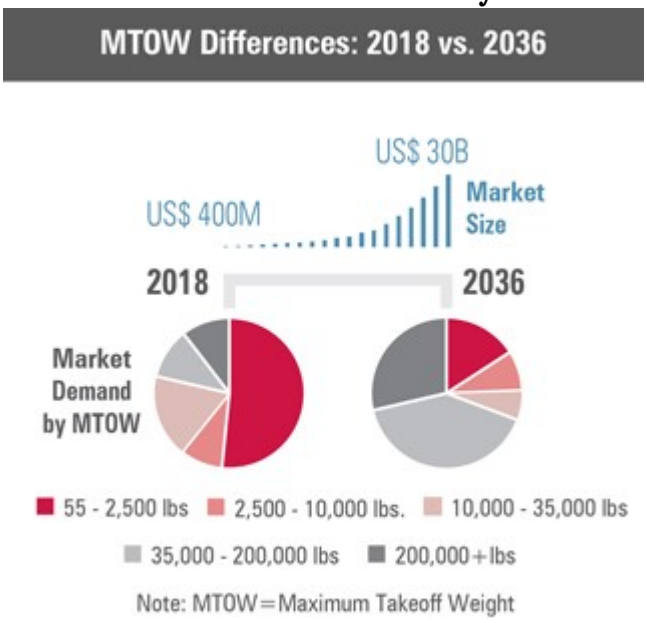
Figure 18-1: UAS Market Growth 2018 -2036



Source: (AIA & Avascent Report, 2018)

The demand for ever larger systems continues to push the UAS industry to meet this need. (see Figure 18-2) Increased payload capacity also increases the destructive potential for UAS systems when misused for malicious purposes. As these systems continue to grow in capability, so too will C-UAS to match.

Figure 18-2: UAS MTOW Market Analysis 2018 – 2036



Source: (AIA & Avascent Report, 2018)

As of October 2018, the United States government implemented its first policy that directly affects drone usage. Known as the FAA Reauthorization act of 2018, HR 302 directs the FAA

to begin drafting the way ahead for a UAS usage framework. Subtitle B – Unmanned Aircraft Systems, contains all directed actions the FAA will have to address to include C-UAS operations. (115th-congress, 2018) Most of the directed actions involve developing a practical way forward for C-UAS practices within the US and its territories. As of this moment, very few if any national policies are in place that regulate or even guide what can and cannot constitute C-UAS technology. Nor is there any governance on where and when C-UAS tech can be used outside of common laws that are already in use. It remains vague as to how a drone and its use is governed as personal property.

C-UAS is more than just using a system to knock a drone from the sky. The users must take into consideration the implications of what could happen if a UAS falls from the sky and damages property or injures people. If a drone is hovering over a large crowd for example, steps must be taken to allow the drone to be successfully removed without harming bystanders. This was the case recently when a drone was spotted dropping leaflets over a pro football game in Nov 2018. The operator was eventually identified and arrested but nothing could be done about the UAS while it was in flight. (Laris, 2018) This incident could have been far worse if the UAS operators' intentions were more sinister in nature.

The US population has a vested interest in the future of UAS and C-UAS operations. Civil and -military agencies, academic researchers as well as the everyday citizen already have access to UAS technology. These systems are well on their way to becoming part of our daily lives and there is currently no limit to what they can achieve. Knowing when, where, and having the ability to stop UAS misuse will be paramount.

Introduction

Counter Unmanned Air Systems is an array of linked technology designed to detect, identify / analyze a threat and if necessary, intercept unmanned air systems / drones. Rogue and hostile drone use is becoming an exponentially increasing concern for the Department of Homeland Security (DHS) and the Department of Defense (DoD). Illicit drones have also stirred the general public into seeking technological means of preventing UAS from violating privacy or exploiting intellectual property. The recent passing of HR 302, the FAA Reauthorization Act of 2018, has directed the FAA to conduct multiple inter agency reviews in order to determine the current status of C-UAS affairs in the United States. It also directs the FAA to work with the DOD to glean current best practices and procedures for acquiring and operating C-UAS systems for future use with the US and its territories. The intent for this research is to illustrate the current lack of legislation and regulation regarding the use of C-UAS within the US as well as review current and future technology trends in use. This research also aims to review C-UAS technology under development with the Department of Homeland Security (DHS) and the Department of Defense (DOD).

