UNMANNED AIRCRAFT SYSTEMS: THE NAS AT A CROSSROADS

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Abstract

The rapid growth of the unmanned aviation sector has game-changing implications for every stakeholder associated with the operation and future of the National Airspace System (NAS). The sector's economic clout is growing, and the existing body of rules and accommodations that enable unmanned aircraft systems access to the NAS is struggling to keep up with demand, innovations, and the ever-widening range of business opportunities to which unmanned aircraft are being applied. At the same time, hazards created by unmanned aircraft operated outside the existing regulatory structure threaten the safety of manned aircraft and the reputation and opportunities of commercial UAS operators. Re-thinking of the entire notion of unmanned aircraft system "integration" in the NAS is needed to consolidate and build upon the initial progress made in advancing the evolution of the sector as a whole.

Introduction

Unmanned aircraft systems (UAS) are often thought of as new factors to be dealt with simply in terms of their actual or potential impact on the safety, capacity, or efficiency of the existing National Airspace System (NAS). However, it is increasingly important for UAS to be acknowledged and accommodated as a user community with the potential to make significant economic contributions to the nation in its own right.

Many challenges remain for regulators to meet UAS operator demand for ever-broader access to the NAS, side by side with current manned aircraft users. This raises the question: *At what point will the NAS itself need to change to accommodate the needs of the unmanned aviation sector, and what form might UAS-oriented changes take?*

Unmanned Aircraft Systems as "Game-Changers"

In June of 2016, the formal publication of Part 107 of Title 14 of the Code of Federal Regulations (14 CFR) cleared the way for tens of thousands of newly certificated "small unmanned aircraft system (sUAS) operators to make use of unmanned aircraft weighing less than 55 pounds for all manner of commercial uses." Already booming in terms of both registrations and requests for authorization to operate in controlled airspace, the small UAS sector has the potential to grow far beyond its current level of activity.

The increasing sophistication of larger unmanned aircraft, emerging technologies aimed at enabling UAS operations far beyond the visual line of sight of their pilots in command, and the many commercial uses that unmanned aircraft with greater payload capacity could be applied against, all suggest that we are only seeing the beginning of a true revolution in how the NAS is used and how it will need to be shared in the coming years.

Even as these trends gain momentum, many current users of the NAS have resisted the growing presence of UAS. While their primary and legitimate concern is for the safety of other aircraft, there are also some commercial activities long supported by manned aircraft that are likely to become increasingly attractive for unmanned platforms as well.

For these reasons, unmanned aircraft systems may be seen as an ideal example of what is known as "disruptive technology." [1] This term has been variously defined with respect to its relationship with different industries. However, one commonly used version in the context of unmanned aviation – paraphrased – is, "A technology that displaces or has the potential to displace an established technology, or that creates a completely new industry."

Writing in the *Harvard Business Review* in December of 2015, Clayton Christensen described how disruption affects the status quo:

> "Disruption" describes a process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses. Specifically, as incumbents focus on improving their products and services for their most demanding

[1] Clayton M. Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston, MA: Harvard Business Review Press, 1997), p. xix.

(and usually most profitable) customers, they exceed the needs of some segments and ignore the needs of others. Entrants that prove disruptive begin by successfully targeting those overlooked segments, gaining a foothold by delivering more-suitable functionality—frequently at a lower price.[2]

With the above precepts in mind, it becomes necessary to take a step back from how the current NAS works and whom it serves, and instead consider what the rise of unmanned aviation might suggest about its future direction and priorities.

The Shifting Economic Landscape

For more than forty years, the FAA has made regulatory and investment decisions based, in part, on economic analyses. These revolve around three program priorities:

- The need to maintain and update air traffic communication, navigation, surveillance and management services;
- The development and enforcement of regulations for the safe and efficient operation of the NAS; and
- The administration of the Airport Improvement Program (AIP).

Analyses aimed at servicing these program areas are based on five “benefit” domains: safety, capacity increases (to minimize delays), prevention of flight disruptions (especially due to adverse weather), overall cost savings (including “cost avoidance”), and a catch-all “other” category.

How does the unmanned aviation sector fit into this model, as currently constituted? The answer is: not very well. Over time, the safety, capacity, and efficiency of the NAS itself have been measured by the extent to which the needs of the “aviation industry” – particularly the commercial air carriers – are met. This has been a reasonable approach due to the significant contributions to the annual Gross Domestic Product (GDP) that the industry has made over time. The *Airlines for America* (A4A) estimates that these economic impacts represent roughly 5% of GDP and 10 million jobs over at least the past decade.[3] In addition, the Air Transport Action Group places the industry’s worldwide GDP contribution at 3.5%.[4]

Table 6 in the November 2016 edition of the FAA’s annual *Economic Impact of Civil Aviation on the U.S. Economy* (on the following page) bears out A4A’s claims regarding the importance of the aviation industry’s contributions to the economy. What is *not* included in this table – nor is it in any way yet factored into the FAA’s overall decision-making calculus – is how *unmanned* aviation is beginning to make its own distinct contributions to the nation’s economic health. However, some roughly comparable data is contained in a study commissioned by the Association of Unmanned Vehicle Systems International (AUVSI) in 2013, suggesting those contributions could be substantial.

[2] https://hbr.org/2015/12/what-is-disruptive-innovation (accessed March 31, 2017).

[3] A4A Presentation: *Industry Review and Outlook* (March 8, 2017) - http://airlines.org/blog/dataset/a4a-presentation-industry-review-and-outlook/ (last accessed March 31, 2017).

