Prospective Unmanned Aerial Vehicle Operations in the Future National Airspace System

Matthew DeGarmo* and Gregory M. Nelson†
The MITRE Corporation, Center for Advanced Aviation System Development, McLean, Virginia 22102

The Unmanned Aerial Vehicle (UAV) market is expected to grow dramatically by 2020, as military, civil and commercial applications continue to develop. The National Airspace System (NAS) is also expected to change significantly over the next 16 years, with the introduction of new technologies and procedures. Potential changes include the creation of an information management system to exchange information among Air Traffic Management users and providers, the introduction of 4-D navigation, and the development of alternative separation procedures. This paper compares prospective UAV applications against underlying assumptions of the future NAS. Seven UAV operational scenarios that describe how UAVs may operate in the future NAS are presented. The impact of each scenario on the future NAS is summarized, and associated issues identified. The paper concludes by describing the need for a UAV roadmap to the future, which would identify the critical steps required to ensure UAVs are fully integrated into the future NAS.

In recent years, Unmanned Aerial Vehicles (UAVs) have become a very popular aviation topic. Pick up any major aviation trade magazine and there is sure to be mention of, if not a feature article on, some aspect of UAVs. Even the mainstream media, in covering recent international conflicts, has given mass exposure to the world of UAVs. This increased awareness has helped to generate an ever-increasing set of proposed new applications for these vehicles in both civil and commercial markets. However, a number of issues must be addressed before the wide-spread introduction of UAVs into civil airspace.

This paper examines how UAVs may operate in the National Airspace System (NAS) of the future. The unique operating characteristics and related challenges of operating UAVs in the NAS are described, the future aviation context and related assumptions regarding both the NAS and UAVs are detailed, and seven UAV operational scenarios and their associated issues and impacts are profiled.

I. The Emerging UAV Market

Military investment in UAV research, systems, and applied technologies is increasing, and potential uses for UAVs in civil operations, particularly for homeland security, is being investigated by federal, state, and local governments. These developments, along with growing scientific interest in UAVs, are fueling commercial interest in the unmanned market. The growing enthusiasm for UAVs is not unfounded. The vehicles offer a unique range of features, most notably ultra-long endurance and high-risk mission acceptance, which cannot be reasonably performed by manned aircraft. Coupled with advances in automation and sensor technologies, and the potential for costs savings, it is understandable that interest in and demand for UAVs is on the rise. But how this demand will manifest itself in a future market remains highly speculative.

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* Senior Multi-Disciplinary Systems Engineer, Near Term Procedures, 7517 Colshire Dr., McLean, VA 22102-7508.
† Lead Economics Business Analyst, Air Transportation Performance and Policy Analysis, 7517 Colshire Dr., McLean, VA 22102-7508.

Current trends and estimates indicate that a viable civil and commercial market for UAVs will likely emerge within the next 15 years, if not sooner. Already, plans have been drawn up to have high-altitude UAVs transitioning into civil airspace within the next five years.[i] In the initial transitioning years, standards, procedures, and regulations specific to UAVs will be codified and assessments of operational effectiveness, risks, and costs associated with UAV operations will be better understood. Following this developmental phase, the market will take on a more robust form; operations will become more routine and the numbers more prevalent.

From an air traffic management (ATM) perspective, future UAV operations will pose a unique set of issues. First, because UAV designs and capabilities will vary widely, their performance characteristics will differ significantly from those of manned aircraft. UAVs will range in size from several ounces to thousands of pounds. Many will fly slowly and lack maneuverability, whereas others will operate at very high speeds with great agility. Some UAVs will be launched and recovered from virtually any location (ship, buildings, runways, etc.). Additionally, sophistication will vary among vehicles, from those having fully autonomous flight controls to those requiring more direct pilot inputs. Communication systems will range from those capable of global reach to those limited to line of sight. Further, the types of missions being planned for UAVs of the future are rarely point to point but typically involve some form of patterned flight or tracking activity that may include intermittent short- or long-term orbits. Endurance will last from hours to months, depending on the vehicle and mission. Taken together, these variations have the potential to significantly affect air traffic operations, although the ATM system of the future will be better equipped to manage the additional complexity related to the rise of UAVs.