Current Civil Restrictions / Policy, Directed Reviews from HR 302

"There are several legal impediments to utilizing counter-UAS technology. The Communications Act of 1934 prohibits the use of unlicensed radio equipment such as jammers or other devices that interfere with communication, such as the UAS command link." (Embry Riddle Aeronautical University, 2018) "The general public is further prohibited to manufacture, import, market, sell or operate jamming equipment in the U.S. under 47 CFR 2.803." (Embry Riddle Aeronautical University, 2018) "Finally, 18 USC section 32 imposes imprisonment or fines upon those that damage, disable, or destroy civil aircraft which can be interpreted to include drones." (Embry Riddle Aeronautical University, 2018) "Operators may also be subject to liability associated with tort claims arising from the potential collateral damage, injury, or adverse effects of counter UAS activities." (Embry Riddle Aeronautical University, 2018) Such liability issues may include interference caused by jamming equipment or damage / injury caused by the forced disabling of the offending unmanned aircraft. (Wallace, 2018)

Steps to Easing Restrictions

In 2016, Congress passed the National Defense Authorization Act of 2017. In Sec. 1697,

"Congress codified new authority for military leaders to mitigate UAS threats. The statute gave relatively broad powers for the armed forces to disrupt control, intercept, seize, disable, damage, and destroy offending aircraft." (Embry Riddle Aeronautical University, 2018) The security risk posed by unmanned aircraft has not gone unnoticed by commercial entities either. Stadiums and other open-air public gatherings are recognizing the need for counter-UAS activities. On November 28, 2017, Tracy Mapes was arrested after flying a small UAS over NFL game at both the Levi Stadium and Oakland Coliseum two days earlier. (Gomez, 2017) The unmanned aircraft allegedly dropped leaflets over the stands at Levi Stadium. After reviewing surveillance footage of the initial incident, law enforcement personnel anticipated the alleged perpetrator would try the same activity at the nearby Oakland Coliseum. Santa Clara Police Lt. Dan Moreno highlighted the risk of UAS operations over the crowded areas stating, "A drone can lose control and injure someone in the crowd or drop material that may be harmful. We are evaluating our security practices with state and federal authorities to make sure this doesn't happen again." (Gomez, 2017) This and other incidents have led to the need for more robust yet public friendly C-UAS technology.

HR 302: FAA Reauthorization Act of 2018

For this theme the author spent a great deal of time reviewing two sections within HR 302

passed by congress in October of 2018:

- Section 364, U.S. C-UAS Review of Interagency Coordination Processes
- Section 365, Cooperation Related to Certain C-UAS Technology (115th-congress, 2018)

From these sections, the author was able to infer what the government was trying to accomplish. Congress directed the review of how the FAA and other agencies were using C-UAS within the United States and its territories. The reviews directed specific considerations to address, the most significant of these are listed below:

- Safety in the national airspace
- Protecting individuals and property on the ground
- Coordination procedures and protocols with the FAA during the operation of C-UAS systems
- Adequate training for personnel operating C-UAS systems
- Best practices for the consistent operation of C-UAS systems to the maximum extent practicable (115th-congress, 2018)

The last significant piece of information from HR 302 was that Congress directed the FAA to specifically conduct a review of any additional authorities needed by the FAA to effectively oversee the management of C-UAS systems within the US and its territories. (115th-congress, 2018)Section 365 deals directly with the deployment of C-UAS systems in the national airspace. Congress also directed the Secretary of Transportation to consult with the Secretary of Defense to streamline deployment of C-UAS systems by drawing upon the expertise and experience of the DOD in acquiring and operating C-UAS systems consistent with the safe and efficient operation of the national airspace system. (115th-congress, 2018) Once the directed reviews are complete and made public, C-UAS procedures will become standardized and regulated by the FAA. Industry will then be able to evolve, and narrow down existing trends moving forward and develop C-UAS technology that complies with these new standards. This moves industry one step closer to opening the door for broader general public use of C-UAS.

