Airspace Access Priorities Aviation Rulemaking Committee (ARC)

ARC Recommendations Final Report

August 21, 2019

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1. EXECUTIVE SUMMARY

The U.S. navigable airspace is part of the Nation's critical infrastructure and is a limited national resource that Congress has charged the Federal Aviation Administration (FAA) to administer in the interest of the public to ensure safety and its efficient use. With ever increasing traffic and forecasted demand from both existing and new operators, National Airspace System (NAS) users have become progressively sensitive to inefficiencies. This is underscored by the rapid evolution of commercial space transportation and new entrants, for which airspace segregation stresses current NAS management practices and systems. The FAA recognized the need to develop an improved framework to facilitate equitable access while better balancing the respective needs of the wide variety of airspace users. During the course of deliberations, a number of other rulemaking activities took place that will further inform integration of NAS operations.

The Airspace Access Priorities (AAP) Aviation Rulemaking Committee (ARC) was chartered to provide recommendations for criteria that may be used to ensure equity in considering competing airspace access requests and accommodating operations on a diverse group of operators with widely varying flight systems. These currently include Government, commercial, business, and general aviation; space transportation, airports and spaceports, unmanned aircraft system (UAS) operations, and balloon operations. The AAP ARC was also tasked to provide input on improved capabilities to manage the airspace, including tools, operational practices, and where necessary, policies, to minimize potential airspace conflicts. This supports FAA consideration of the respective constraints across the community of stakeholders to meet their respective needs.

The ARC agreed that prioritization was not the most effective way to manage competing needs for NAS access, but that optimization is preferred. While full integration of all NAS users is the goal, it may not be achievable in the near term. The ARC envisions prioritization to be primarily reserved for tactical issues in daily NAS operations for all stakeholders.

The ARC recommendations summarized in Table 1 below are intended to enhance communication, data sharing, and collaboration between the FAA disciplines and among the NAS operators, and allow for more efficient optimization and utilization of the NAS through enhanced tools and capabilities. Recommendations are intended to improve the integration of operations into the NAS in the near-term, with the insights gained to inform future integration of new entrants. The recommended changes would enable a future NAS state where air traffic management shifts from segregation to integration, utilizing much smaller protected airspace while implementing the capability to dynamically close airspace and protect from hazardous events.

Table 1: Summary of ARC Recommendations

Recommendations	Implementation Details
Rulemaking and Process Considerations	
Accelerate efforts to allow more efficient use of airspace needed for spaceflight operations Mandated equipage should be established through regulatory or rulemaking process only Convene follow-on ARC to further advise on measures to achieve full integration of the NAS	
Committee Establishment	
Within 30 days of submission of the AAP ARC Final Report, establish a Steering Committee to advise the FAA on policy and strategy regarding airspace access and integration	The Steering Committee should: • Take the form of collaborative decision-making forum • Develop Terms and Guidelines for Participation in the collaborative process • Review and provide ongoing feedback to FAA on the implementation of ARC-recommended NAS improvements • Make recommendations on planning information/data for sharing with FAA and other stakeholders • Develop data standard that establishes recommended elements and formats for the automated exchange of operational data for input to the collaborative process • Reevaluate Aircraft Hazard Area calculation assumptions
Within 60 days of submission of AAP ARC Final Report, establish a space operations committee to recommend appropriate information to be exchanged with the FAA for more dynamic airspace management and situational awareness	The Space Committee should focus on: • Further defining the data sets and metrics moving forward to assess applicability of new entrants • Methods of achieving near-term improvements on airspace operations through the use of improved information exchange
NAS Automation Changes	
Implement the ability to create dynamic airspace areas on controller automation systems that can identify potential conflicts between airborne flight trajectories	Dynamic Airspace Areas: • Initial input may come through web interface • Capability to share annotations from one radar position to another within the air traffic control (ATC) facility should not be dependent on ingestion source inputs being fully deployed • Enable automated dynamic display and sharing of nominal and off-nominal hazard areas on air traffic controller and traffic manager displays • Hazard areas created or modified should be pushed to air traffic controller displays and updated in real time as appropriate
Implement decision support tools in the automation systems for air traffic controllers and managers	Decision support tools should include mission status timers, airspace activation and deactivation, indicators and conflict probe alerts to identify affected aircraft

Recommendations	Implementation Details
Procedures and Training should be developed to enable future automation capabilities	Procedures and Training should include: • Procedures for air traffic controllers and traffic managers to use when managing nominal hazard areas that allow maximum use of the affected airspace before or after spaceflight operations • Procedures for air traffic controllers to clear airspace when necessary in case of off-nominal debris-generating event • Training for air traffic controllers and traffic managers to ensure proficiency in the application of the applicable tools and procedures
Tools and Capabilities	
Implement a Hazard Risk Assessment and Management (HRAM)-like capability available to ATC to allow for dynamic airspace management	HRAM-like capabilities should: • Calculate nominal pre-mission SAAs and make results available • Establish online portal • Utilize improved operator information to activate and deactivate special activity airspace (SAA) • Enable HRAM to receive and process real-time tracking data from vehicles • Deploy the HRAM capability for real-time debris mitigation • Leverage the real-time debris response capability
Implement and enable an Space Data Integrator (SDI)-like capability that allows the industry to share telemetry data with ATC systems and should be deployed to process telemetry to be supplied to HRAM and other automation platforms as necessary	This SDI-like capability would: • Be required for real-time off nominal response capability • Provides situational awareness to ATC
Data and Information Sharing	
Implement a NAS operational airspace utilization assessment for planning and post-analysis capability and make it available to operators online	This utilization assessment should: • Utilize nominal aircraft hazard areas (AHA)/SAAs and provide operators with NAS assessments • Be developed and tested with input from various NAS users and stakeholders
Implement a Collaborative Decision Making (CDM)-like process for providing advanced notification time prior to an event requiring SAA	Advanced Notification should: • Be given 72 hours prior to SAA activation • FAA policy of 4 hour notification for smaller impact areas
Ensure sharing of real-time spaceflight status, including readiness forecasts prior to flight, with other NAS users	Process timeline for sharing: • Interim: utilize hotline • Mid-term: Automation • Far-term: Full integration
Implement procedure updates for tactical information exchange between space operators and the FAA regarding on-time operations to enable more dynamic airspace activation/deactivation	Updates for on-time operations should: • Within 6 months of procedural development, be validated by running demonstration • Include training at air traffic facilities to avoid rerouting aircraft too early, ensure prompt recovery when SAAs are deactivated

2. BACKGROUND

The ARC roster included a wide range of participants across the National Airspace System (NAS) user community—commercial, business, and general aviation; space operations, airports and spaceports, unmanned aircraft system (UAS) operations, and balloon operations. A full list of ARC members and observers is included in Appendix A. While these diverse interests were represented in the plenary sessions (the dates of which are also listed in Appendix A), the UAS community was under-represented in the three task groups that were formed to address specific issues in support of the ARC. Nevertheless, the task groups did consider that sector throughout discussions and called upon UAS representatives when needed. The three task group focus areas and taskings are described in Section 2.3.

2.1. OBJECTIVES (Scope)

The FAA tasked the AAP ARC to:

1. Review historical and projected growth in operations for the respective stakeholders, along with the methods currently used by the FAA to accommodate requested operations in the NAS.

2. Review the respective operational needs and constraints across the community of stakeholders for access to the NAS to meet their respective objectives. This review should include any representative quantified or characteristic indicators (i.e., "metrics") that are used in the community to measure needs, constraints, and impacts.

3. Provide specific consensus recommendations and their supporting rationale, including any potentially applicable metrics that will assist the FAA in developing policy to make airspace prioritization decisions when needed between various operations that are requested.

4. Prior to the ARC sunsetting, submit a recommendation report.

The stated objectives of the AAP ARC were to "assist the FAA in developing criteria that may be used to consider competing requests for airspace access. In addition, the examination, development and recommendation of methods (quantifiable and non-quantifiable) that can be used to accommodate different operations and support operational decisions regarding the prioritization of airspace access will further these goals." A copy of the ARC's charter is included as Appendix B.

2.2. ASSUMPTIONS

The ARC deliberations yielded the following assumptions as the ARC evolved and developed recommendations:

- The scope of this ARC's efforts considers all NAS users: commercial aviation, general aviation (GA), business aviation, helicopters, space operations, U.S. Government operations, UAS, balloons, gliders, etc.
- The ability to safely conduct operations within the NAS remains the priority.
- The NAS is a limited national resource to which all users should have fair and equitable access.
- All NAS users are important to public interest and their growth should be supported.
- International operations outside the U.S. Flight Information Region are outside the ARC's scope.
- The Department of Defense (DoD) normally operates like other NAS operators when outside special use airspace (SUA).

2.3. ARC TASK GROUPS

In addition to the plenary meetings of the full AAP ARC, three task groups were formed and met separately to address the specific issues they were tasked to consider. Table 2 below includes a summary of each task group's focus area and tasking. The findings and conclusions of the individual task groups were presented to and considered by the full ARC and form the basis of the ARC's recommendations. Task Groups 1 and 2 generated individual reports, copies of which are included in Appendix D and Appendix F, respectively.

Table 2: Key Task Groups Commissioned by the ARC

Task Group	Focus Area	Tasking
1	Airspace Optimization	Evaluate ongoing work and future technologies in each domain that contributes to NAS optimization. Construct a description of the NAS that incorporates these improved processes, procedures and technologies including how airspace design and air traffic management will be affected.
2	Operator Constraints and Limitations	Evaluate constraints, challenges and limitations faced by operators in the Balloon, Commercial Space, UAS, and traditional manned aviation sectors. Provide a clear description of constraints, challenges, and limitations faced by each industry sector that impede seamless integration of all operations in the NAS.
3	Criteria	Build on the work of the Airspace Optimization Task Group and the Operator Constraints and Limitations Task Group to provide a final ARC report that includes: • Recommendations to improve traffic flow management and reduce or eliminate restrictions for all NAS operators, including a collaborative process wherein all NAS operators participate. • Criteria to be considered by the FAA Air Traffic Organization when considering implementation of a policy or policies that ensure safe, efficient, and equitable procedures for balancing capacity and demand among all operators in the NAS. • Applicable metrics and associated thresholds to be established related to NAS access priority decisions.

2.4. CURRENT STATE OF THE NATIONAL AIRSPACE SYSTEM

The NAS is the busiest and most complex airspace in the world. In a given year, approximately 15.5 million flights operate in the NAS. In 2018, 36 space launches and 3 reentries transited the NAS. The NAS is a system of systems consisting of: air navigation facilities, equipment and services, airports or landing areas, aeronautical charts, information and services, rules, regulations and procedures; technical information and manpower; and material. The network also includes system components that the Government shares with operators. (See Table 3).

Table 3: NAS Overview

Note: The numbers referenced in Table 2 were accurate as of time of report finalization

Infrastructure	Approximate Number
Airports	19,624
Aircraft (Large, regional, and General Aviation)	216,082
Unmanned Aircraft	1,314,768
En route Control Centers (ARTCC)	21
Center Radar Approach Controls (CERAP)	4
Terminal Radar Approach Facilities	160
Ground Based Navigational Aids	2,856
Oceanic Control Centers	3
FAA Air Traffic Controllers	14,695
Other FAA Employees	30,530
Pilots	594,366
Remote Pilots	121,126
US (fixed) Launch/Reentry Sites	14
Annual Space Launches/reentries	39
Military Flights in the NAS	2,000,000+

The Air Traffic Control (ATC) system, which is a principal component of the NAS, comprises a vast network of surveillance; automated data processing, navigation, and communication equipment; and air traffic control facilities. More than 14,000 air traffic controllers control aircraft in the system and provide critical data throughout every stage of operation. They work in the 160 terminal radar control facilities, the 21 air route traffic control centers that manage aircraft in the en route environment, and the 3 oceanic control centers. The Air Traffic Control System Command Center (ATCSCC) in Warrenton, Virginia, monitors and manages the flow of air traffic throughout the NAS, producing a safe, orderly, and expeditious flow of traffic while minimizing delays. The NAS also includes thousands of navigational aids throughout the United States that provide critical location information to pilots at all stages of their operations.

The nation's 19,624 airports are key components of the NAS, as they serve as gateways to air travel. Because the NAS functions as an interdependent network, delays at these airports can quickly create a "ripple" effect of delays impacting other airports across the country. For example, flights scheduled to take off from these airports may be delayed due to weather or limited airspace.

Similarly, an aircraft late in leaving the airport where delays are occurring may be late in arriving at its destination, thus delaying the departure time for that aircraft's next flight.

The current NAS continues to reflect its origins as a system where aircraft flew directly between ground-based navigational aids along FAA-defined routes. The existing airspace structure and boundary restrictions strongly reflect the constraints that communication and computer systems imposed as the NAS developed over the past 80 years. The advanced information technology available today, such as satellite navigation systems onboard aircraft, digital communications, and computer decision-support systems, enable the potential for increasing airspace capacity, improving aviation safety, and providing efficiencies to aircraft operators and service providers. The FAA is working to harness this new technology by transitioning the NAS from a ground-based system to a system that uses ground-based, satellite-based, and airborne systems. Making this transition requires that procedures, roles, responsibilities, equipment, and automation functions evolve into a structure that gives users greater flexibility in planning and conducting flights.

Depending on the intended use and type of aircraft, the FAA provides rules for operation, licenses, permits, waivers, or for common carriage transportation, the FAA certifies the aircraft and its maintenance. The FAA also regulates the NAS's practices, and licenses personnel, such as commercial pilots. The FAA further ensures public safety by licensing all commercial space launch and reentry activities, and licensing commercial space launch and reentry site operations.

Additionally, the FAA instituted Collaborative Decision Making (CDM), which is a joint government/industry initiative aimed at improving air traffic flow management (TFM) through increased information exchange among aviation community stakeholders. CDM is comprised of representatives from government, general aviation, airlines, private industry and academia who work together to create technological and procedural solutions to the TFM challenges faced by the NAS.

CDM is an operating paradigm where TFM decisions are based on a shared, common view of the NAS and an awareness of the consequences these decisions may have on the system and its stakeholders. There are two central tenants to CDM: that better information will lead to better decision-making, and tools and procedures need to be in place to enable air navigation service providers and the flight operators to more easily respond to changing conditions. By sharing information, values, and preferences, stakeholders learn from each other and build a common pool of knowledge, resulting in decisions and actions that are most valuable to the system. CDM plays an integral part in Air Traffic Management and is instrumental for global harmonization.

The NAS is a shared public resource operated by highly skilled professionals from the U.S. Government and industry. As the NAS has evolved, the systems and tools used to manage it have not kept pace with growth in the aviation or space industries. The growing demand for airspace access necessitates updated systems and tools to enable efficiencies for operations in the NAS.

Prior to our country’s successes over the last decade in capturing a majority share of the commercial space launch market, the majority of space launches in the United States were undertaken in support of the U.S. Government. The emergence of commercial launch and reentry activities has highlighted the need to more efficiently integrate space activities into the NAS. Coordinated efforts between the U.S. Government and industry are underway (e.g., this ARC) to find solutions that improve the integration and efficiency of the NAS while promoting safety.

Space vehicles are complex machines that rely on highly volatile propellants, move at very high speeds, and are exposed to extremely high dynamic forces during launch and reentry. In addition, a large percentage of space vehicles have either been recently developed or are still in development and testing. Space vehicles are not required to meet the same reliability requirements as aircraft.

Both vertically- and horizontally-launched space vehicles, as well as reentry vehicles, require segregated airspace for their transit. Airspace closures are also associated with landing/return of launch vehicle components, reflecting the time and space required for the launch or reentry vehicle components to transition through controlled airspace back to the Earth’s surface. In some cases, components fall back to Earth without active flight control; in others, reusable components may return under power to the landing site. In either case, vehicle controllability is limited, and it is generally not possible for these components to avoid collisions with other airborne vehicles or objects.

Historically, launch airspace closures have been fixed for the duration of launch activities. The closures start at a pre-determined time prior to launch and conclude after the spacecraft leaves controlled airspace and transitions to suborbital or orbital phases of flight.

When a space launch or reentry occurs, NAS inefficiencies are amplified by the heritage approach used to protect air traffic from spaceflight. Specifically, the FAA segregates the airspace around a launch or reentry trajectory. While segregation is effective for maintaining safety, it’s extremely inefficient for NAS utilization, particularly without timely dissemination of real-time activity. Simply stated, too much airspace is closed for too long, and real-time information about launch and reentry is not available to air traffic controllers and NAS users.

3 DISCUSSION

3.1. PRIORITIZATION VS. OPTIMIZATION

Use of the word "prioritization" in the name of the ARC reflects the current state with respect to airspace management among NAS users, particularly between aviation and spaceflight operations. For example, the traditional closure of large volumes of airspace around planned space launches or reentries can necessitate rerouting of some air traffic. Conversely, periods of high commercial aviation demand (e.g., holidays) can constrain planning for some commercial space operations. Prioritization assumes a choice must be made between operations; however, recommended process and system enhancements will enable improved access of multiple NAS user sectors and an associated evolution from airspace segregation to optimization and dynamic management.

As such, the ARC consensus was that airspace optimization should be the primary objective of airspace management regarding aviation and space transportation going forward. Prioritization would continue to be a routine element of tactical airspace management, just as weather and emergencies are today.

The ARC determined the use of prioritization could be minimized with the goal of a fully integrated NAS. After a review of existing prioritization schemes in use in the NAS, including those used by ATC (e.g., operational priority: first come, first served), the DoD (e.g., SUA scheduling), airspace hierarchy (e.g., Class B airspace applies when overlapping Class E airspace), and right-of-way rules for aircraft, the ARC decided it would not be valuable or effective to create a new prioritization schema. Therefore, the ARC focused on the strategic goal of optimization due to the efficiency and operational gains that could be achieved.

All Users Participate in Optimization

To achieve optimization, the FAA needs a systematic and integrated approach to manage multiple concurrent needs for NAS use. An integrated approach is important to ensure events and user requests for airspace access across the NAS are evaluated appropriately and, if necessary, deconflicted. A systematic approach also ensures all NAS users are considered in airspace management decisions based on operational capabilities, system efficiency and public interest.

Information the FAA needs to accommodate multiple NAS users includes:

- The duration of overlapping needs to use the NAS
- The specific airspace access being requested by each NAS user
- Communication, navigation, and surveillance capabilities required for the operation
- Whether the flight, mission or operation changes dynamically or is inflexible
- Vehicle maneuverability and flight characteristics, including responsiveness to real time change requests.
- Vehicle reliability

Based on the information provided, an optimized accommodation scheme and airspace conflict mitigations can be identified to reduce or negate inefficiencies in the NAS.

Airspace Use Considerations

With the goal of full NAS user integration, there will be instances in which optimization is not possible; managing the NAS while accommodating concurrent airspace needs from multiple users may require the FAA to consider a range of factors including:

- National security or defense operations
- Disaster response / medical emergency
- Government operations/ National need (missions performed by or for the government)
- Frequency of opportunity (e.g. launch window is once every 15 days)
- Predicted air traffic volume and downstream effects
- Impact of delay to mission success (e.g., miss launch window for interplanetary mission, schedule integrity for airlines, etc.)
- Accumulated delay for a specific user
- Input from affected facilities and Air Traffic Control System Command Center
- First come, first served

3.2. NAS USER, AIRSPACE AND SYSTEM CONSTRAINTS

One of the three task groups formed under the ARC developed a report outlining key sector characteristics, constraints, and limitations associated with various current and prospective users of the NAS. These users included manned aviation (inclusive of airports and heliports), commercial space (inclusive of spaceports), balloon operators, and UAS/remotely piloted aircraft systems (RPAS) operators, with their associated constraints summarized below.

Common Challenges and Constraints Across User Groups

The Task Group found that historically there have been challenges in effective communication and collaboration among the user sectors, particularly between commercial space and manned aviation. There are many causes of these challenges—including "siloed" regulatory and operational environments, rapid proliferation of new operators, especially in the commercial space and drone sectors, and resource constraints. These challenges contribute to inadequate coordination among sectors, which results in inefficient, un-dynamic, and conflicting airspace needs. These challenges also impede effective advanced planning of "missions" that could balance various sectors' airspace access requirements.

Both NAS users and Federal government agencies (e.g., DoD, NASA) face negative consequences of financial and resource constraints that affect operations research and development of new capabilities; and regulatory refinement.

Weather Constraints

Weather plays a significant role in determining how operations will utilize the NAS. Severe weather limits how airspace can be used on a given day or during a given hour. Conditions dictate runway use at airports and route selection between origin and destination airports. Weather also affects the ability of a space vehicle to launch or reenter. Because the weather is uncontrollable, operators must be flexible, adapting their operations to environmental conditions and being prepared for contingencies that may develop while en route.

Manned Aviation Constraints

All manned aviation users have a substantial number of long-established regulatory and statutory requirements they have to meet to assure they safely operate in the NAS. These include aircraft certification, aircraft equipage, flight crew training, medical, flight planning, and air traffic control requirements.

In addition, to ensure the safe and efficient operation of the NAS, the FAA, aircraft operators, and airport operators, over decades and with substantial investment, have developed air traffic rules and procedures; airspace structures; navigational aids, air traffic control tools, systems, and infrastructure; and airport infrastructure. These elements that define the NAS impose limits on how, when, and where manned aviation operations can take place.

Aviation operators also face financial constraints and typically attempt to reduce the costs and increase the efficiency of their flight operations by seeking faster or more direct routes between their origins and destinations to improve efficiency, reduce fuel consumption and emissions. Airspace closures and other limits on access to the NAS that increase flight times or increase airspace congestion and delays, exacerbate these constraints.

Additional discussion of constraints specific to scheduled commercial and on-demand business and general aviation manned operations are included in the Task Group 2 report.

Spaceflight Constraints

Space operators face a variety of operational constraints related to their mission requirements. These include:

- Launch and reentry timing is constrained by orbital mechanics that are dictated by mission objectives. For example, missions to the International Space Station have limited launch and reentry windows; if missed, launch or reentry may need to be delayed until at least the next day when the desired intercept trajectory can be achieved. Planetary missions, which have complex trajectories and can involve the use of the Earth, Moon or other planets to accelerate their spacecraft, face even more stringent constraints in terms of launch timing. If these missions miss their launch windows, they can be delayed for years - literally until the planets realign to suit the trajectory. Similarly, spacecraft reentries are subject to extremely tight deorbit time constraints to reach the targeted landing site.

- Launch and landing trajectory requirements can constrain an operator's choice of sites. For example, spacecraft with payloads that need to achieve geostationary orbits need to be launched from facilities that enable the spacecraft to reach positions over the Earth's equator. Similarly, payloads that need to be positioned in polar orbits need to be launched from facilities where the spacecraft can achieve orbits aligned with respect to the North and South Poles. Reentry sites are similarly constrained by the orbit from which the spacecraft is returning.

