What are the Challenges and Payoffs

for UAS to Operate in the National Airspace?

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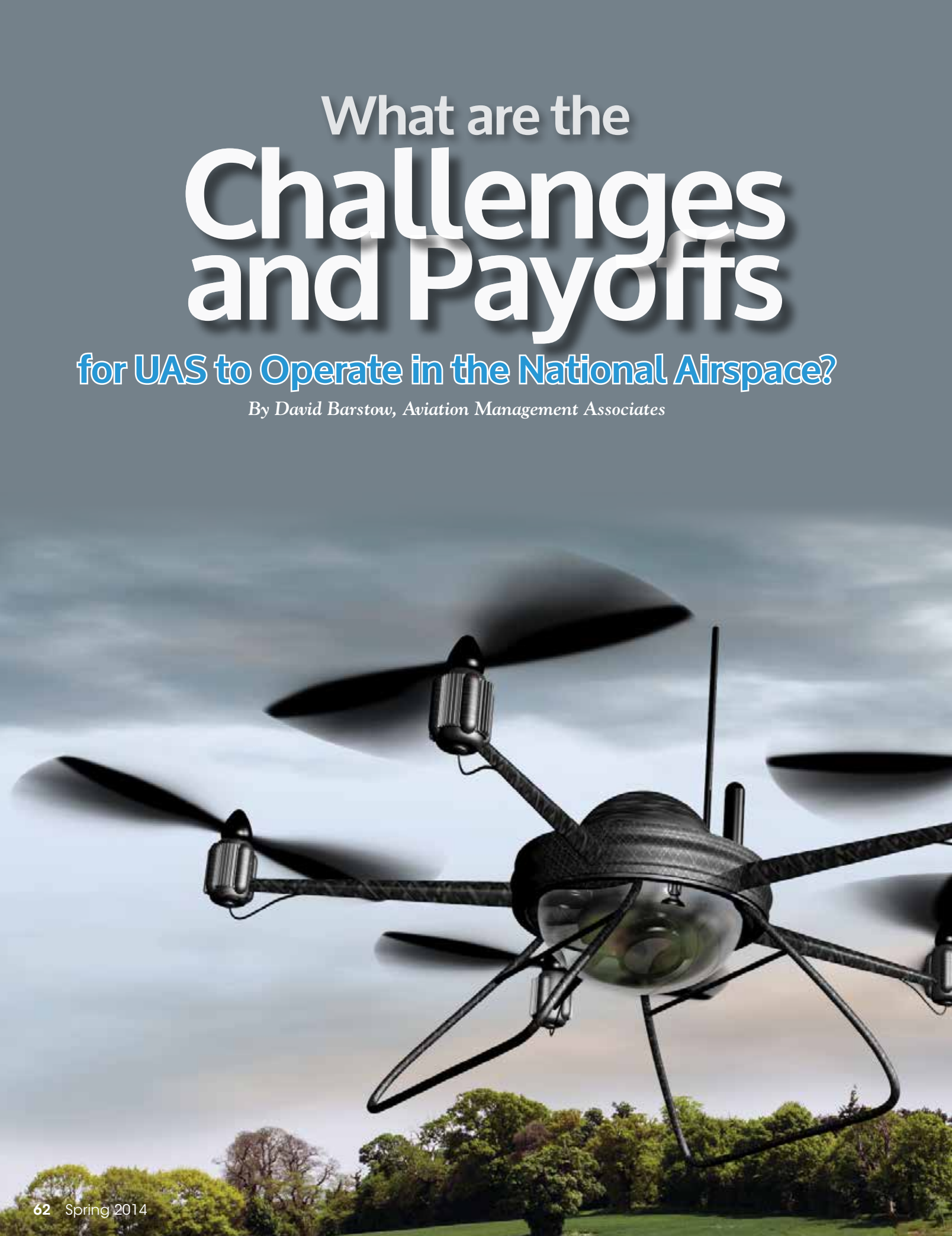


Unmanned Aircraft Use Has Grown Considerably, as have Benefits

Technological developments are mission enablers in the same way that mission requirements drive technological changes.

