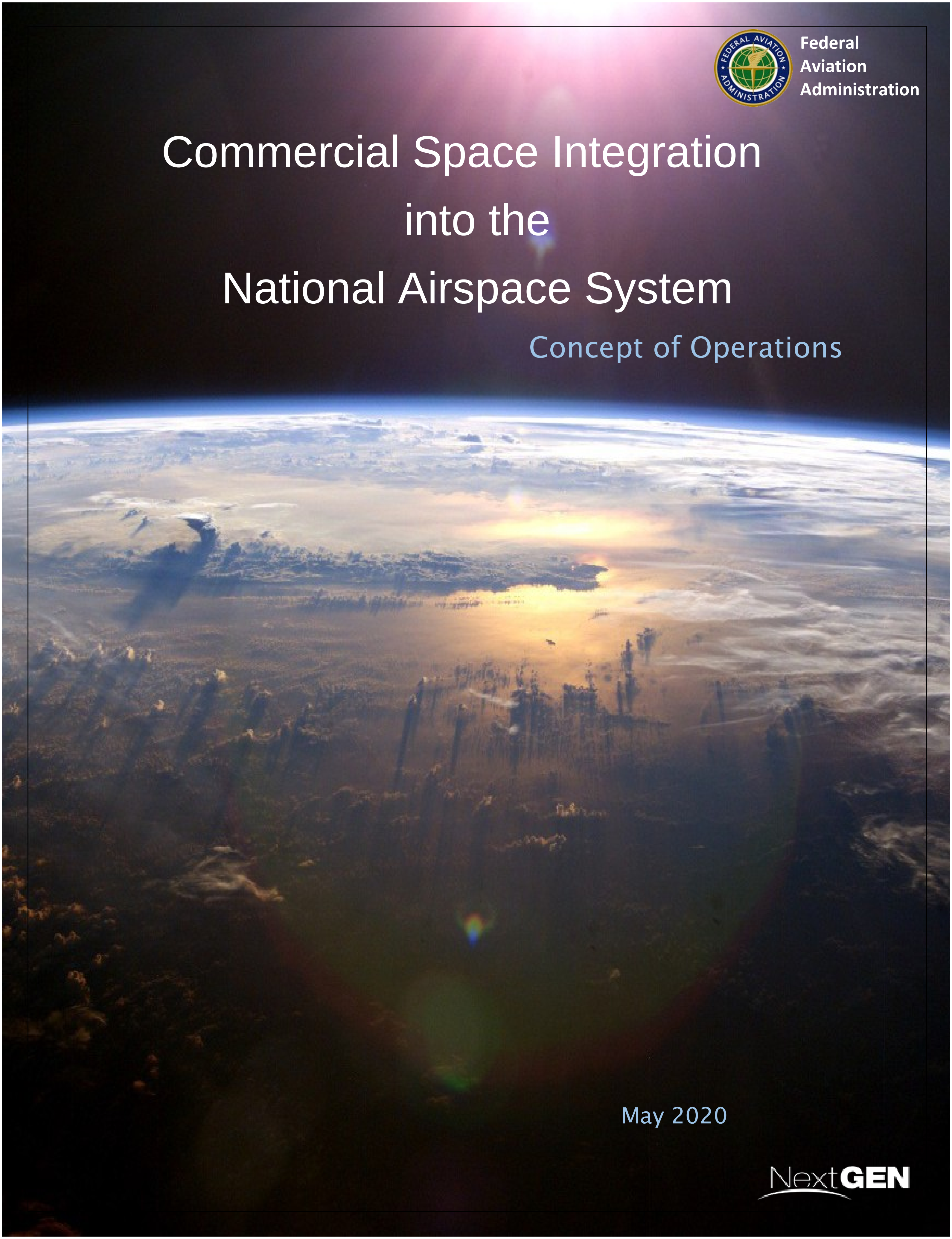
Federal
Aviation
Administration

Commercial Space Integration into the National Airspace System

Concept of Operations



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NextGEN

Commercial Space Integration into the National Airspace System (CSINAS)

Concept of Operations

This document was developed in collaboration with key representatives from the following organizations: Air Traffic Organization (ATO), Office of Commercial Space (AST), Office of Airports (ARP), and Office of NextGen (ANG).