II. UAVs and the National Airspace System in 2020

The National Airspace System is the web of communication, navigation, and surveillance systems that ensures safe flight. The NAS is expected to change significantly over the next 16 years with the introduction of new technologies and procedures. Many of these changes will be motivated by increasing demand in the number and diversity of system users, including the addition of UAVs. To facilitate the analysis of how UAVs will interact with the future NAS, a set of seven representative scenarios was developed. Each scenario describes a potential UAV use in 2020.

The following broad assumptions regarding the future NAS and UAV characteristics were used to develop the scenarios. The assumptions are drawn from research and policy initiatives underway that are establishing the foundation for the future NAS and routine access of UAVs into civil airspace.

- In the future NAS, an information management system will aggregate, integrate, fuse, and disseminate tailored information to both air traffic service users (pilots, airlines, military, etc.) and providers (controllers, meteorologist, traffic flow managers).[‡] The system will provide common situational awareness, facilitate collaboration, and link systems and users together for effective decision making. UAVs will be both consumers and providers of this information.
- The future NAS will support user's filing and flying flight plans that contain 4-D trajectories. By using a 4-D flight plan, each flight will navigate at selected latitude, longitude, and altitude (similar to the current system), as well as self delivering to a time tolerance at a series of 4-D waypoints. 4-D flight plans will reduce uncertainty and increase predictably for both air traffic service users and providers. Although most UAVs will be equipped with GPS or other approved navigation system, only the more sophisticated UAVs will be able to take advantage of the 4-D option because of the stringent certification requirements for 4-D flight. Those UAVs and manned aircraft unable to meet the 4-D criteria will instead file 3-D flight plans. Other non-trajectory defined flight plans will also be allowed for operations where exact routes or altitudes cannot be predetermined.
- Communications between operators of both manned and unmanned aircraft and the air traffic system will be dominated by electronic data exchanges. These exchanges will require the operators' acknowledgment

[‡] The concept of a NAS-wide information system is further described in RTCA's "National Airspace System Concept of Operations and Vision for the Future of Aviation," which introduces the idea of SWIM (system-wide information management system). Further details can be found in RTCA, 2002, *National Airspace System: Concept of Operations and Vision for the Future of Aviation.*

and approval prior to execution of the air traffic instruction. Depending on the aircraft, these instructions may automatically feed into the flight control systems, whereas in other vehicles, manual control actions will still be required. For most advanced aircraft and nearly all UAVs, voice communications will largely be limited to special advisories and emergency situations.

- The air traffic system will strategically adjust air traffic control sector boundaries to increase flexibility in the provision of air traffic services. The air traffic system will employ this strategy to distribute workload more evenly when demand for services is expected to exceed the sector capacity. These actions will be transparent to the operators of manned and unmanned aircraft.
- Alternative separation methods will be provided, with separation responsibility delegated to pilots for limited durations, when and where appropriate. This will mitigate controller workload and improve the efficiency of operations. Minimum separation standards for delegated maneuvers would be smaller due to the closed loop control and response time capability of both manned aircraft and UAVs, thus increasing system capacity. Further, separation criteria between UAVs will be less than with manned aircraft due to the lower risk associated with UAV-on-UAV operations.
- UAVs operating in the future NAS will possess a range of autonomous capabilities to perform or assist in navigation, system monitoring, and flight control functions. Only a small minority of UAVs will be operated exclusively by a remote pilot without assistance from any type of automation.
- Safety and security classifications, approvals and controls will be required for all civil and commercial UAV operations. For example, all UAVs will have certified and approved plans for lost communication links and system failures, and datalink communications for vehicle control and flight telemetry will be encrypted, thereby limiting the potential for rogue transmissions.
- UAVs will have various levels of equipage for interacting with the air traffic system (i.e., transponders and 4-D navigation system). Equipage levels will be determined by limitations in size, power generation, and payload capacities of the vehicle, as well vehicle cost and mission needs. Those UAVs with lower levels of air traffic control interactive equipment will, in general, have greater limits set on their movements in the NAS.
- As a condition of their certification, nearly all medium and large UAVs will have approved markings and lights as well as the capability to "sense and avoid" other air vehicles, making them eligible to operate freely in visual flight rules, similar to general aviation aircraft today.

