Strategy Research Project

Unmanned Aircraft Systems: Integration into the National Airspace System

by

Colonel Mark A. Colbrook
United States Army

United States Army War College
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Although the Department of Defense (DoD) has a critical need to be able to develop and train Unmanned Aircraft Systems (UAS), it does not currently have the authority from the Federal Aviation Administration (FAA) to access the airspace it needs to fully realize the potential of these assets. Each Service has distinct airspace requirements that relate to how they train and utilize UAS. Due to these differences there is not a “one-size-fits-all” approach that meets each Service’s needs. Each Service, in coordination with the DoD, FAA, and other government organizations as necessary, must develop the policies, procedures, training programs, and equipment to meet the requirements necessary to gain this access. UAS already offer capabilities that are vital to DoD missions. As technologies continue to mature it is extremely likely that additional missions will continue to migrate to unmanned platforms. It is essential to the long-term strategic interests of DoD to maximize unmanned capabilities and retain a technological advantage in this discipline over any potential adversaries. Access to the necessary airspace to develop, train, and operate UAS is essential to maintaining this advantage.

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U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

Abstract

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Although the Department of Defense (DoD) has a critical need to be able to develop and train Unmanned Aircraft Systems (UAS), it does not currently have the authority from the Federal Aviation Administration (FAA) to access the airspace it needs to fully realize the potential of these assets. Each Service has distinct airspace requirements that relate to how they train and utilize UAS. Due to these differences there is not a "one-size-fits-all" approach that meets each Service's needs. Each Service, in coordination with the DoD, FAA, and other government organizations as necessary, must develop the policies, procedures, training programs, and equipment to meet the requirements necessary to gain this access. UAS already offer capabilities that are vital to DoD missions. As technologies continue to mature it is extremely likely that additional missions will continue to migrate to unmanned platforms. It is essential to the long-term strategic interests of DoD to maximize unmanned capabilities and retain a technological advantage in this discipline over any potential adversaries. Access to the necessary airspace to develop, train, and operate UAS is essential to maintaining this advantage.

Unmanned Aircraft Systems: Integration into the National Airspace System

Unmanned Aircraft Systems (UAS) provide a wide range of capabilities to the Department of Defense (DoD). UAS are incorporated into each Service and are increasingly relied upon to provide capabilities spanning such diverse areas as Intelligence, Surveillance, and Reconnaissance (ISR), precision attack, and logistics. As technologies continue to mature, missions will increasingly migrate to unmanned platforms. However, there are many obstacles that must be overcome to realize the full potential of UAS.

One of the pressing issues is determining how to safely operate UAS within the United States and the National Airspace System (NAS). Although the DoD has a critical need to develop UAS and train operators within the NAS, it does not currently have the approval from the Federal Aviation Administration (FAA) to access the airspace it needs to fully achieve the potential of these assets. To successfully gain access to the necessary airspace the DoD must synthesize the varied and sometimes unique requirements of each Service and develop a coherent strategy that is acceptable to the Services, the FAA, and the greater interagency environment.

In order to develop a successful strategy for this issue it is necessary to focus on four separate areas. The first focuses on why we need UAS, how we intend to use them, and how quickly we need a certain capability or access to airspace. Secondly, it is necessary to understand each Services' needs and requirements. A "one-size-fits-all" approach may not be either practical or appropriate. Therefore the DoD strategy must consider and incorporate each of the Services' needs. Next it is critical to understand the interagency environment, identify the key players, and determine friction points. Lastly, it is necessary to examine, influence, adapt, and/or create the policies, procedures, training standards, and equipment to facilitate safe and routine access to the NAS.

Importance and Urgency of UAS to the DoD

When assessing the importance of UAS to the military, a good starting point is to examine the Joint Capability Areas (JCAs) that DoD uses to manage capabilities and identify where UAS contribute the most.[1] There are nine tier 1 JCAs of which UAS are potential key contributors in four: Battlespace Awareness, Force Application, Protection, and Logistics.[2] Current operations demonstrate the linkage, such as ISR support to Battlespace Awareness and Protection, current weaponized platforms support to Force Application, and initial usage of systems such as K-MAX in Afghanistan for support to Logistics.[3] As technologies and capabilities of UAS increase, so will their utility within these four JCAs with the potential to expand into the other JCAs.

As the capabilities of UAS are assessed, it is not appropriate to focus solely on what can be done by unmanned systems that cannot be done by manned platforms. There are very few tasks that UAS can accomplish that cannot also be accomplished by manned aircraft. Rather, it is important to focus on what capabilities are better fulfilled by UAS. DoD, in the Unmanned Systems Integrated Roadmap FY2013-2038, assesses that “Unmanned systems have proven they can enhance situational awareness, reduce human workload, improve mission performance, and minimize overall risk to both civilian and military personnel, and all at a reduce (sic) cost.”[4] The Roadmap goes on to assert that UAS “provide persistence, versatility, survivability, and reduced risk to human life, and in many cases are the preferred alternatives especially for missions that are characterized as dull, dirty, or dangerous.”[5] All of these attributes demonstrate the operational benefits of UAS for some roles over manned platforms. However, equally important to what can be increased will be what can be reduced: human workload (manpower), costs, and risk to human life in high threat or "dangerous" environments.

In an era of dwindling resources characterized by shrinking budgets and reduced manpower, UAS provide a way to preserve or even increase capabilities while simultaneously requiring lower cost platforms, less personnel, and reduced operations and maintenance (O&M) funding requirements.[6] Access to the NAS is critical in order to make the decisions necessary to achieve these benefits. The lack of routine access is detrimental to both the training of UAS operators and, more importantly, the ability to integrate the capabilities of UAS into joint training opportunities. The current limited access to the NAS makes it much more difficult for senior leaders to make the difficult decisions between investments in different platforms and technologies by introducing an element of risk associated with both the inability to demonstrate integrated concepts now and the lack of surety of gaining the required access in the future.

There are many decisions that must be made in the short term about the size and composition of the military that will have long term consequences. The more obscure the path for gaining that access becomes, the more likely senior leaders will have to commit limited resources to other areas that perhaps produce less benefits for the investment, but carry less risk with the decision. Additionally, some investments are already being made, such as building new airfields within restricted areas in order to ensure access to training areas within restricted airspace. Some of these investments could be avoided if routine access to the NAS was available, obviating the need for building dedicated UAS airfields in restricted airspace. The scope of these investments will only grow larger as UAS become more integrated into DoD operations if routine access to the NAS remains unaddressed.