[4] http://aviationbenefits.org/economic-growth/value-to-the-economy/

Table 6. U.S. Civil Aviation: Growth of Total Output, Earnings, and Jobs (Real)

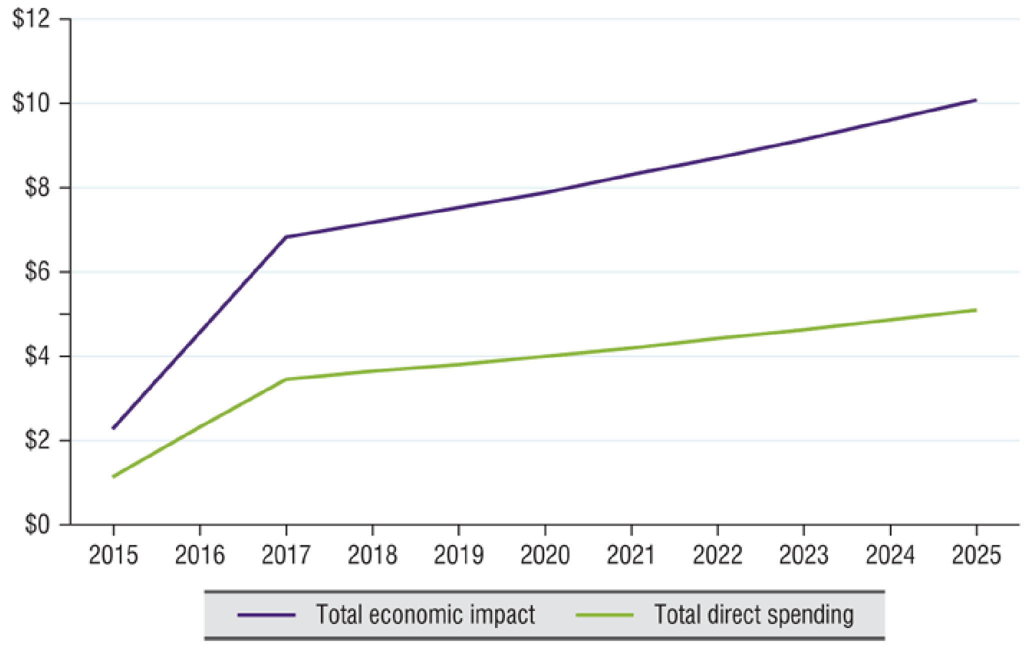
	Output (2012 $Billions)			Earnings (2012 $Billions)			Jobs (Thousands)		
Description	**2012**	**2014**	**Percent Change**	**2012**	**2014**	**Percent Change**	**2012**	**2014**	**Percent Change**
Airline Operations	300.4	314.3	4.6	73.4	76.8	4.6	1,412	1,528	8.2
Airport Operations	70.9	73.4	3.6	22.6	23.4	3.6	490	524	7.1
Civilian Aircraft Manufacturing	122.7	138.9	13.2	30.7	34.8	13.2	547	640	17.1
Civilian Aircraft Engine and Engine Parts Manufacturing	15.9	17.0	6.9	3.8	4.1	6.9	71	78	10.6
Civilian Other Aircraft Parts and Equipment Manufacturing	63.6	71.4	12.3	16.0	17.9	12.3	311	361	16.1
Civilian Avionics Manufacturing	22.9	21.9	-4.3	5.8	5.5	-4.3	112	111	-1.0
Civilian Research and Development	22.7	31.3	38.3	7.2	10.0	38.3	135	193	43.0
Air Couriers	58.1	60.6	4.4	17.6	18.4	4.4	468	505	8.0
Visitor Expenditures	712.4	745.4	4.6	206.7	216.3	4.6	5,649	6,114	8.2
Travel Arrangements	16.4	17.9	9.0	4.8	5.2	9.0	112	126	12.7
Subtotal - Commercial	**1,406.0**	**1,492.3**	**6.1**	**388.5**	**412.3**	**6.1**	**9,305**	**10,181**	**9.4**
General Aviation Operations	34.6	38.5	11.4	8.5	9.4	11.4	163	183	12.2
GA Aircraft Manufacturing	20.0	29.5	47.3	5.0	7.4	47.3	89	132	48.4
GA Visitor Expenditures	11.7	11.6	-0.9	3.4	3.4	-0.9	93	93	-0.2
Subtotal - General Aviation	**66.3**	**79.6**	**20.1**	**16.9**	**20.3**	**20.0**	**345**	**408**	**18.2**
Total Impact	**1,472.3**	**1,571.9**	**6.8**	**405.4**	**432.6**	**6.7**	**9,650**	**10,589**	**9.7**

That report – *The Economic Impact of Unmanned Aircraft Systems Integration in the United States* – makes (and defends) the following conclusions:

1. The economic impact of the integration of UAS into the NAS will total more than $13.6 billion in the first three years of integration and will grow sustainably for the foreseeable future, cumulating to more than $82.1 billion between 2015 and 2025.
2. Integration into the NAS will create more than 34,000 manufacturing jobs and more than 70,000 new jobs in the first three years.
3. By 2025, total job creation is estimated at 103,776.
4. The manufacturing jobs created will be high paying ($40,000) and require technical baccalaureate degrees.
5. Tax revenue to the states will total more than $482 million in the first 11 years following integration (2015-2025). [5]
6. Every year that integration is delayed, the United States loses more than $10 billion in potential economic impact. This translates to a loss of $27.6 million per day that UAS are not integrated into the NAS.