- Commercial space operators perform extensive safety risk assessments of their launches and reentries in accordance with procedures established by statute and further defined in regulations, orders, and advisory circulars published by the FAA's Office of Commercial Space. These safety assessments are focused on the protection of people and property on the ground, in aircraft, and in marine vessels near the launch or reentry site and beneath the vehicle's flight trajectory. To manage safety risks and meet FAA safety criteria, launch and reentry sites are often located in rural or coastal areas with flight paths that carry spacecraft over oceans or sparsely populated or unpopulated areas. These risk assessments are time consuming and mission-specific.

- Space vehicle dynamics can also impose operational constraints due to high velocities, rapid acceleration, and limited maneuverability while under rocket power.

The current regulatory framework—specifically obtaining commercial space launch licenses and safety approvals under Title 14, Chapter III of the Code of Federal Regulations (CFR), requires analyses and approval processes for what are oftentimes very similar launch operations. These approval processes are indirectly related to the airspace access issues considered within Task Group 2 in that launch and reentry licenses or permits are a necessary prerequisite to commercial space operators gaining access to the airspace. Launch sites operated by other federal agencies (i.e., DoD, National Aeronautics and Space Administration (NASA)), require their own approval processes separate and apart from those required by the FAA, adding to regulatory complexity.

Balloon Operator Constraints

Balloon releases are based on a number of flight conditions, as are most NAS users. When faced with delays, real time communication with ATC can be very similar to traditional NAS users. Balloon operations can accept most ATC instructions, and accept release times, if known in advance, much like flow control delays faced by aviation industry. The primary difference is the time on 'runway'. But those are not uncommon with other NAS users, like Military, UAS, mix of heavy vs. light aircraft, and others. (Example: 4 minutes wake turbulence delay for a light aircraft departing behind a heavy/super aircraft. Balloons normally need a 5-minute release window, not a massive impact). Communication with ATC and other users can ease these concerns with little impact. The FAA needs to ensure that times and effects on other users are accurately assessed. Although balloons climb at the same rate as most GA aircraft, and their route of flight is predictable, balloons are treated as exceptions to normal NAS operators when they could fit in much like other users.

UAS/RPAS Operator Constraints

UAS/RPAS operators seeking to conduct operations in controlled airspace face the following constraints and limitations:

- Uncertainty in the regulatory framework that could account for a rapidly-evolving and diverse array of UAS, with a wide array of physical and aerodynamic characteristics, performance capabilities, propulsion systems, and control systems

- Limited definition of air traffic operational procedures for integrating UAS operations with manned aviation operations in controlled airspace

- Removing the onboard pilot enables UAS to conduct missions that have not been seen before in the NAS. Examples include ultra-long duration flights at high altitudes; long-duration, slow-moving surveying or monitoring flights over specific locations (referred to by some as "mowing the lawn" because of flight patterns that resemble back and forth patterns of lawn mowers); and intra- and inter-urban passenger and cargo flights that begin and end not at airports or heliports, but rather at homes or businesses in urban or suburban neighborhoods. The new types of missions that UAS will be able to fly coupled with differences in performance characteristics between UAS and manned aircraft, create additional challenges with respect to the prioritization of airspace access between UAS and manned aviation. For example, a slow flying UAS conducting a photogrammetric survey mission over a large area ("mowing the lawn" as described previously) could conflict with manned aircraft that need to transit that same airspace.

A more extensive discussion of the constraints various types of UAS/RPAS operators face can be found in the Task Group 2 report.

3.3. DATA AND COLLABORATION

The ARC believes integration, through optimization, is the goal, but realizes segregation is still the reality for many future stakeholder operations. Communicating airspace segregation to other operators is critical to the FAA notification of these restrictions. The fundamental communication mechanism the FAA uses, a Notice to Airmen (NOTAM), presents a challenge with communicating information given its static representation of what may be a dynamic situation. However, operators and pilots must treat the NOTAM as the authoritative source for that activity, and will normally plan their operation based on such NOTAMs, so publishing the NOTAM adequately in advance is critical.

After conducting a review of various FAA-imposed notification timelines and holding discussions of what an ideal timeline would be for users, we determined the notification timeline must vary based on the expected airspace utilization of the operation. For example, the Super Bowl has a significant effect on operations, so flight restrictions and required routes are generally published seven days in advance. The ARC determined a 72-hour notification for large NAS events, like space launches, was an ideal compromise between a proponent and other users. This amount of time for large, uncharted flight restrictions allows the spectrum of other users to find ways to utilize airspace around the segregated operation.

The current 4-hour minimum notice documented in FAA Order 7400.2, Procedures for Handling Airspace Matters, was considered sufficient for smaller airspace areas. This policy is utilized primarily for charted SAA activation, but can be applied to other types of activity. Other local factors and mitigations beyond SAA size should be considered when determining if a shorter notification period is acceptable.

Collaborative Planning and Scheduling

Despite the significant impact of spaceflight operations on the NAS, there is currently no integration of spaceflight schedule forecasts to inform NAS planning. While spaceflight schedule information is available months in advance, aviation operators typically receive notice of a forthcoming launch or reentry event only days before the operation. At that point, it is too late for operators to reallocate resources; instead they must tactically respond to interruptions in traffic flow. If aviation stakeholders had more advance notice when a spaceflight event might occur, they could deploy resources or make changes to adapt to the potential disruption of their flight schedules.

Various U.S. government agencies already maintain schedules of commercial and government spaceflight operations. Much of the spaceflight forecast is also available to the public, published on websites for space enthusiasts. Pooling this existing spaceflight schedule information, along with associated airspace requirements, would help integrate the NAS and provide greater visibility into potential impacts for all NAS users.

Tactical Information Sharing

The management of airspace closures should be improved through better real-time information exchange with operators and enhanced air traffic controller decision support tools. Currently, airspace closures follow a pre-determined schedule, with airspace closed for operation and aircraft rerouted before the window is activated. However, the operator has additional planning information, already available to the FAA that could be used to dynamically close the airspace at a shorter time horizon.

The FAA is currently collaborating on development of procedures that enable more flexible airspace management. Dynamic launch windows (DLWs) allow air traffic controllers to adapt to changes in launch time, leveraging real-time operator communications to maximize use of the SAA prior to activation. The Space Vehicle Operations (SVO) Concept of Operations (ConOps) refers to this as "Just-in-Time Activation" and proposes automation support for enabling this capability. Time-based launch procedures (TBLPs) utilize flight safety analysis data to evaluate when airspace is no longer subject to hazard. This allows re-opening of airspace after a launch or reentry, and should be further optimized to reduce unnecessary reroutes or delays once the risk to NAS users has passed.

3.4. TOOLS AND CAPABILITIES

Automation – Planning

During mission planning for all NAS users, which can span a period of years to days before an operation, stakeholders need to have access to NAS impact assessment tools. A summary of capabilities currently in development is shown in Appendix H. Industry access to such tools could provide significant benefits for planning spaceport locations and launch dates to optimize NAS use and mitigate impacts on other operations in the NAS. While certain missions have little flexibility in scheduling, there are others that may benefit from the ability to predict and avoid peak NAS impact dates or times. An effective NAS impact assessment requires defined aircraft hazard area dimensions; therefore, any tools developed should include the ability to calculate nominal hazard areas because many commercial space operators either do not determine these airspace volumes themselves, or do not produce them far enough in advance of a mission to be useful for NAS planning.

Automation - Operations

NAS optimization will require new tools and procedures. The ARC reviewed several prototype tools, shown in Appendix H, that could enable the use of much smaller protected airspace for nominal space launch and reentry, augmented with the capability to dynamically close airspace and safely move NAS traffic away from hazards in the case of off-nominal events. To enable smaller preemptive airspace closures, the capability for off-nominal debris response is critical. Debris Hazard Volumes (DHVs) are envisioned[1] to be used in the rare case of a space vehicle anomaly or other event that generates debris falling through the NAS that could pose a hazard to other NAS

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[1] Larson, et al. "Protecting Aircraft In Real-Time from a Launch or Re-Entry Failure." 34th Space Symposium, Colorado Springs, Colorado, 16-19 April 2018. Space Foundation, 2018, www.spacefoundation.org/sites/default/files/tech-track-papers/Larson-Erik_Protection of Aircraft.pdf.

users. While the SAA is envisioned to contain nominal spaceflight operations, the DHV is proposed as the real-time, off-nominal airspace volume that would be created in response to an unexpected debris-generating event. The capability to calculate a DHV in real-time during an off-nominal event is critical to the goal of reducing the size and duration of nominal SAAs.

The key features for accommodating spaceflight operations in NAS management automation tools are:

- Pre-mission calculation of optimized nominal SAAs utilizing improved methodology and the assumption of a real-time debris response capability for off-nominal events.
- Real-time position of the space vehicle during NAS operations is made available to automation for use on ATC and Air Traffic Management (ATM) displays, as appropriate in off-nominal events.
- Real-time calculation of DHVs when an off-nominal event occurs.
- Automated display of SAAs and DHVs on ATC and ATM displays, as appropriate.

Improvement of aircraft hazard area calculation and management would yield by far the greatest NAS benefit of any reviewed by the ARC. The aircraft hazard area size and duration directly affects the number of aircraft rerouted or delayed, and reduction of these large preemptive airspace closures would produce results ranging from significant reduction of NAS impact, to near elimination of the impact.[2]

In addition, the development of a debris response capability utilizing DHVs calculated in real-time in the event of a space vehicle breakup should be an integral strategy to reducing nominal airspace closures. The debris response capability would also provide additional enhancement to NAS safety in those rare cases where nominal airspace closures do not currently provide protection, such as in the case of unplanned satellite reentries or the 2003 Space Shuttle Columbia breakup.[3]

As NAS users have started collaborating, it is clear the Next Generation (NextGen) Air Transportation System has the opportunity to contribute to integrated, safe, and efficient use of the NAS, not only for spaceflight, but for all operations in the NAS. It is important that new entrants, such as UAS and urban air mobility vehicles, continue to integrate into the NAS.

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[2] Colvin, Thomas J., and Juan J. Alonso. "Near-Elimination of Airspace Disruption from Commercial Space Traffic Using Compact Envelopes", AIAA SPACE 2015 Conference and Exposition, AIAA SPACE Forum, (AIAA 2015-4492)

[3] Lin, Mark Y. Y., Erik W. F. Larson, and Jon D. Collins, "Determination of Debris Risk to the Public Due to the Columbia Breakup During Reentry," Columbia Accident Investigation Board Report, Vol 2, Appendix D.16, September 2003.

3.5. METRICS

The following metrics are defined to evaluate the effects of spaceflight operations on other NAS users.

For commercial aviation operators, serving the needs of the passengers (shippers in the case of cargo) is dependent on being able to meet scheduled flight times. Therefore, evaluation metrics should be directly related to the following: flight time, miles flown, fuel consumed and emissions, weight restrictions in cases where additional fuel is required, and passenger delays. Flight delays propagate into the aviation carrier's system and create additional impacts, which include regulatory compliance with flight duty time of flight crewmembers, missed connections, availability of airport facilities (gates, passenger handling), and the completion of the aircraft scheduled use for the day.

Similarly, for commercial space operators, being able to meet customer commitments is dependent on meeting scheduled operations timelines that are already significantly constrained. Launch delay costs can be incurred, including range availability, propellant consumption, extended launch site equipment use, and additional shifts for hundreds of operations personnel. Customers are also impacted by loss of revenue from space-based assets that do not reach their destinations on time to provide paid services.

As the FAA makes a determination on the metrics to evaluate, it is important to consider the cumulative impacts by evaluating the previous system interruptions. This will also support the business and need for developing a process for integrating all users.

Table 4 summarizes ARC-recommended metrics both for consideration in decision-making to accommodate airspace requests, as well as for post-operation assessment. While much of this data is currently available, it may not be current practice to share with FAA or other operators, as noted in the data availability column. Data sources have also been included since data may reside in distributed locations and be disseminated by various entities. The metrics are grouped into four categories: vehicle flexibility, SAA characteristics, system/operator impact, and NAS efficiency.

Table 4: NAS Prioritization and Optimization Metrics

Metric	Decision-Making	Post-Op Analysis	Data Availability	Data Source	Notes
Vehicle Flexibility					
Capability to deviate from intended trajectory	X		Planned/on-demand data available but not shared with FAA; not incorporated for space vehicles	Operators	
Ability to loiter	X		Available but not shared for all operators	Operators	
Time required to reconfigure for same day launch attempt	X		Available but not shared	Operators	Could be used tactically to allow pass-through traffic

Metric	Decision-Making	Post-Op Analysis	Data Availability	Data Source	Notes
SAA Characteristics					
Dimensions of airspace area/volume	X	X	Available and shared.	NOTAMs	
Operational window(s)	X		Available and shared	NOTAMs	Bound hazard times, but may include margin
Duration of planned airspace closure	X	X	Available, commercial space operators share with FAA	Operators, Ranges	for nominal operations
Advance notification (e.g., weeks before start of operation)	X	X	Available and sometimes shared, but not usually available to ATO	Operators, Ranges, Spaceports	
System/Operator Impact					
Cost to delay or reschedule operation	X	X	Available, not currently shared by commercial space, UAS, some manned operators	Operators	Often proprietary, some public estimates available
Additional miles flown due to reroutes	X	X	Available and tracked/shared for manned aviation, N/A for space	FAA, Operators	May need to be expanded to other operator types
Mission scrubbed or delayed due to SAA violation		X	Data available but not tracked. Probably should be tracked for consolidated review/assessment by CDM-like group.	Operators, Ranges, Spaceports	Needed to truly assess what kind of airspace should be activated per mission.
Delays (both direct and indirect). For carriers these are delayed arrivals and departures, including propagated delays	X	X	Data available	Operators, FAA ATO	
NAS Efficiency					
Actual duration of airspace closure	X	X	Available	FAA	Nominal or off-nominal
Access restrictions to NAS (i.e., takeoff/launch)	X	X	Anything over 15 minutes delay is captured in OPSNET, airport/ ramp closures may be available at airport level,	Operations Network (OPSNET), Airports, Launch/ landing facilities, Traffic Management Initiative (TMI), NOTAMs	May not cover unplanned impacts. Should be limited to restrictions that are captured by OPSNET, TMIs, closures, NOTAMs

Metric	Decision-Making	Post-Op Analysis	Data Availability	Data Source	Notes
Airspace demand	X	X	Aviation forecast data available and shared, space forecasting data available but not necessarily shared, historical demand data available but not shared	Operators, FAA, ranges, spaceports	Space mission schedules sometimes changed to avoid peak demand
Resiliency of airspace operational recovery (ratio of actual vs. planned closure time)		X	Data available from two previous metrics.	FAA	Consolidated metric to measure progress, encourages latest closure, earliest release
Next available opportunity	X		Available but not always provided	Operators	Could include near and far term
Spaceflight schedule reliability (on-time/first-time with reasons for scrub), could be categorized by vehicle, maturity level, facility		X	Available but not reported	Operators, ranges	Addresses changes prior to start of operations. Reasons include: 1-weather, 2-range issue, 3-vehicle issue, 4-payload issue, 5-collision avoidance

4. ARC RECOMMENDATIONS

At the time the AAP ARC was deliberating, several other Aviation Rulemaking initiatives were underway that could have pertinent and potentially helpful recommendations to enable greater optimization of the NAS. One example of overlapping benefit came from the UAS in Controlled Airspace ARC. In that ARC, automation recommendations were included to support the normalized operation of UAS in controlled airspace to enable dynamic airspace management. This automation capability has been needed for decades and would benefit many existing and new operators while enhancing optimization. It is likely other ARC recommendations will have benefits leading to greater airspace and NAS optimization, and we encourage the FAA, in collaboration with industry and government stakeholders, to move forward with implementation of those recommendations that provide benefit beyond just one sector of the industry and provide benefit NAS wide.

Similar to the UAS in Controlled Airspace ARC automation recommendation, dynamic activation and deactivation of airspace during both nominal and contingency operations enables optimized ATC procedures for all operations in the NAS. The capability to dynamically "push" the display of the SAA boundaries directly to air traffic controller and traffic manager displays, would greatly improve the safety and efficiency of NAS air traffic management.

The ARC recommendations include two very short-term items shown in Table 5, consisting of establishing industry and FAA workgroups to provide guidance on how all NAS operators can be integrated into collaborative planning and operations processes. Other recommendations, shown in Table 6, endorse implementation of mid- and long-term automation tools, capabilities, and processes that will enhance optimization of the NAS. Some mid-term items are already in the NAS NextGen enhancement planning stage or are already in development; see Appendix H for tool descriptions. While such technologies may have been developed specifically to integrate space operations, they support integration of all NAS users and a variety of flight systems. The long-term items will build upon those enhancements and move the NAS closer to full integration of all users. The development and implementation of tools and capabilities will enable a future NAS state in which air traffic management shifts from segregation to integration with separation assurance.

Table 5: Summary of Recommendations for Establishment of Committees

Committee Description	Implementation Details
The ARC recommends that within 30 days of the submission of the AAP ARC Final Report, the FAA establish a Steering Committee (SC) to advise the FAA on policy and strategy regarding airspace access and integration.	The SC is intended to focus on items at the strategic level and set the course and vision for the FAA on mid- and long-term strategies for airspace access and integration.
The ARC recommends that within 60 days of the submission of the AAP ARC Final Report, the FAA establish a CDM-like space operations committee (including operators, DOD, and NASA) to recommend appropriate information to be exchanged with the FAA for more dynamic airspace management and situational awareness and to help implement the details charted by the SC.	Take the form of a CDM-like group or a similar forum Develop Terms and Guidelines for Participation in the collaborative process Review and provide ongoing feedback to FAA on the implementation of NAS improvements Make recommendations to the FAA on the appropriate planning information/data for sharing with FAA and other stakeholders Develop data standards that establish recommended elements and formats for the automated exchange of operational data for input to the collaborative process

Table 6: Summary of Recommendations on NAS Automation, Process & Tools

Recommendation	Interim State (within 6 months of ARC report) - Segregation	Interim State-Enabling Technologies[4]	Future State (within 3 years of ARC report)-Optimization	Future State – Enabling Technologies[4]
Automation-Planning Implement automation to improve forecasting of potential NAS conflicts	Utilize operator/facility planning data (as determined by proposed committee) as input into the existing CDM process	web-interface, NEAP/ ACACP	Implement capability to calculate nominal planning SAAs.	NEAP/ACACP
	N/A	N/A	Implement web interface for input of operator mission plans and dissemination of calculated planning SAAs across ATC sectors and facilities	N/A
Automation-Operations Implement automation to increase airspace efficiency during segregated operations	Develop proposal and plan for implementation of SAA and DHV airspace designations.	HRAM	Implement SAA and DHV airspace classifications and define associated procedures.	HRAM
	Exploit draw feature for SAA static display on existing ATC platforms	N/A	Implement capability to provide real-time space vehicle tracking information to FAA automation systems.	SDI, Advanced ADS-B, HRAM operator telemetry, other tracking sources
	Implement capability to share annotations from one ATC control position to another ATC control position within the ATC facility	ERAM	Implement capability to calculate and update operational SAAs in real-time. (nominal)	HRAM, SDI
	N/A	N/A	Implement capability to calculate real-time DHV in the event of mishap or accident. (off-nominal)	HRAM, ERAM, STARS, Micro EARTs, TFMS, ATOP
	N/A	N/A	Implement automated dynamic real-time display of SAA that are all conflict probed.	HRAM, ERAM, STARS, Micro EARTs, TFMS, ATOP
	N/A	N/A	Share data from HRAM on ATC displays	HRAM, ERAM, STARS, Micro EARTs, TFMS, ATOP

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[4] “Enabling Technologies” includes existing or prototype systems, automation platforms, or other technologies. See Appendix H for tool names and descriptions. Where a prototype technology is listed, the intent is to recommend pursuit of the capabilities represented by the prototype. Where an existing technology is listed, the technology is identified as a key enabler of the desired capability, and may require enhancement to meet the objective.

Recommendation	Interim State (within 6 months of ARC report) - Segregation	Interim State-Enabling Technologies[4]	Future State (within 3 years of ARC report)- Optimization	Future State – Enabling Technologies[4]
Decision Support-Implement tools for Air Traffic Managers and Controllers	N/A	N/A	Tool set to include data on mission status times, SAA activation and deactivation event indicators and conflict probe alerts	HRAM, ERAM, STARS, Micro EARTs, ATOP, TFMS, TBFM
Procedures and Training-Develop and implement procedures, and associated training, to streamline processes and mitigate impact	Utilize real-time communications procedures (e.g., voice hotlines, existing real-time displays) between operators/facilities and ATC Develop and implement procedures for ATC and ATM to use when managing nominal SAA that allow maximum use of the affected airspace before and after spaceflight operations. Develop and implement procedures for ATC to clear airspace when necessary in the case of an off-nominal debris-generating event.	N/A	Develop and implement training for ATC and ATM to ensure proficiency in the application of the future tools and procedures	N/A

1. **The ARC recommends the FAA accelerate efforts to allow more efficient use of airspace needed for spaceflight operations.**

2. **The ARC recommends that within 30 days of the submission of the AAP ARC Final Report, the FAA establish a Steering Committee (SC) to to advise the FAA on policy and strategy regarding airspace access and integration.**

The SC is intended to focus on items at the strategic level and set the course and vision for the FAA on mid- and long-term strategies for airspace access and integration. For the details of implementing the strategy in the near term see recommendation 3.

3. **The ARC recommends that within 60 days of the submission of the AAP ARC Final Report, the FAA establish a CDM-like space operations committee (including operators, DoD, and NASA) to recommend appropriate information to be exchanged with the FAA for more dynamic airspace management and situational awareness and to help implement the details charted by the SC.**

The ARC recognizes that CDM in its current form was designed around current stakeholders and their needs. The ARC wants to caution against adding commercial space and future stakeholders into CDM as it is today. The ARC recommends the SC (from recommendation 2) and the CDM-like group collaborate when introducing future stakeholder activities within a CDM-type environment. The ARC recommends the CDM-like group should:

- Take the form of a collaborative decision making forum.
- Develop Terms and Guidelines for Participation.
- Participate in review of FAA responses to CDM-like group recommendations.
- Make recommendations to the FAA on the appropriate planning information/data and schedule milestones for input to the collaborative process.
- Develop a data standard that establishes recommended elements and formats for the automated exchange of operational data for input to the collaborative process.
- Help with the development of new procedures
- Reevaluate Aircraft Hazard Area calculations to validate assumptions – i.e., continuous aircraft presence or risk based upon historical predicted aircraft density in the affected airspace.
  - Validate HRAM algorithms

It is important that relevant data elements and formats be specified and standardized to ensure efficiency and interoperability. While the ARC has developed an initial set of metrics to be considered, the CDM-like group should further define the data sets and metrics moving forward and assess applicability to NAS Users.

The CDM-like group should focus on methods of achieving near-term improvements in airspace operations through the use of improved information exchange, which may include launch scheduling, enhanced day-of-launch coordination, more dynamic air traffic management through better information sharing, processes, procedures, and capabilities to improve the actual operation.

4. The ARC recommends the FAA implement the ability to create dynamic airspace areas on controller automation systems that can identify potential conflicts between airborne flight trajectories.