It is also important to understand that these decisions are not made in a vacuum. If the only potential negative consequence was a temporary delay in investment or a one-time investment with no other implications, then a slow deliberate process of gaining access to the NAS would be less of a concern. However, two separate factors converge to greatly increase the risk. The first is with limited budgets and program lifecycles measured in decades, a decision to bypass a UAS capability now may create a gap of decades before it becomes economically viable to make a major investment again. Secondly, adversaries get a vote. As technologies associated with UAS keep improving, in many cases mirroring Moore's Law, there is a risk of technologies becoming mature without a DoD ability to invest in them. This would allow some adversaries to be better positioned to make the investments and take advantage of leap-ahead technologies.[7] Even capabilities that may be export-controlled risk being compromised by traditional espionage or cyber theft. There is already ample evidence of competitor nations being able to make rapid advancements in areas by reconstructing either pilfered/captured equipment or using data obtained through cyber-attacks.[8]

In order to realize these benefits and avoid the risk of other actors closing the technology gap or even surpassing the DoD's capabilities, it is necessary to continue to invest in UAS.[9] Failure to establish routine access to the NAS will hinder the United States' ability to test and operate these systems and train their operators to their fullest extent, reducing the value of return on investment and potentially placing entire programs at risk. Additionally, some of these potential programs and related missions could be transformative in nature or even change the character of warfare, such as the development of fully autonomous fighter and bomber aircraft that could benefit from increased maneuverability and reaction times to make current manned platforms obsolete. Failure to maintain the technological advantage could cede air superiority to an adversary in a future conflict.

Budgetary issues and concerns not only drive the decisions to invest in future UAS capabilities, but also affect the decisions made on procuring or divesting manned assets. Although there are still significant challenges that must be addressed to be able to realize the full potential of UAS support to DoD operations, some decisions to divest current manned platforms are already being made. This includes the recent decision to divest the Army's OH-58D aircraft without replacement, instead relying on UAS and the integration of UAS and AH-64E to cover the capability.[10] The Air Force also was forced to make a similar decision, divesting the U-2 in favor of the RQ-4 Global Hawk.[11] These decisions highlight both the importance of UAS, especially in a resource constrained environment, and the need to address outstanding issues that serve as impediments to UAS usage, such as airspace integration.

Service Needs and Requirements

Each Service utilizes UAS within their core mission areas creating different applications for platforms which in turn drive unique airspace requirements. These differences greatly compound the problem of DoD developing a comprehensive approach to NAS integration and virtually eliminate the ability to create a "one-size-fits-all" approach to airspace. To understand what drives these issues it is necessary to look at the Services' airspace requirements, which varies even within each Service when different size and category of aircraft are considered.

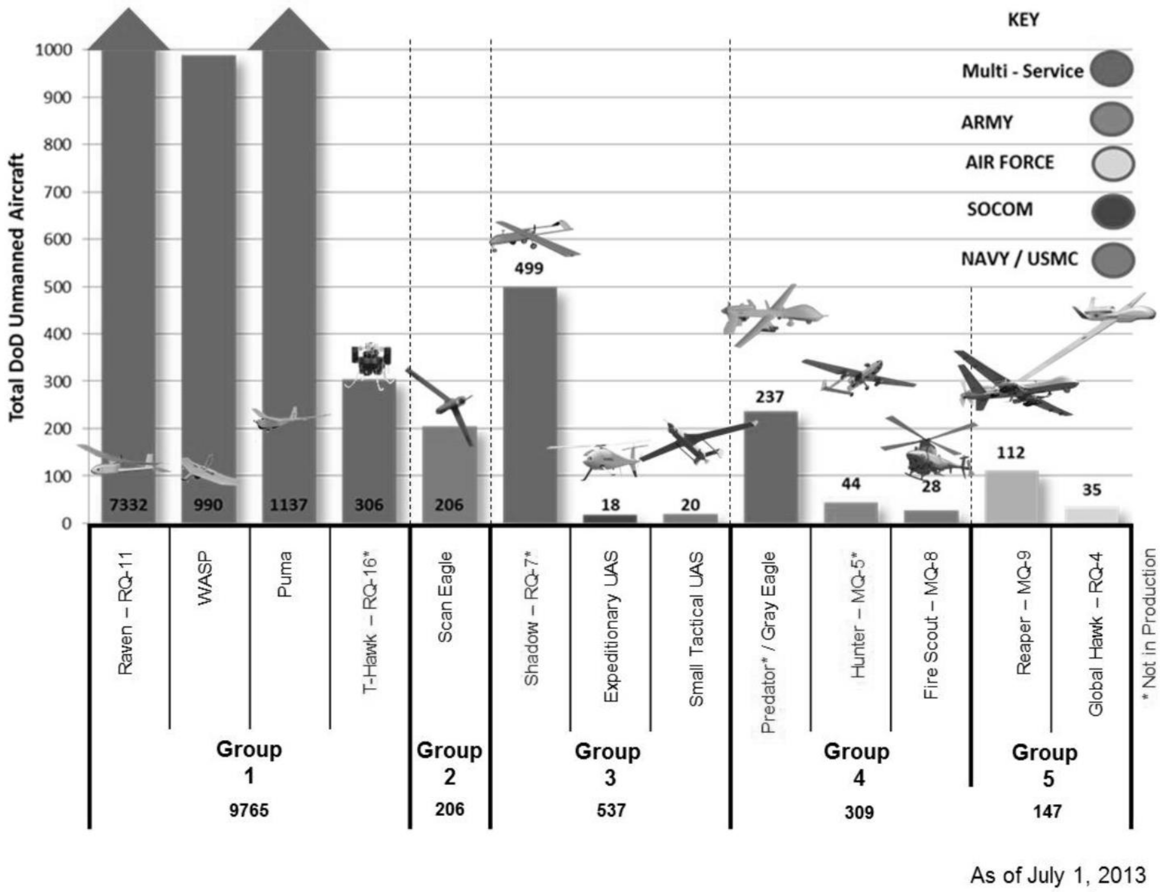

Figure 1. Inventory of DoD UAS[12]

The Army owns the largest number of UAS within DoD with over 8,000 aircraft including the Raven, Puma, Shadow, Hunter, and Gray Eagle systems. The Raven and Puma systems are small, hand-launched UAS that may operate at altitudes up to 1,000 feet but generally operate within 100 to 300 feet of the ground with limited payloads.[13] The Shadow and Hunter systems are larger systems that can operate at altitudes up to 15,000-18,000 feet, have greater payload capacity, and are rarely weaponized.[14] The Gray Eagle is a Predator-sized UAS that can operate up to nearly 30,000 feet, and is routinely weaponized.[15] The very diversity of platform types, physical sizes, and capabilities help to illustrate a wide range of missions and the diverse types of airspace they require.