C-UAS and the Department of Homeland Security

To increase safety, lower costs and increase efficiency more and more private companies are looking to add drones to their workforce. These drones have the potential for use in dangerous aerial inspection jobs as well as local deliveries normally performed by humans. The largest hurdle for these companies is how to incorporate the large volume of drones necessary for these jobs safely into the national airspace without collisions or infringement on privacy. (Sullivan-Nightingale, 2015) This increased interest ultimately means more drones will soon be flying around localities and neighborhoods. This increase in drone activity will continue to pose a problem for privacy, security and general public safety. Presently, UAS and drones are an inexpensive way to gain real time situational awareness over any venue to include large gatherings and sporting events. Hovering drones pose a real danger to the crowd below should they malfunction or loose link with their pilot. (Warwick, 2016) Until recently, most C-UAS systems used kinetic means to physically remove a drone from the airspace. Researchers are now able to identify, track and if needed commandeer the drone and land it safely. Current technology

can also be used to triangulate the offending pilot's location to pass on if notifying the authorities is necessary. (Warwick, 2016) With the eventual increase in drone activity, local government authorities will need access to C-UAS in order to maintain the security and safety of its citizenry.

C-UAS and the Department of Defense

The militarization of drone use began during the opening years of the Global War on Terror (GWOT) in the early 2000's. Before this time, the average citizen had no concept of what UAS capabilities were at the time. Large systems such as the MQ-1 Predator and RQ-9 Reaper have since become the face of GWOT. Their ability to conduct long endurance reconnaissance and precision strike operations vs large scale bombing campaigns has made drone proliferation a priority in most of the militaries of the world moving forward. China has declared that it will have produced over 20,000 drones by the year 2020 in order to protect its ever growing "One Road," initiative as it seeks to expand is economic influence in the region. Other countries that would be considered potentially adversarial to the United States have also dramatically increased drone acquisitions within the past decade. Simplicity and low cost of UAS technologies make their proliferation difficult to control. (See Figure 18-3 and 18-4)

Figure 18-3: Unmanned Systems Funding by Service *Source:* (Krasnov, 2017)