- While initial input may come through web interface or HRAM, it could be input initially through web-interface for other operations (i.e., UAS Local area ops, DoD, etc.).
- While there could be many sources the information is ingested from, the capability to share annotations from one ATC control position to another ATC control position within the ATC facility should not be dependent on those inputs being fully deployed.
- Enable automated dynamic display and sharing of nominal and off-nominal hazard areas (SAAs and DHVs) on air traffic controller and traffic manager displays (TFMS, ERAM, STARS, Micro EARTs, ATOP, and any other controller automation systems)
- Hazard areas created or modified by HRAM or a similar source should be pushed to

air traffic controller displays and updated in real time as appropriate.

5. **The ARC recommends the FAA implement decision support tools in automation systems for air traffic controllers and traffic managers.**

    - The tool set should include mission status timers, SAA and DHV activation and deactivation event indicators, and conflict probe alerts to identify affected aircraft.

6. **The ARC recommends procedures and training be developed to enable future automation capabilities.**

    - Develop and implement procedures for air traffic controllers and traffic managers to use when managing nominal DHVs/SAAs that allow maximum use of the affected airspace before and after the spaceflight operations.
    - Develop and implement procedures for air traffic controllers to clear airspace when necessary in the case of an off-nominal debris-generating event.
    - Develop and implement training for air traffic controllers and traffic managers to ensure proficiency in the application of the applicable tools and procedures.

7. **The ARC recommends the FAA implement an HRAM capability available to ATC to allow for dynamic airspace management.**

    - The HRAM capability should calculate nominal pre-mission SAAs and make the results available to operators and NAS assessment tools.
    - Ensure that HRAM is designed, developed and tested with input from the various NAS users and stakeholders to ensure it is optimized for diverse vehicles and operations.
    - Establish an online portal so operators can input mission plan data and determine preliminary SAA.
    - Utilize improved operator information to activate and deactivate SAAs more dynamically, reducing the impact to other airspace users.
    - Enable HRAM to receive and process real-time tracking data for vehicles (from operator telemetry, SDI, ADS-B, or other tracking source).
    - Deploy the HRAM capability for real-time debris mitigation (calculation of DHVs in the event of a space vehicle failure). This includes transfer of this data between HRAM and air traffic control and traffic management automation systems.
    - Leverage the real-time debris response capability to reduce the physical and temporal dimensions of nominal SAAs, thereby reducing NAS impact.
    - HRAM development should be conducted with industry engagement to ensure the tool is optimized for diverse vehicles, locations and operations.
    - The final HRAM product should be available to industry in a manner that allows full transparency into its operations and methodology, without a subscription requirement.

8. **The ARC recommends the FAA implement and enable an SDI-like capability that allows the industry to share telemetry data with ATC systems and should be deployed to process telemetry to be supplied to HRAM and other automation platforms as necessary.**

   - Required for real-time off nominal response capability.
   - Provides situational awareness to ATC.

9. **The ARC recommends the FAA implement a NAS operational airspace utilization assessment for both planning and post analysis capability (e.g., RIA, NEAP, or ACACP) and make it available to operators online.**

   - This capability should utilize nominal AHAs/SAAs and provide operators with NAS assessments that can aid in pre- mission planning.
   - Ensure this capability is developed and tested with input from the various NAS users and stakeholders to ensure it is optimized for diverse vehicles and operations.

10. **The ARC recommends the FAA implement a CDM-like process for providing advanced notification time prior to an event requiring SAA.**

Given the wide range of variables associated with any event that could require an SAA, the ARC recommends that the FAA implement a CDM-like process to define and refine the process of giving notice. As tools and automation evolves, the process should be regularly reevaluated. Some near-term guidance is provided below, but it is understood that simply giving notice for each of the possible times an SAA may be required is ultimately insufficient to allow for integrated optimization of the NAS. Ideally, airspace users will work with the FAA to integrate operations such that no SAA is required, allowing the FAA to manage events in the NAS as a routine operation.

- A 72-hour notification prior to SAA activation was determined to be an ideal compromise between a proponent and other users.
- The current FAA policy of ideally 4-hour notification for smaller impact areas was considered sufficient.

As tools and automation evolves, a reassessment should be completed to ensure the near term recommended notification timeframes continue to make sense.

The ARC acknowledges that launches from outside the United States may not adhere to the recommended timelines, but to the greatest extent possible, the FAA should coordinate and disseminate information in a timely manner.

11. **The ARC recommends the FAA ensure sharing of real-time spaceflight status, including readiness forecasts prior to flight, with other NAS users.**

- Interim – Utilize hotline and share information per Letter of Agreement.
- Mid Term – Automation as a means of real time information sharing.
  - Enables early release or delayed use of segregated airspace.
  - Range or company could provide this input.
  - Streamline process between commercial and public operations.
- Far Term – Full integration.

12. **The ARC recommends the FAA implement procedure updates for tactical information exchange between space operators and FAA regarding on-time operations to enable more dynamic airspace activation/deactivation.**

- Within 6 months of procedural development, run demonstration to validate procedures, including TBLP and DLW.
- Accomplish training at air traffic facilities to avoid rerouting aircraft too early and to ensure prompt recovery when airspace areas are deactivated.

13. **Mandated equipage for any operation should be accomplished through established regulatory or other rulemaking process, and should not be implemented through ad hoc means, such as a Letter of Agreement.**

14. **The ARC recommends the FAA convene a future, follow-on ARC to further advise on measures to achieve full integration of the NAS.**

APPENDIX A: ARC MEMBERSHIP AND SUMMARY OF ACTIVITIES

ARC Participants

The AAP ARC was composed of participants representing a diverse set of aviation and space operations stakeholders. The ARC participants were:

- ACTA, Inc.
- Aerospace Industries Association
- Aircraft Owners and Pilots Association
- Air Line Pilots Association, International
- Airlines for America
- Airports Council International – North America
- American Association of Airport Executives
- Association of Unmanned Vehicle Systems International
- Blue Origin
- Commercial Spaceflight Federation
- Defense Advanced Research Projects Agency (ARC Observer)
- Delta Air Lines
- Denver International Airport
- General Atomics Aeronautical Systems, Inc.
- Department of Defense Policy Board on Federal Aviation (ARC Observer)
- Google X Project Loon
- Helicopter Association International
- International Air Transport Association (ARC Observer)
- Lockheed Martin
- Mojave Air and Spaceport
- MITRE Corporation (ARC Observer)
- National Aeronautics and Space Administration/Human Exploration and Operations (ARC Observer)
- National Air Traffic Controllers Association (ARC Observer)
- National Air Transportation Association
- National Association of State Aviation Officials
- National Business Aviation Association
- Northrop Grumman
- Regional Airline Association
- Sierra Nevada Corporation
- Space Florida
- SpaceX
- Spaceport America/New Mexico Spaceport Authority
- The Boeing Company
- United Airlines (Subject Matter Expert)

- United Launch Alliance
- USAF 45th Space Wing (ARC Observer)
- USAF Space Command (ARC Observer)
- Virgin Orbit/Virgin Galactic
- World View

ARC Plenary Meetings

The full AAP ARC met on the following dates for discussions and deliberations:

- February 28, 2018
- April 6, 2018
- June 4 – 5, 2018
- July 19 – 20, 2018
- September 18, 2018
- December 11, 2018
- April 24, 2019

A series of ARC discussions, briefings and demonstrations provided input and helped educate the ARC on concepts and technologies. Representatives of the following organizations provided briefings on the identified topics:

ARC Site Visits:
FAA Air Traffic Control System Command Center
Delta Airlines Air Operations Center
Space Florida
Kennedy Space Center and Cape Canaveral Air Force Station, including 45th Space Wing Morrell Operations Center
FAA William J Hughes Technical Center

ARC Briefings and Discussion Topics:

- Systems under development
- Current airspace operations and impacts
- Future concepts
- Optimization
- Needs and constraints
- Airspace segregation vs integration
- Terminology, phraseology and definitions

- Information and data flow
- Collaborative Decision Making
- Traffic flow management
- Strategic and tactical planning and operations
- Predictability and efficiency gains
- Metrics
- Airspace risk management
- UAS
- Part 101
- Systems forecasts
- Budget
- Airports and Spaceports

ARC Demonstrations:

- Human-in-the-loop testing of prototype tools to implement reduced hazard area size and duration, real-time tracking of space vehicles, real-time activation of hazard areas, and real-time response to off nominal events.
- A prototype for receiving and displaying space operator-provided telemetry

APPENDIX B: ARC CHARTER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Aviation Rulemaking Committee Charter

Effective Date: 11/20/17

SUBJECT: Airspace Access Priorities Aviation Rulemaking Committee

1. **PURPOSE.** This charter establishes the Airspace Access Priorities (AAP) Aviation Rulemaking Committee (ARC), according to the Administrator's authority under Title 49 of the United States Code (49 U.S.C. § 106(p)(5)). The sponsors of the ARC are the Chief Operating Officer of the Air Traffic Organization and the Associate Administrator of Commercial Space Transportation. This charter outlines the ARC's organization, responsibilities, and tasks.

2. **BACKGROUND.** The U.S. navigable airspace is part of the Nation's critical infrastructure and is a limited national resource that Congress has charged the FAA to administer in the interest of the public to ensure safety and its efficient use. Although the FAA must protect the public's right of freedom of transit through the airspace, full consideration must be given to all airspace users including national defense, commercial and general aviation, and space operations. Accordingly, a sincere effort must continue to be made to negotiate equitable solutions and minimize potentially conflicting requests to access the airspace. The FAA is committed to fair and equitable airspace access to all users of the national airspace system (NAS). As such, the FAA has recognized a need to develop an improved framework that will allow the FAA to balance the respective needs of its wide-variety of controlled airspace users, including general aviation, business aviation, amateur rockets, commercial space operators, commercial air carriers, cargo operators, operators of Unmanned Aircraft Systems in positive control airspace, airport and spaceport operators and the Department of Defense and other Federal agencies in the event of conflicting requests. This is especially important as commercial space transportation operations continue to grow and new types of orbital and suborbital operations begin to emerge, resulting in the possibility of increased competition for airspace. The recommendations of the AAP ARC will assist the FAA in providing the appropriate framework to develop policy and regulations, as appropriate, that meet the needs of airspace users and the public interest.

3. **OBJECTIVES OF THE ARC.** Equitable airspace access is an essential concept that needs to be understood and embraced by the varied users of the NAS to maximize value to the United States. Through its work, the AAP ARC will assist the FAA in developing criteria that may be used to consider competing requests for airspace access. In addition, the examination, development and recommendation of methods (quantifiable and non-quantifiable) that can be used to accommodate different operations and support operational decisions regarding the prioritization of airspace access will further these goals.

   Overall, the AAP ARC will provide a forum for the United States aviation and space communities to review and discuss information and data such as the historical and projected growth in operations for the respective stakeholders, the methods currently used by the FAA to accommodate requested operations in the airspace, and the respective operational needs and constraints across the community of stakeholders for access to the national airspace to meet their respective needs. This will enable the AAP ARC to provide recommendations that will improve the integration of commercial space operations into the NAS in the near-term, while the insights gained through the AAP ARC will also be of great value to future integration of NAS operations overall.

4. **TASKS OF THE ARC.** The tasks of the AAP ARC are:

   a. Review historical and projected growth in operations for the respective stakeholders, along with the methods currently used by the FAA to accommodate requested operations in the NAS.

   b. Review the respective operational needs and constraints across the community of stakeholders for access to the NAS to meet their respective objectives. This review should include any representative quantified or characteristic indicators (i.e., "metrics") that are used in the community to measure needs, constraints, and impacts.

   c. Provide specific consensus recommendations and their supporting rationale, including any potentially applicable metrics, that will assist the FAA in developing policy to make airspace prioritization decisions when needed between various operations that are requested.

   d. Within six months from the first meeting, submit a recommendation report.

      i. The Industry Co-Chairs send the recommendation report to the FAA Co-Chair and the Director of the Office of Rulemaking.

      ii. The FAA Co-Chair determines when the recommendation report and records, pursuant to paragraph (8), will be made available for public release.

5. **ARC PROCEDURES.**

   a. The ARC acts solely in an advisory capacity by advising and providing written recommendations to the FAA Co-Chair.

   b. The ARC may propose related follow-on tasks outside the stated scope of the ARC to the FAA Co-Chair.

   c. The ARC may reconvene following the submission of the recommendation report for the purposes of providing advice and assistance to the FAA, at the discretion of the FAA Co-Chair, provided the charter is still in effect.

6. **ARC ORGANIZATION, MEMBERSHIP, AND ADMINISTRATION.** The FAA will set up a committee of members representing the aviation and space communities. Members will be selected based on their familiarity and experience with orbital and suborbital commercial space transportation operations, air traffic operations, and airspace policies. Membership will be balanced in viewpoints, interests, and knowledge of the committee's objectives and scope.

The provisions of the August 13, 2014 Office of Management and Budget (OMB) guidance, "Revised Guidance on Appointment of Lobbyists to Federal Advisory Committees, Boards, and Commissions" (79 FR 47482), continues the ban on registered lobbyists participating on Agency Boards and Commissions if participating in their "individual capacity." The revised guidance allows registered lobbyists to participate on Agency Boards and Commissions in a "representative capacity" for the "express purpose of providing a committee with the views of a nongovernmental entity, a recognizable group of persons or nongovernmental entities (an industry, sector, labor unions, or environmental groups, etc.) or state or local government." For further information, refer to the OMB Guidance at 79 FR 47482.

Membership is limited to promote discussion. Attendance, active participation, and commitment by members is essential for achieving the objectives and tasks. When necessary, the ARC may set up specialized and temporary working groups that include at least one ARC member and invited subject matter experts from industry and government.

The ARC will consist of members from the aviation and space communities. FAA and other Agency subject matter experts may be requested to participate as Observers and to provide technical support to the ARC members.

a. At the request of the Sponsors, the Deputy Assistant Administrator for Policy, International Affairs, and Environment will function as the FAA-Co-Chair and will:

    1) Select and appoint industry and the FAA participants as members,
    2) Select the Industry Co-Chairs from the membership of the ARC,
    3) Ensure FAA participation and support from all affected lines-of-business,
    4) Provide notification to the members of the time and place for each meeting, and
    5) Receive any status report and the recommendations report.

b. The Industry Co-Chairs will be appointed, one from the commercial space community, and one from the aviation community. Once appointed, the Industry Co-Chairs will:

    1) Coordinate required ARC meetings in order to meet the objectives and timelines,
    2) Establish and distribute meeting agendas in a timely manner,
    3) Keep meeting notes, if deemed necessary,
    4) Perform other responsibilities as required to ensure the objectives are met,
    5) Provide status reports, as requested, in writing to the FAA Co-Chair, and
    6) Submit the recommendation report to the FAA Co-Chair and the Director of the Office of Rulemaking.

7. **PUBLIC PARTICIPATION.** Meetings are not open to the public. Persons or organizations outside the ARC who wish to attend a meeting must get approval in advance of the meeting from the Industry Co-Chairs and the FAA Co-Chair.

8. **AVAILABILITY OF RECORDS.** Consistent with the Freedom of Information Act, Title 5, U.S.C., § 552, records, reports, agendas, working papers, and other documents that are made available to or prepared for or by the ARC will be available for public inspection and

copying at the Office of Rulemaking, FAA Headquarters, 800 Independence Ave. SW, Washington, D.C. 20591. Fees will be charged for information furnished to the public according to the fee schedule published in Title 49 of the Code of Federal Regulations, part 7.

You can find this charter on the FAA Committee Database website at: http://www.faa.gov/regulations_policies/rulemaking/committees/documents/.

9. **DISTRIBUTION.** This charter is distributed to: Office of the Associate Administrator for Aviation Safety, Office of the Associate Administrator for Commercial Space Transportation, Office of the Chief Operating Officer of the Air Traffic Organization, Office of the Associate Administrator of Airports, the Office of the Chief Counsel, the Office of Assistant Administrator for Policy, International Affairs, and Environment, Office of the Assistant Administrator for NextGen, and the Office of Rulemaking.

10. **EFFECTIVE DATE AND DURATION.** The ARC is effective upon issuance of this charter and will remain in existence for a maximum of 24 months, unless the charter is sooner suspended, terminated, or extended by the Administrator.

Issued in Washington, D.C. on November 20, 2017.

Michael P. Huerta
Administrator

APPENDIX C: TASK GROUP 1 CHARTER

Terms of Reference
FAA Airspace Access Priorities ARC: Airspace Optimization Task Group

1.	**Statement of Objective, i.e. what is the problem/requirement:** This ARC must recognize the rapid evolution occurring in the National Airspace System (NAS). In order to formulate educated recommendations, the ARC must consider the research, development and implementation activities being conducted by each facet of the industry: commercial space, drones, balloons and traditional manned operations. Processes, procedures and technologies that will result in more optimized airspace and fundamentally change how the NAS is managed have been proposed and are in some phase of development. The ARC must understand the breadth of these changes and visualize an optimized NAS in order to complete its work.
2.	**Statement of scope of task/activity:** Evaluate any and all ongoing work in each domain that will contribute to NAS optimization. Examples include: use of ADS-B to precisely track commercial space vehicles or improvements in Detect and Avoid technologies that will facilitate the seamless integration of drones. Construct a description of the NAS that incorporates these improved processes, procedures and technologies—including how airspace design and air traffic management will be affected.
3.	**What is the expected deliverable/product:** An illustration and description of the optimized NAS that will be considered by the ARC when formulating proposals for policies associated with priority of NAS access.
4.	**Special Considerations:** Recommendations should include an evaluation of the risks associated with achieving any NAS improvement.
5.	**What is the schedule of activities:** The Task Group Lead will determine frequency of meetings based on progress of the group. The final Task Group deliverable is due to the ARC plenary on July 25, 2018.
6.	**Related Activities:** Work closely with appropriate FAA Lines-of-Business; other government agencies as needed, including NASA; MITRE and other research and development entities; key ARC industry stakeholders and other industry operators and manufacturers as necessary.
7.	**What are the resource requirements and commitments:** • Participation commitment by Task Group members. • Meetings may be face-to-face, via telcon or Webinar.

8.	**What is the urgency/criticality:** Completion of this work is necessary to inform the ARC plenary deliberations regarding policy related to priority of NAS access.
9	**Who are the customers for the product/deliverable:** The Airspace Access Priorities ARC.
10.	**Will this result in UASCA ARC recommendations or is this coordination to keep UAS ARC aware of significant related activities:** Task Group results will contribute to the formulation of ARC Recommendations.
11.	**Action Team Leader:** Kevin Hatton (Space X)
12.	**Action Team Members:** Kevin Hatton; Captain Marc Henegar Darrell Pennington Melissa Sabatine Scott Henderson George Merritt Brandon Suarez Ashish J. Solanki Heidi J. Williams Ernie Stellings Meagan Eisentein Christopher DeMars Christopher Allison Mark Heinrich SMEs will be used from government and industry as needed.

APPENDIX D: TASK GROUP 1 REPORT

August 2018

TECHNICAL REPORT

ARC Task Group 1 Report on Optimized Airspace Management

Concepts, Tools, and Procedures for the Integration of Commercial Space Operations in the National Airspace System

PREPARED BY THE
Airspace Access Priorities Aviation Rulemaking Committee
Task Group on Optimized Airspace Management

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Airspace Access Priorities
Aviation Rulemaking Committee

Task Group On
Optimized Airspace Management

Chair: Kevin Hatton, Space Exploration Technologies Corp.

Members

Marc Henegar	Air Line Pilots Association
Darrell Pennington	Air Line Pilots Association
Melissa Sabatine	American Association of Airport Executives
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Glenn Morse	United Airlines
Todd Ericson	Virgin Orbit/Virgin Galactic
Sirisha Bandla	Virgin Orbit/Virgin Galactic
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Taber MacCallum	WorldView

ACKNOWLEDGMENTS

The Task Group is grateful for the support of our sponsoring Aviation Rulemaking Committee and its co-chairs: Nan Shellabarger, Federal Aviation Administration; Eric Stallmer, Commercial Spaceflight Federation; and Mike Cirillo, Airlines for America.

The Task Group gratefully acknowledges the participation and input of ACTA, Inc., Advanced Sciences and Technologies (AS&T), Stanford University, The MITRE Corporation, Millennium Engineering and Integration Company, the NextGen Integration and Evaluation Capability (NIEC) laboratory at the FAA William J. Hughes Technical Center, and the FAA offices of Commercial Space Transportation, NextGen, and Air Traffic System Operations.

KEYWORDS

FAA, NAS, Integration, Commercial Space, NextGen, Air Traffic Management, Air Traffic Control, HRAM, SDI, SVO, NEAP, ACACP, STC, DHV, FIXM, ERAM, TFMS, STARS

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EXECUTIVE SUMMARY

The Airspace Access Priorities Aviation Rulemaking Committee (AAP ARC) was organized and kicked off in February 2018 with the goal of assisting the Federal Aviation Administration (FAA) in developing criteria that may be used to consider competing requests for airspace access. The ARC members identified a need to assess the proposed procedures and technologies that are currently in development that may contribute to the optimized management of commercial space operations in the National Airspace System. The Task Group on Optimized Airspace Management was created to evaluate any and all ongoing work in each domain that will contribute to National Airspace System (NAS)[1] optimization. The Task Group was asked to provide a description of the optimized NAS to be considered by the AAP ARC when formulating proposals for policies associated with priority of NAS access.

The Task Group found that there is wide agreement among government and industry experts that NAS efficiency during space launch and reentry operations could be improved through the introduction of new technologies and procedures. Air traffic controllers and traffic managers currently do not have the tools necessary to optimize the handling of these operations while minimizing NAS impact. The Task Group recommends that FAA, in collaboration with NAS stakeholders, expand and accelerate efforts to reduce the size and duration of airspace closures, develop a real-time debris response strategy, deploy necessary decision support tools for air traffic controllers and traffic managers, develop a NAS assessment capability for use during the mission planning phase,, and facilitate stakeholder engagement in data sharing and collaboration on NAS optimization. The task group believes that the implementation of these recommendations will transition the NAS from a system that assumes a spacecraft failure, to a more efficient system that reacts if needed to a failure scenario, while maintaining safety and efficiency.

The Task Group recommends that FAA increase its emphasis and efforts to reduce the NAS impact of space vehicle operations, thereby benefiting all airspace users and reducing or eliminating the need for operational prioritization. The Task Group recommends that the AAP ARC consider optimized airspace management as the desired approach to safely and efficiently integrate commercial space operations in the NAS, as opposed to prioritization.

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[1] NAS as defined by the FAA Aeronautical Information Manual Pilot/Controller Glossary (03.29.18): “The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and manpower and material. Included are system components shared jointly with the military.” Throughout this document, NAS includes all U.S.-controlled Flight Information Region (FIR) airspace.

1.0 TASK GROUP ACTIVITIES

1.1 Approach

The Task Group executed a series of defined activities in order to gather and analyze available data on proposed improvements for the management of commercial space operations in the NAS:

1.1.1. Literature Review

A review was conducted of published literature related to commercial space operations in the NAS, focusing on issues related to NAS integration, airspace management, and aircraft protection from hazards. Several key focus areas or observations recur throughout the literature:

1) As commercial space operations evolve, there is a need to develop new capabilities and procedures to integrate the management of these operations with other NAS operations.