What is common among the various UAS in the Army is their focus on supporting ground operations. While it is possible to task Army UAS in direct support to the Joint Force Commander, their normal usage is tied to Army ground operations. This leads to airspace requirements that are closely tied to ground maneuver units. In a training environment this means that the predominance of airspace requirements take place within restricted airspace over military installations. It also drives the fielding strategy for Army UAS which is based on embedding UAS into existing units.[16] Raven and Puma systems are integrated down to the platoon-level, Shadow systems are embedded in the Brigade Combat Teams (BCT), and Gray Eagle systems are assigned to the Combat Aviation Brigades (CABs). This co-locates them with their maneuver elements that train on military installations overlaid with restricted airspace. This airspace is managed by the military and not subject to the same restrictions on UAS usage as the NAS. However, many of the airfields that the Army utilizes are not within this restricted airspace, requiring special authorities from the FAA in order to transit to this restricted airspace. This is a key vulnerability that integration into the NAS would solve.

Whereas the Army is focused primarily on support to ground operations, the Air Force is inherently more focused on global projection and air domain issues. Air Force core functions, such as Global Integrated ISR, Global Precision Attack, and Air Superiority, dictate operations outside of limited restricted airspace surrounding military training areas in the continental United States (CONUS).[17] Current Air Force UAS operations happen predominately in forward-based locations where the United States can dictate deconfliction procedures. As the focus of operations shifts from current conflict areas to either CONUS training sites or dispersed global operations, the ability to integrate both into the United States NAS and other sovereign nations' airspace will become critical. The policies, procedures, and technology leveraged to gain routine access to the NAS can also be used as a model for future overseas operations where the Air Force will need to operate on a regular basis.[18]

This global focus enables the Air Force to gain efficiencies by consolidating UAS operations at a limited number of CONUS sites, as opposed to the Army's concept of distributing the assets to the supported unit. While this is clearly the best basing strategy to meet Air Force and Combatant Commander requirements, it creates a dependency on NAS access to transit aircraft to other training sites to support joint training exercises. It is possible in most cases to transport the systems via ground or military airlift to airfields closer to the training exercises. However, this creates additional costs and commits more assets, such as additional launch and recovery elements, that could otherwise be supporting Combatant Commander requirements. These problems will become more acute as combat operations decrease and CONUS training is relied upon to provide the bulk of the joint force experience with integrating UAS into their operations.

The Navy's airspace requirements are also unique to its Service. With a focus of operating UAS primarily over the oceans and seas, their airspace requirements and necessity to access the NAS are much different from both the Air Force and the Army. When operating within the global commons outside of any country's sovereign airspace, flight operations are held to a different standard. The term “due regard” is used to denote the standards associated with operating in this airspace.[19] The Navy’s primary need to transit the NAS is for launch, recovery, and transit to due regard airspace. Since this can be conducted through very predictable air corridors, it is possible to use existing authorities and procedures for most Navy NAS requirements. However, these authorities and procedures, which all of the Services rely upon to a greater or lesser extent, are considered exceptions to normal operations and are subject to cancellation by the FAA at any time.

The Marines’ requirements closely mirror those of the Army and in many cases they utilize both the same assets and training programs as the Army. This allows them to leverage other Service’s capabilities, processes, and investments. However, they have the same need to be able to both support and be supported by other joint assets and are therefore still dependent on the successful resolution of all of the NAS issues listed above.

Within the DoD there are multiple different stakeholders and offices that have either interest or authorities associated with UAS. The Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD (AT&L)) provides direction to, oversight of, and leads the OUSD UAS Task Force (TF). The UAS TF focuses on the acquisition, development, and integration of UAS into the Services.[20] Subordinate to the UAS TF is the UAS Airspace Integration Integrated Product Team (UAS AI IPT) which is chartered to focus on improving airspace access, including integration into the NAS.[21]