[5] The Economic Impact of Unmanned Aircraft Systems Integration in the United States. Retrieved from http://robohub.org/_uploads/AUVSI_New_Economic_Report_2013_Full.pdf

SAGE Publication's *Business Researcher* rendered the AUVSI report's data as an easier-to-understand graph ("Projected direct spending and economic impact of commercial drone use, in $U.S. billions, 2015–25")[6]:



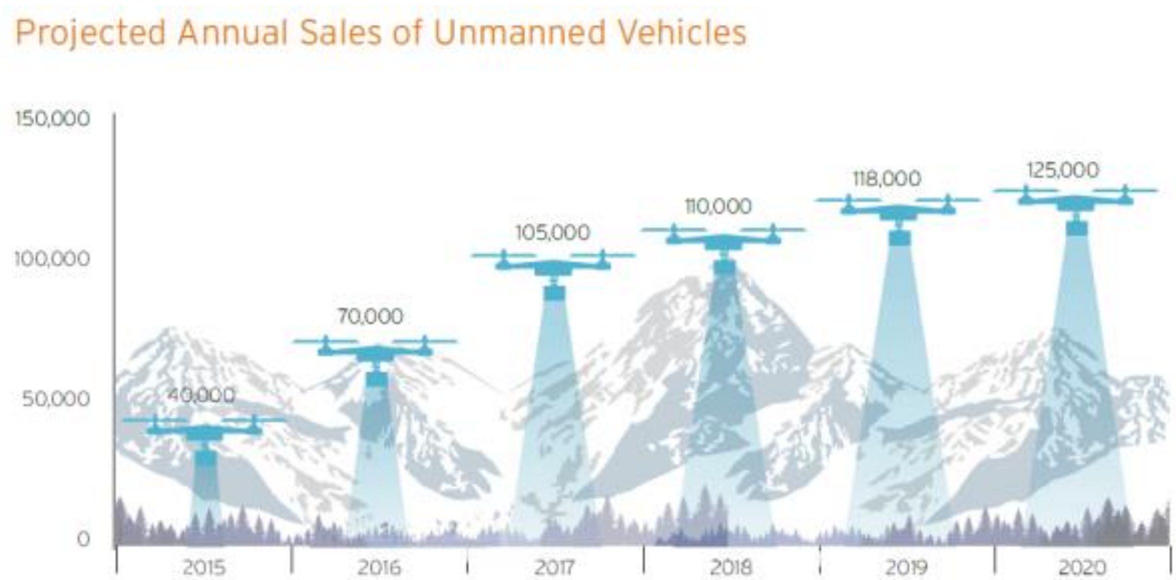
Some of the implications of the above with respect to the FAA's priorities in NAS infrastructure and regulation are potentially significant. Regardless of whether UAS are treated as a separate category or are clustered with "general aviation" operations (whose GDP contributions would grow by more than 50% at a stroke with such a bookkeeping change), unmanned aviation may require substantially more deference in the FAA's future infrastructure and regulatory calculus.

Projected Sales Growth of the Unmanned Sector

No treatment of this subject would be complete without at least a brief look at just how many unmanned aircraft are likely to be plying the skies in just a few years' time. The following graphic[7] was assembled from AUVSI data by *Cognizant*, a business and technology-oriented analytics firm:

[6] "Business Researcher." http://businessresearcher.sagepub.com/sbr-1775-98070-2712950/20160118/economic-impact-of-commercial-drones

[7] https://www.cognizant.com/InsightsWhitepapers/drones-the-insurance-industrys-next-game-changer-codex1019.pdf



In other words, by 2020, more than one-third of the aircraft registered in the United States could be unmanned.[8] In terms of sheer numbers alone, their presence and impact will expand substantially within the next few years. The question is, can the manned and unmanned sectors coexist under the current NAS architecture and priorities, or will change become inevitable?

Adapting to Disruption

Over the past two years, the growth of unmanned aircraft systems as part of the aviation user community has been nothing short of explosive. Demand for the economies, flexibility, and new uses of UAS has driven the sector's rapid growth. In turn, this growth requires airspace within which UAS can operate without increasing risk to current users of the NAS.

The FAA has traditionally seen the aviation industry – especially the major air carriers – as its "customers" and has sought to meet their needs over time. Today, unmanned aviation is impacting the long-standing relationship between "air commerce" and "air safety," while at the same time being guided by those same two principles. It represents a new and disruptive notion of air commerce itself.

The proponents of unmanned aviation are increasingly challenging the notion that their activities adversely affect existing stakeholders from a safety perspective, suggesting that their impact is minimal and acceptable if they are given due consideration in the allocation of airspace and resources to support the ongoing development of their industry.

As the expansion of the unmanned aviation sector has soared, permanent changes in the operating environment may be needed to accommodate it. This is forcing both the regulators of and the participants in the present-day aviation system to confront a landscape that is shifting beyond what were once considered established and immutable norms. Both will need to adapt to unmanned aircraft technology (including its operational limitations), the economic potential it carries with it,

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[8] https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_11.html

and the technology's impact on "air safety" itself. Indeed, all may need to consider changes in the operating environment in order to accommodate it.

Regulations for sUAS

As mentioned above, Part 107 has enabled small unmanned aircraft system (sUAS) operations to be carried out with minimal and acceptable increase in risk to other aircraft and the general public. It does this by limiting the maximum altitude of such operations to less than 400 feet above ground level (AGL) and the maximum speed of small unmanned aircraft to less than 88 knots. It also limits the operations themselves to day visual meteorological conditions, within the visual line of sight of the pilot in command, and in uncontrolled airspace.