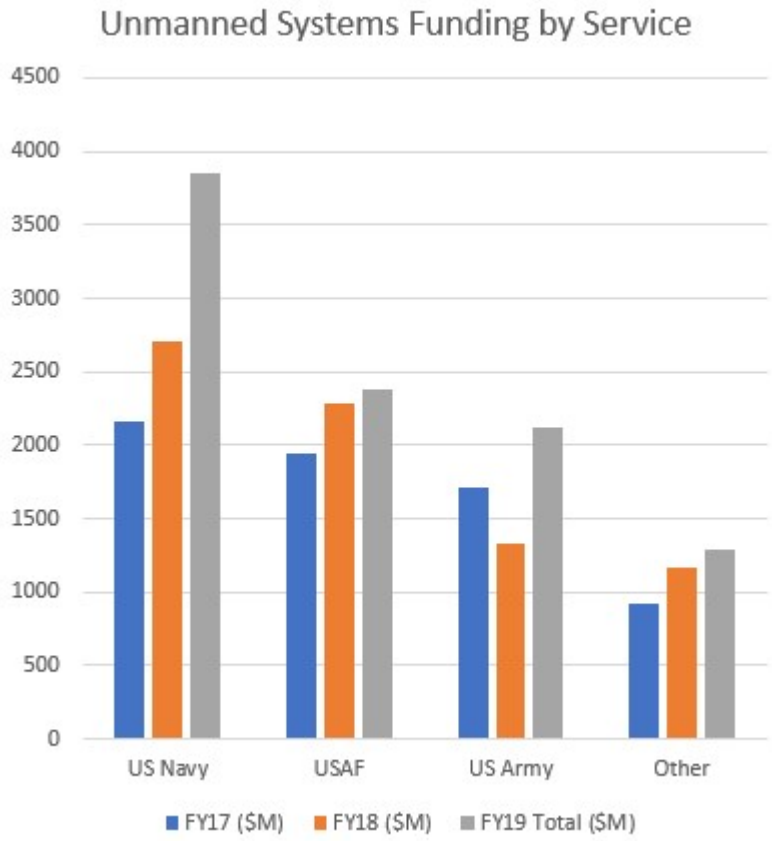
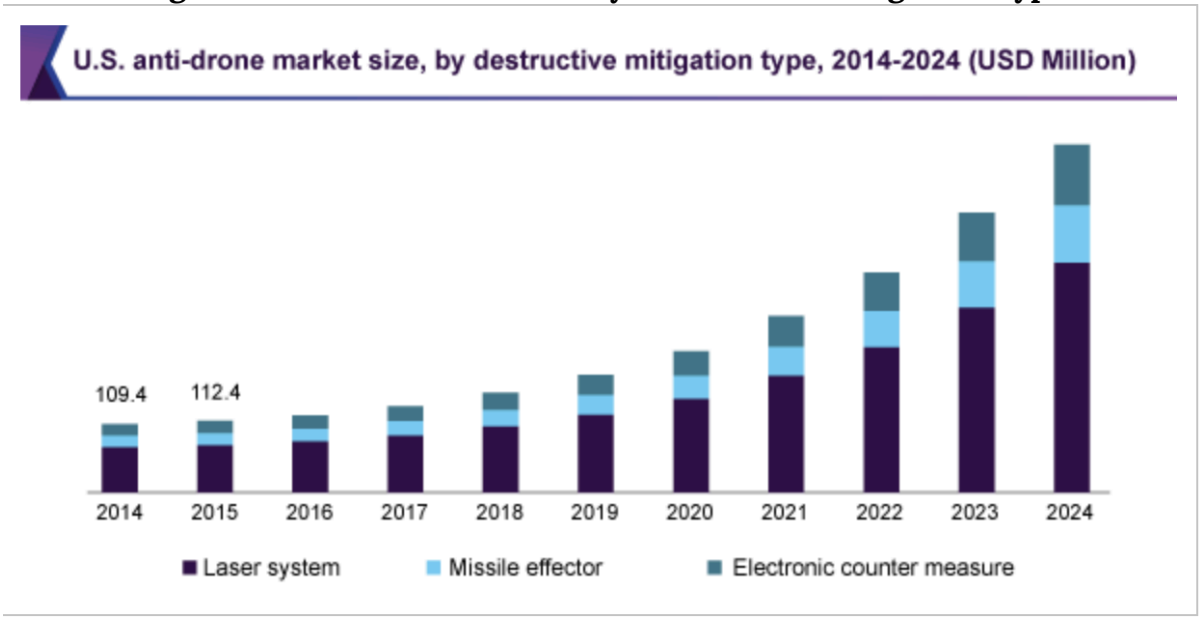


Figure 18-4: UAS Market Size by Destructive Mitigation Type



Source: (Grandview, 2018)

As more and more drones prepare to enter the future battlespace, the US Department of Defense (DoD) has begun to re-look its short- and long-range air defense capabilities. Vulnerabilities for each service have recently been identified based on the services given specific mission and current drone technology available to enemy combatant to observe and counter their operations. The DoD has specifically focused on brigade and below sized levels for the Army and Marines, individual vessels for the Navy and large airfield infrastructure for the Air Force. Each service has made C-UAS technology and system acquisitions a top priority in recent years and will remain a priority for the near future.

SWARMS

The threat(s) UAS pose continue to evolve with the most recent development of drone "SWARMS." Drone swarm is used in two separate ways, cooperative and coordinated swarming. For a cooperative swarm, drones perform complex functions en masse such as land surveying, mapping, complex entertainment displays, manned / unmanned teaming, single attack performed by several drones against one target. Coordinated SWARMS, drones perform separate tasks aimed to achieve one goal. Examples include transmission line repair and complex attacks against multiple targets at the same time. Swarming has been carried out by low slow and small drones with varied success, the most notable was an attack against a Russian air base in Syria in January 2018, where several home-built drones carrying crude munitions penetrated Russian defenses and successfully damaged aircraft and equipment on the base. This attack proves drone SWARMS are difficult to track and engage effectively using current systems. The US DoD has taken great strides to create and expand C-UAS doctrine and update existing systems.