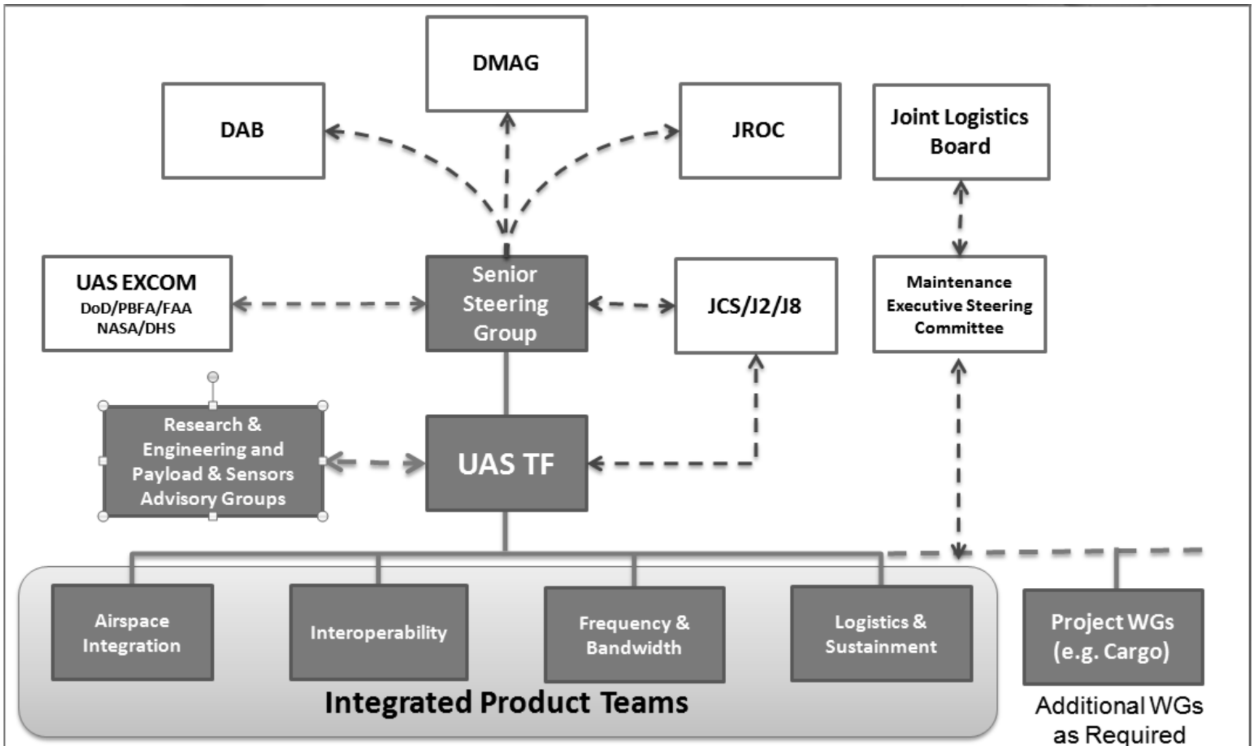

Figure 2. UAS TF Relationships[22]

The Combatant Commands are also key stakeholders for NAS integration. Although the majority of Combatant Commands are only impacted by the ability of units to train in the NAS, US Northern Command (NORTHCOM) is directly affected by the ability to operate within the NAS for both exercise support and operational missions. US Special Operations Command (USSOCOM) also has unique UAS requirements when compared to other Combatant Commands resulting from their "Service-like" authority to develop, acquire, and train UAS. The final significant DoD stakeholder is the DoD Policy Board on Federal Aviation (PBFA) which coordinates DoD and FAA common requirements.

> The PBFA provides policy and planning guidance for comprehensive airspace planning to: (1) ensure that the Military Departments have sufficient airspace to fulfill operation, training, and test and evaluation requirements, (2) cooperate with the FAA for the effective and efficient

management of the NAS, and (3) ensure operational interoperability between the DoD and the FAA.[23]

Interagency Environment

Although the DoD is currently the foremost user of UAS there are many other interagency stakeholders that have both requirements for UAS and inherent responsibilities within their agencies. The other primary users of UAS within the government are the Department of Homeland Security (DHS) and the National Aeronautics and Space Administration (NASA). Beyond these users the single most important interagency activity is the Federal Aviation Administration (FAA) which has the authority to regulate aviation activities within the United States.[24]

The FAA is tasked by Congress to take the lead in integrating UAS into the NAS through the FAA Modernization and Reform Act of 2012.[25] The FAA currently manages and authorizes all UAS operations using a Certificate of Waiver or Authorization (COA) process which provides limited access to the NAS.[26] The COAs are site-specific and tailored to individual UAS types and are therefore very narrow in scope. However, COAs also contain inherent risk for any organization utilizing them. Since they are in effect waivers to existing rules, they are subject to cancellation by the FAA at any time.

In order to progress towards full integration, the FAA requires a significant amount of safety and operational data to demonstrate the ability of UAS to safely operate in the NAS, which the FAA will approach cautiously.[27] In 2011 the DoD provided the FAA with seven years of data, but due to differences in definitions and analytical approach the FAA was not able to use the data to support publishing updated standards.[28] The DoD and FAA are continuing to work to establish the appropriate methods and data metrics to create usable data, but data collection and analysis remains a concern.[29] This highlights the safety conscious nature of the FAA as it approaches new technologies and some of the difficulties the UAS user agencies face in trying to expedite integration to support their own agency priorities. It also highlights how the process of integrating UAS into the NAS could be drawn out indefinitely due to a climate that encourages an abundance of caution.

The other two primary user agencies, DHS and NASA, have their own discreet requirements. DHS both trains its operators and primarily operates UAS within the NAS. The predominant users within DHS are Customs and Border Patrol utilizing UAS for border security and the Coast Guard which is integrating UAS to support maritime surveillance, reduction of maritime crime, and protection of maritime infrastructure.[30] UAS also have the ability to support other DHS organizations such as the Federal Emergency Management Agency (FEMA) during times of crisis or disaster response. NASA focuses its UAS usage primarily on research, science, and exploration; however, their assets are occasionally used to support responses to natural disasters.[31] These two agencies are arguably more dependent on NAS access than the DoD due to the CONUS nature of their missions. The DoD may occasionally support DHS and work alongside NASA during Defense Support to Civil Authorities (DSCA) missions, where DoD would require the same access to airspace as these agencies.

Senior leaders designated with responsibilities for UAS within these agencies, plus the DoD, serve on a UAS Executive Committee (ExCOM), an interagency committee dedicated to providing executive direction for gaining access for UAS into the NAS.[32] The ExCOM is the primary instrument through which interagency users of UAS can provide input to the FAA in order to help shape future FAA policies to meet the needs of the each agency. The ExCOM also provides a medium for feedback from the FAA on the procedures, training, and equipment necessary to comply with anticipated policy changes. The most pressing policy issue that currently requires clarification from the FAA is redefining “see and avoid” to allow for a “sense and avoid” capability and how that should be applied to various levels of autonomy. As an example, if a UAS “senses” an imminent collision, should it autonomously maneuver to avoid it? Although in normal circumstances an operator would make this decision, what if the UAS is in a lost link procedure and operating independently of the operator? These types of policy decisions will then drive the technology and equipment utilized and the procedures and training necessary to ensure safe integration into the NAS.