IN NOVEMBER 2013, THE FAA RELEASED ITS ROADMAP ROADMAP TO INTE-grate Unmanned Aircraft Systems (UAS) to fly in the National Airspace System (NAS). It outlines nine major areas of research and a total of 34 goals to be achieved over the next decade and beyond. In addition to the Roadmap, a UAS Comprehensive Plan was published that summaries a coordinated government agency plan that describes the overarching, interagency goals, objectives, and approach to integrating UAS into the NAS.

In September of this year, a technical report titled, *Unmanned Aircraft System (UAS) Service Demand 2015–2035 Literature Review & Projections of Future Usage*, was prepared for the United States Air Force through support from the John A. Volpe Transportation Systems Center that assessed the opportunities, risks, and challenges affecting UAS forecast growth from 2015 to 2035 attendant to the future development and deployment of Unmanned Aircraft Systems (UAS) within the National Airspace System (NAS). A link is provided on page 67.

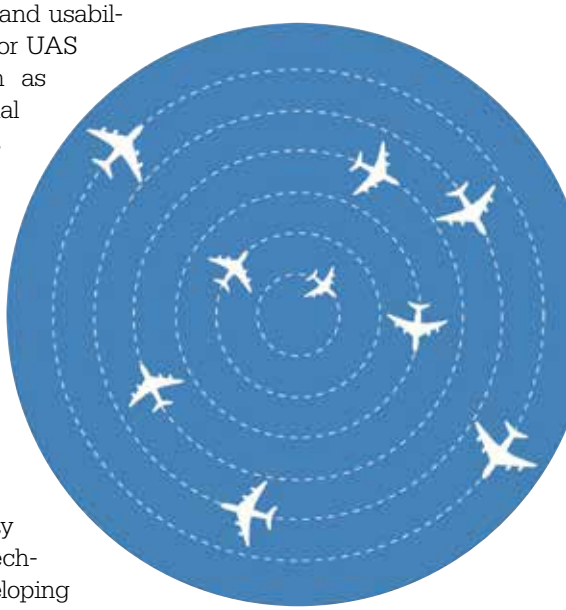
The single goal of the comprehensive technical report is to provide readers a better understanding of UAS to support better decisions related to UAS development, deployment, and operations. The report provides an overview of historical achievements, early developments and modern development for UAS. It discusses the mission needs or applications, economic considerations and challenges for the government defense and public markets as well as the commercial market.

The technical report includes comprehensive recommendations for future research considerations and approaches to address the many challenges that may stifle or threaten the introduction and growth of UAS in the NAS.

Analysis of four key areas was instrumental in developing sound forecasts for UAS demand over the period 2015 to 2035. These areas are: technology, mission needs, economics, and existing or anticipated challenges to routine UAS use in NAS operations.

1. Technology

The global defense industry is currently investing heavily in research and development, which has led to the development of technologies to enhance the endurance, survivability, and usability of UAS. The paper identifies five major UAS subsystem technologies that are seen as enablers for both military and commercial Unmanned Aircraft Vehicle (UAV) market development and growth:



- Airframe
- Power plants
- Sensors
- Communication
- Command, and control (C3) systems
- Information technologies (IT)

Each of these subsystems will be driven at varying paces, depending upon research and development investments coupled with the financial viability of emerging markets. Some of these technologies – such as IT – are rapidly developing because of the high growth in user demand and the development of web-based services.

Some of the many mission characteristics and requirements that will drive

The Air Force also expects that its large unmanned aircraft fleet will grow to about 750 vehicles, leaving the bulk of the Air Force fleet modernization focused on optionally piloted vehicles satisfying broad mission needs.

future UAS development include:

- Lightweight (composite structures)
- Long endurance
- High payload carrying capacity
- Interchangeability between standardized payload modules

Continuing microminiaturization, sensor fusion, C3 standardization, and infrastructure integration will result in smaller and more capable UAVs. They will also be more efficient and less costly. Increase capability at less cost drives market growth.