2) Real-time tracking of space vehicles and dynamic display of space vehicle hazard areas is needed in FAA air traffic control and traffic management systems, including the En Route Automation Modernization (ERAM) system, Standard Terminal Automation Replacement System (STARS), and the Traffic Flow Management System (TFMS).

3) There is a need for the capability to detect and respond to catastrophic debris-generating events in real-time to improve the safety and efficiency of air traffic management.

4) If needed, nominal and off-nominal space operations hazard areas should be managed dynamically, with reduced spatial and temporal impact on the NAS.

A bibliography of literature included in the review may be found in Appendix A. Selected passages of interest are presented here:

> *Analyses initiated after the Columbia accident demonstrated that a real-time system to track a launch or re-entry vehicle and activate aircraft hazard areas in the event of a catastrophic break-up may be necessary to provide a high level of aircraft protection without excessive impact on normal air-traffic patterns.*
>
> - Gowan, J., Silvestri, R., Stahl, B., Rosati, P., & Wilde, P. Achieving the Proper Balance Between Crew and Public Safety. 5th International Association for the Advancement of Space Safety Conference. Versailles, France. October, 2011.

> *Sharing additional data, such as the tracking of a vehicle's position in regard to the debris hazard areas, at a real time rate will also enhance air traffic manager and controller judgment and decision making in the event of off-nominal operations requiring air traffic rerouting.*
>
> *Tool adaptation and flexible support for numerous vehicles will permit real time debris hazard area calculations for minimizing risk and enhancing the safety of the NAS.*
>
> \- Murray D.P. and Mitchell M. Lessons Learned in Operational Space and Air Traffic Management. AIAA2010-1349. 48th AIAA Aerospace Sciences Meeting. Orlando, Florida. January 2010

> *Lastly, in the case of an off-nominal event resulting in an SV [space vehicle] breakup or explosion above airspace occupied by other NAS users, ERAM would need to display debris hazard volumes calculated in real-time by SV operations automation. Air traffic controllers use this information to maneuver other NAS users located in or heading towards the debris hazard volume to safe airspace.*
>
> \- Wargo, C.A., Hunter, G., Leiden, K., Glaneuski, J., Van Acker, B. and Hatton, K., "New entrants (RPA/space vehicles) operational impacts upon NAS ATM and ATC," 2015 IEEE/AIAA 34th Digital Avionics Systems Conference (DASC), Prague, 2015, pp. 5B2-1-5B2-13.

> *The concept of operations for future control of space and air traffic calls for the use of space transition corridors (STCs) to safely segregate traffic. STCs would be defined by strategically sized airspace restrictions that would be dynamically issued and withdrawn, as necessary, to maximize safety while minimizing the impact to air traffic.*
>
> \- Murray, D.P. and VanSuetendael, R., “A Tool for Integrating Commercial Space Operations Into the National Airspace System,” AIAA Atmospheric Flight Mechanics Conference and Exhibit, Keystone, Colorado, 2006, p. 3.

1.1.2. Identification of Concepts, Technologies, and Research

FAA’s 2014 Space Vehicle Operations (SVO) Concept of Operations (ConOps) articulated the following desired improvements in the NAS:

- Develop streamlined and standardized planning process between ANSP (Air Navigation Service Provider) and SV operators to increase efficiency, effectiveness, situation awareness and data sharing.
- Develop automated tools to evaluate the impact of SV operations in the NAS.
- Develop automated data sharing mechanisms among the relevant stakeholders.

- Develop improved off-nominal hazard analysis methodologies to decrease the required size of the protected airspace.
- Realize the benefits of planned improvements in air traffic surveillance and communication capabilities.
- Develop tools and procedures that enable the ANSP to more efficiently plan for and respond to nominal and off-nominal SV operations, including real-time decision support instead of preemptively closing large amounts of airspace.
- Develop seamless surveillance and communication capabilities for SVs from surface to the upper NAS automation boundary and back to surface.

The Task Group conducted outreach to experts in DOT, FAA, industry, and academia to identify current research and development activities intended to support the above NAS improvements.

1.1.3. Technical Interchange Meetings and Technology Demonstrations

The Task Group met in Washington, D.C. on May 17, 2018 for a Technical Interchange Meeting (TIM) on concepts and technologies identified by the Task Group. The TIM agenda is included in Appendix B. Representatives of the following organizations provided briefings on the identified topics:

FAA Office of NextGen (ANG) and FAA Office of Commercial Space Transportation (AST):
Space Vehicle Operations ConOps
ACTA, Inc.:
Hazard Risk Assessment and Management (HRAM) prototype
Stanford University:
4D Compact Envelope concept
Millennium Integration and Integration Company:
Space Data Integrator (SDI) prototype
MITRE Corporation:
NAS Effects Analysis Prototype (NEAP) and Data Exchange Flow analysis
Advanced Sciences and Technologies:
Airspace Constraint Analysis and Conflict Prediction (ACACP) prototype and NAS Impact Modeling
FAA Office of NextGen:
Commercial Space research roadmap

The Task Group attended a technology demonstration of the HRAM and SDI prototypes at the FAA William J. Hughes Technical Center on May 18, 2018. The demonstration included replays of NextGen Human-In-The-Loop (HITL) experiments which utilized the HRAM prototype to implement reduced hazard area size and duration, real-time tracking of space vehicles on TFMS and ERAM, real-time activation of hazard areas, and real-time response to debris-generating events. The Task group also received a demonstration of the SDI prototype for receiving operator-provided telemetry and displaying space vehicle position.

1.1.4. Review of FAA Roadmaps for Implementation of Improvements

The Task Group reviewed FAA’s New Entrants roadmap and Automation roadmap. The New Entrants roadmap revealed that, while numerous research activities are identified, the vast majority are not funded and are not currently being pursued. The Automation roadmap identified a single planned investment, “Space Integration Enhancements” for the TFMS system, which represents space vehicle tracking capabilities for traffic management systems only, slated for implementation by the end of 2022. Appendix C contains the New Entrants roadmap, with an excerpt from the Automation roadmap.

1.1.5. Task Group Vision for Optimized NAS

The Task Group met in Washington D.C. on June 28, 2018 to review and discuss the proposed NAS improvements and identify key features envisioned for the optimized management of space vehicle operations in the NAS. These improvements are discussed in Section 2.0.

2.0 CONCEPTS AND TOOLS

The Airspace Access Priorities ARC (AAP ARC) was established, in part, to provide a forum for U.S. aviation and space communities to discuss methods currently used by the FAA to accommodate requested operations in the NAS. In addition, the AAP ARC is expected to provide recommendations that will improve the integration of commercial space operations in the NAS. The Task Group identified several shortfalls in current NAS capabilities related to commercial space launch and reentry operations.

1) There is a lack of NAS impact information available to NAS operators during the mission planning phase
2) There is no provision for automated space “flight plan” processing for new entrants, including space operations, UAS, balloon operations, etc.
3) There is no standardized format established for automated information exchange of space “flight plan” data
4) Aircraft hazard areas are too large and are active for too long
5) Risk analysis tools used to determine aircraft hazard areas have not been optimized to eliminate overly-conservative assumptions and enable real-time off-nominal response
6) Aircraft hazard areas are not activated and deactivated efficiently to minimize NAS impact

The Task Group found that a number of concepts and tools have been proposed to address many of these shortfalls, as discussed below.

2.1 Concept of Operations

FAA’s 2014 Space Vehicle Operations (SVO) ConOps identifies similar NAS deficiencies as those listed above. The SVO ConOps envisions a future NAS (2025+) where air traffic management in the vicinity of space operations shifts from today’s preemptive segregation (large hazard areas for extended time periods) to a separation assurance focus, with the capability for reactive separation in the event of a debris-generating event. The concept outlines methodologies for utilizing much smaller protected airspace for nominal launch and reentry, while implementing the capability to dynamically close airspace and safely move NAS traffic away from hazards in the event of off-nominal events.

2.2 Key Research, Concepts, and Technologies

Space Transition Corridor (STC) –

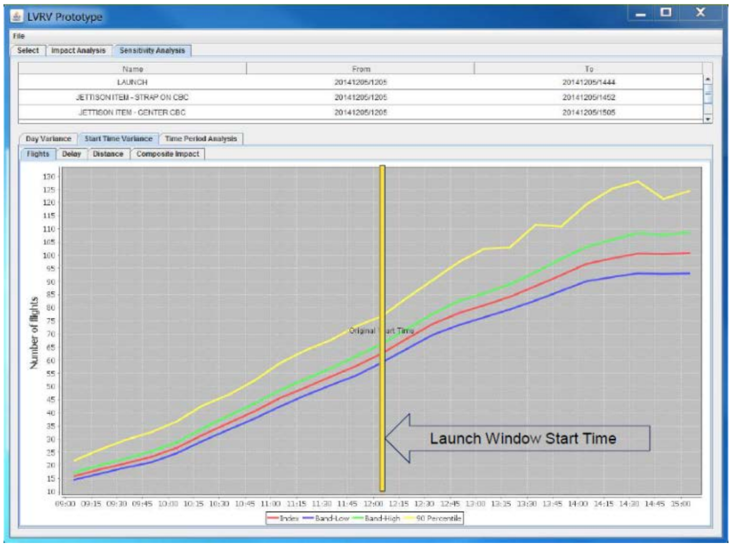
Currently, space operations make use of a variety of airspace types (Temporary Flight Restriction (TFR), Restricted Airspace, Altitude Reservation (ALTRV), etc) that were not originally created for that purpose. This introduces limitations due to procedures and separation criteria that have not been designed specifically for space operations. An STC is a proposed type of Special Activity Airspace (SAA) designed for the unique characteristics of space vehicle operations. The STC concept has existed for over two decades and has been referenced in FAA, NASA, and international publications. The STC is envisioned to be a volume of airspace that encompasses the predicted path of the space vehicle and the associated near-term hazard areas (those which cannot be reacted to in real-time). An STC would be smaller than current aircraft hazard areas and could adapt to different vehicles and operations (shrinking for lower risk operations when possible). The designation of STCs as a specific type of SAA would enable FAA procedures to be tailored to the unique characteristics of space operations, enabling increased NAS efficiency.

Debris Hazard Volume (DHV) –

To enable smaller preemptive airspace closures, the capability for off-nominal debris response is necessary. While the STC is envisioned to contain nominal space vehicle operations, the Debris Hazard Volume is proposed as the real-time off-nominal airspace volume that would be created in the event of an unexpected debris-generating event. When a space vehicle operating far above other NAS traffic experiences a failure that results in debris falling toward the NAS, a DHV would be calculated using real-time information. A DHV would have temporal parameters that would inform air traffic controllers of the time period that debris would be at aircraft altitudes.

NAS Effects Analysis Prototype (NEAP) –

Developed by MITRE, NEAP (Figure 1) is a prototype tool for estimating the impact of space launch and reentry operations during the mission planning phase. NEAP uses a large sample of historical flight data to predict future NAS impact for a given date and time. NEAP also has tools for visualizing NAS impacts of different launch or reentry windows for a given date. It should be noted that NEAP does not generate the predicted aircraft hazard area for its analysis – this information must be provided to NEAP.

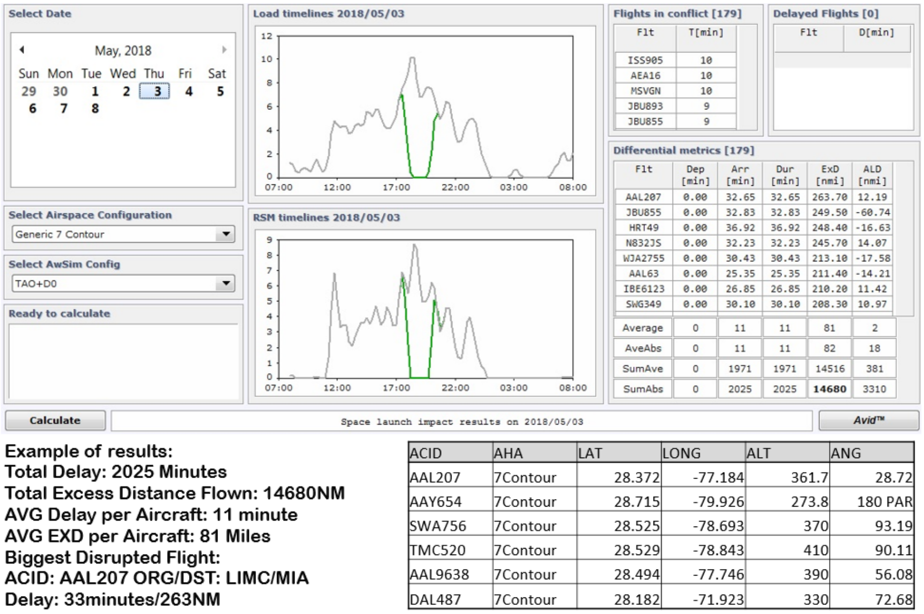


Name	From	To
LAUNCH	20141205/1205	20141205/1444
JETTISON ITEM - STRAP ON CBC	20141205/1205	20141205/1452
JETTISON ITEM - CENTER CBC	20141205/1205	20141205/1505

Figure 1: NEAP flight impact analysis with variable launch window

Airspace Constraint Analysis and Conflict Prediction (ACACP) –

Developed by AS&T, ACACP (Figure 2) is a prototype tool for providing NAS assessment of space launch and reentry operations. ACACP includes a planning mode that uses historical or real-time air traffic data. ACACP also provides discrete aircraft IDs for affected flights, as well as overall NAS delay, average NAS delay and discrete flight metrics.



Select Airspace Configuration: Generic 7 Contour

Select AwSim Config: TAO+D0

Space launch impact results on 2018/05/03

Flights in conflict [179]

Flt	T[min]
ISS905	10
AEA16	10
MSVGN	10
JBU893	9
JBU855	9

Delayed Flights [0]

Flt	D[min]

Differential metrics [179]

Flt	Dep [min]	Arr [min]	Dur [min]	ExD [nmi]	ALD [nmi]
AAL207	0.00	32.65	32.65	263.70	12.19
JBU855	0.00	32.83	32.83	249.50	-60.74
HRT49	0.00	36.92	36.92	248.40	-16.63
N832JS	0.00	32.23	32.23	245.70	14.07
WJA2755	0.00	30.43	30.43	213.10	-17.58
AAL63	0.00	25.35	25.35	211.40	-14.21
IBE6123	0.00	26.85	26.85	210.20	11.42
SWG349	0.00	30.10	30.10	208.30	10.97
Average	0	11	11	81	2
AveAbs	0	11	11	82	18
SumAve	0	1971	1971	14516	381
SumAbs	0	2025	2025	**14680**	3310

Example of results:
Total Delay: 2025 Minutes
Total Excess Distance Flown: 14680NM
AVG Delay per Aircraft: 11 minute
AVG EXD per Aircraft: 81 Miles
Biggest Disrupted Flight:
ACID: AAL207 ORG/DST: LIMC/MIA
Delay: 33minutes/263NM

ACID	AHA	LAT	LONG	ALT	ANG
AAL207	7Contour	28.372	-77.184	361.7	28.72
AAY654	7Contour	28.715	-79.926	273.8	180 PAR
SWA756	7Contour	28.525	-78.693	370	93.19
TMC520	7Contour	28.529	-78.843	410	90.11
AAL9638	7Contour	28.494	-77.746	390	56.08
DAL487	7Contour	28.182	-71.923	330	72.68

Figure 2: ACACP NAS impact analysis with aggregate and flight-specific metrics

Flight Information Exchange Model (FIXM) –

FIXM is a data exchange schema that captures flight and flow information and is globally standardized for aviation stakeholders. Inclusion of standardized data elements and formats for commercial space operations is planned for Release 5.0.0 of the FIXM U.S. Extension[2], with a release date currently TBD. The FAA Office of NextGen (ANG) has developed data element descriptions for space operations as part of research supporting the upcoming FIXM U.S. Extension release. ANG declined to release the draft commercial space data definitions to the Task Group.

Hazard Risk Assessment and Management (HRAM) –

Sponsored by ANG and developed by ACTA, Inc., HRAM (Figure 3) is a next-generation risk analysis platform designed to incorporate a variety of space vehicle types and launch and reentry profiles. HRAM is built upon and evolved from ACTA's Range Risk Analysis Tool (RRAT), which has traditionally been used by the FAA and Air Force for risk analysis. HRAM calculates nominal Space Transition Corridor (STC) areas pre-mission, as well as real-time Debris Hazard Volume (DHV) areas in the event of a space vehicle failure. HRAM was designed to receive real-time space vehicle tracking information and provide STCs and DHVs directly to FAA systems for display to Air Traffic Controllers and Traffic Managers. HRAM has been tested by ANG with air traffic controllers in the loop, and results suggest that the concept of reduced nominal hazard areas, coupled with real-time reactive separation from debris is feasible.

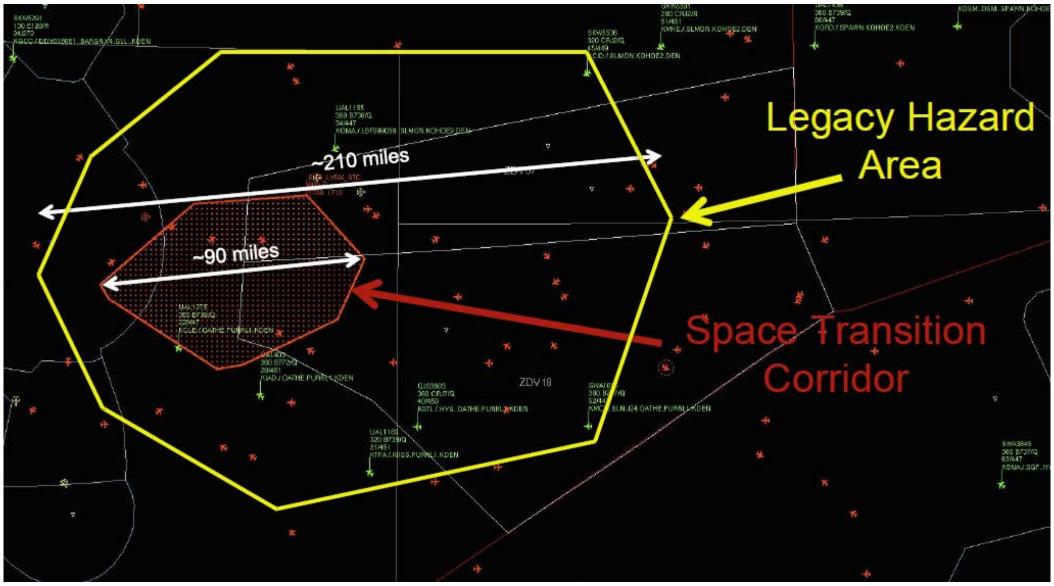


Figure 3: HRAM-generated nominal STC compared to traditional Hazard Area for a simulated suborbital launch

Space Data Integrator (SDI) –

SDI was developed by Millennium Engineering and Integration Company (MEI), under contract by FAA's Office of Commercial Space Transportation. SDI was designed to receive space vehicle state data (telemetry) from a commercial space vehicle operator and

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[2] https://www.fixm.aero/about/extensions/extensionschedule.pl

process the data for output to FAA's Traffic Flow Management System (TFMS) for display on a Traffic Situation Display (TSD) (Figure 4). The SDI prototype has been demonstrated using real-time telemetry from SpaceX for Dragon capsule reentries, as well as with telemetry from Blue Origin for ascent of the New Shepard vehicle.

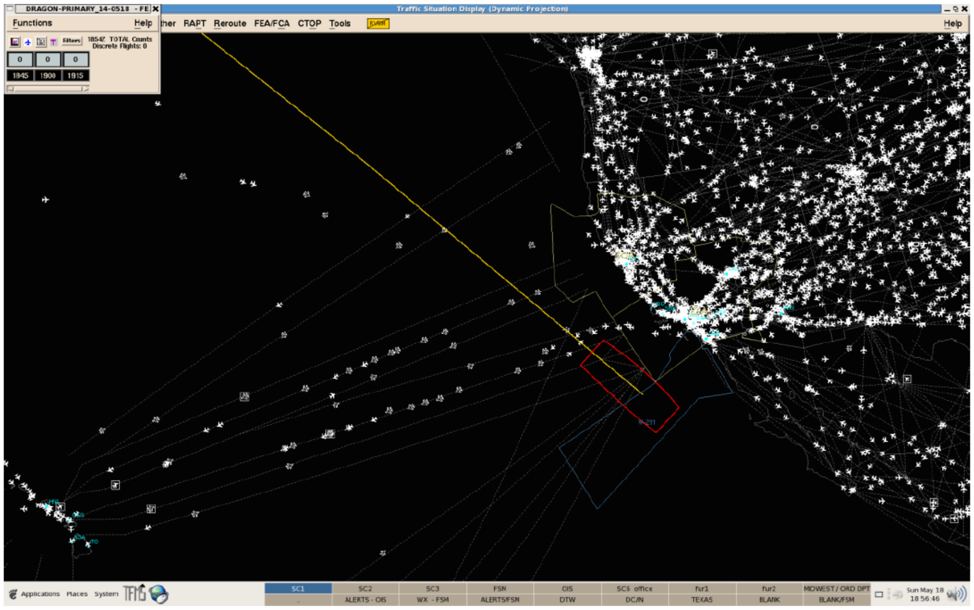

Figure 4: SDI-generated Dragon capsule track displayed on TSD (yellow)

3.0 DISCUSSION AND RECOMMENDATIONS

As the full AAP ARC considers the issue of airspace prioritization, potential NAS efficiency gains that may be realized through the proposed improvements reviewed by the Task Group should be taken into consideration. FAA should increase its emphasis and efforts to reduce the NAS impact of space vehicle operations, thereby benefiting all airspace users and reducing or eliminating the need for operational prioritization.

Improvement of aircraft hazard area calculation and management would yield by far the greatest NAS benefit of any reviewed by the Task Group. The aircraft hazard area size and duration directly affects the number of aircraft rerouted or delayed, and reduction of these large preemptive airspace closures would produce results ranging from significant reduction of NAS impact, to near elimination of the impact[3]. In addition, the development of a debris response capability, utilizing Debris Hazard Volumes calculated in real-time in the event of a space vehicle breakup, should be an integral strategy to reducing nominal airspace closures. The debris response capability would also provide additional enhancement to NAS safety in those rare cases where nominal airspace closures do not

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[3] Colvin, Thomas J. , and Juan J. Alonso. "Near-Elimination of Airspace Disruption from Commercial Space Traffic Using Compact Envelopes", AIAA SPACE 2015 Conference and Exposition, AIAA SPACE Forum, (AIAA 2015-4492)

currently provide protection (such as in the case of the 2003 Space Shuttle Columbia breakup[4]).