The most difficult challenge faced by the DoD is developing and implementing C-UAS across a Joint Force. Each service has its own methods, technologies and systems but the hard part is getting them all to talk and coordinate with each other. Some of these challenges include being able to identify current enemy UAS, integrating short range defense (SHORAD) and operating with the absence of robust joint doctrine that allows commanders to wield all forms of C-UAS within their respective battle space.

AI and Machine Learning

Advances in C-UAS tech has begun to see emerging technology, like artificial intelligence (AI), as a means of supporting non-lethal counter-UAS applications. Citadel Defense Company recently launched its newest counter-UAS specific system, Titan. The system is designed for anti-drone scenarios such as drug trafficking, espionage, cyber-attacks and attacks on airports. Titan provides the user real-time information, identifying and classifying a single approaching unmanned aerial vehicle or a larger swarm. The system selectively applies precise countermeasures to induce the UAV(s) to land or return to its home base. Citadel Defense uses machine learning, artificial intelligence and software defined hardware technology to rapidly address new threats and protect people and assets. (Rees, 2019)

C-UAS and the General Public

Reviewing currently available C-UAS technology yielded three major types that best suite usage by the general public in a civil domain. These systems have the lowest chances of posing any potential harm bystanders:

- Local radar systems
- Integrated microphone / RF signature detection systems
- Acoustical systems for passive detection / offensive destruction

Local Radars have seen success as recently as this year's super bowl in Atlanta, GA. The FAA declared a restricted flying zone for one mile around Mercedes Benz Stadium. Local radar was used to track and if needed, direct integrated systems to remove the drone. The radars lead to the successful interception and safe landing of multiple drones without incident. (O'kane, 2019)A commonly occurring theme is that most vendors still do not know what they need as far as C-UAS systems and the demand for security experts with this knowledge continues to grow. (Warwick, 2016) The need for C-UAS systems extends to non-standard facilities such as correctional institutions. In recent years, prisons have seen an increase in illicit drone activity in the form of contraband drops to inmates. By integrating RF detection systems / jammers linked with passive microphones, correctional facilities have been able to identify when and where drones conduct these drops. (Dedrone, 2018)

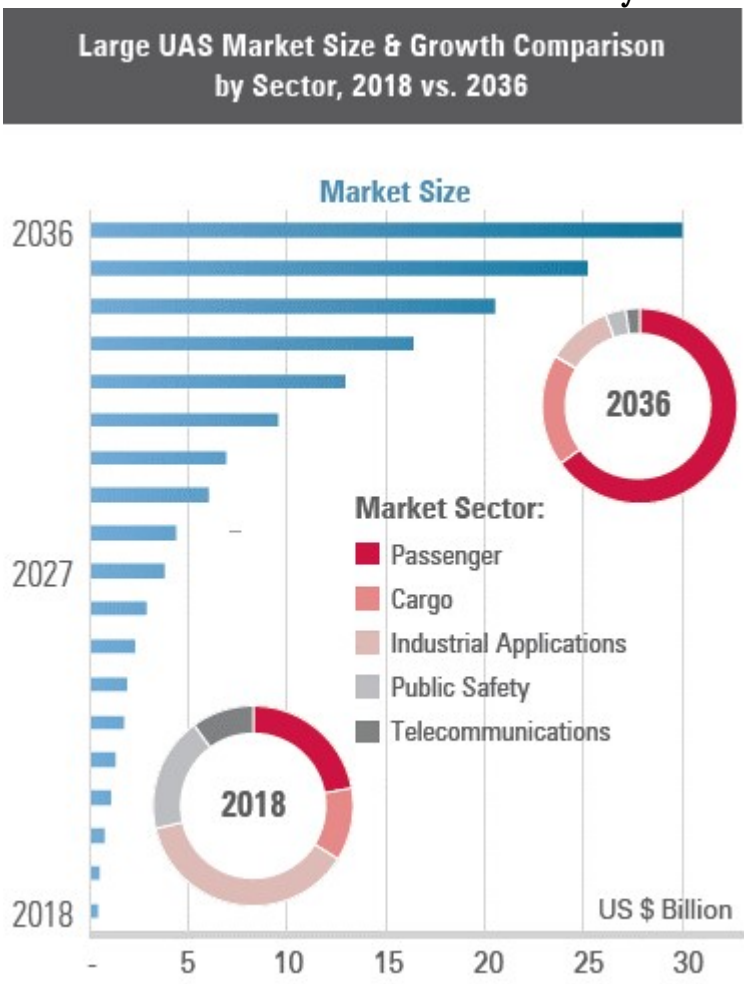
The final emerging C-UAS tech trend is acoustical systems. Small teams in academia are cur-