2. Missions

While technology enables, it is the cost effective delivery of capabilities that meets needs and in turn, will drive UAS markets. Identification of mission needs is foundational to forecasting future types and number of UAS. The report considers major mission requirements to continue to be in intelligence, surveillance, and reconnaissance (ISR), as well as new areas such as stores delivery, cargo transport, search and rescue, and pilot augmentation. Mission need is tightly coupled with technology, meaning technological developments are mission enablers in the same way that mission requirements drive technological changes.

Historically, the UAV have been primarily utilized by the military in war zones and within restricted airspace in the U.S. As such, UAV designs did not fully consider longevity or robustness, which is important for operation in the NAS. New domestic missions and vehicles present a new paradigm. The UAS Service Demand 2015–2035 anticipates expansion of UAS into a myriad of public, private, and commercial missions routinely using the national airspace alongside other air traffic has highlighted both operational needs and public concerns associated with UAS operations.

3. Economics

A business model tells the story of the business and how the elements of that business work together to produce value to the customer. The model also describes how the business differentiates itself from other competition in the same product area. The report relies upon research from a Massachusetts Institute of Technology team, who in 2005 examined the business models of the largest 1,000 U.S. firms[1]. The research team found that business models were a better predictor of operating income than existing business segment classifications. If this is the case, then a business model can be used to test a range of approaches for generation of revenue for UAS applications. If a business is to receive financing to start up (the case with nearly all civil applications using UAS) then a good business model must consider customers, cost, revenue, and the value proposition for the product or service being delivered. A November 2013 article in the Washington Post, *As drones evolve from military to civilian uses venture capitalists move in*, by Olga Kharif, validates this approach.

4. Challenges

At the moment, there are major constraints to the use of UAS due to the underlying number and complexity of issues regarding operating UAS in the NAS. To this point, initiatives to promote and facilitate the use of UAS in civilian applications have been relatively uncoordinated and *ad hoc*. Another challenge is pilot training and certification. Future users of UAS have to prove that they can operate (piloted from the ground or autonomously) safely. The military has been leading the training and certification process, including rules, pilot certification processes, and training and simulation requirements. The military anticipates leading the future of UAS operation training and certification into the NAS.

While existing restrictions and procedures for the operation of UAS in the NAS mitigate safety concerns for other air traffic and persons and property on the ground, the Federal Aviation Administration (FAA) is currently developing regulations for safe and routine UAS operations in the civilian NAS. Additional challenges to UAS market growth for operations within U.S. include: regulatory,

Policy, and procedural issues

- Environmental issues (noise and emissions)
- Safety
- Social issues (privacy and nuisance concerns)

Unresolved social issues can doom the most promising technologies. One of these key areas is the perceived concern for privacy. Even when the technical and safety concerns are overcome, there is still a growing challenge to widespread use of UAS in the NAS brought on by the public's privacy concerns. This is due to the predominant belief that use for UAS is only for intelligence, surveillance, and reconnaissance (ISR).

Most stakeholders, including FAA, recognize the time and cost challenges these policies and procedures place in the way of achieving UAS benefits. As a result, efforts are underway through the RTCA Special Committee 228 to address a myriad of issues associated with integration of UAS into the NAS. Timely deployment of UAS into the NAS is dependent upon reducing, circumventing, and eliminating these and other challenges.