Taken together, these assumptions indicate that new technologies and procedures adopted by the air traffic system, coupled with advances in UAV designs and capabilities, will ease the entry of UAVs into the future NAS.

III. Future UAV Mission Scenarios

The following seven scenarios were developed to represent the broad cross-section of proposed UAV applications and vehicle types that may be operational in 2020. The performance characteristics of the UAVs are loosely based on similar vehicles currently in development or those already in use by the military or scientific community.

A. Scenario 1: Stratospheric Telecommunications Airship

A large telecommunications airship spanning over 500 feet in length and capable of carrying a 2 ton payload is set to launch from a docking facility located on a towered airport near Seattle. This airship will replace an existing airship that has been station keeping in the stratosphere over Seattle for the last three months. The launch has been coordinated in advance with the local airport tower facility and with regional air traffic control. Weather is carefully monitored due to the variable winds on the surface and at altitude, especially the high winds in the upper troposphere. Predicting the winds accurately is vital to safely launching the airship, achieving the proper vertical ascent profile, and planning for lost control link or system failure Predicting the winds accurately is vital to the safe launch andvertical ascent profile of the airship and to planning for lost control link or system failure.

The flight plan describes a slow ascent from the docking facility to 70,000 feet. This cruise altitude is well above the normal operating level for commercial aircraft, which operate upto to 50,000 feet. This altitude is also above the upper limit for FAA-controlled airspace (60,000 feet). Because the airship has a maximum forward speed of only 50 knots, and winds are expected to be variable at lower altitudes and in excess of 120 knots in the upper troposphere, the resulting ground track is somewhat erratic. The flight takes place just after midnight to minimize the impact on traffic and to take advantage of the stable atmosphere and low surface winds.

Prior to departure, information regarding the slow-moving vehicle and its vertical flight is shared with other users via the information management system. This notification is necessary due to the poor maneuverability of the airship and its operations near high-speed vehicles. The airship ascends at an average of 500 feet per minute, reaching its operational altitude in just over two hours. Air traffic control monitors the ascent to ensure safe separation. Once established at altitude, the airship begins its months-long station-keeping mission. Although the weather in the stratosphere is relatively innocuous, careful attention is paid to rare atmospheric phenomena (e.g., blue jets and sprites[§]) that may pose hazards to the flight controls and payload of the airship. The airship's location is also communicated to all interested parties via the information management system.

> *Impact summary*: The information management system facilitates operation of airships in the NAS by sharing data on the vertical ascent and eventual descent of the airship. In addition, the system provides weather planning and monitoring data, which are critical factors for the successful operation of airships. Because the flights occur outside major traffic areas and during low traffic times, the overall impact on the NAS is minimal.

B. Scenario 2: High-Altitude Imagery

A UAV is contracted to take aerial images of a large section of the Western U.S. for an annual land-use survey. A 4-D flight plan is filed showing a large sweeping pattern defined by gridded waypoints located in the high-altitude route structure above 40,000 feet. The route traverses rural, urban, and coastal areas. The mission will last for 36 hours and its airspeed will average 150 knots (optimal speed for the sensors). The vehicle is based at a tower-controlled airport but is being operationally monitored from a secured office located in the Midwest.