At the same time, these operating rules do not allow commercial sUAS operators to do the kinds of things they want to do for business purposes. In effect, Part 107 is largely a codification of 35-year old guidelines for the operation of model aircraft contained in a 1980s-vintage advisory circular,[9] with added content specific to "remote pilot certification" and a few rules derived from Part 91.

Part 107 was necessary because small unmanned aircraft systems simply cannot comply with significant requirements contained in Part 91 applicable to "aircraft," regardless of them being manned or unmanned, large or small. Even at that, as published, Part 107 contains an opportunity for sUAS operators to obtain relief from virtually all of the operating restrictions contained in the rule through the Certificates of Waiver or Authorization (COA) process – which has become essential to realizing their vision of "commercial operations."

There are three principal reasons why the final rule reads as it does:

1 - External Stakeholders

About six years ago, Congress developed an interest in allowing unmanned aviation greater access to the NAS. By early 2012, this manifested itself in formal legislation embedded in Subtitle B of the *FAA Modernization and Reform Act of 2012* (P.L. 112-95, often referred to as "FMRA"), which contains a series of sections specific to unmanned aircraft systems. The language of these sections explicitly required fast action from the FAA on a variety of fronts, including rulemaking.[10]

2 - UAS Limitations versus Regulatory Objectives

The initial movement toward sUAS rulemaking came with the recommendations of the "Small Unmanned Aircraft System Aviation Rulemaking Committee" (sUASARC), which issued its recommendations in April of 2009.[11] While the sUASARC report devoted most of its content to matters of safety, the first sentence in its Foreword makes the purpose of their work clear: "The Small Unmanned Aircraft System (sUAS) Aviation Rulemaking Committee (ARC) was focused on making recommendations for Federal regulations for the operation of civil (commercial) sUAS."

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[9] AC 91-57, *Model Aircraft Operating Standards* (originally issued June 9, 1981; revised January 2016 as AC 91-57A).
[10] *See* FMRA Section 332 *et seq. at* https://www.faa.gov/uas/media/Sec_331_336_UAS.pdf
[11] https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/SUASARC-4102008.pdf.

Part 107's Subpart D ("Waivers), Section 107.200 ("Waiver policy and requirements") states, "The Administrator may issue a certificate of waiver authorizing a deviation from any regulation specified in §107.205 if the Administrator finds that a proposed small UAS operation can safely be conducted under the terms of that certificate of waiver." This includes provisions intended to reduce the likelihood of hazards associated with the most prominent and frequently referred to limitation of unmanned aircraft – the inability of a UAS pilot in command to see and avoid other aircraft and conform to right-of-way requirements – all of which can be eliminated with the stroke of a waiver pen.

3 - Constraints on Needed Regulation

The rulemaking team that developed Part 107 was also constrained by a different aspect of FMRA: a legislative ban on the FAA's ability to regulate an entire family of small unmanned aircraft systems, namely, *model aircraft*.[12]

Model aircraft are listed as a subset of the larger family of "small unmanned aircraft" in the legislation for good reason: a Part 107-operated sUAS is physically indistinguishable from one flown for "hobby and recreational purposes." It is remarkably easy to obtain and operate a small unmanned aircraft – buy it and fly it. The FAA has called for all small unmanned aircraft to be registered regardless of their planned use, but the mechanism for doing so walks a fine line that skirts the "no rule applicable to model aircraft" mandate in FMRA.

At the same time, on a daily basis, the FAA receives "sighting" reports of small unmanned aircraft operating in airspace where they are prohibited. They are almost always far above Part 107's 400-feet AGL ceiling, and frequently are too close to working airfields for comfort (or safety). To date, *none* of these operations have been traceable to a Part 107 operator who was granted permission to operate in the affected airspace.

The *Academy of Model Aeronautics* (AMA), which has sought to be recognized as one of the "community-based organizations" referred to in FMRA, is noticeably silent on the question of operating altitude in its "National Model Aircraft Safety Code."[13] The AMA's safety guidelines only require model aircraft pilots to "Not fly higher than approximately 400 feet above ground level within three (3) miles of an airport without notifying the airport operator."

Under FAA rules, a model aircraft flown in compliance with the parameters established by FMRA is largely free to operate at will, as long as it meets two conditions:

- The aircraft is operated in a manner that does not interfere with and gives way to any manned aircraft; and
- When flown within 5 miles of an airport, the operator of the aircraft provides the airport operator and the airport air traffic control tower (when an air traffic facility is located at the airport) with prior notice of the operation.[14]

[12] FMRA Section 336 - h*ttps://www.faa.gov/uas/media/Sec_331_336_UAS.pdf*

[13] http://www.modelaircraft.org/files/105.pdf.

[14] 14 CFR Part 101, Subpart E, "Special Rule for Model Aircraft."

The bottom line is that if it suits an individual's purpose to fly at an altitude higher than prescribed by Part 107, that individual can do so at will by asserting that the operation is for "hobby and recreation." In effect, the FAA has been obliged to treat aircraft with equal capabilities and presenting equal risk to the NAS if operated improperly as somehow being different based on the intent of the operator. One must consider the safety implications of this standard that potentially allows a path to non-compliance.

"See and Avoid" in the NAS

Beyond the extent to which it is addressed by Part 107 (or can be waived under that Part's authority), the "see and avoid" challenge remains unresolved. Most of the alternate means of compliance (AMOC) with 14 CFR §91.113 are likely to be impractical to implement on a long-term, widespread basis. Government/industry efforts to establish firm standards for "detect and avoid" (DAA) systems – both ground-based and airborne – continue to move forward. However, the former tend to be expensive and highly localized in their coverage, and the latter are likely to be impractical for small UAS (being complex, potentially heavy, power-hungry and expensive on a per unit basis).