[1.] Peter Weill, Thomas W. Malone, Victoria T. D'Urso, George Herman and Stephanie Woerner. "Do Some Business Models Perform Better than Others? A Study of the 1000 Largest US Firms". Sloan School of Management, Massachusetts Institute of Technology, MIT Center for Coordination Science Working Paper No. 226, 2005

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Three Market Forecasts for UAS: Methodology, Development, and Trends

In order to provide realistic forecasts of future UAS markets, the "S" curve model of technology-driven market development over the last 50 years is utilized. The "S" curve is represented by a number of key phases in product development and deployment starting with technological innovation. If this innovation is coupled with emerging wants, needs, or desires, market growth follows predicated upon economic benefits balanced against costs. Further insight into the S-curve is generated from one of the most commonly used tools known as the Diffusion of Innovations Model that identifies and analyzes the different phases of growth, saturation, and decline of a certain product, technology, new idea, or innovation. This valuable model helps forecasters make long term plans and design strategy around existing product portfolios and new product launches.

A number of short-range forecasts that address Department of Defense (DoD) planned investments in UAS are performed. Coupled with past acquisition trends, these forecasts provide an opportunity to lay a foundation for future UAS development and deployment in Federal, state, and local government organizations as well as a potential commercial market. For other UAS markets identified by this report, the DoD baseline is biased to the forecast effects of emerging technologies as well as anticipating new technological innovations in areas of aircraft: airframes, power plants, sensors, C3 systems, and information technology and processing. A robust commercial market contributes to cost effective innovation as well as economies of scale that bring economic benefits back to the DoD.

Part of the effort to identify UAS technologies and market trends has been a five-year data collection and analysis effort that serves to track the developments and deployments of UAS around the world. This 1,500-entry database archives media reports, press releases, and documentation from government and industry sources and provides insight into UAS trends that are forecast to drive non-DoD UAS markets. The database is segmented to address: accidents and incidents; Congressional activities; regulatory activities, including policy and procedures; missions; vehicles; training, research and development; and economic and contract issues.

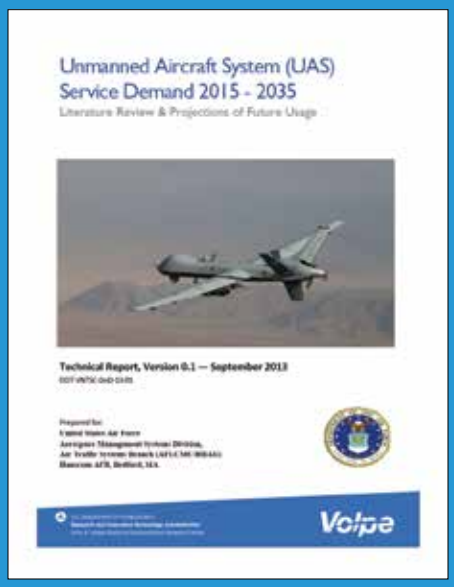
Ultimately, all of the above factors are considered and evaluated to develop the U.S. UAS forecasts 2015 to 2035. These forecasts are viewed as most probable given the political, economic and regulatory environment to date. Validation of these forecasts, which rely upon regression analysis and other statistical forecast methods, will eventually come as the non-DoD markets begin to develop and UAS is deployed within the NAS.

Forecast for DoD UAS

The DoD expects its inventory of aircraft, both conventionally manned as well as unmanned, to grow to 27,000 vehicles by 2035, including 8,000 traditional aircraft, 14,000 UAS of all sizes and types, and 5,000 new aircraft with UAS technologies for pilot augmentation or optional pilot replacement. This growth is paced by the introduction of new and more capable unmanned or optionally manned aircraft accomplishing broader DoD missions. The DoD projects that the percentage of unmanned vehicles will UAS Service Demand 2015-2035 grow from 25 percent in total today to 70 percent of the DoD fleet by 2035, including new, optionally manned or pilot augmented aircraft.