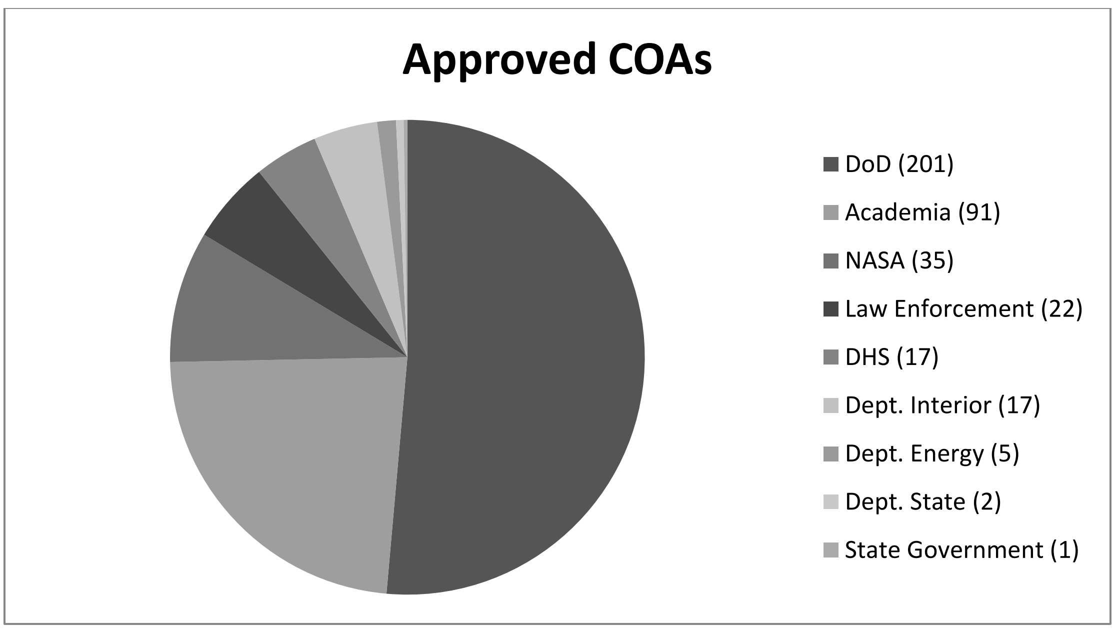

Figure 3. FAA approved COAs for 2012[33]

There are other parties with an acute interest in UAS and access to the NAS outside of the governmental agencies. Although there are no currently authorized commercial UAS activities, both the commercial sector and academia have strong interests in the development and integration of UAS.[34] An analysis of the COAs issued in calendar year 2012 shows that while DoD was the greatest user of COAs, it was followed closely by academia (see figure 3). The number of COAs approved for academia helps illustrate the interest of non-governmental entities in UAS. This convergence of interests between government agencies and the commercial/academic sector is beneficial to a general acceptance of the need to integrate UAS into the NAS. However, just because the needs converge does not necessarily mean that the same policies, procedures, training, and equipping standards acceptable to DoD will be embraced by other agencies or the commercial/academic sector.

Policies, Procedures, Training, and Equipment

The FAA has the statutory authority by the U.S. Code to manage the sovereign airspace of the United States and it regulates this through Federal Aviation Regulations (FARs), notices, and directives. One of the fundamental underlying problems with integrating UAS into the NAS is the FARs were not written to take into account unmanned operations. The primary obstacle within the FARs to UAS integration is found in Title 14 of the U.S. Code, Part 91 §91.113 which states "… vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft."[35] This "see and avoid" requirement is a serious impediment when there is no person in the aircraft to "see" other aircraft. The FAA is working to gather the data to modify policy to accommodate UAS, as was mandated by Congress. Meanwhile the uncertainty created by the lack of clear policy guidance creates difficulties in developing and investing in UAS that may or may not conform to future FAA regulations. The DoD must continue to work closely with the FAA to develop policies that meet DoD UAS airspace requirements.

Unfortunately, policy alone cannot address all issues surrounding NAS integration. The DoD and the individual Services have already implemented various procedures in order to both operate UAS within restricted airspace and to gain approval of COAs for limited use of the NAS. Many of these procedures are currently individually tailored to the location where the UAS are utilized. As the reality of routine integration into the NAS nears, it will be necessary for these numerous procedures to be standardized within DoD. Work towards that standardization is already happening, but is not complete. In the short term, standardized procedures adopted by DoD as a whole will assist the department in "speaking with one voice" to the other agencies and improve the DoD's ability to positively influence policy.

The FAA not only sets policy and standards for access to airspace, but also certifies personnel to operate aircraft within the airspace. Although the DoD has the ability to "self-certify" both its equipment and personnel, in practice there are very few divergences from FAA requirements.[36] The training of UAS operators varies greatly between the Services and even within the Services depending on the platform. Additionally, some Services either utilize fully qualified pilots from manned aircraft or certify their personnel under the same standards as manned aircraft, awarding FAA compliant ratings, such as instrument qualifications. There are also significant differences in training standards between the small UAS operated primarily within visual line-of-site (VLOS), which are generally not military occupational specialty (MOS) specific skills, and the larger platforms that require dedicated pilots/operators. Differences in training standards between the Services and between different platforms are significant obstacles to comprehensive DoD approaches to FAA requirements.

Equipment and technological approaches also vary between the Services and negatively affect DoD's ability to present a consolidated approach to the interagency environment. The Army, Air Force, and Navy are all pursuing different methods to overcoming the "see and avoid" requirement in the FARs. Through a combination of applying new technologies and different equipment, each Service is developing both separate methodologies and procedures. From a purely DoD-internal standpoint, this allows the department to evaluate the various costs and benefits of each approach to establish the best path forward. From an interagency perspective, this demonstrates the lack of a clear path to safely integrating UAS into the NAS. Internal friction between the Services can easily be used by outside agencies to hinder or delay the acceptance of these individual approaches, negatively impacting the ability to gain the airspace access necessary to support DoD training, operations, and investment strategies.

Additional Background Information

Before it is possible to look exclusively at the DoD airspace requirements of UAS it is necessary to acknowledge potential barriers to the advancement of UAS. Barriers such as ethics, privacy concerns, autonomous operations, artificial intelligence, bandwidth availability, vulnerability to interference, and risk to human life must be considered and acknowledged. However, resolution for most of the barriers is not crucial to UAS integration in the NAS. For example, ethical issues such as how the law of war applies to unmanned platforms, what are the rights of UAS to self-defense, the de-humanizing of warfare, and the impacts of lethal autonomous systems are significant issues but do not have linkage to airspace access.[37] Similarly artificial intelligence (the ability to perceive something complex and make appropriate decisions), bandwidth availability for both system control and payloads, and vulnerabilities to interference are all issues that must be addressed, but do not impact integration into the NAS.[38] Key barriers which have an impact on the process of integration include autonomous operations, risk to human life, and possibly privacy.