During the pre-launch phase of space mission planning, which can span a period of days to years, there is a need for a NAS impact assessment capability available to stakeholders. The availability of NAS impact assessment tools to industry could provide significant benefits for long-range spaceport siting planning as well as the planning of launch times and trajectories to minimize impacts to the NAS. While many missions have little flexibility in scheduling, there are others that may benefit from the ability to predict and avoid peak NAS impact dates or times. Because NAS impact assessment requires defined aircraft hazard area dimensions, any tools developed should include the ability to calculate nominal hazard areas, as many commercial space operators either do not produce these airspace volumes themselves, or do not produce them far enough in advance of a mission to be useful for NAS planning. In addition, there is a need for improved data sharing capabilities and greater visibility into launch and reentry schedules for all NAS users. Although space mission schedules do shift, aviation stakeholders can benefit from improved awareness of planned launches and reentries further in advance.

The management of aircraft hazard area closures should be improved through better real-time information exchange with space vehicle operators and enhanced air traffic controller decision support tools. Current airspace closures follow a pre-determined schedule, with airspace closed and aircraft rerouted at the start of the launch window. However, in most cases, the space vehicle operator has additional information available throughout the countdown that could be used to dynamically close the airspace at a shorter time horizon from the actual launch or reentry. The SVO ConOps refers to this as “Just-in-Time Activation”, and proposes automation support for enabling this capability. Similarly, the re-opening of airspace after the launch or reentry should be optimized to reduce unnecessary reroutes or delays once the risk to aircraft has passed. Real-time debris response capability, such as that provided by HRAM, requires tracking information for the space vehicle. FAA has pursued a link to operator telemetry through the SDI prototype and has developed and tested Advanced ADS-B for space vehicles as two possible sources of tracking information. In addition, new ERAM and TFMS capabilities, such as hazard area dissemination and display for air traffic controller and traffic manager workstations is important for efficient airspace activation and deactivation.

The Task Group believes that FAA should collaborate with NAS stakeholders to identify and prioritize next steps on the proposed NAS improvements. Industry stakeholders are open to discussions with FAA on opportunities to expedite the implementation of airspace integration tools.

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[4] Lin, Mark Y. Y., Erik W. F. Larson, and Jon D. Collins, “Determination of Debris Risk to the Public Due to the Columbia Breakup During Reentry,” Columbia Accident Investigation Board Report, Vol 2, Appendix D.16, September 2003.

Risks associated with the implementation of the proposed improvements include:

- FAA fails to effectively prioritize the improvements necessary to keep pace with UAS, balloon, and commercial space operations in the NAS
- Insufficient FAA funding to develop and implement the necessary technologies within an expeditious timeframe.
- Lack of a lead organization to perform system integration across the wide array of tools and capabilities presented.
- Insufficient procedures or training could limit the effectiveness of the improvements

3.1 Summary of Recommendations

The Task Group submits the following recommendations, which are intended to optimize NAS operations and avoid the need for prioritization. Implementation of these recommendations could be expected to improve NAS safety and efficiency during commercial space operations while accommodating all NAS users.

Near Term:

- ➢ FAA should pursue improved procedures to utilize existing capabilities and information.
- ➢ FAA should provide stakeholder access to a NAS assessment tool for launch and reentry planning as soon as possible.
- ➢ FAA and NAS users should identify and pursue opportunities for enhanced stakeholder information exchange to enable more efficient planning and data sharing

Far Term:

- ➢ FAA should enhance automation platforms, such as ERAM, STARS, and TFMS, as necessary, to process and display nominal and off-nominal hazard areas and other information as needed to improve the management of hazard areas
- ➢ FAA should accelerate development and deployment of improved hazard area calculation methodologies and procedures to reduce the size and temporal impact of airspace closures
- ➢ FAA should accelerate development and deployment of a capability to respond to off-nominal debris-generating events in real time, rather than preemptively closing large volumes of airspace
- ➢ FAA should develop and deploy a capability to obtain and process real-time tracking information for space vehicles
- ➢ FAA should develop procedures that utilize the new tools and capabilities to realize NAS benefits

- FAA should develop and conduct operator training to ensure maximum NAS benefit is realized
- FAA should update their budget planning to capture requirements to develop the above proposed capabilities

3.2 Recommended Actions and Schedule

The Task Group suggests that the FAA work to accomplish the following actions to achieve the above recommendations:

Immediately:

Industry Collaboration

- The ARC has provided a useful, albeit temporary, forum for NAS stakeholder collaboration. A stakeholder steering committee should be established to provide ongoing input to FAA as NAS improvements are developed and implemented. This could take the form of a Collaborative Decision Making (CDM)-type group or a similar forum.

Near Term (next 12 months)

Collaborative Planning (Figure 5)

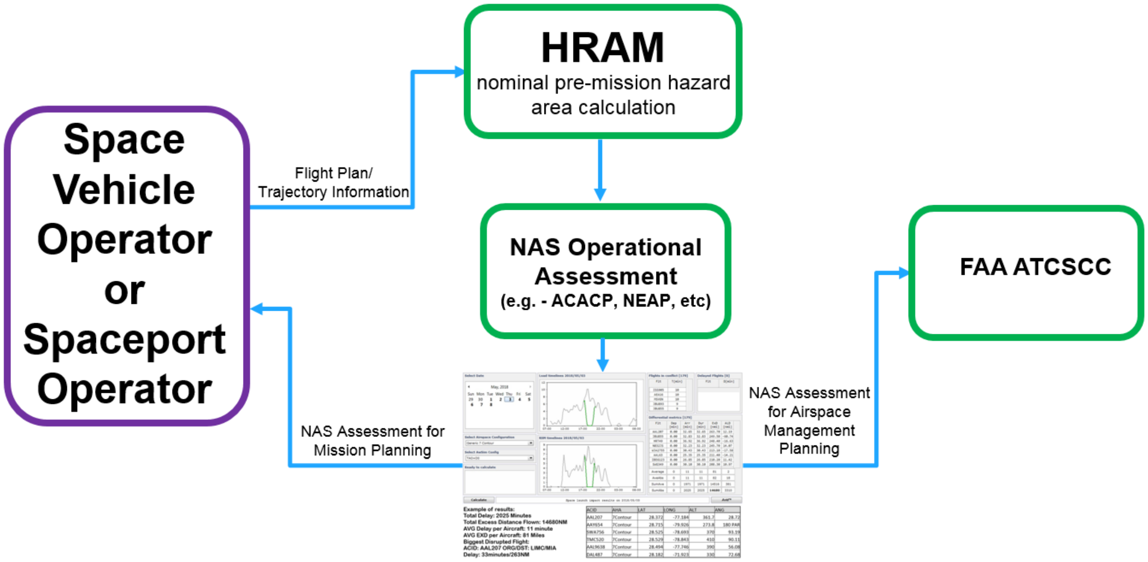
- Implement the HRAM capability to calculate nominal pre-mission STCs and make the results available to operators and NAS assessment tools
- Implement a NAS operational assessment capability (similar to NEAP or ACACP) and make it available to operators online. This capability should utilize nominal STCs from HRAM and provide operators with NAS assessments that can aid in pre-mission and spaceport planning

Enhance Data Sharing

- Work with operators to improve information exchange that can enable more dynamic airspace activation/deactivation
- Develop a data standard that establishes recommended elements and formats for the automated exchange of commercial space operational data

Improved Hazard Area Management

- Utilize improved operator information to activate and deactivate STCs more dynamically, reducing the impact to other airspace users
- Implement procedures and training at air traffic facilities to avoid rerouting aircraft too early and to ensure prompt recovery when STCs are deactivated



Example of results:
Total Delay: 2025 Minutes
Total Excess Distance Flown: 14680NM
AVG Delay per Aircraft: 11 minute
AVG EXD per Aircraft: 81 Miles
Biggest Disrupted Flight:
ACID: AAL207 ORG/DST: LIMC/MIA
Delay: 33minutes/263NM

ACID	AHA	LAT	LONG	ALT	ANG
AAL207	7Contour	28.372	-77.184	361.7	28.72
AAY654	7Contour	28.715	-79.926	273.8	180 PAR
NWA756	7Contour	28.525	-78.693	370	93.19
TMC520	7Contour	28.529	-78.843	410	90.11
AAL9638	7Contour	28.494	-77.746	390	56.08
DAL487	7Contour	28.182	-71.923	330	72.68

Figure 5: Near-term collaborative planning

Far Term (12-36 months) (Figure 6)

FAA Automation Enhancements

(Note: Dynamic SAA display capabilities in existing FAA automation platforms would yield efficiency benefits for commercial space, UAS, and balloon operations, even before additional recommended automation tools are available)

- Enable automated dynamic display of nominal and off-nominal hazard areas (STCs and DHVs) on air traffic controller and traffic manager displays (TFMS, ERAM, STARS, etc.) Hazard areas created or modified by HRAM or a similar source should be pushed to air traffic controller displays and updated in real time as appropriate.
- Implement decision support tools in automation systems for air traffic controllers and traffic managers, including mission status timers, STC and DHV activation and deactivation event indicators, conflict probe alerts to identify affected aircraft, and other capabilities as needed.

HRAM

- Enable HRAM to receive and process real-time tracking data for space vehicles (from SDI, ADS-B, or other tracking source)
- Deploy the HRAM capability for real-time debris mitigation (calculation of Debris Hazard Volumes in the event of a space vehicle failure). This includes transfer of this data between HRAM and FAA air traffic control and traffic management automation systems
- Leverage this real-time debris response capability to reduce the physical and temporal dimensions of nominal STCs, thereby reducing NAS impact

- Improve HRAM algorithms to remove unnecessarily conservative assumptions, such as continuous aircraft presence. Hazard area calculations should evaluate risk based upon historical or predicted aircraft density in the affected airspace

SDI

- Enable SDI-processed telemetry to be supplied to HRAM and other automation platforms as necessary.

FAA Procedures and Training

- Develop and implement procedures for air traffic controllers and traffic managers to use when managing nominal STCs that allow maximum use of the affected airspace before and after the space vehicle operation.
- Develop and implement procedures for air traffic controllers to clear airspace when necessary in the case of an off-nominal debris-generating event.
- Develop and implement training for air traffic controllers and traffic managers to ensure proficiency in the application of the applicable tools and procedures.

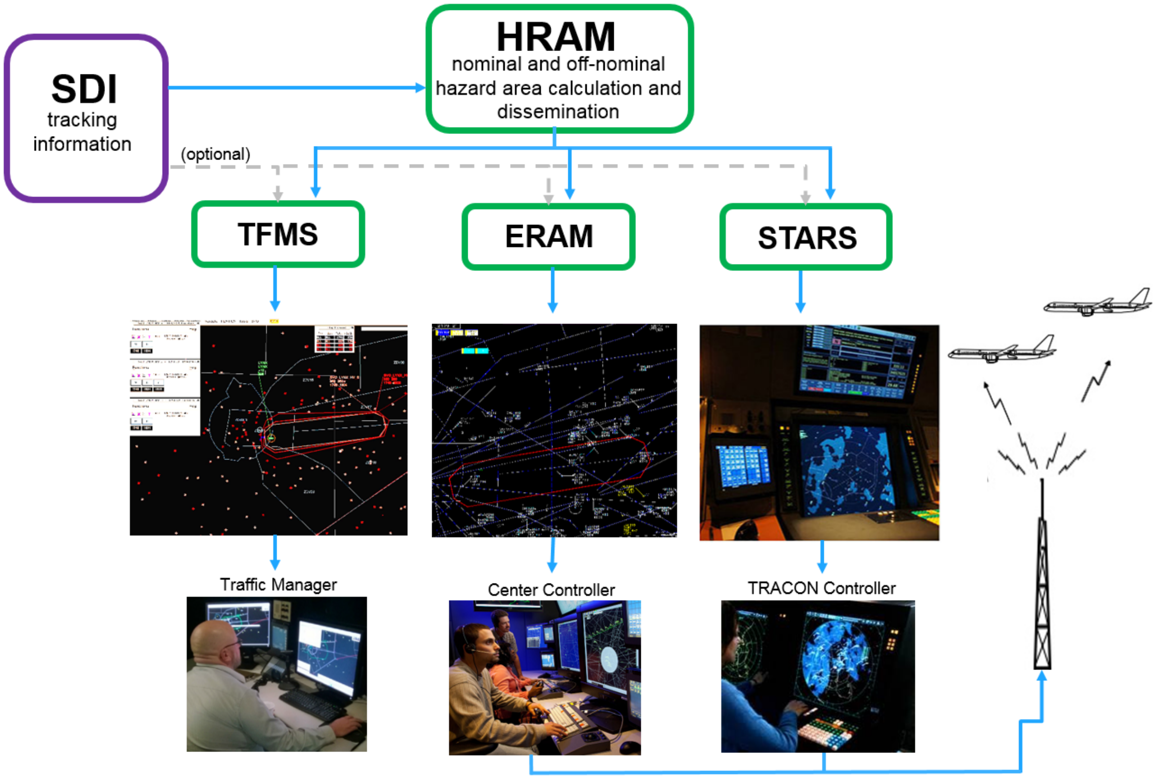


Figure 6: Far-term NAS state

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APPENDIX B Technical Interchange Meeting Agenda

May 17th, 2018 **9:00AM – 4:00PM**

Location: The Portals III, 1201 Maryland Avenue SW, Washington, DC 20024

Nearby Resources:

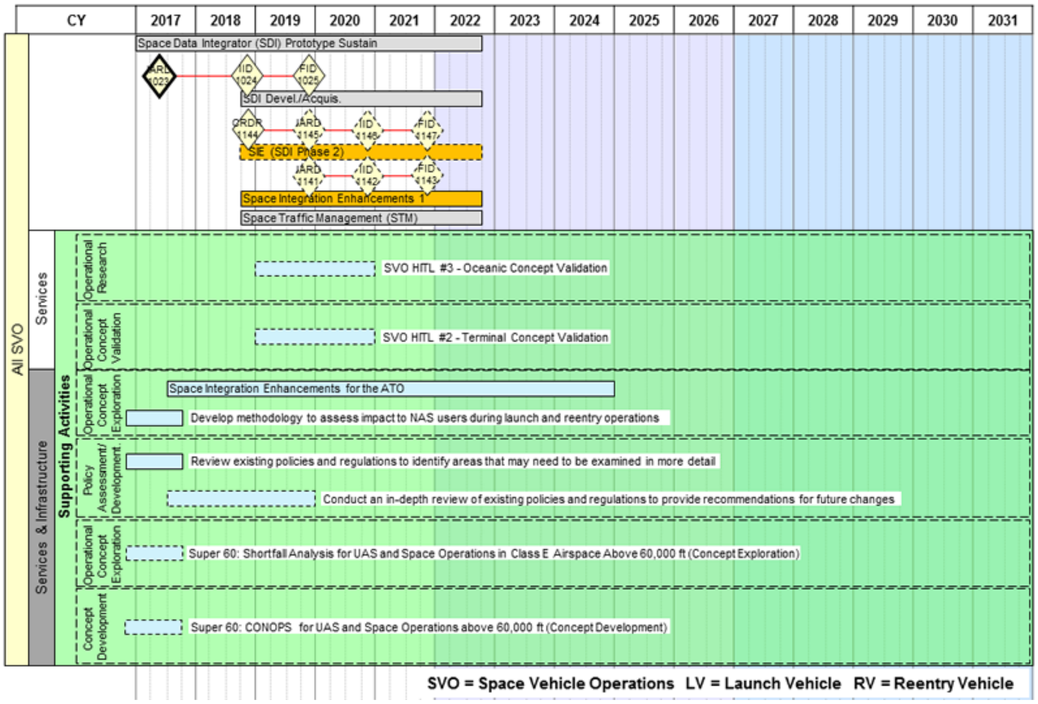
- Starbucks and CVS on the ground floor
- Potbelly Sandwich and Flippin' Pizza across the street
- Capital Café (buffet) near the courtyard of the FCC building across the street
- Mandarin Oriental Hotel across the street

Agenda

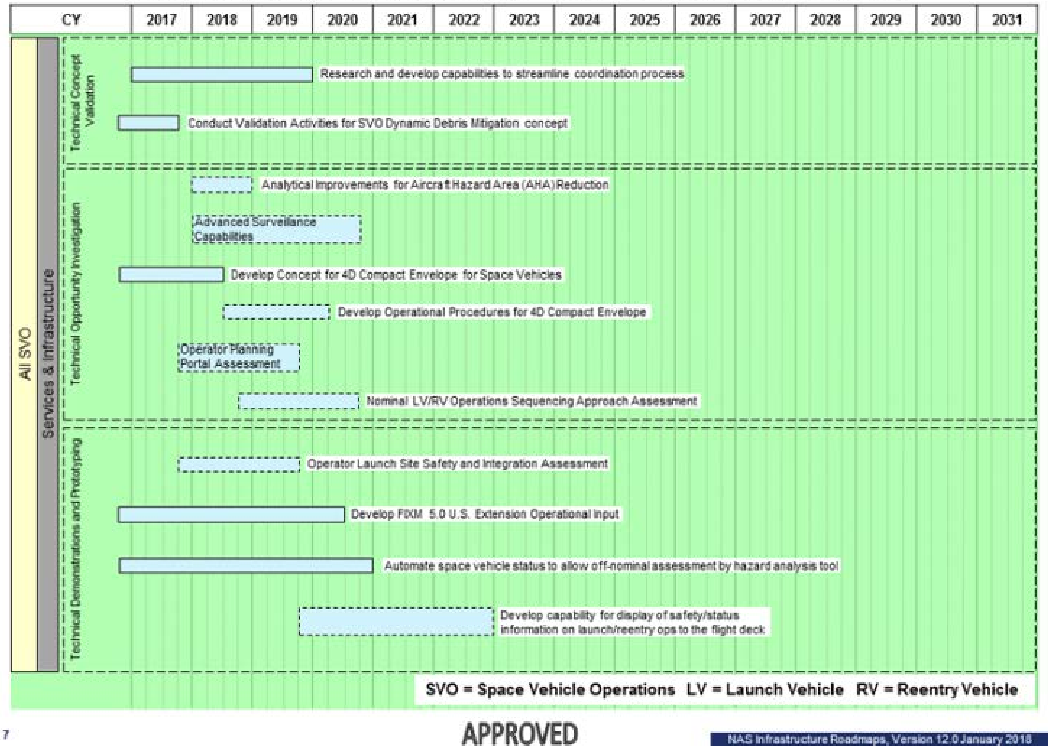
8:45 – 9:00 AM	Arrival / Check-In
9:00 – 9:15 AM	Introduction and Logistics
9:15 – 10:00 AM	Space Vehicle Operations (SVO) Concept of Operations
	Phil Bassett, FAA Office of NextGen (ANG)
	Dan Murray, FAA Office of Commercial Space (AST)
	Harry Bergmann, FAA Command Center, Space Operations (AJR)
10:00 – 11:00 AM	Hazard Risk Assessment and Management (HRAM)
	Erik Larson, ACTA, Inc.
11:00 – 11:15 AM	Break
11:15 – 12:00 PM	4D Compact Envelopes
	Professor Juan Alonso, Stanford University
12:00 – 1:00 PM	Lunch
1:00 – 1:30 PM	Commercial Space Integration Capabilities
	Devin Dickens, Millenium Engineering & Integration
1:30 – 2:00 PM	FAA/Operator Data Exchange Diagrams
	NAS Effects Analysis Prototpye
	Zheng Tao, MITRE Corp.
2:00 – 2:30 PM	NAS Impact Modeling
	Dan Bogdan, AS&T
2:30 – 2:45 PM	Break
2:45 – 3:15 PM	FAA Commercial Space Roadmap
	Frank Weber, NAS Enterprise Planning & Analysis Division
3:15 – 4:00 PM	Group Discussion, Adjourn
	Task Group Members

APPENDIX C NextGen Commercial Space Roadmap

New Entrants Roadmap (6 of 7: Commercial Space)



New Entrants Roadmap (7 of 7: Commercial Space)



Dashed borders indicate UNFUNDED activities

APPENDIX E: TASK GROUP 2 CHARTER

Terms of Reference
FAA Airspace Access Priorities ARC: Operator constraints and limitations Task Group

1.	**Statement of Objective, i.e. what is the problem/requirement:** ARC industry representation includes participants from the Balloon, Commercial Space, Drone, and traditional manned aviation sectors of the industry. During our plenary session on April 6 we discussed constraints, limitations and challenges associated with the airline industry. It became apparent that many ARC participants clearly understand constraints facing their own industry sector, but do not have adequate knowledge of nor appreciation for the constraints faced by their colleagues in the other sectors. We realized that in order to develop educated recommendations we must all have a much more in-depth understanding of constraints faced by each National Airspace System (NAS) operator.
2.	**Statement of scope of task/activity:** Evaluate any and all constraints, challenges and limitations faced by operators in the Balloon, Commercial Space, Drone, and traditional manned aviation sectors. Constraints include, but are not limited to: Fiscal or other resource challenges, conflicting business models, political challenges, technology shortfalls among operators and also those associated with FAA ATM service delivery, inefficient airspace design and utilization, inefficient ATC facility sectorization, infrastructure constraints, operational or mission-related imperatives that impede seamless integration, communications gaps, inefficient strategic coordination and planning, inefficient operational concepts relative to spaceport and airport activities in an integrated NAS.
3.	**What is the expected deliverable/product:** A clear description of constraints, challenges and limitations that impede seamless integration of all NAS operators in the NAS faced by each industry sector: Balloons, Commercial Space, Drones and Traditional manned Operators, to be used to inform ARC deliberations regarding the formulation of proposals related to policies associated with priority of NAS access.
4.	**Special Considerations:** Recommendations should include an evaluation of the risks or outcomes associated with the inability to overcome the identified challenges.
5.	**What is the schedule of activities:** The Task Group Lead will determine frequency of meetings based on progress of the group. The final Task Group deliverable is due to the ARC plenary on July 25, 2018.
6.	**Related Activities:** Work closely with appropriate FAA Lines-of-Business; other government agencies as needed, including NASA; MITRE and other research and development entities; key ARC industry stakeholders and other industry operators and manufacturers as necessary.

7.	**What are the resource requirements and commitments:** • Participation commitment by Task Group members. • Meetings may be face-to-face, via telcon or Webinar.
8.	**What is the urgency/criticality:** Completion of this work is necessary to inform the ARC plenary deliberations regarding policy related to priority of NAS access.
9	**Who are the customers for the product/deliverable:** The Airspace Access Priorities ARC.
10.	**Will this result in UASCA ARC recommendations or is this coordination to keep UAS ARC aware of significant related activities:** Task Group results will contribute to the formulation of ARC Recommendations.
11.	**Action Team Leader:** George Merritt (Denver International Airport)
12.	**Action Team Members:** Captain Marc Henegar Darrell Pennington Melissa Sabatine Scott Henderson Brandon Suarez Ashish J. Solanki Heidi J. Williams Ernie Stellings SMEs will be used from government and industry as needed.