rently working to see how ultra-high frequency noise that cannot be heard by the human ear, can be used to safely disrupt drones while in flight. There has been success in disrupting the microscopic gyroscopes (MEMS) within the drone motors causing the rotor heads to spin at differing speeds resulting in the drone becoming unstable and crashing. (Son, 2015) In its current form this technology is best used as an area denial system. Acoustical technology will most likely be used to defend an area from a multiple drone's swarm and could possibly be coupled to part of an existing network of C-UAS systems to form a layered defense for a private facility.

Emerging Threat of Large Civil UAS

The next evolution for the UAS industry will to begin to dramatically increase payload capacities. This would enable more economical uses for delivery services to begin delivering large goods right to consumers or deliver goods across long distances reducing costs of aerial transport. As this trend seeks to take hold of the UAS market, C-UAS researchers will have to begin to visualize the threats scenarios these systems will pose and how they can be safely countered. (See Figures 18-5 to 18-7)

Figure 18-5: UAS Market Growth Predictions by Civil Sector



Source: (Unmanned Airspace.info, 2019)

Figure 18-6: Think Bigger: Large UAS and the Next Major Shift in Aviation

Source: (News, 2019)

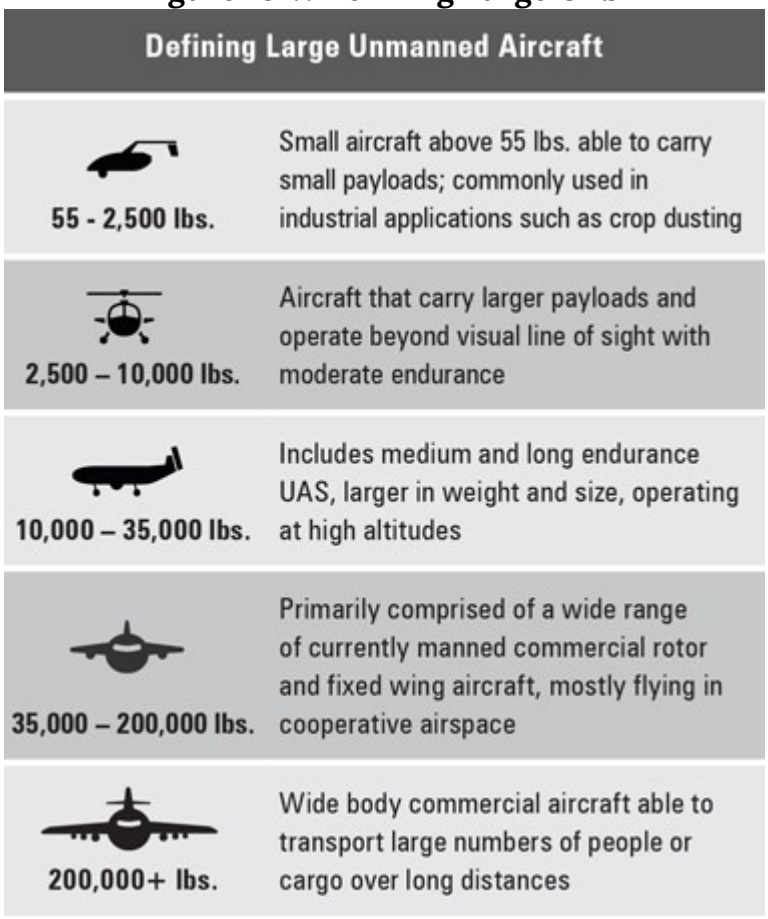
Results

Current Restrictions / Policy, Directed Reviews from HR 302

Once the final reports from HR 302 are released, the FAA in coordination with the DOT and DoD will begin to standardize current best practices. This will establish rules and regulations that industry can then use to guide its research and development as it clamors to meet market need. Drone use will continue to grow exponentially as shown by market research as applications for UAS' continues to be developed. It is the opinion of the researcher that once the FAA

has established a firm precedent for civil C-UAS operations, the C-UAS industry will see very similar exponential growth to match the UAS industry.

Figure 18-7: Defining Large UAS



Source: (AIA & Avascent Report, 2018)

C-UAS and the Department of Homeland Security

Civil authorities will soon have no choice and will have to address / budget for local government use of C-UAS in order to protect local infrastructure and public gatherings. The threat(s) posed to open space venues and facilities will require affordable and adaptable systems that can be used to protect the public at large. Fortunately, private industry has already been developing integrated systems that are designed for this purpose(s). As drones become increasingly sophisticated, potential adversaries and drug cartels can also potentially use these systems to conduct cross border incursions.

C-UAS and the Department of Defense

Addressing current gaps for the DoD and finding ways forward for joint doctrine integration