Privacy concerns do not appear to have a direct relationship to NAS access or to the FAA's statutory authority to regulate airspace. However as part of the process to gather data to support UAS integration the FAA has authorized six UAS test sites to conduct NAS integration testing. Initially the FAA did not address privacy as part of the test site process and focused only on the safe and efficient management of the NAS. The FAA later updated their policies to include privacy as an issue it must address at the test sites, though it is still unclear if privacy will have an impact on the final policies for NAS integration.[39]

The ability for UAS to act autonomously within the NAS is a potential concern. Understanding the various levels of autonomy can help pinpoint the potential policy implications. The levels of autonomy range from very little true autonomy to fully autonomous operations. At the near end of the spectrum are UAS constantly in contact with and monitored by a person on the ground. The autonomous modes are designed to operate only when there is a loss of the primary control link. At the far end of the spectrum are UAS operating independent of a ground controller in accordance with previously programmed guidance and that have the ability to adjust its flight path to react to both changing conditions and other traffic. The level of autonomy will undoubtedly be addressed by policy and will likely change over time as technology improves, new capabilities are fielded, and testing is conducted to validate the safety of the level of autonomy being employed.

It is important to note that at a minimum, autonomous modes are built into all DoD UAS to address “lost link” situations where the control of the UAS by a ground operator is temporarily interrupted. In those cases the UAS operates in accordance with prior programmed instructions in an attempt both to re-establish the control signal and fly by a predictable path to a location where the risk of the UAS causing damage to either other aircraft or to personnel on the ground can be minimized. These procedures are already included as part of the COA process and will be addressed by both policy and procedural means.

The procedures managing what happens when a UAS loses its control link or has some other significant failure that renders the aircraft unflyable can place human life at risk. The overriding concern in integrating UAS into the NAS is safety, both to other aircraft in the air and to personnel and property on the ground. Procedures such as avoiding flight over populated areas and developing “lost link” recovery sites away from man-made structures are utilized to manage this risk and may be reflected in future policy. Accordingly, the policies, procedures, training, and equipment necessary to integrating UAS into the NAS will have safety as the primary objective in all cases.

To understand the NAS and the implications of integrating UAS operations it is necessary to have a basic knowledge of the various types and classes of airspace and some of the control measures that are used to manage it. There are five classes of controlled airspace, Class A through E, and one class of uncontrolled airspace, Class G, within the United States. The level of restrictions differs for each class though the requirement to see and avoid remains constant throughout all classifications. In general, Class A is the most restrictive class of airspace and Class G is the least restrictive.[40]

Conversely, the challenges for operating the larger UAS grow greater the less restrictive the airspace. As an example, in Class A airspace all aircraft are required to be operated under instrument flight rules (IFR), have minimum equipment requirements that include two-way radio ability and an operational transponder.[41] These rules eliminate uncooperative traffic, such as aircraft flying under visual flight rules (VFR) that may be operating solely on see and avoid authority and not in contact with any air traffic control (ATC) service. Because of this highly controlled environment, UAS operations in Class A airspace are the only ones that do not require a visual observer. At the other end of the spectrum, aircraft are allowed to operate in Class G airspace without any of the above listed equipment, relying on see and avoid exclusively for separation from other aircraft. Therefore, more restrictive airspace imposes more order into the usage of that airspace and simplifies the processes and procedures necessary to integrate UAS that do not have an inherent see and avoid capability.

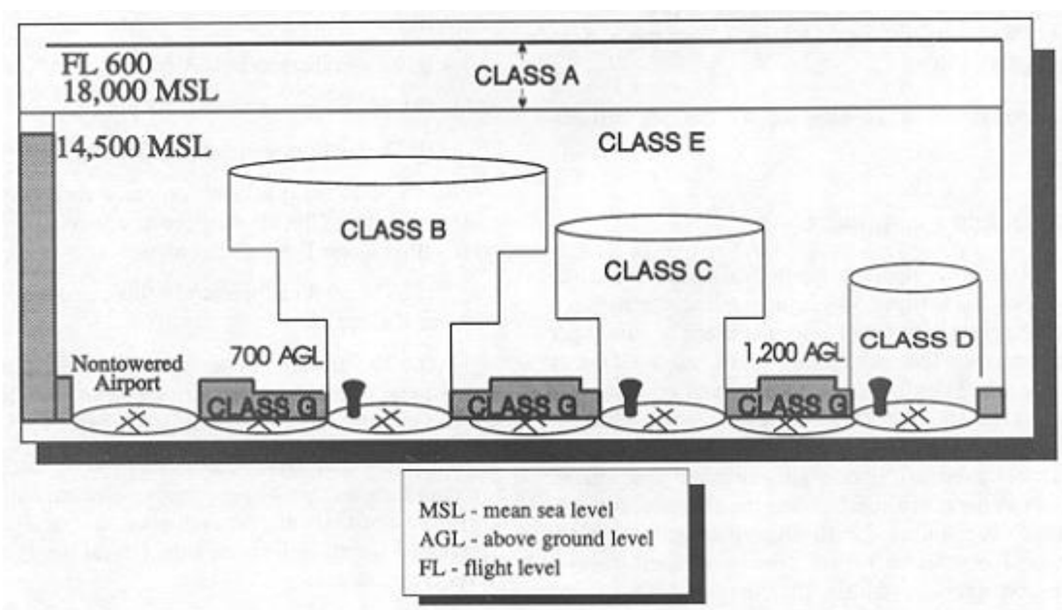

Figure 4. Classes of Airspace[42]

There is a “sweet spot” of airspace that has relatively little traffic that could be a good candidate for initial UAS integration into the NAS. Unpressurized aircraft, which constitute a great portion of the general aviation aircraft commonly flown by private pilots and the aircraft most likely not to have a transponder-enabled collision avoidance system capability, reach physiological limits between 10,000 and 14,000 feet due to reduced oxygen levels in the atmosphere. A large portion of air traffic is eliminated in Class E airspace above 14,000 feet and below 18,000 feet where Class A airspace begins. Most aircraft that are capable of pressurized flight will not remain at these altitudes due to increased fuel efficiency gained by climbing to higher altitudes. The larger class UAS can access this zone and operate with minimal manned traffic and aircraft equipped with both radios and transponders. This airspace provides a significantly risk-reduced area that could most readily be utilized for initial UAS integration into the NAS.