Upon approval from the airport tower, the UAV operator is given permission to taxi. The taxi operations are normally performed autonomously, but due to traffic and construction at the airport, the vehicle is manually taxied using a forward-looking video camera. After being cleared for take-off, the UAV ascends autonomously in accordance with a 4-D departure procedure. The ground pilot monitors flight progress and conducts system safety checks during ascent. At 30,000 feet, the air traffic control system detects a potential traffic separation conflict and automatically sends instructions to the ground pilot for the vehicle to level off for traffic separation. These instructions are electronically acknowledged by the ground pilot and transmitted to the UAV. A short time later, the vehicle resumes its intended ascent profile and climbs to its initial cruise altitude of 50,000 feet. Because weather and traffic are not significant at that altitude, the flight is conducted in accordance with the originally filed 4-D flight plan. After completing its mission, the aircraft returns uneventfully to the originating airport.

> *Impact summary*: Due to the high altitude of operations, the predictable 4-D nature of the flight, and the full suite of navigation and communication equipment onboard the UAV, there is very little impact on the system. The slow climb rate and speed of the vehicle does create some air traffic control challenges, but these are manageable.

C. Scenario 3: Border Patrol

The U.S. Border Patrol is set to launch its second UAV of the day. These 6,000-pound UAVs are intended to provide 24-hour surveillance of the Canadian border from Michigan to Maine. Each has fully autonomous capabilities and can be manually controlled when exploring targets of interest (e.g., suspect vehicles or individuals near the border). The border flights typically operate at altitudes between 20,000 and 35,000 feet to accommodate the surveillance sensors, but they can fly higher or lower to avoid weather or perform a broader or closer inspection.. The aircraft and ground control stations are located at an airbase in Ohio.

A routine 4-D flight plan is filed and approved, with a notation that the flight may occasionally leave the plan if operationally warranted. One ground controller from the Border Patrol is responsible for this flight as well as the

[§] Blue jets and sprites are electrical disturbances that shoot upward from thunderstorm tops into the stratosphere. Little is known about the cause or potential hazard posed by these phenomena.

other UAV launched earlier in the day. At a prescribed time, the UAV ground pilot instructs the vehicle to taxi and depart on its intended route. While cruising at 130 knots at 25,000 feet near Cleveland, a sector in the air traffic system is dynamically reconfigured to accommodate the relatively slow speed of the UAV—and its consequential long dwell-time in the heavily trafficked sector—in order to avoid sector saturation.

The UAV continues north uneventfully as its sensors feed live data to an imagery analyst located at a facility on the East Coast. Hours later, while over the relative calm of the Maine/Quebec border, the ground pilot receives an instruction from the imagery analyst to return to a point and circle where several vehicles have been spotted. The ground pilot requests a clearance to break from the intended flight plan and perform a 10-mile orbit. The procedure is approved, but the UAV is requested to conduct the maneuver at 20,000 feet to better facilitate cross-border flows of air traffic. The UAV ground pilot acknowledges the air traffic control request and remotely maneuvers the UAV into a wide circular pattern at 20,000 feet. The air traffic system accommodates the circular flight pattern by creating a temporary containment area. After 20 minutes, the imagery analyst communicates that border patrol units have been dispatched to investigate and that the UAV should resume its planned route. The UAV resumes a revised 4-D route after requesting and receiving a clearance from the air traffic control system.

> *Impact summary*: Dynamic sectors facilitate the slow speeds and the occasional orbits that the UAV makes during its surveillance flight. Accommodating these occasional departures from the 4-D flight plan is not difficult in low-traffic areas, but likely would be more difficult to manage in high-volume areas. The full set of navigation and communication equipment onboard the UAV allows the air traffic system to treat the UAV in a manner similar to manned aircraft.