Both Congress and the FAA have defined unmanned aircraft as "aircraft," meaning their pilots are just as responsible for following the "rules of the road" as their manned aircraft counterparts. Title 49 of the United States Code (49 U.S.C.), Section 40103 states, "The Administrator of the Federal Aviation Administration shall develop plans and policy for the use of the navigable airspace and assign by regulation or order the use of the airspace necessary to ensure the safety of aircraft and the efficient use of airspace."

As the numbers and uses of UAS continue to grow, keeping manned and unmanned aircraft safely separated is likely to become an ever-growing challenge. This fact, coupled with the steadily growing economic benefits resulting from unmanned aircraft applications in a host of different industries and applications, is likely to challenge the current paradigm of manned aviation taking absolute precedence over unmanned aviation throughout the NAS, even in nominally "visual" operations.

At the same time, the *manned* aircraft pilot's obligations under the "see and avoid" requirement are becoming increasingly difficult to carry out in the presence of unmanned aircraft operations thanks to the size and speeds of many of the newest and most popular drones. In many instances, such as is the case in trying to avoid "bird strikes," small unmanned aircraft cannot be seen until it is too late to take effective avoidance action. To date, a viable set of solutions to these challenges has not been found.[15]

This issue has given rise to conversations regarding two considerations related to it: ensuring that UAS pilots in command (PIC) actually participate in the see-and-avoid process, and keeping unmanned aircraft separated from each other.

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Automated vs. Autonomous Operations

Terminology often tends to be imprecise in discussing distinctions between *automated* versus *autonomous* UAS operations. The former is a natural outgrowth of technology; the latter represents a specific type of flight activity that raises significant questions of safety as the NAS is currently constituted.

Automation supports unmanned aviation in a variety of forms. Even the simplest multi-rotor small unmanned aircraft can be affordably equipped with rotor speed control and altitude monitoring that substantially reduces the workload previously associated with flying any kind of radio-controlled helicopter or fixed-wing aircraft.

On the other hand, the notion of *autonomous* UAS operations across the "size" spectrum of unmanned aircraft has always been suspect in regulatory circles. Conceptually, a purely "autonomous" aircraft is one that is launched, guides itself to a particular location, performs an assigned task (e.g., delivery, aerial photography, aerial application), and returns to its point of origin or a designated alternate location *without the possibility of human intervention in the operation*.

The qualifier at the end of that description is crucial. Years of research into "human in the loop" (HITL) and "human on the loop" (HOTL) UAS concepts has been conducted with the goal of minimizing workload, maximizing efficiency, and reducing the opportunity for human error to adversely affect a given operation. However, both HITL and HOTL provide for the possibility of human intervention into the conduct of a given UAS flight at any time. The key distinction is the fact that autonomous flights are self-executing, while others are not.

Other concepts that rely heavily on automation, such as "swarming" or other multi-aircraft operations managed by fewer pilots than aircraft involved in a given operation, are seen with a degree of wariness. However, these are not "autonomous" thanks to the supervision each aircraft receives and the possibility of immediately terminating any such operation where the safety of the surrounding airspace is in danger of being compromised. Given the inability of most unmanned aircraft to autonomously detect and avoid in-flight conflicts, a valid safety case for allowing autonomous operations may not exist at this writing.

Traffic Monitoring versus Traffic Management

One capability intended to supplement DAA-based AMOCs that has been gaining traction in research and development in recent years is collectively referred to as "unmanned traffic management" (UTM). As with many aspects of unmanned aviation, this is a useful concept possessing a name that resembles a manned aviation functionality, but which in reality is quite different.

Contrary to what one might expect, UTM is not about "managing" traffic as the term is generally used and understood by the air traffic community, and it does not in any way interact with the existing air traffic control system. For that reason, it might be more accurate to think of UTM as a "traffic monitoring" capability specific to unmanned aviation.

The National Aeronautics and Space Administration (NASA) describes its vision of UTM as follows:

> Currently, there is no established infrastructure to enable and safely manage the widespread use of low-altitude airspace and UAS operations, regardless of the type of UAS. A UAS traffic management (UTM) system for low-altitude airspace may be needed, perhaps leveraging concepts from the system of roads, lanes, stop signs, rules and lights that govern vehicles on the ground today, whether the vehicles are driven by humans or are automated…
>
> While incorporating lessons learned from today's well-established air traffic management system, the UTM system would enable safe and efficient low-altitude airspace operations by providing services such as airspace design, corridors, dynamic geofencing, severe weather and wind avoidance, congestion management, terrain avoidance, route planning and re-routing, separation management, sequencing and spacing, and contingency management.
>
> One of the attributes of the UTM system is that it would not require human operators to monitor every vehicle continuously. The system could provide human managers with the data to make strategic decisions related to initiation, continuation, and termination of airspace operations. This approach would ensure that only authenticated UAS could operate in the airspace.
>
> NASA envisions concepts for two types of possible UTM systems. The first type would be a Portable UTM system, which would move between geographical areas and support operations such as precision agriculture and disaster relief. The second type of system would be a Persistent UTM system, which would support low-altitude operations and provide continuous coverage for a geographical area.[16]

In the conceptual diagram provided on their UTM home page (see below), it is clear that NASA's vision of the "need" to which they are responding essentially anticipates a band of airspace below 500 feet above ground level that would be the exclusive domain of unmanned aircraft. This would greatly reduce the consequences of failing to see and avoid in time to prevent a collision; the only other aircraft that should be in the vicinity would be similarly unoccupied.