In addition to the different classifications of airspace, there are different types of special use airspace that can be more readily utilized by UAS. The primary types of special use airspace that may apply to UAS operations are restricted airspace, warning areas, and military operations areas (MOAs). Restricted airspace prohibits non-authorized aircraft from operating within the confines of that airspace without approval of the controlling agency.[43] This is the most commonly utilized airspace for DoD UAS. As an example, the Army utilizes the restricted airspace over military installations and training areas for the vast majority of its UAS training in CONUS. Warning areas and MOAs serve to alert other aircraft of potential danger or to exercise extreme caution when operating in that airspace and may provide an acceptable environment for UAS operations in the short term as a bridging strategy until full integration into the NAS. To operate a UAS within a MOA currently requires a COA from the FAA, but since the warnings associated with operating within a MOA are defined by the FAA this is an area that could be easily addressed by both policy and procedural means to gain rapid access to this airspace on a routine basis. However, access to warning areas and MOAs only account for a small portion of U.S. airspace and is insufficient on its own to fulfill all the requirements of the DoD stakeholders.[44]

UAS Operations in the NAS

The procedures that are currently utilized by DoD UAS to gain limited access to the NAS are delineated in COAs that are specific to each site where the UAS are operated. While the COAs typically subject UAS to numerous limitations and conditions for operations, they do form a baseline of agreed upon procedures between the FAA and DoD on how to comply within the context of existing policy.[45] The most common procedures currently in use include creating transition corridors of pre-defined airspace and maintaining separation of manned and unmanned traffic during terminal area operations. The corridors enable the UAS to transition from an airfield to its operating area within restricted airspace or a warning area. However, these procedures still require either a visual observer on the ground or in a manned aircraft to follow the UAS to provide the ability to see other aircraft and communicate with the UAS operator to avoid the traffic, imposing significant limitations on UAS operations. The requirement for visual observers also adds a significant burden to UAS operations. The observer must maintain FAA validated medical certificate, must be able to both see the aircraft and surrounding air traffic unaided by optical devices, be able to communicate directly with the UAS operator, and meet minimum training requirements.[46] The FAA will usually only approve a single ground observer to monitor for other air traffic, as opposed to “daisy chaining” observers to cover longer distances.[47] Due to this, transits of more than a few miles will almost always require an aerial observer in a manned aircraft, with the cost in people, equipment, and flight hours that entails.

Besides the limitations placed on operations under a COA, a key vulnerability to relying on COAs as a primary control measure is they can be suspended or revoked by the FAA at any time. While there are a significant number of DoD UAS operations currently utilizing COAs, this is far short of what DoD requires in order to have effective and efficient access to the airspace it requires. With the DoD currently operating in over 200 COAs both the burden and costs associated with complying with the COAs and the risk to DoD operations due to revocation of COAs becomes clear.

In addition to procedures, training standards are integral to the safe operation of UAS in the NAS. The level of training provided to UAS operators varies greatly depending on the platform being utilized. Although there is a Chairman of the Joint Chiefs of Staff Instruction, CJCSI 3255.01, which “serves as the foundational crewmember training enabler with the FAA toward UAS integration into the NAS,” the Services have varied approaches to achieving these UAS training standards.[48] Small UAS, such as the Raven, Wasp, and Puma require relatively limited training to operate and utilize a very limited amount of airspace, normally Class G or restricted airspace within visual sight of the operator. As the platforms get larger and more complex they also increase in range, altitude capability, and endurance, which greatly increase the potential airspace requirements. CJCSI 3255.01 classifies the operator training into four categories denoted as Basic UAS Qualification (BUQ) Levels 1-4 that roughly translate into BUQ-1 operating in Class E and G airspace below 1,200 feet, BUQ-2 including Class D airspace and up to 18,000 feet, BUQ-3 including Class B & C airspace, and BUQ-4 including Class A airspace.[49] It also mandates that BUQ-2 will meet all FAA requirements for a sport pilot license, BUQ-3 for a private pilot license, and BUQ-4 for a private pilot license with instrument rating as a minimum requirement.[50] Although BUQ-2 through BUQ-4 qualified operators utilize UAS in areas commonly accessed by IFR traffic and BUQ-4 operators are required to be instrument qualified, there is not a corresponding requirement to certify the UAS platforms for IFR operations, creating a mismatch between operator training requirements and equipping requirements. These training standards, matched with the equipment and technology to enable the operations and address policy concerns, assist in enabling access to the NAS.

There are multiple ways in which equipment and technology can affect the ability for UAS to gain access to the NAS. Improved sensors capable of providing holistic 360 degree sensing to identify aircraft and the appropriate software to categorize the aircraft and either warn operators of their presence or take autonomous action to avoid potential mid-air collisions are important technology requirements. Current sensors commonly employed on UAS do not have the capability to provide this level of awareness. The DoD is pursuing two different paths to achieve this type of capability. The first is an integrated approach that includes integrating sensors into the platform that can fulfill this requirement. Known as airborne based sense and avoid (ABSAA), this requires the platform to have the available size, weight, and power (SWaP) to support the added sensors while still maintaining the capability to conduct the aircraft's primary mission. This is feasible for the larger UAS platforms, but becomes problematic for smaller aircraft with less payload and power capacities. This approach is driven primarily by the Air Force and Navy which operate the largest classes of UAS currently in DoD.

The alternative approach is to develop off-platform sensors that can provide a similar capability. Known as ground based sense and avoid (GBSAA), this technique includes creating a system of ground based sensors and radars that can digitally map the airspace and provide the data back to the UAS operator for situational awareness to avoid potential collisions. GBSAA has the benefit of not adding an increased SWaP burden onto the UAS, thereby retaining the full capability of the platform to conduct its primary mission. This approach has the most relevance to smaller, limited range UAS or to areas with routine UAS operations, such as military operations areas (MOAs) or warning areas. However, GBSAA limits the area that can be covered with the ability to sense and avoid other traffic. A potential hybrid ground based approach also exists, where currently existing radars, both ground based and ship based, could be networked in order to provide a level of fidelity that may meet future sense and avoid standards.