D. Scenario 4: Maritime Surveillance

A U.S. Coast Guard cutter located in Baltimore harbor receives an alert that a high-altitude UAV conducting broad area maritime surveillance has identified a suspect vessel 100 miles offshore. Aboard the cutter is a 3,000-pound low-altitude surveillance UAV, which is immediately readied for departure. A 3-D flight plan is electronically filed with the air traffic system via the information management system to a point just outside the harbor area, where the flight will resume under visual flight rules.

Within 5 minutes of the initial alert, the flight plan is accepted and the UAV takes off vertically from the ship. The UAV pilot located onboard the cutter is given vectors and altitudes by the air traffic system in order to navigate around the busy Baltimore/Washington International Airport air traffic flow. Within 15 minutes, the UAV is cruising at 5,000 feet at 200 knots in oceanic airspace and operating under visual flight rules. An electro-optical/infrared device, combined with proximate traffic positions provided by the information management system, gives the UAV ground pilot sufficient information to maintain safe separation from other traffic while enroute to the designated location.

Once over the assigned coordinates, sensors aboard the UAV detect three ships within a 30-mile radius. The UAV descends to 1,000 feet and hovers over the first target, sending detailed images of the vessel to a central Coast Guard facility for analysis. This is repeated for the other two ships. In a short time, the images have been processed, and the UAV ground pilot is given orders to return the vehicle to the initial vessel and stay on station for 20 minutes, observing activities until a Coast Guard cutter arrives. Once the cutter appears and the suspect ship is boarded, the ground pilot files a 3-D flight plan for a return to the Baltimore harbor area and a shipboard landing.

> *Impact summary*: The rapid nature of the UAV Coast Guard operation requires frequent use of the information management system for flight planning and operational updates. Although the UAV operates in congested controlled space using a 3-D plan, it is able to react quickly to instructions from the air traffic control system for local traffic separation using electronic data exchange. Operations in the low-altitude oceanic airspace are conducted with no air traffic involvement, but instead rely on sensory systems aboard the UAV to avoid other aircraft.

E. Scenario 5: Environmental Sensing

As part of a scientific mission to collect data on airborne pollution and dissipation rates, three 30-pound, long-endurance UAVs are being readied to fly 150 miles over rural and urban environments in central Ohio to a site where power plant emissions will be monitored. The enroute portions of the flight will be conducted in a tight formation at 4,000 feet. The formation allows the UAV ground pilot and air traffic control system to treat the individual vehicles as one aircraft.

The UAVs are launched from ramps located near a suburban industrial park in airspace not controlled by an air traffic facility. The routes are flown autonomously at an indicated speed of 50 knots for the entire mission. Due to payload and power generation limitations, the vehicles cannot carry a transponder, making them undetectable by traditional radar. Instead, the UAV transmits GPS location information to the UAV ground station, which in turn sends the data via landline to the information management system. An added surveillance system, consisting of light-weight, low-power beacon tags, is affixed to the UAVs. These tags, while limited in transmission range, contain information such as vehicle type, registration number, owner's name, primary base of operation, and an encrypted security code. The tags can be queried by specialized equipment located on the surface and aboard government aircraft to assist agencies in identifying and sorting out legitimate, pre-approved operations from potential security threats. A visual and infrared system certified to detect aircraft for visual collision avoidance is also aboard the UAVs.

A 3-D flight plan is electronically filed for the higher altitude initial and final legs, and the power plant monitoring activities, taking place at the lower altitudes, will be conducted using visual flight rules. Weather reports, supplied by the information management system, are tracked carefully as the vehicles are susceptible to winds and even the smallest amounts of ice accumulation. The vehicles depart and fly the intended 3-D path without any difficulty. When at the monitoring site, the UAVs break formation and descend to altitudes of 500, 1,000, and 1,500 feet, where each vehicle will simultaneously fly, along the same ground track, a repeated 10-mile out-and-back route at progressively greater distances downwind from the plumes. The monitoring time extends for 16 hours. The intended flight area for the experiment is recorded in the information management system, thereby providing notice to any aircraft planning flights in the area. At the completion of the mission, the UAVs reenter a formation pattern and return to the launch site under a 3-D flight plan. During the return mission, one UAV experiences a loss of communication and autonomously selects a predefined area to execute an emergency landing. The errant vehicle is later recovered with no damage to the vehicle or property.