The Air Force currently operates about 5,400 aircraft. Less than 5 percent of this total represents unmanned aircraft, and none are optionally manned aircraft. The Air Force projects that its fleet could grow to some 5,800 aircraft by 2035, with almost 60 percent optionally manned or unmanned. For example, replacement of the traditional long-range manned bomber fleet is under discussion to be replaced by an initial new fleet of 80 optionally manned aircraft at a cost of some $100 billion. The Air Force also expects that its large unmanned aircraft fleet will grow to about 750 vehicles, leaving the bulk of the Air Force fleet modernization focused on optionally piloted vehicles satisfying broad mission needs.

The shift in the Navy and Marine's assets toward optionally manned and unmanned aircraft will likely parallel that of the Air Force, although the Navy will also employ smaller UAS Carrier Launched Airborne Surveillance and Strike System (UCLASS) shipboard tactical vehicles for surveillance and weap-



ons ordinance delivery. In addition, the Marines will increase the use of tactical UAS for both ISR and weapons ordinance delivery. This should increase the naval and marine aircraft inventory from 3,700 vehicles today to some 4,800 by 2035, including as many as 2,500 UAS vehicles. A much more significant change is expected in the Army in terms of the development and deployment of UAS.

Currently, 55 percent of the Army's aircraft are represented by some 6,200 predominantly Small UAS. This number is expected to grow to some 10,000 UAS representing more than 75 percent of Army aviation assets. As optionally manned aircraft will drive Air Force UAS development and investments, tactical UAS platforms that can effectively deliver ordinance will be a notable driver in the future for the Army. This is not unlike the introduction of aircraft in WWI when the initial reconnaissance mission developed into combat roles, both attacking ground targets and air-to-air combat. In addition, the Army is advancing its requirements for larger UAS vehicles, such as the Grey Eagle, for "regional theater" activities and in some cases may overlap with Air Force missions and vehicles.

Forecast for Public Agency UAS

Currently, a number of federal agencies, including the Central Intelligence Agency (CIA), Homeland Security, Department of Justice, and the Department of the Interior, Department of the Treasury, and National Aeronautics and Space Administration (NASA) operate some 125 UAS for a variety of missions.

Assuming existing FAA regulatory challenges can be significantly mitigated by 2015, it is expected that federal agencies will begin to acquire UAS to meet their mission needs in a more cost-effective manner. In addition to the agencies currently using UAS, it is expected UAS will play notable support roles for the Department of Agriculture, Department of Commerce, and the Department of Energy.

Between 2015 and 2035, it is expected that federal agency UAS fleets will grow from a few hundred to approximately 10,000, with over 90 percent of these vehicles categorized as Nano, Micro, or Small UAS. Ultralight, Light Sport, and Medium sized UAS will find a role with a number of agencies, such as Bureau of Land Management or Coast Guard, who need to survey large tracts of land or water for a variety of missions. In all cases, the UAS is the transport for the payload, be it sensors or cargo. The number and type of UAS developed, acquired, and deployed will be driven by mission needs and costs. UAS Service Demand 2015-2035

In addition to the non-DoD federal public sector, there are 50 states and other U.S. territories and possessions that will find great potential benefits in adopting and using UAS technologies. The pace of acquisition and use is expected to parallel the federal public sector since many states have programs aligned with very similar federal interests. From the modest acquisition of a few hundred UAS in 2015, state UAS inventories are expected to grow to 10,000 vehicles by 2035. These estimates include modest UAS inventories at colleges and universities.

All told, the federal and state sectors are forecast to be collectively operating some 36,000 UAS vehicles by 2035. This number is comparable to the Nano, Micro, and Small UAS forecasts for local governments; especially including some 18,000 metropolitan police departments and other first responders. The number of UAS vehicles forecast for first responders jumps from a few hundred in 2015 to a number almost equal to all others except the commercial sector – some 34,000 UAS vehicles by 2035. This means an expected population of 70,000 state and local public UAS by 2035.