There are other traffic avoidance systems that are already available within manned aircraft that could supplement UAS to provide better warnings and situational awareness for the UAS operators. Traffic collision avoidance systems (TCAS) utilize the transponder readings of other transponder equipped aircraft to determine relative position and provide the pilot with warning data and recommended changes to course and altitude to avoid a collision. These systems could be modified to remotely inform the UAS operator of other transponder equipped aircraft operating in the area that could pose a collision hazard. While this does not account for all air traffic, since private pilots are allowed to operate in some airspace without transponder equipped aircraft, it would account for a large portion of air traffic and all air traffic operating in Class A airspace.

There are multiple threats to the ability to integrate UAS into the NAS. These can be categorized into five different areas. The first is internal non-consensus within DoD on the appropriate policies, procedures, training strategies, and technological systems to pursue as discussed earlier. The next is external non-consensus with other interagency entities that create friction between the various stakeholders on the appropriate strategies to gain access to the NAS. The third is conflicting priorities within the interagency environment based on the differences of the agencies' fundamental missions. All three of these areas can be addressed within either the DoD or ExCOM forums.

The final two are more difficult to address. Conflicts between government and commercial interests and usage of UAS in the NAS could create detrimental policy implications for DoD. Additionally, public perception of UAS operating in the NAS may be greatly influenced by concerns of abuse by both commercial and law enforcement usages. Public sentiment is likely to be reflected in policy, as demonstrated in the FAA adding privacy requirements to the six UAS test sites. The last issue is the implications of a significant event, such as an accident leading to fatalities. Great care and effort must continue to be focused on safety to avoid a singular event that could have a negative ripple effect throughout the UAS community and force policy decisions detrimental to DoD requirements. Although not all of these potential pitfalls can be directly controlled by the DoD, by partnering with the different stakeholders and creating mechanisms to address conflicts of interest and public perceptions, most of the risks can be managed to ensure DoD successfully gains routine access to the NAS.

Conclusion

In the short term the DoD can continue to be successful in training and operating UAS utilizing the existing COA process to meet most of the DoD's requirements, albeit at an increased cost in personnel, equipment, and funding. As the availability of personnel and funding decrease and the number of training requirements increase this system is likely to prove unsustainable. The lack of clear guidance and policies that support gaining routine access to the NAS creates uncertainty that adversely affects the Services' ability to integrate UAS into current training and DoD level decisions necessary to guide the future composition of the military. The DoD must continue to focus on consolidating and standardizing its internal approach to UAS in order to demonstrate clear requirements that can then help shape future policy within the interagency environment. The DoD made great strides in this direction over the past 15 years as evidenced in the multiple DoD and JCS documents that address the policy, procedures, training, and equipping goals and standards within the Services. However, continued emphasis and energy should remain focused on these areas to ensure they both reach their maturity and reflect the concerns of external stakeholders.

The DoD should continue to work closely with its interagency partners in order to inform policy decisions by clearly stating DoD operating requirements and demonstrating that existing DoD guidance is resulting in safe UAS flight operations within the limited NAS access currently available. This includes ensuring mutually understood data collection methods are utilized to provide the FAA and other agencies the information required to merit updated policies. Additionally, there are some intermediate steps that can be taken short of full integration into the NAS to start addressing the shortcomings of current policy and help inform future policy decisions.

Within DoD the Joint Staff can mandate that training and equipment standards be uniform throughout the Services. This includes matching equipment standards to training requirements. An example would be to require that all UAS capable of operating in Class A airspace be required to be IFR certified. This would match the equipment requirements with the training standards already mandated within CJCSI 3255.01, which is not currently being accomplished throughout all of the Services. If both the equipment and training meets FAA IFR standards, and there is no requirement for "see and avoid", then Class A airspace provides the most obvious airspace that could accept routine UAS operations without the requirement for a COA.

Very similar to Class A airspace, Class E airspace above 14,000 feet represents another type of airspace that could quickly be utilized by UAS by a policy change from the FAA. As noted earlier, due to the combination of physiological limitations and flight performance characteristics, this is some of the most under-utilized airspace within the NAS. With very little VFR air traffic and most other traffic being fully IFR equipped and only transitioning the airspace to enter or exit Class A airspace, this airspace provides an area for UAS to operate at a greatly reduced risk of uncooperative traffic.

The current MOA definition and purpose does not reference UAS operations. MOAs serve the purpose of informing other aircraft of military flight operations that are performed in those areas and provide a published means for pilots to contact the controlling authority to identify the times and types of activities taking place. Expanding the definition and purpose of MOAs to include UAS operations would greatly increase the airspace available to UAS operations while keeping other aircraft informed of the operations. This could also include procedures to prescribe specific altitudes for the operations, allowing civilian aircraft to avoid altitudes that conflict with UAS operations.

It should be noted that although all of the inter-agency users and managers of airspace have safety as an overriding principle, risk management is the focus. From a risk management standpoint, operating aircraft is no different than any other activity. It is possible to manage and reduce risks, but impossible to completely eliminate all risk. Good risk management includes shaping the environment by applying technology to the policies, procedures, training, and equipment utilized in order to achieve reduced risk relative to the costs incurred and the benefits derived from the actions. The DoD must be able to demonstrate that it is taking the appropriate steps to both manage this risk, collect the data necessary to validate their decisions, and articulate the benefits derived from UAS operations to justify the risk.

DoD should pursue immediate access to Class A airspace, Class E airspace above 14,000 feet, and MOAs with appropriately equipped aircraft as a bridging strategy to full NAS integration. This would greatly expand the airspace available for UAS operations, provide guaranteed routine access to enable both current training and actual operations, reassure senior leaders responsible for making force shaping decisions, and enable great amounts of data to be compiled by the DoD of actual UAS operations within the NAS to support the Congressional mandate to the FAA of full integration of UAS into the NAS.

Full integration into the NAS will undoubtedly require additional technological solutions beyond those currently available in order to meet the intent of “see and avoid” requirements. This will likely include ABSAA, GBSAA, or a combination of the two. DoD must work with the FAA to define the attributes of these systems that will meet the intent of the requirement and resource those efforts. Failure to do this may result in the inability to fully realize the future benefits of UAS to DoD operations. With continued focus on both DoD internal and external stakeholders it is possible to achieve the policy outcomes necessary to ensure both the short term access to limited portions of the NAS and the long term access required by DoD UAS.

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