will be crucial for the Defense Department to stay ahead of growing threats posed by peer / near peer state actors and rogue organizations / individuals. The DoD was the first organization to see and begin to adapt to the growing threat of drone use. There guidance and expertise will be invaluable for the FAA and DHS to expand C-UAS from. With the largest budget for C-UAS technology development, the DoD will maintain its current position as the industry leader for C-UAS in the US.

C-UAS and the General Public

As the commercial and private use of drones and other UAS systems continues to grow, systems to limit their use will inevitably see use to limit the areas in which they can fly. With several forms of non-kinetic C-UAS technology emerging, the author predicts that the general public will soon be able to own and operate these systems once Congress has formalized further authorizations allowing the FAA to regulate C-UAS use. General safety for the public is paramount when considering using C-UAS technology in the public domain. The three emerging technologies discussed, I feel, have the greatest potential to serve the public safely and effectively. Large open-air vendors and correctional institutions are two of the many organizations along with private citizens who could use these types of C-UAS systems. They will be able to maintain their privacy and security while not inadvertently harming bystanders or creating collateral damage in the general area around them.

Conclusion(s)

The literature collected shows the growing need for C-UAS for national defense, civil defense and private property protection market(s). The only limiting factors appear to be the lack of government regulation. Once the FAA has identified and recommended to Congress C-UAS standard operating procedures and best practices, stemming from HR 302, Congress will then create legislation that will help guide the C-UAS industry in developing new and better technology for civil use. Outside of the DOD, private industry has recognized the growing need for C-UAS and has already developed technologies that allow for the safe removal of drones from private airspace. Once the regulations are in place, the C-UAS industry is ready to grow exponentially.

The rapid pace of UAS development will soon introduce larger UAS to the public airspace. This will further drive the need to develop systems that can counter / deter there use for nefarious reasons. Large UAS will be able to inflict more severe damage to varying degrees of structures and venues if they are repurposed or digitally hi-jacked. Currently the only way to combat large UAS is using kinetic means which is only operated by the DoD and is in very sparse location across the country. As this sector grows, so too will the need for larger and more integrated systems across the US.

Counter-UAS will continue to grow exponentially to match the capabilities of the UAS indus-

try. This growth will be bolstered once Congress and the FAA formalize procedures and operating parameters for these systems.

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