[16] https://utm.arc.nasa.gov/.

It is important to note that NASA's concept – while occasionally referring to "integration" elsewhere in program-related technical documents –is clearly directed toward airspace use that would be at its core *segregated* and totally devoted to supporting low-altitude UAS activity, in actual operation. While not congruent with the goals established by the FAA in its 2012 *Integration of Unmanned Aircraft Systems into the National Airspace System: Concept of Operations*,[17] UTM offers a realistic vision for traffic de-confliction that acknowledges the inherent risk in mixing manned and unmanned aircraft in the same volume of airspace, while simultaneously presenting a model for how to manage growth in the sector safely.

Sustainability of the Operational Approval Process

The sUAS regulatory construct described above, in combination with UAS limitations related to their see-and-avoid obligations, places a large administrative burden on both would-be commercial sUAS operators *and* the FAA, especially the Air Traffic Organization (ATO). While both the Unmanned Aircraft Systems Integration Office and ATO are required to review each waiver application, in practice, the burden is on the ATO and individual air traffic control facilities to approve each non-standard use of controlled airspace on a case-by-case basis.

Another equally important consequence of this new process is that it continues the pattern of requiring the FAA to make risk decisions regarding currently regulated activities involving non-conforming aircraft or operations. If observed in all particulars, Part 107 allows sUAS activity to take place in a manner and environment that minimizes risk to other users. As soon as any relief is granted from any part of that construct, risk in the NAS increases so as to require a separate, specific risk assessment of the non-conforming aspects of the proposed operation. COA applications are not assessed under the aegis of the FAA's "safety risk management" process, but for all practical purposes, every approval requires such an assessment.

[17] https://www.suasnews.com/wp-content/uploads/2012/10/FAA-UAS-Conops-Version-2-0-1.pdf.

If the unmanned aviation sector is to grow, the challenges their operations present from a purely regulatory perspective – especially in the context of their known limitations – must be approached differently. This may require flexibility in the application and enforcement of other long-standing regulatory components of the NAS.

However, it also requires the FAA to be permitted to let the pendulum swing back toward a neutral position between “promoting air commerce” and “promoting air safety” in future rulemaking. Lessons learned over time through accidents have shaped the current structure and operational framework for flying in the National Airspace System. These should not be erased simply because of the differences and limitations of unmanned aircraft. A middle ground needs to be sought.

Potential Registration and Equipage Rule Changes

As a first step (and a necessary prelude to rulemaking), FMRA will need to be revised to remove its prohibitions on rulemaking associated with model aircraft operations. The operation of small unmanned aircraft outside the existing regulatory structure is adding risk to the NAS itself. The model aviation community cannot police itself. So, hobbyists need to be required to accept greater responsibility for the safety of the finite resource that is the national airspace by becoming subject to more prescriptive, enforceable regulations.

Once legally permissible, the current requirement for universal *registration* of UAS[18] should go hand in hand with a requirement for universal *regulation* of UAS (exempting the proposed ‘micro-UAS’ class of extremely small unmanned aircraft). To some extent, this requirement is already in place. However, it needs to be modified and strengthened for two reasons:

1. Current provisions for identifying the registration number of an unmanned aircraft involved in a major accident (e.g., colliding with a manned aircraft) are unlikely to survive impact forces or post-crash fires. Solid, potentially survivable components, such as electric motors, battery packs or engine blocks, should be required to bear engraved, permanent registration information if there is to be any reasonable chance of tracing them back to their operator.
2. As with manned aircraft, registration information should be applied to the assignment of discrete Automatic Dependent Surveillance – Broadcast (ADS-B) identifiers to support universal equipage of all aircraft – manned and unmanned alike – with at least ADS-B Out. This would support surveillance in terminal airspace where low-flying small unmanned aircraft at low altitude may be in close proximity to arriving and departing aircraft at busy airports and bring the unmanned sector into closer compliance with “squawk and talk” requirements established in Part 91 for Class B and C airspace.

Despite protests to the contrary, additional safety-oriented regulation will in no way harm model aviation as a hobby, except to add some cost where model activity is to be conducted in close proximity to working airfields. Responsible modelers will be able to continue to operate much as they have over time, while *irresponsible* modelers could be subjected to civil or even criminal enforcement action as needed. The artificial distinction between commercial and “hobby” operations has proven meaningless in practice, and the steady growth of sUAS activity for all purposes mandates better regulation of it.

[18] https://www.faa.gov/licenses_certificates/aircraft_certification/aircraft_registry/UA/

Potential NAS Management Strategies

Once the FAA is free to act in ways that give equal consideration to all parties desiring or affected by the use of airspace by unmanned aircraft of all sizes and capabilities, it is likely that action in three separate domains will be required to safely accommodate (*not* "integrate") UAS in the NAS in the years ahead. In decreasing order of feasibility and increasing order of cost, they are:

1. Restructuring how airspace is used and by whom;
2. Re-thinking of the rules governing all aircraft operations in the NAS in consideration of UAS limitations; and
3. Investing in NAS infrastructure specific to the needs of UAS, but that results in a safer operational environment for all NAS stakeholders.

Re-imagining Airspace

The NAS has never been fixed in form and scope. It puts aircraft where they need to be to keep them safe and efficient, consistent with the needs of other NAS users. Now, unmanned aircraft challenge how the NAS itself currently is constituted in terms of airspace classification and apportionment.