APPENDIX F: TASK GROUP 2 REPORT

Draft Report

TASK GROUP 2— OPERATOR CONSTRAINTS AND LIMITATIONS

Airspace Access Priorities Aviation Rulemaking Committee

This document summarizes the findings and recommendations compiled by Task Group 2 of the Airspace Access Priorities Aviation Rulemaking Committee (ARC). Task Group 2 was charged with addressing the second of four tasks assigned to the ARC: "Review the respective operational needs and constraints across the community of stakeholders for access to the National Airspace System to meet their respective objectives."[1]

Task Group Scope

As noted above, the Task Group was assigned to address the second of the four tasks that the ARC was given by the FAA in its November 20, 2017 committee charter—reviewing the operational needs and constraints for access to the NAS. The scope of the Task Group was detailed further in Terms of Reference issued by the ARC's leadership team in April 2018, which are included in Attachment A. This scope was as follows:

> *Evaluate any and all constraints, challenges and limitations faced by operators in the balloon, commercial space, drone[2], and traditional manned aviation sectors. Constraints include, but are not limited to: fiscal or other resource challenges, conflicting business models, political challenges, technology shortfalls among operators and also those associated with FAA ATM service delivery, inefficient airspace design and utilization, inefficient ATC facility sectorization, infrastructure constraints, operational or mission-related imperatives that impede seamless integration, communications gaps, inefficient strategic coordination and planning, inefficient operational concepts relative to spaceport and airport activities in an integrated NAS.*

The Task Group further refined its definition of the sectors enumerated in its scope as follows:

- Balloons: Operators of lighter-than-air aircraft that is not engine driven, and that sustains flight through the use of either gas buoyancy or an airborne heater and the operators of the sites from which such aircraft are launched. In this effort, the Task Group focused primarily on unmanned free balloons, rather than on manned free or tethered balloons. The Task Group also did not consider airships—engine-driven, lighter-than-air aircraft that can be steered—in its deliberations.

- Commercial space: Commercial operators of either vertically or horizontally-launched, powered vehicles destined for sub-orbital, orbital, or extra orbital trajectories. As interpreted by the Task Group, this sector excludes military and other government launch and reentry activity, although it does include commercial operations that carry military or government payloads. The sector also includes operators of spaceports that serve commercial spacecraft during vehicle launch, recovery, or both.

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[1] Airspace Access Priorities Aviation Rulemaking Committee Charter, 20 November 2017.

[2] The term "drone" has been replaced below by the more technically accurate terms "Unmanned Aircraft System" (UAS) and "Remotely Piloted Aircraft System" (RPAS).

- Unmanned Aircraft Systems (UAS)/Remotely Piloted Aircraft Systems (RPAS): Operators of devices used for flight that have no onboard pilot, excluding balloons and unmanned rockets/spacecraft. The sector also includes facilities from which UAS/RPAS are launched and recovered.

  UAS currently operated under 14 CFR 107 are known as “small UAS” and weigh less than 55 pounds. These small UAS and the pilot community that flies them are projected to rapidly increase over the next 10 years. In the last three years alone (2016 to 2018) the current number of UAS pilots certified by the FAA has reached 93,000 and continues to rise.

  The number of applications for advanced operations, below 400 feet above ground level (AGL) and drifting into low altitudes above 400 feet AGL, with larger drones exceeding 55 pounds is also a consideration that must be included the operational constraints placed on the NAS. Low altitude advanced operations include urban air mobility platforms, medevac services and infrastructure maintenance. While lighter drones may be largely contained into a UTM, advanced drone operations that fall into the heavier and advanced operations category, will utilize existing and new vertiports, vertistops and heliports and transit to and from airports operating across UTM, ATM boundaries in all classes of lower airspace.

  ICAO defines a RPAS as “A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design.” The differentiation of the ICAO definition for RPAS versus Drones has been a deliberate one in an effort to accommodate the projected use of drones in higher altitude and lower altitude respectively.

- Manned aviation: Operators of aircraft—both fixed wing and rotorcraft—that have an onboard crew and are not balloons or spacecraft. The sector also includes the facilities used by these aircraft for takeoff and landing (i.e., airports, seaplane bases, and heliports). Manned aviation encompasses a range of operator types including general aviation, business aviation (including on-demand air taxi operations), commercial passenger airlines, and commercial all-cargo airlines.

With the exception of low altitude (roughly defined as below 400 feet AGL) UAS operations, the Task Group generally limited the scope of its assessment to the consideration of operational limitations and constraints that affect the vehicles’ use of controlled airspace (e.g., FAA Airspace Classes A, B, C, D, and E), primarily Class A and E airspace.

Task Group Members

The member roster of the Task Group is included in Attachment B. As shown, this roster includes representatives from commercial airlines, business and general aviation, manned aviation pilots, airports, balloon operators, vertical and horizontal space launch operators, state government, and aerospace manufacturers/vendors.

Approach

Initially, Task Group members were asked to complete a brief survey to establish an initial understanding of the needs and constraints of various stakeholder sectors as well as to get initial impressions of the types of metrics and performance indicators that could be used to assess the effects the identified constraints have on NAS and space/high-altitude operations.

The data collected from this survey, anonymized by industry sector, are provided in Attachment C.

Following the survey, the Task Group held several two conference calls during which industry sector definitions were refined and sector constraints and limitations were developed. The Task Group concluded its work by developing a series of findings and recommendations based on its deliberations regarding sector needs and constraints.

Key Sector Characteristics, Constraints, and Limitations

Balloons

The operators of unmanned free balloons must to comply with regulations prescribed in 14 CFR Part 101. Section 101.33 of these regulations specifies the following operating limitations for unmanned free balloons:

> “No person may operate an unmanned free balloon—
>
> (a) Unless otherwise authorized by ATC, below 2,000 feet above the surface within the lateral boundaries of the surface areas of Class B, Class C, Class D, or Class E airspace designated for an airport;
>
> (b) At any altitude where there are clouds or obscuring phenomena of more than five-tenths coverage;
>
> (c) At any altitude below 60,000 feet standard pressure altitude where the horizontal visibility is less than five miles;
>
> (d) During the first 1,000 feet of ascent, over a congested area of a city, town, or settlement or an open-air assembly of persons not associated with the operation; or
>
> (e) In such a manner that impact of the balloon, or part thereof including its payload, with the surface creates a hazard to persons or property not associated with the operation.

Due to these operational limitations, balloon operators face challenges in siting launch and recovery sites at locations that enable them to avoids overflight of populated areas. For launch sites located within or under Class B, C, D, or E airspace, also face the need to coordinate their operations with local air traffic control to manage airspace interactions/conflicts.

In addition to the visibility constraints contained in §101.33, balloon operators also face weather-related launch constraints. Wind conditions are of particular concern, with calm or low-velocity winds being needed during balloon inflation and during launch to prevent balloon damage and ensure balloon controllability.

Since balloons considered in the Task Force’s work are not mechanically-powered (although they are controllable), their maneuverability in the airspace is more limited than manned aircraft and drones and constraints their ability to see and avoid other aircraft in the airspace and/or take action to avoid airspace conflicts.

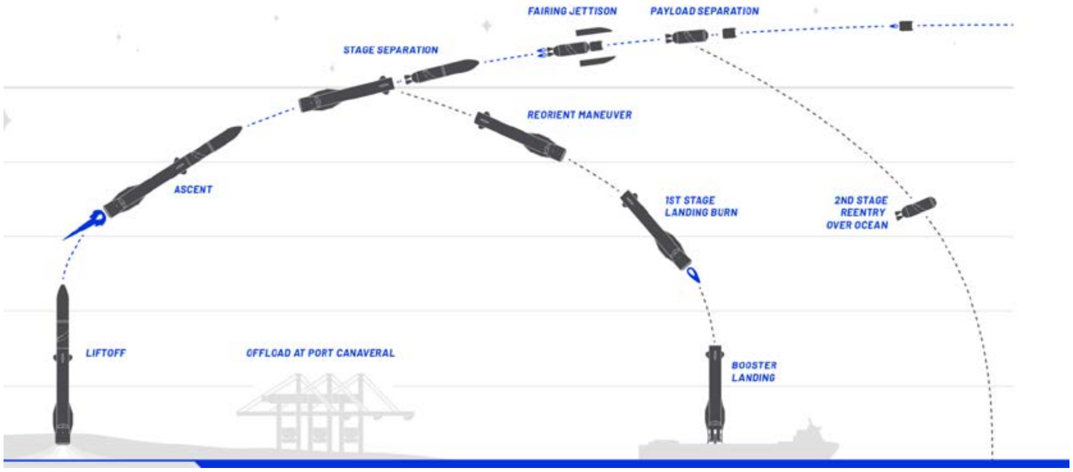
Commercial Space

Commercial space vehicles and launch systems come in a variety of types that directly affect the airspace constraints and limitations they face. As noted, previously, the Task Force focused specifically on the constraints and limitations associated with the passage of these vehicles through controlled airspace on their way to or back from space. This occurs during both during the launch phase and reentry/recovery phases of space missions.

The Task Force considered the following types of commercial space vehicles in its deliberations.

Vertically-launched vehicles. Vertically launched spacecraft are powered by either liquid or solid propellants and can have one or more stages depending on the mission type, payload, and desired trajectory, among other factors. Some vertically-launched vehicles consist of entirely expendable components (e.g., booster stages, farings) that either fall back to Earth or burn up on reentry following launch. Examples of this class of vehicles include the ULA's Atlas V and Delta IV rockets and Orbital ATK's Minotaur family of rockets. They also include smaller suborbital vehicles such as the Black Brant and Orion sounding rockets.

Other vertically-launched vehicles include reusable components that are capable of powered reentry and landing. Examples include Space X's Falcon rocket family and Blue Origin's New Shepard and New Glenn rockets. With these vehicles, the reusable components—most typically first stage boosters—perform a reorientation maneuver to position themselves for deceleration and landing and then fire retrorockets to slow themselves as they approach their landing site. These reusable components also include some aerodynamic control surfaces that are used to steer, slow, and stabilize the vehicle. The figure below, taken from Blue Origin's website, depicts this operational concept.



Source: https://www.blueorigin.com/new-glenn, 2018.

Vertically-launched vehicles also include reusable vehicles as their payloads. A well-known historical example is NASA's Space Shuttle. A more current example is Sierra Nevada Corporation's Dream Chaser, which is slated to be carried into orbital space by an Atlas V rocket in the near future. After being launched into space vertically, much like the Space Shuttle before it, the Dream Chaser will reenter the atmosphere and glide towards its landing site—termed a skid strip because the vehicle has a skid instead of a nosewheel—using aerodynamic control surfaces for steering, altitude, and speed control.

Horizontal-launched vehicles. A second type of space vehicles are launched horizontally and include three major subtypes. The first of these, termed “Concept X” by the FAA, resemble aircraft with wings and aeronautical control surfaces. Concept X vehicles use jet engines for takeoff and their initial climb through the atmosphere. At altitudes of between 40,000 and 55,000 feet above mean sea level, these vehicles transition to rocket power in flight to propel them into suborbital space. Upon reaching the top of their suborbital trajectories, these vehicles then descend back into the atmosphere where they either glide unpowered or resume jet powered flight back to a runway or “skid strip” for landing.

The second subtype, termed “Concept Y” by the FAA, use rocket motors for takeoff, aeronautical climb, and post-aeronautical climb into suborbital space, during which time the rocket motors cut off. Upon reaching the top of their trajectories in suborbital space, these vehicles glide back to a runway or skid strip for landing.

The third subtype, termed the “Concept Z”, is composed of two separate vehicles—a carrier aircraft and a carried spacecraft. The spacecraft can be either an expendable rocket or a reusable launch vehicle (. In either case, the carrier aircraft and its carried spacecraft takeoff and climb to altitude in a manner similar to other manned aircraft. Upon reaching the desired launch altitude and position, the spacecraft is launched from the carrier aircraft. After spacecraft launch, the carrier aircraft returns to its base under powered flight. If the spacecraft is expendable, its launch components either fall back to earth or burnup on reentry into the atmosphere. If the spacecraft is instead reusable, it will return via either vertical or horizontal landing, depending on the spacecraft’s operating characteristics. Virgin Galactic’s White Knight aircraft paired with its SpaceShipTwo RLV is an example.

Commercial Spacecraft Constraints and Limitations

Spacecraft face a variety of operational constraints related to their mission requirements. These include:

- **Launch timing constraints imposed by the need to intercept other spacecraft or achieve necessary orbital or extraorbital trajectories.** For example, missions to the International Space Station (ISS), for which there are only limited launch time windows available to the launch operator. If these are missed, launch may need to be delayed for hours or days until the desired intercept trajectory can be achieved again. Extraorbital missions, which have complex trajectories and can involve the use of the Earth, Moon or other planets to accelerate their spacecraft, face even more stringent constraints in terms of launch timing and sites. If these missions miss their launch windows, the missions can be delayed for weeks, months, or even years—literally until the planets align.

- **Launch site constraints driven by launch trajectory requirements.** For example, spacecraft with payloads that that need to reach achieve geostationary orbits need to be launched from facilities that enable the spacecraft to reach positions over the Earth’s equator. Similarly, payloads that need to be positioned in polar orbits need to be launched from facilities where the spacecraft can achieve orbits aligned with the North and South Poles.

- **Launch site constraints associated with safety considerations.** Commercial space operators need to perform extensive safety risk assessments of their launches in accordance with procedures and regulations established by statute[3] and further defined in regulations[4], orders[5], and advisory circulars published by the FAA's Office of Commercial Space. These safety assessments are focused on the protection of people and property on the ground at the launch site and beneath the launched vehicle during its launch. To manage safety risks and meet FAA safety criteria, most launch sites are located in rural areas with launch paths that carry spacecraft over oceans and/or sparsely/unpopulated areas. Reusable launch vehicles must undergo to safety risk assessments of their reentry and landing trajectories. These risk assessments are time consuming and mission-specific.

- **Constraints related to vehicle dynamics.** Because of their high velocities, rapid acceleration, and limited ability to maneuver while under rocket power, both vertically-launched and horizontally-launched spacecraft require the clearance of the airspace that they transit. Historically, such airspace closures have been fixed for the duration of launch activities—starting at pre-determined time prior to launch and concluding some time after the launch, usually as the spacecraft leaves controlled airspace and transitions to suborbital/orbital phases of flight.

  Airspace closures are also associated with spacecraft or RLV reentry and landing/return to Earth. These closures reflect the time and space required for these spacecraft, spacecraft components, or RLV to transition through controlled airspace back to the Earth's surface. In some cases, components are allowed fall back to Earth without active flight control; in others (e.g., Space X's Falcon 9 and other spacecraft with RLV components), the components "fly" to land under power. In either case, vehicle controllability is limited and it is generally not possible for these components to be maneuvered to avoid collisions with other vehicles or objects in the air.[6]

Fueling/Propulsion-Related Constraints and Limitations

In terms of fuel and propulsion types, solid-propellant rockets do not require significant pre-launch processing. Once ignited, solid fuel rockets burn uninterrupted until their fuel is expended; they cannot be throttled, shutdown, or restarted.

On the other hand, liquid-propellant rockets are fueled minutes to hours before their scheduled launch. Most typically, bipropellant engines are used, meaning that the propellant consists of a fuel and an oxidizer. Some fuels are liquid at ambient ground temperatures (e.g., kerosene); others are cryogenic, meaning they need to be kept at low temperatures (and high pressures) to remain liquid (e.g., liquid hydrogen, liquid natural gas). Oxidizers—liquid oxygen being the most typical—are also cryogenic.

The need to keep cryogenic propellants at very low temperatures prior to launch is the primary reason that liquid propellants are not loaded onto these rockets until shortly before scheduled

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[3] Principally 51 U.S.C. Ch. 509, §§ 50901-23.

[4] Principally 14 CFR Parts 401, 411, 413, 414, 415, 417. 431, 433, and 435.

[5] FAA AC 431.35-2A. *Reusable Launch and Reentry Vehicle System Safety Process:* FAA AC 431.35-1, *Expected Casualty Calculations for Commercial Space Launch and Reentry Missions*; and *Safety Approval Guide for Applicants*, FAA Office of Commercial Space Transportation, July 20, 2012, among others.

[6] After launching their carried spacecraft, Concept Z carrier aircraft are expected to resume operating as manned aircraft and would be treated as such in controlled airspace. Similarly, Concept X spacecraft that have returned to the atmosphere from orbital space are also expected perform as aircraft.

launch. The time required to fuel these rockets does act as an operational constraint—one that can be further complicated by environmental factors such as lightning in the vicinity of the launch site during which fueling activities must be halted.

Once loaded, cryogenic propellants “burn off” at rates that vary depending on the spacecraft design and environmental conditions. If the launch of the spacecraft is delayed, this “burn off” can result in there being insufficient propellant for the mission, preventing launch entirely until the rocket’s fuel tanks can be recycled (i.e., emptied and refilled). Accordingly, launch operators seek to minimize/control external factors that can lead to launch delays once fueling has commenced.

Whether liquid or solid propellants are used, the volume and hazardous nature of fuels used in spacecraft also constrains where launch, fueling operations, and fuel storage can take place at a spaceport/launch site.

Vehicle Reliability Constraints and Limitations

Commercial space vehicles are complex machines that rely on highly volatile propellants, move at very high speeds, and are exposed to extremely high dynamic forces during launch and reentry. In addition, a number of commercial space vehicles have either been recently developed or are still in the process of development and testing. They do not (nor should they have to) meet the same reliability requirements as commercial aircraft.

Accordingly, there are higher likelihoods that commercial spacecraft will fail during its various phases of flight. To protect individuals and property on the surface of the earth or in the airspace near launch or reentry sites, hazard areas are defined well prior to any launch and unauthorized people and vehicles are excluded from these areas for some time prior to and following launch and reentry activities.

Safety risk assessment and approval processes required by the FAA[7] and—depending on the launch site operator—additional oversight from the US Department of Defense or NASA—account for vehicle reliability and drive both allowable trajectories and the size and duration of airspace volumes that need to be closed during launch (and reentry/landing) activities.

These safety assessment processes to take into consideration the demonstrated reliability of particular spacecraft/launch systems. Vehicles with proven track records of successful operations will have smaller volumes of airspace that need to be cleared than those that do not.

Regulatory Constraints & Limitations

Several commercial space operators noted that the current regulatory framework—specifically obtaining commercial space launch licenses and safety approvals under 14 CFR Parts 400-435, is cumbersome and requires redundant and time-consuming analyses, paperwork, and approval processes for what are oftentimes very similar launch operations. These approval processes are indirectly related to the airspace access issues considered within Task Force 2 in that launch permits are a necessary prerequisite to commercial space operators gaining access to the airspace.

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[7] These are specified in 14 CFR Parts 400-435 and related FAA Advisory Circulars.

A related concern is that launch sites operated by other federal agencies (i.e., U.S. Department of Defense, NASA), require their own approval processes separate and apart from those required by the FAA which add to regulatory complexity.

Unmanned Aircraft Systems (UAS)

Unmanned aircraft systems (UAS) are a rapidly-evolving sector of NAS users and as a community contain as diverse a set of interests as aviation itself. The FAA defines an Unmanned Aircraft as:

> “an aircraft operated without the possibility of direct human intervention from within or on the aircraft”

Although considerable attention over the past five years has focused on how small UAS (less than 55 pounds) can operate safely in the NAS and low altitudes (roughly below 400 feet above ground level), there is growing interest on the part of the FAA, UAS operators, and those that will rely on UAS for new capabilities and services to enable UAS operations in controlled airspace—including operations in Class A and E airspace.

The potential for international operations of UAS has been a driving force in ICAO developing the RPAS Manual (ICAO DOC 10019) and establishing the RPAS Panel to develop SARPS and PANS. As noted above, UAS that would be operating in controlled airspace are those considered in this report. Furthermore, the Task Force focused its attention primarily on civilian UAS operations.

Government-operated UAS (e.g., those operated by the Department of Defense, Department of Homeland Security, and Department of Justice) were not considered. However, the Task Group does acknowledge that these types of operations which are conducted pursuant to national defense, border protection, law enforcement, or public safety will have high priority for access to and use of the NAS.

It should be noted that at the time Task Force 2 was deliberating, a separate ARC—the Unmanned Aircraft Systems in Controlled Airspace (UASCA) ARC—was also underway. The UASCA was chartered in 2017 to:

- Develop and recommend scenarios that encompass the most desired operations.
- Identify where gaps exist in research and development needed to inform the successful integration of UAS into controlled airspace.
- Develop and recommend up to five prioritized changes and/or additions to capabilities and/or procedures required to achieve the successful integration of UAS into controlled airspace.

Because the work of the UASCA ARC was underway at the same time of Task Force 2’s work, Task Force 2 could not take full advantage of UASCA’s very similar and more detailed efforts. This said, members of the UASCA—including its co-chair, did participate in Task Force 2’s deliberations and provided limited insight into the UASCA’s efforts.

Common UAS Constraints and Limitations

Central to the definition of a UAS is the dislocation of the pilot from the aircraft, therefore all UAS share a constraint that they may end up in a state, possibly by design, where human intervention is not possible in the flight. For RPAS, ICAO defines this state as “Loss of C2 Link State” and it is commonly known as “Lost Link”. Some UAS may be designed with such high levels of automation, and even autonomy, such that human intervention is not possible from the beginning of the flight. However a Loss of C2 Link State is entered, NAS users will experience an aircraft on a pre-determined or pre-programmed trajectory. Special procedures have been developed by the FAA to efficiently manage this situation today, but additional development is required for these procedures to scale to the NAS. Additionally, further technological development is needed for UAS without pilot intervention to operate in the NAS in manner completely consistent with how an onboard pilot would operate. A standardized set of procedures for Loss of C2 Link in controlled airspace are envisioned to prioritize safety over efficiency, initially.

In addition to the C2 Link, UAS must incorporate technological solutions to replace functions performed by the onboard pilot. Critical among these is Detect and Avoid systems to replace the pilot “see and avoid” responsibilities. Detect and Avoid (DAA) has been defined by the FAA as both the ability to Remain Well Clear (RWC) and perform Collision Avoidance. There are many other functions that pilots perform by “looking out the window”, even when operating under IFR, so UAS will need to replace those functions with either procedures or technology. Even something as simple as a UAS not being able to accept a “maintain visual separation” request from ATC may have big impacts on a terminal area during busy time in VMC.

It is worth noting that if UAS technology (e.g. Detect and Avoid) is introduced to traditionally manned aircraft in order to enhance safety and/or enable reduced crew operations, this constraint may not be present since the onboard pilot would still be capable of managing the flight even in the event of a Loss of C2 Link.

Remotely Piloted Aircraft Systems (RPAS)

Currently, the scope of potential UAS, both in terms of vehicles and operations, is unbounded and could be considered as broad as aviation itself. For this reason, some additional distinctions are helpful to refine the scope and bound the discussion. ICAO has defined RPAS in Annex 2 as:

> “A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design.”

And Remote Pilots as:

> “A person charged by the operator with duties essential to the operation of a remotely piloted aircraft and who manipulates the flight controls, as appropriate, during flight time.”

While these broad definitions allow for many technical, regulatory, and policy details to be developed, they provide helpful architectural boundaries. The ICAO RPAS Panel is currently working to develop Standards and Recommended Practices (SARPS) and Procedures for Air Navigation Services (PANS), which will update nearly every ICAO Annex and generate new Guidance Material, for the context of “international RPAS operations under IFR in controlled airspace”. The FAA will have significant flexibility to enable UAS operations in the NAS, but as a signatory to the ICAO treaty, will eventually have to enable RPAS operations that comply with ICAO SARPS.