> *Impact summary*: Because the monitoring site is remote and the altitude low, there is minimal effect on air traffic operations. During the initial and final portions of the flight, when the three aircraft are under observation by the air traffic control system, they are treated as one aircraft, further minimizing the impact. The information management system is used extensively during this operation to communicate location and intent information to the air traffic system and other airspace users.

F. Scenario 6: Media and Traffic Reporting

A television news center is set to dispatch a UAV to the scene of a major traffic accident. The UAV is based atop a building near downtown Chicago. Due to the launch site's proximity to two major airports, air traffic clearance is required for all operations down to the surface. Flights are conducted under visual flight rules and are flown within predetermined areas to reduce the impact of aircraft noise and remain clear of airspace that is more heavily traveled. The vehicle, weighing 300 pounds and capable of vertical take-off and landing, is equipped with a transponder that permits the air traffic control system to monitor the flight.

The vehicle is leased by a media group and operated by a UAV contractor located in a secured facility. The UAV ground pilot notifies the air traffic system of its intent to fly under visual flight rules to the scene of the accident. A security code, which indicates that the vehicle is pre-approved to operate within designated areas of the city (e.g., away from sensitive sites such as airport departure/arrival paths), is also transmitted to the air traffic control system. The ground pilot programs the vehicle to fly along a set of waypoints within its designated areas and conveys this data to the air traffic system via the information management system. Air traffic control approves the flight and monitors its progress. The UAV departs and cruises at an average speed of 100 knots at 1,000 feet above the ground, before descending to 400 feet over the accident area.

Upon arrival at the scene, the media group, who controls the camera aboard the UAV, communicates with the ground pilot on positioning the aircraft for best viewing angles. Within a minute, another media UAV and manned rescue helicopter also arrive at the scene. The two media UAVs are instructed by the air traffic control system to move to a temporary holding area a short distance from the accident scene, thus allowing the rescue helicopter to safely maneuver and land. After 40 minutes on scene, the vehicle returns autonomously using a pre-planned route to its downtown landing pad.

> *Impact Summary:* The information management system facilitates operation in a contained urban environment by providing integrated, real-time geographic data on planned routes relative to restricted or sensitive locations (e.g., noise sensitive areas). A system certifying the right to fly in urban areas allows approved users rapid access to specific airspace. The air traffic system also enables the coordinated operations of civil and commercial users in tightly confined airspace.

G. Scenario 7: Tactical Law Enforcement

Police in Los Angeles are called to investigate potential criminal activity at a warehouse complex near Los Angeles International Airport. Prior to entering the complex, officers at the scene decide to deploy a canister-launched small tactical UAV fitted to their police cruiser to scout the area. The UAV weighs 8 pounds and is electrically powered, making it relatively silent. Operating at a speed of between 30 and 70 knots, it is capable of staying aloft for 2 hours. The vehicle is designed for autonomous operations with control error correction, thereby requiring only minimal training and operational skills. The control station is integrated into the police cruiser.

The UAV is to be flown in airspace that, for most aircraft, requires positive air traffic control down to the surface. However, because this aircraft is incapable of carrying a transponder due to weight and power restrictions (normally a requirement in this airspace), restrictions on its movements are imposed. A precondition for all UAVs unable to carry transponders is that they be equipped with a low-weight, low-power beacon tag containing an encrypted approval code in order to make its security classification and presence known to air traffic control and other users. This UAV, like others in its category, must also have a certificate indicating that the vehicle has geographic data encoded into the navigational system permitting the vehicle to operate only in areas deemed safe, and avoid those areas that are “off limits” (e.g., departure and arrival paths at airports). Should the operator try to launch or manually direct the vehicle to airspace outside that approved area, the system would merely return to its prescribed airspace or, in the case of take-off, would not permit a launch.