Over time, countless changes to how the NAS is managed, controlled and protected have emerged based on the needs of both safety and commerce. For example, airspace needed for safe instrument approaches has come to be protected, charted and closely monitored for obstructions, and maximum airspeed and minimum vectoring altitude parameters have been established to support safe arrival, departure and close-in terminal operations.

The FAA cannot "create" airspace, despite frequent requests for them to do exactly that. "Corridors" and "tunnels" through controlled airspace have all been suggested to meet the needs of narrowly defined operating locations or to serve individual users. Beyond some of their underlying assumptions about airspace being flawed, such case-by-case proposals would be impractical to implement at a national level.

For that reason, some have suggested in effect "flipping the script": giving priority or even exclusivity to UAS in lower altitude bands and requiring other visual flight rules (VFR) operations to fly above them. Of course, there are several potential consequences of such a philosophical shift that could serve as lightning rods for resistance to such a notion, including:

- Adverse impact on manned aviation operations traditionally (or necessarily) conducted at low altitude, e.g., helicopter emergency medical service, public safety aircraft, aerial application operations, and electronic news-gathering.
- Reduced separation between VFR and instrument flight rules (IFR) operations where the former would wind up higher and closer to IFR Minimum Enroute Altitudes or Minimum Safe Altitudes.
- Increased likelihood that manned aircraft attempting to remain in visual meteorological conditions would wind up inadvertently entering instrument meteorological conditions.
- Reduced efficiency and increased cost for short-haul general aviation operations due to required climb above the altitudes typically used by such activities.

In effect, UAS are square pegs in round holes. They have operational needs and limitations worthy of consideration in the apportionment of space in which to operate, to the extent that such is possible without adversely affecting other stakeholders. Since they began flying in the NAS in significant numbers, managing UAS individually has consisted of rounding off the corners of the pegs. Perhaps it is time to begin making some of the "holes" permanently big enough to accommodate them, regardless of the UAS pegs' shape.

Reconsideration of Rules and Procedures

This second strategy relates to the first. Currently, the only process by which unmanned aircraft (other than sUAS) can gain access to the NAS is by exception. If a given operation requires relief from Part 107 provisions, or if Part 107 itself cannot be applied due to the maximum takeoff weight (MTOW) of the unmanned aircraft, all of the various non-conformities of a given UAS to existing Part 91 rules must be taken into account in granting a COA for specific operations.

There is growing acceptance of the proposition that some types of unmanned aircraft, or operations conducted by them, are poorly suited to full-up participation in the NAS. This is why sUAS operations are not considered either "VFR" or "IFR." Along these lines, existing requirements for transponders, two-way radio communications and the like may be impractical for a variety of reasons, or they may simply be unnecessary. But, they must be consciously addressed.

This suggests a need to rethink where UAS operations most commonly are conducted, as well as the Part 91 equipage requirements for access to certain classes of controlled airspace, from a regulatory perspective. Perhaps it would be appropriate and safe to excuse UAS from compliance with certain requirements in certain airspace; in those cases, they should be granted permanent regulatory relief from those requirements. On the other hand, it may be that, upon reflection, the growing amount of unmanned aircraft activity may not be tenable under some operational conditions unless they – as "aircraft" – are required to comply with existing rules.

Had Part 107 said, in effect, "all Part 91 rules apply to small unmanned aircraft, except as follows," the path to follow-on rulemaking for other classes of unmanned aircraft most likely would be much clearer. However, as is the case with other aspects of trying to make UAS operations in the NAS more routine, initial rulemaking and proposed follow-on rules are being accomplished on a patchwork basis in response to whichever part of the unmanned aviation sector currently is exerting the most political influence based on its real or potential contributions to the economy.

Whether addressing small UAS, large UAS or something in between, future rulemaking should keep four fundamental tenets of unmanned aviation as it relates to manned aviation firmly in mind:

1. **See and Avoid.** Any unmanned aircraft operation conducted beyond the visual line of sight of the pilot in command and/or visual or "electronic" observers (e.g., using UTM or some form of DAA) places all of the see-and-avoid burden on any manned pilots who might encounter it. Kinetic force and impact modeling, traffic density studies and the like are fine in the abstract, but they must lead to complete understanding and clear rules quantifying the risks that unmanned aircraft pose to manned aircraft, where one pilot can become a casualty as a result of another's actions. "See and avoid" is an established aspect of how

the NAS works, and unmanned aircraft systems must not be excused from conforming to it in some manner.

2. **Standardization.** There is no standardization among system types with respect to attributes of prime importance to those responsible for controlling or managing airspace (control link reliability, link failure response, on-board equipage for NAS operations, provisions for two-way radio communications, etc.). Without broadly applicable UAS certification and airworthiness standards aimed at reducing variable performance and unpredictable behavior, purely regulatory or procedure-based mitigations for their common limitations cannot succeed.

3. **Existing rules and procedures**. These should be applied to *all* aircraft uniformly unless the risk to human life can be minimized *and* the economic advantage is sufficient to justify their modification. However, by their very nature, unmanned aircraft are incapable of conforming to some rules. In such cases, requirements for alternate means of compliance must be explicitly and uniformly provided or, alternately, explicitly ruled out on a NAS-wide basis. Although virtually every Class B, C and D facility and airspace differs in some respects from all others of the same class, they are similar enough that general rules pertaining to all are possible. The same is true of unmanned aircraft systems; whether highly sophisticated or extremely simple, their commonalities are an adequate base upon which to design rules that can be broadly applied.