The FAA’s UAS in Controlled Airspace ARC has developed two operational use cases; Transit and Local Area of Operation. The UASCA ARC report contains more details on this use cases and figures from the report are provided below.

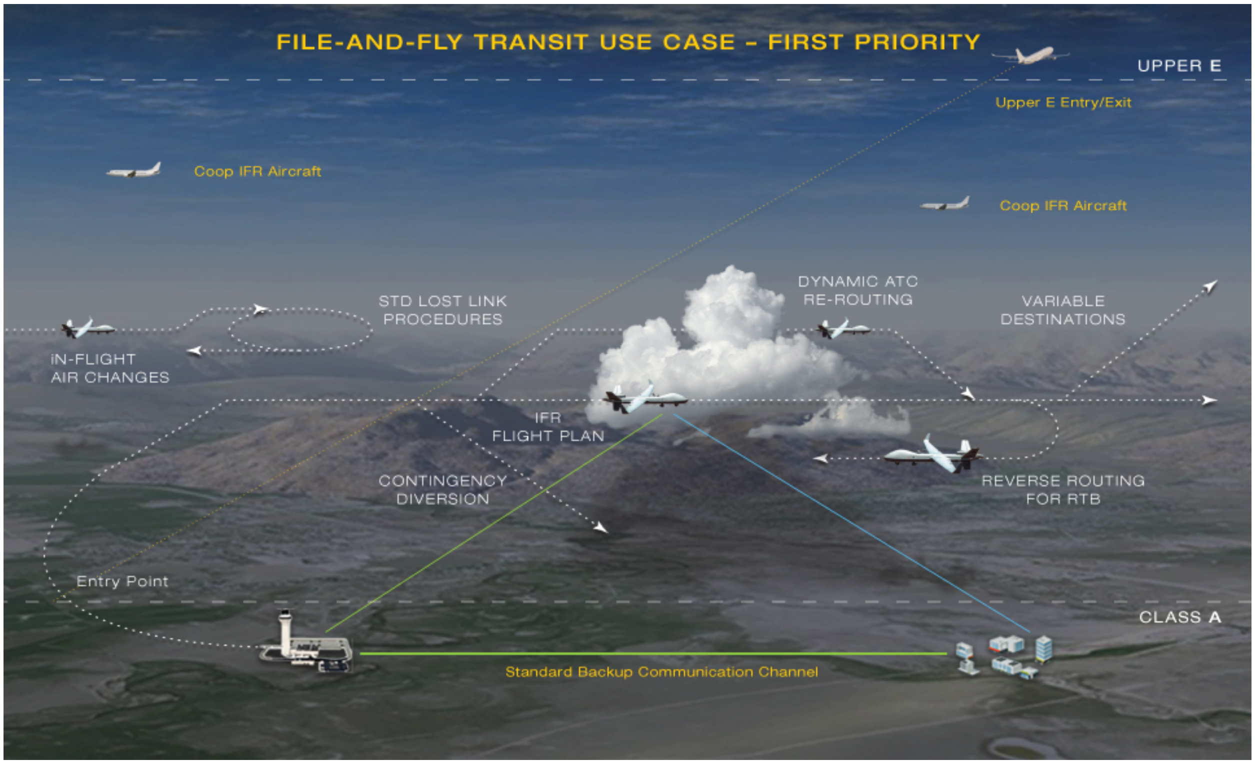

Figure 1: UAS will “file and fly” under IFR in Controlled Airspace with the safety and operational flexibility of today’s IFR operations.

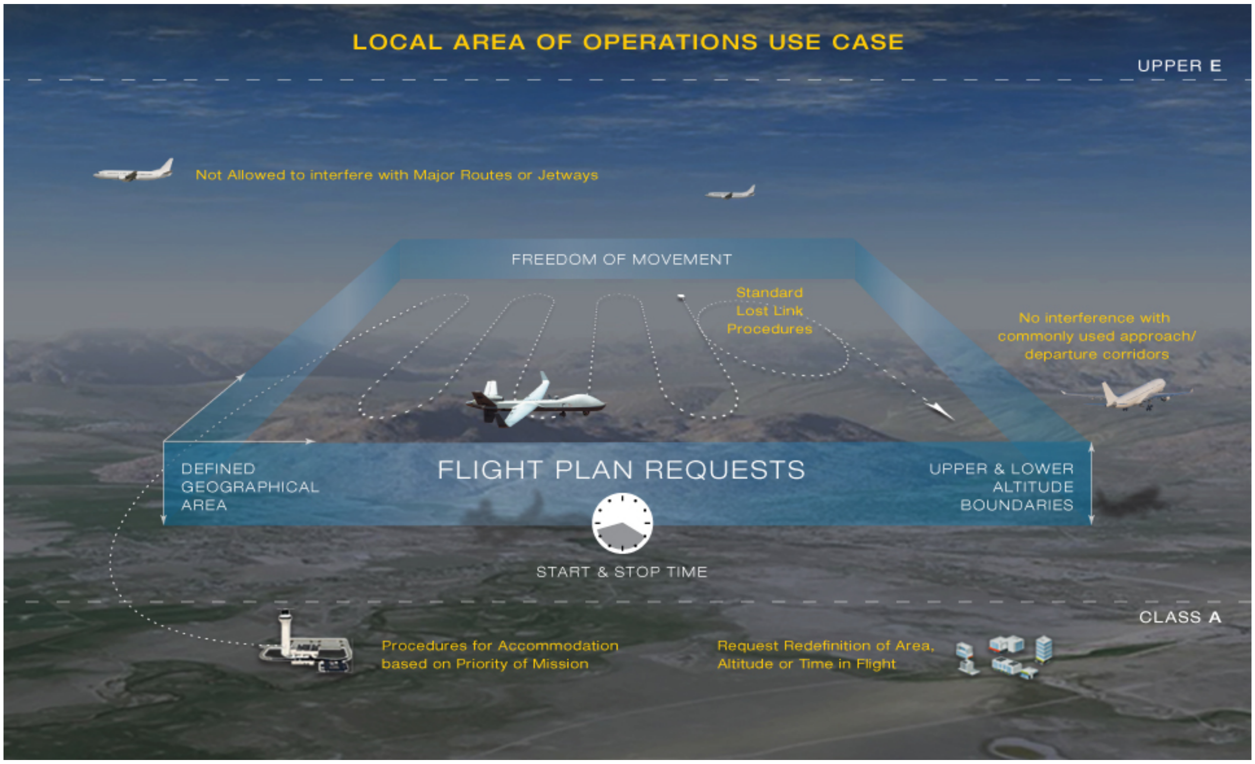

Figure 2: The unique capabilities of today's long-endurance UAS are best utilized in Local Area Operations under IFR.

RPAS Constraints and Limitations

Although government users have been operating large RPAS for over a decade in the NAS, it has been well documented that those RPAS have not complied with existing equipage and performance requirements for aircraft of similar size, weight, and capability. Public UAS users (e.g. USAF RQ-4 Global Hawk and DHS/CBP MQ-9 Guardian) currently utilize a mixture of Special Use Airspace, chase aircraft, and special procedures to enable access to the NAS. It is generally agreed that the status quo arrangements enable Public UAS operations in Controlled Airspace with minimal impact to other NAS users.

All of the constraints and limitations listed above for UAS apply to RPAS, but in addition, even for an RPAS designer that sets out to completely comply with existing regulations and equipage requirements, there are many unknowns. The FAA has yet to issue a Type Certificate for a UAS with the size and complexity of a manned aircraft that would be capable of operating under IFR in the NAS, so many design, certification, and operational questions remain unanswered.

'small' UAS/Drones

Commonly known as 'Drones', UAS that have historically weighed less than 55 lbs, and now those that operate under 14CFR §107, are known in the community as "Small UAS". The FAA defines a small unmanned aircraft as:

> "an unmanned aircraft weighing less than 55 pounds on takeoff, including everything that is on board or otherwise attached to the aircraft"

While the general parameters of Part 107 operations (e.g. Visual Line of Sight, Class G airspace, below 400 ft AGL) keep small UAS away from controlled airspace operations, the rules also allow for significant operational flexibility under provisions that are subject to waiver. This means that the boundary between Part 107 operations and those conducted under Part 91 (or similar under Part 135, etc…) are unclear. This is especially true with emerging concepts such as Urban Air Mobility (UAM), which aims to fly passengers around metropolitan areas using autonomous aircraft. This report will not explore Part 107 operations or extensions into controlled airspace, but notes that this topic will become increasingly important in the future.

The Task Group recognizes that substantial work has occurred has in other forum to reconcile the needs of the emerging (and accelerating) small UAS industry with the needs of existing NAS users. The Drone Advisory Committee (DAC) had a Task Group dedicated to Airspace Integration and, more recently, the FAA's Remote Identification and Tracking ARC produced detailed recommendations.

Constraints and Limitations specific to 'small' UAS/Drones

By definition, small UAS will have limited available volume, payload capacity, and power for equipment and systems that would enable them to operate like a manned aircraft. While the NAS accommodates many aircraft (e.g. those certified without an electrical system) that do not meet all of the equipage requirements of a transport category aircraft, they tend to be limited in number and are generally not conducting commercial (i.e. non-recreational) operations. There are now millions of drones operating in the US NAS, with some percentage of those operating for commercial purposes.

The FAA and NASA have been working for several years on UAS Traffic Management (UTM), which aims to provide an external system to manage certain aspects of small UAS operations and compensate for some of the limitations mentioned above.

High Altitude Pseudo Satellites (HAPS)/High Altitude Long Endurance (HALE)

The terms HAPS and HALE are used to describe a type of UAS, which may or may not have a Remote Pilot (ICAO term), which pose an especially illustrative case for this ARC. HAPS/HALE are envisioned to have very long, high aspect ratio wings that enable them to stay aloft at very high (>60,000 ft MSL) altitudes for very long (>1 week) periods of time. They may also incorporate renewable energy (e.g. solar cells) that enable flight times greater than 6 months. The same features that enable efficient long endurance flight cause these aircraft to be slow and difficult to maneuver at low altitude (<60,000 ft), which increases the likelihood of impacts to traditional aviation, similar to free balloons.

Generally, it is considered that solutions needed for HAPS/HALE UAS to efficiently share airspace with other users, will be a combination of solutions developed for UAS and those developed for unmanned free balloons destined for high altitudes.

UAS Regulatory Constraints & Limitations

UAS operators seeking to conduct operations in controlled airspace face the following constraints and limitations:

- Uncertainty in the regulatory framework that could account for a rapidly-evolving and diverse array of UAS, with wide array of physical and aerodynamic characteristics, performance capabilities, propulsion systems, and control systems.
- Limited definition of air traffic operational procedures for integrating UAS operations with manned aviation operations in controlled airspace. Currently, routine operations of UAS in controlled airspace would have to be conducted under IFR since there is not a pilot onboard to operate the aircraft using natural human vision.
- Removing the onboard pilot enables UAS to conduct missions haven't been seen before in the NAS. Examples include ultralong duration flights at high altitudes; long-duration, slow-moving surveying or monitoring flights over specific locations (referred to by some as "mowing the lawn" because of flight patterns that resemble back and forth patterns of lawn mowers); and intra- and inter-urban passenger and cargo flights that begin and end not at airports or heliports, but rather at homes or businesses in urban or suburban neighborhoods. The new types of missions that UAS will be able to fly coupled with differences in performance characteristics between UAS and manned aircraft create additional challenges with respect to the prioritization of airspace access between UAS and manned aviation. For example, a slow flying UAS conducting a photogrammetric survey mission over a large area ("mowing the lawn" as described previously) could conflict with manned aircraft that need to transit that same airspace.

Manned Aviation

As noted previously, manned aviation consists of an array of users, from low-performance recreational general aviation flights to high-performance air carrier flights. However, all of these aircraft have a common need for airspace access to fly from their origin airport to their destination airport safely and, ideally, efficiently. Each segment of manned aviation—general aviation, business aviation, commercial passenger aviation, and commercial cargo aviation—have unique constraints and limitations relating to airspace access.

Common Constraints

All manned aviation users must be able to operate safely in the NAS and have a substantial number of long-established regulatory and statutory requirements that they have to meet to assure these safe operations. These include aircraft certification, aircraft equipage, flight crew training and medical, flight planning, and air traffic control requirements.

In addition, to ensure the safe and efficient operation of the NAS, air traffic rules & procedures; airspace structures; navigational aids, air traffic control tools, systems, and infrastructure; and airport infrastructure have all been developed over decades and with substantial investment by the FAA, aircraft operators, and airport operators. These elements which define the NAS do impose limits on how, when, and where manned aviation operations can take place.

Additionally, environmental constraints—particularly weather—play a significant role in determining how manned aviation operations will utilize the NAS. Severe weather can and does limit how airspace can be used on a given day or during a given hour. Wind conditions dictate runway use at airports and route selection between origin and destination airports. Because the weather is uncontrollable, the operators of manned aircraft must be flexible, adapting their flight plans to environmental conditions and being prepared for contingencies that may develop while enroute.

Manned flight operators also face financial constraints and typically attempt to reduce the costs and increase the efficiency of their flight operations by seeking faster or more direct routes between their origins and destinations (when engaged in point to point flight). Airspace closures and other limits on access to the NAS that increase flight times and/or increase airspace congestion & delays exacerbate these constraints.

Scheduled Commercial Aviation

Scheduled commercial aviation operators, which include commercial passenger and cargo airlines, provide an agreed upon service to customers—fly them or their cargo from a designated location to a designated location at dates and times.

Many commercial aviation operators—certainly all of the major air carriers in the U.S.—operate large and complex networks of flight operations that requires the careful orchestration of flight crews, aircraft, aircraft service and maintenance activities, and passenger, baggage & cargo handling to ensure schedule integrity and ultimately meet the service commitments to their customers. Planning these operations at major air carriers takes place months in advance of the scheduled fights and is refined on an ongoing basis to reflect planned airport and airspace constraints, aircraft and crew availability, and—a few days before the flight—forecast weather conditions.

Airspace constraints—particularly those that are unexpected—can result in significant disruptions to airline operations. The effects of these disruptions can ripple across an airlines entire network as delayed or cancelled flights at one airport affect connecting passengers as well as delay flight crews and aircraft on the next legs of their scheduled daily itineraries.

Airspace closures or other access limitations—whether because of weather conditions, use of airspace by other users, temporary flight restrictions—add constraints to already complex scheduling challenges that commercial aviation operators face.

Business & General Aviation (inclusive of non-scheduled commercial aviation/air taxis)

Business and general aviation operators typically operate “on demand” and place a premium on being able to access the airspace flexibly, as a particular mission demands. A range of constraints on business & general aviation are driven by mission requirements. For example, a business aviation operator flying a corporate CEO to a board of directors meeting may have narrowly defined departure and arrival time windows dictated by that CEO’s schedule. Another example is the transportation of a human organ from a donor to a transplant recipient, where the viability of the organ is dependent on its timely arrival at the recipient’s hospital.

Airspace access limitations can make the difference between being able to successfully completing these missions. Accordingly, the business & general aviation communities both have had long-standing interests in reducing airspace restrictions (both volumes and durations).

“Cross-Sector” Constraints

In discussions among our members, Task Group 2 identified several cross-cutting constraints that affect multiple operator sectors. These are summarized in the following paragraphs.

Financial & Other Resource Constraints. Participants recognize that the FAA and other key Federal government agencies (e.g., DoD, NASA) have limited funding and available staff for day-to-day air traffic management, research & development of new operational capabilities, and regulatory refinement, among other needs. The participants also understand that the FAA and other Federal agencies have a wide range funding priorities and commitments that make it challenging to introduce new technologies, programs, and capabilities that would enhance the management and integration of the four sectors of airspace users considered in this effort.

Communications and Collaboration Challenges. During the Task Group 2 discussions, it was also clear that historically there have been challenges in effective communication and collaboration among the user sectors, particularly between commercial space and manned aviation. There are many causes of these challenges—including “siloed” regulatory and operational environments, rapid proliferation of new entrants especially in the commercial space and drone sectors, and the aforementioned resource constraints. As has been discussed, these challenges—and the subpar coordination it creates among sectors that are seeking to use a common NAS—drive inefficient, un-dynamic, and conflicting utilization of airspace. These challenged also impede effective advanced planning of “missions” by various sector participants that balance various sector’s airspace access needs.

These communications and collaboration challenges can be addressed in part by adapting existing and proven tools and methods used primarily by the manned aviation sector (e.g., the U.S. collaborative decision making program), supplemented with new targeted new tools and capabilities discussed in the Task Force 1 report.

ATTACHMENT A:
TASK GROUP 2 TERMS OF REFERENCE

ATTACHMENT B:
TASK GROUP 2 MEMBER ROSTER

Name	Organization
Sirisha Bandla	Virgin Orbit/ Galactic
Julie Brightwell	Boeing Commercial Airplanes
Stephen Browning	Air Line Pilots Association
Mike Cirillo	Airlines for America
Rune Duke	Aircraft Owners & Pilots Association
Todd Ericson	Virgin Orbit/ Galactic
Mark Heinrich	WorldView
Scott Henderson	Blue Origin
Tracy Lamb	Association for Unmanned Vehicle Systems International
Lisa S. Loucks	The Boeing Company
George Merritt	Denver International Airport
Christopher Oswald	Airports Council International – North America
Darrell Pennington	Air Line Pilots Association
Mark Prestrude	National Air Traffic Controllers Association
Melissa Sabatine	American Association of Airport Executives
Ashish J. Solanki	National Association of State Aviation Officials
Eric Stallmer	Commercial Space Federation
Ernie Stellings	National Business Aviation Association
Brandon Suarez	General Atomics Aeronautical Systems, Inc.
Ryan N. Terry	Lockheed Martin
Vernon L. Thorp	United Launch Alliance
Heidi J. Williams	National Business Aviation Association
Matthew S. Zuccaro	Helicopter Association International

ATTACHMENT C:
TASK GROUP 2 NEEDS AND CONSTRAINTS SURVEY RESPONSES

Respondent	Stakeholder Group/Constituency	Needs	Metrics	Challenges
Vernon Thorp/ULA	Commercial space operator	1. Ability to launch during the launch window defined by payload requirements and orbital constraints 2. Ability to rapidly reschedule launch to the next opportunity if technical, weather, or launch range issues prevent a launch 3. Minimizing time required between launches from the same launch range (currently driven by time required for range reconfiguration for different vehicle type)	1. Percentage of time a rocket launches on the first attempt, with Pareto analysis of reasons for delay 2. Cost of launch scrub to the vehicle operator and to payload customer. 3. Time required for launch range reconfiguration between launch of different vehicle types	1. Weather constraints for launch (can better observation and predictive capability allow for reduced constraints?) 2. Launch range constraints due to aircraft or boat violations of closure areas (can real-time verification that Ec requirement is still met allow launch to proceed?) 3. Range assets (radar & comm) required for safety purposes (important parameters include reliability of mandatory assets, redundancy needs, etc.)
Heidi Williams/NBAA	Manned/Traditional Airport Operator	From an existing manned operator's perspective, we need to ensure traffic flows are minimally impacted or interrupted – especially during SWAP season when weather constraints can significantly impact operations leading to additional delays and reroutes which adds expense. The ability to dynamically turn airspace on and off as quickly as possible without needing the entire broad airspace segregation for the entire launch window and rocket reentry is crucial to helping minimize impacts on all operators. With the frequency of new entrant operations (both UAS and Commercial space launches) expected, regulations and standards are needed to allow those operations to be certified and compliant with existing regulations to the greatest extent possible or the disruption to the NAS will be overwhelming. To continue to allow growth without the mechanisms in place to truly "integrate" will result in significant impacts and burden on existing operators.	Metrics are a bit more difficult for the Business Aviation community as on-demand operations do not provide routine or consistent scheduled operations. However, delay time and additional miles due to reroutes are two metrics that should be considered as both have economic implications. The size and duration of temporary flight restrictions should also be considered as they have direct impact on flight operations and Traffic Management Initiatives (TMI's) that lead to delays and reroutes.	From our perspective, traffic flow constraints, delays and NAS efficiencies are key concerns when "segregation" is used as the means to accommodate operations in the NAS. The broad brush, large restrictions we are seeing with current commercial space launches are causing disruption for longer than necessary and impacting larger areas than perhaps are needed for the full duration of the operation.

Ashish Solanki	**State Aeronautical Office**	**1. Timely notification to users** **2. Airspace and airport efficiency (concern over limiting civilian airspace that may restrict traditional aviation in a tighter box that in turn requires delays/rerouting to accommodate ATC needs.**		**ATC staffing/air traffic management – high workload in small airspace means task saturation and in turn delays to manage saturation. Western States are concerned limited civilian airspace and growing special use airspace will limit access to/through airspace due to controller workload which may be a result of airspace saturation.**
Mark Heinrich	Balloon Operator	1. Equitable Access 2. Reasonable delay flexibility 3. Flexible Scheduling	These address multiple of the issues identified above. Reasonable AHA and real time tracking to activate and release airspace back efficiently. Our balloon releases are based on a number of flight conditions, as are most NAS users. When faced with delays, real time communication with ATC can be very similar to traditional NAS users. We can accept most ATC instructions, and accept times if known in advance, much like flow control delays faced by aviation industry. The primary difference is the time on 'runway'. But those are not uncommon with other NAS users, like Military, UAS, mix of Heavy vs. light aircraft, and others. (Example: 4 minutes wake turbulence delay for a light aircraft departing behind a heavy/super aircraft. Balloons normally need a 5 minute release window, not a massive impact). Communication with ATC can ease these concerns with little impact. Ensure that times and affect on other users are accurately assessed. Our balloons climb at	Communication and understanding between ATC and other users can address most of the impact concerns. They can be addressed by working together but lack of understanding stands in the way of addressing these and coming up with resolutions that result in a large reduction of any perceived and real impact to all users of the NAS.

			the same rate as most GA aircraft, our route of flight is predictable, but balloons are treated as exceptions to normal NAS operators.	
Chris Oswald/ACI-NA	Airport operators	1. Ensuring that integrated commercial space and traditional aviation activities can be conducted without detrimentally impacts to airport safety. 2. Ensuring that aircraft can access airports in an efficient manner. 3. Ensuring that when space launch, reentry/recovery, or other types of non-traditional airspace activities (e.g., drone operations, high altitude/sub-orbital balloon operations), that communication and coordination mechanisms are in place to ensure airspace conflicts and associated impacts on airport efficiency can be managed proactively with active efforts to minimize flight delays, reroutings, and airport and airspace closures/	For safety: 1. Size and duration of the airspace area closed for launch activity. 2. Number and significance of off nominal events involving the vehicle of interest For efficiency: 1. Number of flights delayed and the mean and maximum level of those delays associated with airspace restrictions or closures. In severe cases, number of flights cancelled due to restrictions or closures. 2. Total additional flight time incurred due to airspace restrictions and/or reroutes For effectiveness of communication and collaboration: 1. Record of prelaunch coordination meetings with airport operators 2. Record of coordination between airport operators, launch (and recovery, if applicable) facility, and vehicle operator during facility and launch licensing process.	To come.