Forecast for Commercial Market UAS

It is expected that the overwhelming majority of commercial UAS will fall into the Micro and Small UAS categories. The majority of these vehicles will be low-cost and dedicated to specific new and emerging tactical market applications. The source of supply of these vehicles will come initially from the Radio Controlled (RC) type vehicle makers as opposed to the suppliers of DoD and public agency aircraft. After an initial surge or upswing in commercial sales, reduced growth is expected as needs for early adopters and innovators are met. As UAS usage becomes more mainstream, DoD suppliers are expected to seriously enter the commercial marketplace which will encourage changes in business models, especially emphasizing a service model where professional organizations offer routine ISR and other services wanted, needed, or desired by business and individuals. These changes should again accelerate market growth through 2035.

As markets are defined and refined, it is expected that beginning in the 2022 to 2023 period commercial sales of UAS vehicles, including products and services, will experience accelerated growth with total UAS vehicles approaching 250,000 by 2035, of which 175,000 will be in the commercial marketplace.

Proposed Research Considerations

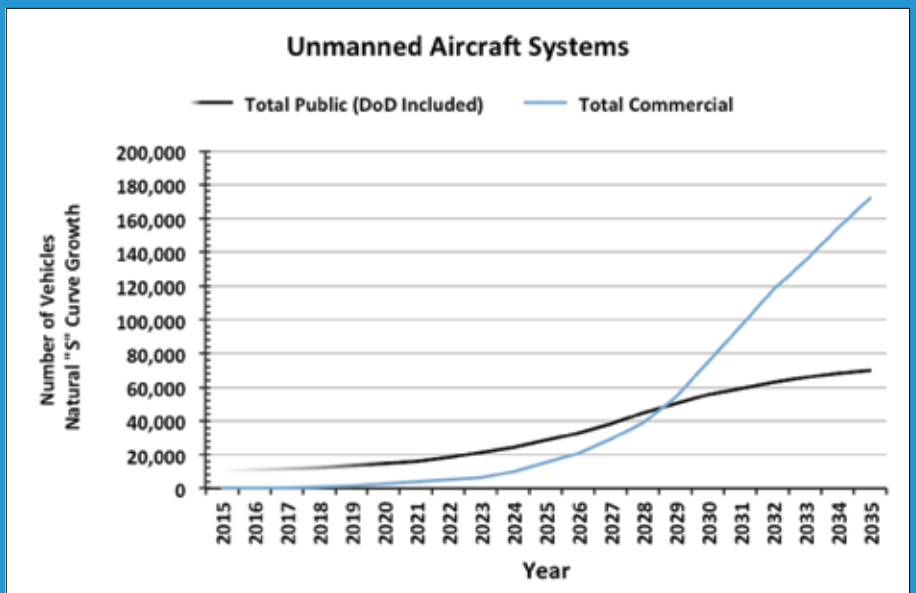
A number of proposed research needs and considerations attendant to advancing routine UAS usage in the NAS in response to the aforementioned challenges are presented below. These proposed research areas are offered for consideration to UAS stakeholders, both government and industry alike. Seventeen specific recommendations were made focused on the FAA while five were focused for the DoD and the FAA to consider and inviting participation from industry stakeholders, where appropriate. A more expansive discussion of many of these considerations is provided in the body of the report.

Conclusion

UAS operations are expected to surpass manned aircraft operations, for both military and commercial domains by 2035. The technologies needed to support this transformation are developing rapidly, costs are diminishing, and applications are growing. However, there are considerable challenges to UAS market growth for operations within U.S. that must be overcome to realize the full economic and social benefits of UAS; these challenges primarily include regulatory, policy, and procedural considerations; social issues, such as privacy and nuisance concerns; environmental issues, such as noise and emissions; and safety.

The report mentioned in this article, *Unmanned Aircraft System (UAS) Service Demand 2015 – 2035 Literature Review & Projections of Future Usage*, was prepared for the United States Air Force through support from the John A. Volpe Transportation Systems Center.

The pdf can be downloaded at http://1.usa.gov/1aKtOv8.



TOTAL UAS FORECAST 2015–2035