4. **Waivers.** Any time new rules or changes to existing rules are under discussion, the responsible parties should bear in mind the need to be as inclusive as possible for all modes of aviation, manned and unmanned alike. The ability to waive portions of a rule is important, but too much reliance upon that mechanism suggests a rule does not work as it should. In the unmanned aviation domain, some things shouldn't be waived under any circumstances and some should require uniform AMOCs if waived. Waivers that depart too far from Part 91 or 107 baselines should require approval at higher levels of the FAA than currently required due to the need for greater risk to be accepted on behalf of other NAS users.

NAS Infrastructure

There are various ways that infrastructure can be leveraged – or created outright – that enables UAS operations by greatly extending their range or by making the operations themselves safer for surrounding aircraft. These could include new or expanded means of supporting unmanned and manned pilots' situational awareness regarding their respective activities, regardless of whether they are in controlled or uncontrolled airspace. Four current or emerging technologies should be brought to bear on these needs.

1. **Air Traffic Control (ATC)-Pilot Communications:** The NAS Voice System (NVS) program could be leveraged to convey UAS pilots' ATC communications from certified, secured ground control stations directly into controllers' headsets via dedicated terrestrial use of the same Voice Over Internet Protocol (VOIP) approach already planned for NVS. This would eliminate the need for UAS operators to devote precious control link bandwidth

to support communications, and would preclude the loss of ATC communications in the event of control link failure by providing them a separate, dedicated path.

2. **UTM:** The UTM concept continues to evolve. It deserves funding with which to do so. However, the current concept is too narrowly drawn to benefit the NAS as a whole. UTM needs to build upon its current architecture by adding in interfaces with both NVS and the rest of the national command and control (C2) infrastructure so it truly supports *management* of unmanned aircraft as a component of overall NAS operations. UTM needs to provide unmanned pilots with situational awareness of surrounding manned operations, and vice versa. Ideally, UTM should become a full-up component of the Next Generation Air Transportation System (NextGen), and would expand on the current practice of using civil and military digital air surveillance radar systems to provide a standard system for ground-based detect and avoid capability for UAS too small to accommodate on-board DAA systems.

3. **ADS-B:** ATC and manned aircraft need to be aware of the presence of unmanned aircraft, especially in congested airspace. Although both sUAS manufacturers and operators resist the notion that the current Part 91 requirements for ADS-B Out by 2020 should apply to them, if small unmanned aircraft cannot be reliably contained to the "below 400 feet" stratum their presence must be known to all other aircraft in their vicinity. There would be a sizeable bill to pay for adding such a capability to unmanned aircraft, and a means for allocating aircraft identifiers to the requisite number of ADS-B sets may not yet exist, but the emergence of ADS-B as the NextGen surveillance system of choice means UAS *must* participate, or they will be effectively invisible to other users and controlling agencies alike.

4. **Command and Control (C2) Network**: Despite the ever-growing collection of business cases for unmanned aviation, it is possible to categorize them as working within one of four types of operational areas, defined in terms of where their ground control station or stations are located and the "reach" of their supporting C2 architecture:
    - Close-in/within visual line of sight (VLOS) only.
    - Defined area beyond visual line of sight (BVLOS).
    - Regional (a larger, defined BVLOS area requiring satellite or terrestrial support to maintain control link continuity).
    - Point-to-point/long-distance (same as above, but requiring sequential changes in the source of C2 connectivity as the flight progresses).

    None of the above are explicitly bound to a given altitude domain, and none can be restricted to a single class of airspace. As such, a class-based "airspace" solution supporting any of them is not feasible. At the same time, the bulk of unmanned aircraft operations (except those that are purely VLOS) require both VLOS and BVLOS C2 capabilities with which to operate.

    RTCA is already suggesting that the FAA needs to get into the "frequency allocation" business to allow UAS to operate in the various regimes listed above; the next logical step would be for a conscious decision to be made for the FAA to build a national backbone for

UAS C2 management itself. This would be analogous to the system of ground stations required for national ADS-B deployment, or to the legacy network of surface-based navigational aids.

In short, unmanned aviation entails new risks to manned aviation that the current air traffic control system cannot mitigate or manage without enlisting new technologies to the task. As a permanent part of the operational landscape, it will require permanent investment and permanent solutions.

Conclusion

UAS operations are unlike manned operations in a number of respects. Most notably, they offer a far less expensive means of obtaining a desirable aerial perspective. Manufacturers and operators have little interest in seeing the cost of UAS operations driven up by other users, but they must bear some responsibility for keeping the existing system safe.

Given the challenge that UAS presents to the current regulatory environment, it may be wise to consider the words of futurist Alvin Toffler from almost a half-century ago, in his seminal work *Future Shock*:

> With such large sums at stake, one would think that governments would plan their technological development carefully, relating it to broad social goals, and insisting on strict accountability. Nothing could be more mistaken.
>
> "No one – not even the most brilliant scientist alive today – really knows where science is taking us," says Ralph Lapp, himself a scientist-turned-writer. "We are aboard a train which is gathering speed, racing down a track on which there are an unknown number of switches leading to unknown destinations… Most of society is in the caboose looking backward."[19]

"Future shock is a time phenomenon, a product of the greatly accelerated rate of change in society. It arises from the superimposition of a new culture on an old one."[20]

The disruptive power of unmanned aviation has yet to be fully realized or managed. However, it is becoming evident that the unmanned aviation sector must receive a reasonable amount of priority in future airspace and air traffic management planning and programming, in the name of both air commerce *and* air safety. The challenge now is to acknowledge the trends and take concrete action in response to them, sooner rather than later.

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[19] Alvin Toffler, *Future Shock* (New York: Bantam Books, 1970), p. 431.
[20] *Ibid*, p. 11.