Scott Henderson/Blue Origin	**Commercial space operator**	**1. Launch Assuredness—ability to predictably launch when needed** **2. Minimize NAS restrictions (smallest closure area, shortest possible closure time)** **3. Quick turn following real time holds due to range or NAS constraints**	**1. Percentage of time a rocket launches on planned day/time** **2. Launch over launch NAS closure space/time→reducing over time.** **3. Time from scrub to reschedule and launch**	**1. Multiple impacts to potential launch—weather, airspace, seaspace, range support systems availability** **2. Need tools to accurately predict closure zones with high certainty and ability to share that data with NAS controllers** **3. Dynamic rescheduling stresses NAS re-planning and range configuration timelines**

APPENDIX G: TASK GROUP 3 CHARTER

Terms of Reference
FAA Airspace Access Priorities ARC: Access Priority Task Group

1.	**Statement of Objective, i.e. what is the problem/requirement:** . Equitable airspace access is an essential concept that needs to be understood and embraced by the varied users of the NAS to maximize value to the United States. This Task Group will build on the work of the Airspace Optimization Task Group and the Operator Constraints and Limitations Task Group to assist the FAA in developing criteria that: acknowledges the diverse mission requirements, airspace requirements and performance characteristics of all NAS operators; and may be used by the FAA Air Traffic Organization to develop strategies for balancing capacity and demand among all NAS operators, including recommended methods (quantifiable and non-quantifiable) that can be used to accommodate different operations and support operational decisions regarding the prioritization of airspace access.
2.	**Statement of scope of task/activity:** Policy is often driven by technological innovation and careful consideration of the challenges and constraints faced by whatever constituency the policy governs. This task group will carefully consider the work of the Airspace Optimization Task Group and the Operator Constraints and Limitations Task Group when formulating its recommendations. • Evaluate procedures and technologies addressed by the Airspace Optimization Task Group and assess whether the acceleration of certain procedures and technologies would facilitate NAS integration of all operators by, e.g.: reducing the size of the airspace block required for a commercial space launch; reducing the duration of a commercial space-related airspace closure and expedited release of airspace for normal use; facilitating the ability of UAS, Commercial Space and balloon operators to evaluate trajectory options that would have the least impact to airspace efficiency while still accomplishing mission goals; increasing the flexibility of air traffic management and aviation operational planning to react to airspace restrictions and releases, and other procedural and technological innovations determined relevant by the task group. • In order to ensure ARC final recommendations are realistic, evaluate the work of the Operator Constraints and Limitations Task Group to ensure challenges of all operators are considered and a determination made regarding the probability of mitigating or overcoming those challenges. • Evaluate equipage for all operators that may facilitate NAS integration.

	• Evaluate regulations, rules, orders and practices and policies that govern priority of NAS access, specifically how Air Navigation Service Providers currently make decisions regarding priority of NAS access. This includes the first come, first served provision and applicability of the Plan, Execute, Review, Train and Improve (PERTI) process, currently in place nation-wide to orchestrate traffic flow management. • , • Evaluate factors ("metrics") in addition to operational constraints that are used by the community to measure impacts such as economics and quality and recommend to the FAA which should be considered in order to achieve the objectives outlined above.. • Evaluate collaborative processes such as Collaborative Decision Making (CDM) to identify data and information that may be shared among all NAS operators to facilitate traffic flow management and more effective use of airspace releases NAS-wide.
3.	**What is the expected deliverable/product:** • A list of recommendations that includes ways and means of improving traffic flow management and reducing or eliminating restrictions for all NAS operators and a collaborative process wherein all NAS operators participate. • Criteria to be considered by the FAA Air Traffic Organization when considering implementation of a policy or policies that ensure safe, efficient and equitable procedures for balancing capacity and demand among all operators in the National Airspace System . • Applicable metrics and associated thresholds to be established related to NAS access priority decisions.
4.	**Special Considerations:** Recommendations should include an evaluation of the risks, if any, associated with achieving any NAS improvement.
5.	**What is the schedule of activities:** The Task Group Lead will determine frequency of meetings based on progress of the group. The final Task Group deliverable is due to the ARC plenary on October 24, 2018.
6.	**Related Activities:** Work closely with the Airspace Optimization Task Group and the Operator Constraints and Limitations Task Group leads to ensure their work products are

<table>
<tr><td></td><td>considered and, if appropriate, incorporated. Work closely with appropriate FAA Lines-of-Business; other government agencies as needed, including NASA; MITRE and other research and development entities; key ARC industry stakeholders and other industry operators and manufacturers as necessary.</td></tr>
<tr><td>7.</td><td>What are the resource requirements and commitments:
Participation commitment by Task Group members.
Meetings may be face-to-face, via telcon or Webinar.</td></tr>
<tr><td>8.</td><td>What is the urgency/criticality:
Completion of this work is necessary to inform the ARC plenary deliberations regarding policy related to priority of NAS access. Decisions regarding final ARC recommendations will be heavily influenced by the work of this Task Group.</td></tr>
<tr><td>9</td><td>Who are the customers for the product/deliverable:
The Airspace Access Priorities ARC.</td></tr>
<tr><td>10.</td><td>Action Team Leader:
Heidi Williams – NBAA
Lisa Loucks - Boeing</td></tr>
<tr><td>12.</td><td>Action Team Members:<table><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr></table>
SMEs will be used from government and industry as needed.</td></tr>
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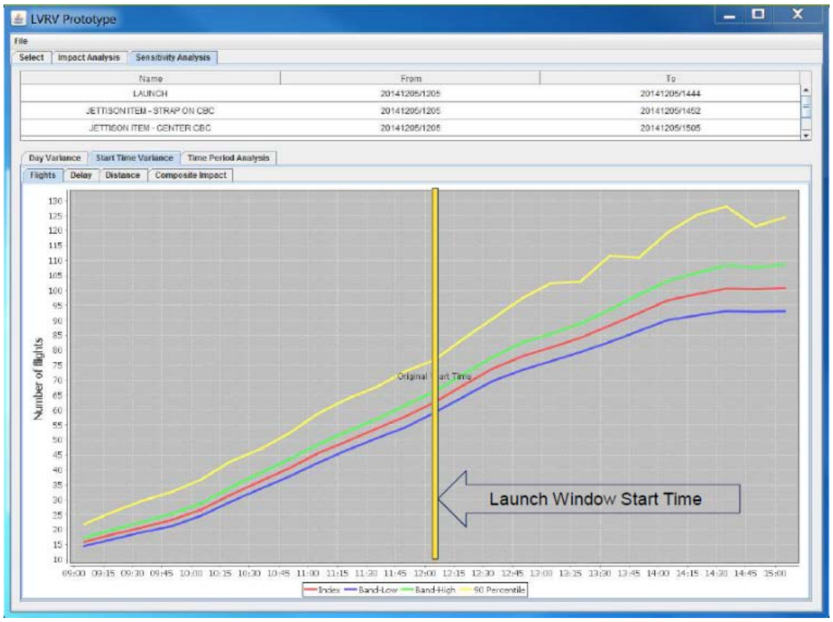
APPENDIX H: TOOLS AND CAPABILITIES IN DEVELOPMENT

The following tools are prototypes currently in development and testing. While discussed here in the context of space operations, they can be applied to many NAS operations.

NAS Effects Analysis Prototype (NEAP)

Developed by The MITRE Corporation, NEAP (Figure 2) is a prototype tool for NAS assessment of space launch and reentry operations during the mission planning phase. NEAP uses a large sample of historical flight data to predict future NAS metrics for a given date and time. NEAP also has tools for visualizing NAS metrics for different launch or reentry windows for a given date. However, NEAP does not generate the predicted aircraft hazard area for its analysis – this information must be provided to NEAP. As part of its research beyond NEAP, MITRE has developed the Rapid Impact Assessment (RIA) model which enables any user to instantaneously examine the collective demand placed on airspace by aviation and launch/reentry operations.

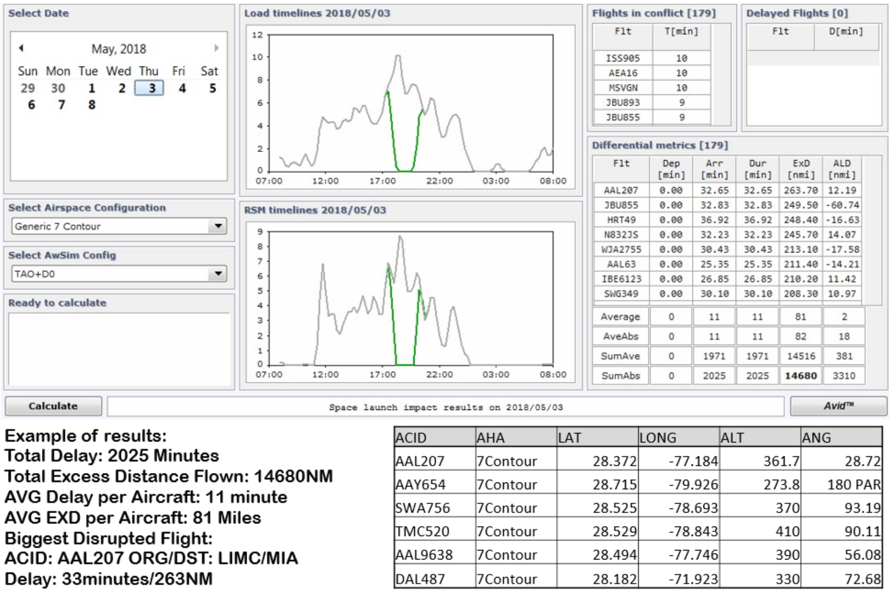


Name	From	To
LAUNCH	20141205/1205	20141205/1444
JETTISON ITEM - STRAP ON CBC	20141205/1205	20141205/1452
JETTISON ITEM - CENTER CBC	20141205/1205	20141205/1505

Figure 2: NEAP flight impact analysis with variable launch window

Airspace Constraint Analysis and Conflict Prediction (ACACP)

Developed by Advanced Sciences and Technologies, LLC (AS&T), ACACP (Figure 3) is a prototype tool for providing NAS assessment of space launch and reentry operations. ACACP includes a planning mode that uses historical or real-time air traffic data. ACACP also provides discrete aircraft IDs for affected flights, as well as overall NAS delay, average NAS delay and discrete flight metrics. ACACP also includes the capability for graphical replay of NAS operations during launch and reentry events.



Select Airspace Configuration: Generic 7 Contour

Select AwSim Config: TAO+D0

Flights in conflict [179]

Flt	T[min]
ISS905	10
AEA16	10
MSVGN	10
JBU893	9
JBU855	9

Delayed Flights [0]

Flt	D[min]

Differential metrics [179]

Flt	Dep [min]	Arr [min]	Dur [min]	ExD [nmi]	ALD [nmi]
AAL207	0.00	32.65	32.65	263.70	12.19
JBU855	0.00	32.83	32.83	249.50	-60.74
HRT49	0.00	36.92	36.92	248.40	-16.63
N832JS	0.00	32.23	32.23	245.70	14.07
WJA2755	0.00	30.43	30.43	213.10	-17.58
AAL63	0.00	25.35	25.35	211.40	-14.21
IBE6123	0.00	26.85	26.85	210.20	11.42
SWG349	0.00	30.10	30.10	208.30	10.97
Average	0	11	11	81	2
AveAbs	0	11	11	82	18
SumAve	0	1971	1971	14516	381
SumAbs	0	2025	2025	**14680**	3310

Space launch impact results on 2018/05/03

Example of results:
Total Delay: 2025 Minutes
Total Excess Distance Flown: 14680NM
AVG Delay per Aircraft: 11 minute
AVG EXD per Aircraft: 81 Miles
Biggest Disrupted Flight:
ACID: AAL207 ORG/DST: LIMC/MIA
Delay: 33minutes/263NM

ACID	AHA	LAT	LONG	ALT	ANG
AAL207	7Contour	28.372	-77.184	361.7	28.72
AAY654	7Contour	28.715	-79.926	273.8	180 PAR
SWA756	7Contour	28.525	-78.693	370	93.19
TMC520	7Contour	28.529	-78.843	410	90.11
AAL9638	7Contour	28.494	-77.746	390	56.08
DAL487	7Contour	28.182	-71.923	330	72.68

Figure 3: **ACACP NAS assessment with aggregate and flight-specific metrics**

Hazard Risk Assessment and Management (HRAM)

Sponsored by ANG and developed by ACTA, Inc., HRAM (Figure 3) is a next-generation risk analysis prototype designed to incorporate a variety of space vehicle types and launch and reentry profiles. HRAM is built upon and evolved from ACTA's Range Risk Analysis Tool (RRAT), which has traditionally been used by the FAA and Air Force for launch and reentry risk analysis. HRAM calculates nominal SAAs pre-mission, as well as real-time DHVs in the event of a space vehicle failure. Pre-mission SAAs calculated by HRAM could be utilized in NAS impact assessment during the mission planning phase. HRAM was designed to receive real-time space vehicle tracking information and provide SAAs and DHVs directly to FAA systems for display to Air Traffic Controllers and Traffic Managers. This real-time tracking information could come from the Space Data Integrator (discussed below), direct operator telemetry, ADS-B, or other sources. HRAM has been tested by ANG with air traffic controllers in the loop, and results suggest that the concept of reduced nominal hazard areas, coupled with real-time reactive separation from debris is feasible.[5]

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[5] Hatton, Kevin, Daniel R. Johnson, Kenneth Schulz, Randy L. Sollenberger, and Tanya Yuditsky. "Space Vehicle Operations Debris Threat Mitigation Study." Federal Aviation Administration, Jan. 2016, hf.tc.faa.gov/publications/2016-04-space-vehicle-operations-debris-threat-mitigation-study/.

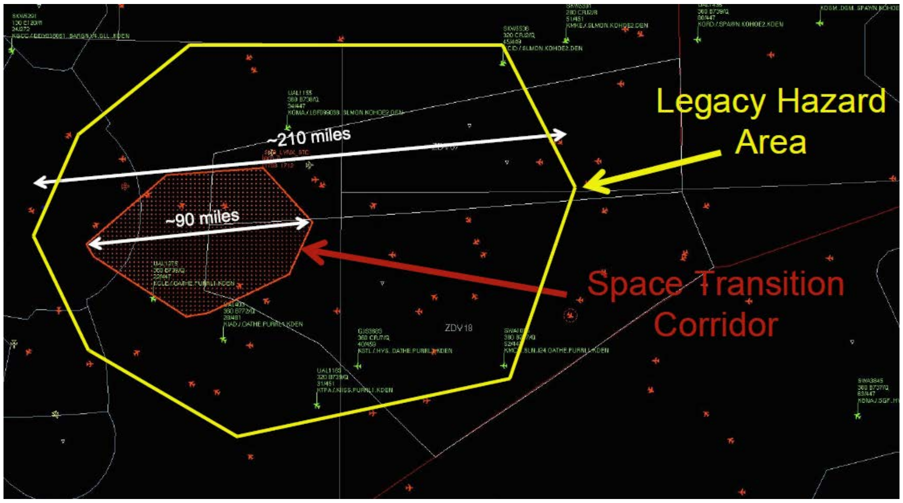

Figure 4: HRAM-generated nominal Hazard Area compared to traditional Hazard Area for a simulated suborbital launch

Space Data Integrator (SDI)

The SDI prototype was developed by Millennium Engineering and Integration Company (MEI), under contract by FAA's Office of Commercial Space Transportation. SDI was designed to receive space vehicle state data (telemetry) from a commercial space vehicle operator and process the data for output to FAA's Traffic Flow Management System (TFMS) for display on a Traffic Situation Display (TSD) (Figure 5). The SDI prototype has been demonstrated using real-time telemetry from both launch and reentry vehicles. Space vehicle tracking data from SDI could be utilized as an input to HRAM for real-time generation of DHVs in the event of space vehicle failures.

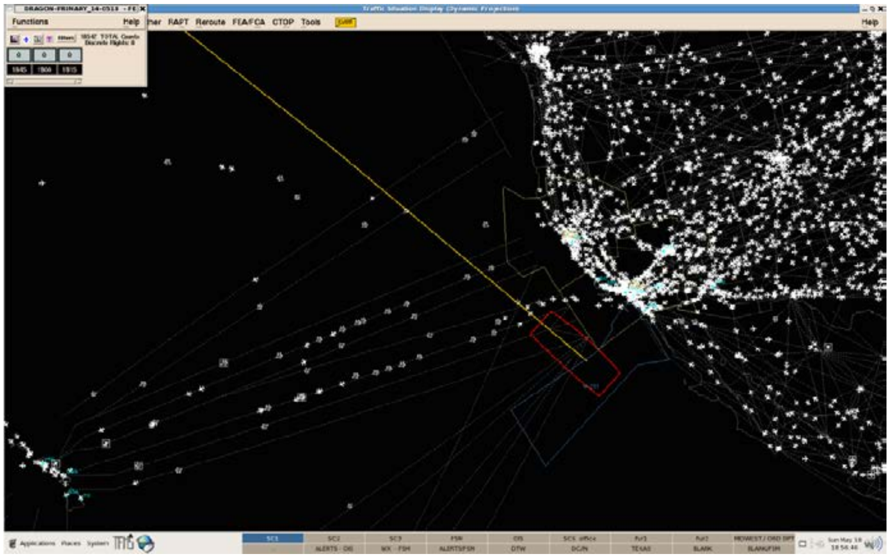

Figure 5: SDI-generated reentry vehicle track displayed on TSD (yellow)

Future System Integration

The ARC envisions a notional future NAS state as depicted in Figure 6. Note that the space vehicle tracking information provided by SDI could be provided by another source (e.g., directly from operator telemetry), and the HRAM automation tool could exist as either an FAA system or an external system providing input to FAA systems.

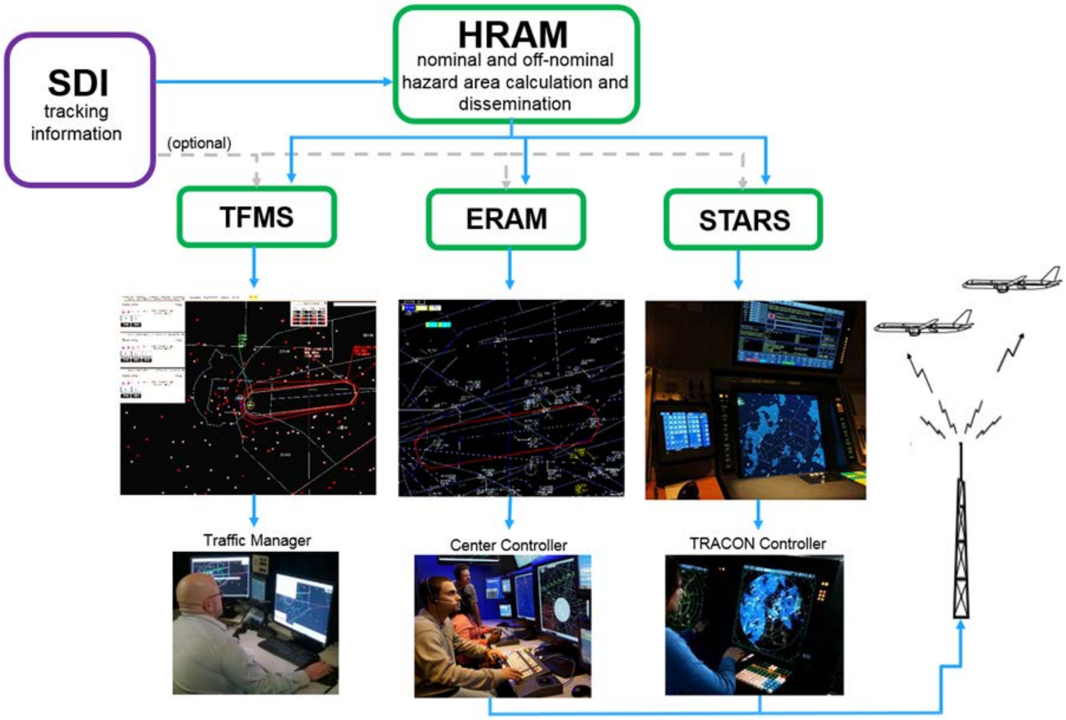

Figure 6: Notional Future NAS state

APPENDIX I: DEFINITIONS

Aircraft Hazard Area (AHA) – airspace subject to restriction to mitigate elevated safety risk

Debris Hazard Volume – conceptual airspace safety buffer around potential debris from a spaceflight anomaly

Future State –envisioned condition after implementation of recommended changes

Integration – incorporation of multiple operations within the NAS without the need for segregation

National Airspace System (NAS) - airspace, navigation facilities, and airports of the United States along with their associated information, services, rules, regulations, policies, procedures, personnel and equipment

New Entrant - type of operation that is new to NAS integration

Prioritization – assigning relative importance to resolve multiple requests for airspace, used in conjunction with segregation

Public Operations – flights by government owned or operated aircraft serving no commercial purpose (see 49 USC § 40102)

Segregation – practice of restricting airspace to specific users

Separation – practice of maintaining safe distances between aircraft and/or other flight vehicles

Space (flight) Operations – activities related to launch or reentry of a vehicle to/from orbit or into space on a suborbital trajectory. Operations include vertical flight of rocket-propelled vehicles, balloons and reentry capsules, and horizontal flight of fixed-wing or hybrid (aircraft plus rocket) vehicles

Special Activity Airspace (SAA) – Any airspace with defined dimensions within the NAS wherein limitations may be imposed upon aircraft operations. This airspace may be restricted areas, prohibited areas, military operations areas, air ATC assigned airspace, and any other designated airspace areas

User Sector - grouping of NAS users with common operational concepts

APPENDIX J: ACRONYMS

List of Acronyms and Abbreviations

AAP	Airspace Access Priorities
ACACP	Airspace Constraint Analysis and Conflict Prediction
ADS-B	Automatic Dependent Surveillance-Broadcast
AHA	Aircraft Hazard Area
ARC	Aviation Rulemaking Committee
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
ATM	Air Traffic Management
ATOP	Advanced Technologies & Oceanic Procedures
CDM	Collaborative Decision Making
CFR	Code of Federal Regulations
ConOps	Concept of Operations
DHV	Debris Hazard Volume
DLW	Dynamic Launch Window
DoD	Department of Defense
EART	En Route Automated Radar Tracking
ERAM	En Route Automation Modernization
FAA	Federal Aviation Administration
GA	General Aviation
HRAM	Hazard Risk Assessment and Management
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEAP	NAS Effects Analysis Prototype
NextGen	Next Generation
NOTAM	Notice to Airmen
OPSNET	Operations Network
RIA	Rapid Impact Assessment
RPAS	Remotely Piloted Aircraft Systems
RRAT	Range Risk Analysis Tool
SAA	Special Activity Airspace
SC	Steering Committee
SDI	Space Data Integrator
STARS	Standard Terminal Automation Replacement System
SUA	Special Use Airspace
SVO	Space Vehicle Operations
TBFM	Time Based Flow Management
TBLP	Time Based Launch Procedures
TFM	Traffic Flow Management
TFMS	Traffic Flow Management System

TMI	Traffic Management Initiative
TSD	Traffic Situation Display
UAS	Unmanned Aircraft System