Upon arrival at the scene, the UAV is rapidly deployed from the police cruiser. No prior coordination or communication with the air traffic control system is required. A system onboard the UAV detects transponder signals from manned aircraft and large UAVs and unique short-range signals from other small UAVs. These sensors assist the UAV in self detecting and avoiding other aircraft that may enter the area. After successfully observing the suspicious activity via video links, the officer instructs the UAV to return to the cruiser, where it lands, using a deep stall technique, and is recovered.

> *Impact summary:* The small size and contained flight areas of the UAV place it outside the control of the air traffic control system. The UAV ground system does receive dynamic updates via the information management system on the number and size of restricted or “no fly” zones. In addition, it is equipped with technology to provide positive identification to the air traffic system and other users should the vehicle stray. Any avoidance actions that may occur would likely be with similarly sized UAVs.

IV. Conclusion

Unmanned Aerial Vehicles are an exciting field in the world of aviation, with new discoveries and proposed uses being documented daily. Over the next 16 years, UAVs will become a significant component of military, civil, and perhaps even commercial aviation. However, the very dynamic nature of the field also creates a significant amount of uncertainty. The wide range of UAV physical and performance characteristics, many of which will be very unlike any current aircraft, will place additional challenges on an air traffic management system already under great strain. However, many of the new paradigms being considered for the future NAS will likely facilitate the routine and safe entry of UAV operations into civil airspace. The information management system, through shared situational awareness, will allow all users of the NAS to know the location and intent of other aircraft (both manned and unmanned). The data provided by the system will also be a vital component to the functioning of autonomous systems embedded in UAVs and other advanced, data-dependent aircraft of the future. 4-D navigation and control will allow properly equipped UAVs to file 4-D flight plans and integrate seamlessly into the NAS. Sectorization strategies will allow controllers to segment slow or loitering UAVs and minimize their influence on surrounding aircraft. And finally, airborne separation and delegation procedures and technologies will provide a paradigm that allows UAVs to safely separate themselves from other aircraft, when appropriate.

The scenarios presented in this paper account for only a fraction of the missions and vehicles that might operate in the future airspace. What is not conveyed is the impact that larger volumes of these and other UAV activities could have on the NAS. The extent to which UAVs actually do develop and assimilate into the civil aviation system will depend on a number of technical, legal, political, and economic factors. One such factor will be the commitment and resources applied to implementing the changes needed to transition the NAS; another is the business case for UAVs. These elements will define the UAV market and with it, the missions, vehicles types, frequency of flights, and areas of operation. But whatever form the market takes, the NAS should be prepared to accommodate its growth. This will require an effective strategy—a national roadmap—that accounts for the interactive complexities and unique properties of UAVs. Additionally, continued research is needed to better assess the potential influence of UAVs on future traffic flows, airspace capacity, infrastructure, and air traffic control procedures. These actions will assist policy makers, manufacturers, air traffic control service providers, and regulators in building a future environment that supports *all* users of the NAS and facilitates the advancement of aviation.

Through its continued support of the Federal Aviation Administration work program, The MITRE Corporation's Center for Advanced Aviation System Development will continue to explore the many dimensions of the future NAS and UAV developments. This work will entail a thorough understanding of the wide variety of initiatives currently proposed for the NAS, refining the initiatives into various integrated concepts of future operations, tracking UAV developments, and exploiting modeling and simulation experience to evaluate the utility of evolving concepts, practices, and technologies.

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[i] NASA has sponsored a five-year program, known as Access 5, which aims to get high-altitude UAVs flying routinely above Flight Level 180. More can be learned about the program at www.access5.org.