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Abstract

This Concept of Operations (ConOps) is an update to the Space Vehicle Operations (SVO) ConOps, Version 1.1, 2014. It evolves the concepts put forth in that document for managing that National Airspace System (NAS) during commercial launch and reentry vehicle operations. The NAS is defined as the following: 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[1]. Air traffic services (ATS) in U.S. are provided over the domestic U.S. and within. In the airspace over the contiguous U.S. and out to 12 nautical miles (NM) from the U.S. shores, domestic air traffic control (ATC) separation is applied (with certain limitations) along with additional services (e.g., traffic advisories, bird activity information, weather and chaff information, etc.). The International Civil Aviation Organization (ICAO) has also delegated some high seas airspace to the United States (U.S.) for the provision of ATS. ATS in U.S. delegated "Oceanic" (certain areas of the western half of the North Atlantic, the Gulf of Mexico, the Caribbean, and the North Pacific) airspace are provided in accordance with (IAW) FAA Orders congruent with ICAO PANS ATM doc 4444. Depending on available CNS capabilities, ATS provided in oceanic airspace differs from services provided in domestic (continental) airspace.[2]

Discussions in this concept do not address Department of Defense (DoD), National Aeronautics and Space Administration (NASA) or other government agency launches. Since the NAS is a shared public resource managed by the Federal Aviation Administration (FAA), an approach to equitably allocating NAS resources (particularly airspace) must be developed. Launch/reentry vehicles traverse the NAS relatively quickly due to their speeds and flight profiles. The FAA has traditionally used airspace segregation, characterized by relatively large volumes of airspace and large time windows, to protect other NAS users from the hazards associated with potential off-nominal events. Even as the frequency of launch/reentry operations has increased, this approach persists due to current planning and real-time shortfalls. As a result, today's methods contribute to inefficiencies for other NAS users, including reroutes, delays, longer flight times, and additional fuel burn leading to increases in operating costs.

Benefits from implementing this ConOps include improved NAS efficiency through a reduction of delays, reduced route deviations, reduced fuel burn, and reduced emissions. For launch/reentry operators, benefits include increased operations availability from more sites. Implementing this ConOps will also provide a strategy toward more efficient and predictable operations for all airspace users, through improved planning and situational awareness among stakeholders.

[1] FAA Aeronautical Information Manual Pilot/Controller Glossary (03.29.18).

[2] Federal Register/Vol. 80, No. 126/Wednesday, July 1, 2015/Notices, pg. 37710, Department of Transportation, Federal Aviation Administration [Docket No. FAA-2015-1497; Airspace Docket No. 15-AWA-4], RIN 2120-AA66 Designation of Oceanic Airspace

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1 – Introduction

This ConOps is the foundational document for managing the integration of commercial space launch/reentry operations into the NAS. The scope encompasses the FAA's mid-term to far-term time frames. It provides focus on and methods for efficiently integrating the operations with other NAS operations.

The development of the Commercial Space Integration into the NAS (CSINAS) ConOps is a Level 2, or Service Level, ConOps. This classification indicates that all future efforts will trace to this document as the high-level, long-term vision.

This ConOps will be used as guidance to derive concept-level requirements for services, systems, technologies, tools, procedures, training, and policies that support commercial space launch/reentry operations integration. It can also be used as a reference for assessing concept feasibility through research validation activities.

This section of the document provides an overview of the ConOps including the methods and tools proposed in this document. It includes the following subsections:

- ***Background*** – describes recent changes in the commercial space industry that necessitate the methods and procedures presented in this document
- ***Challenges of Integrating Launch/Reentry Operations into the NAS*** - describes the effects the new vehicles and operations have on the NAS using existing FAA planning procedures and data-sharing mechanisms
- ***Developing Organizations*** - lists the organizations involved in development this ConOps
- ***Guiding Principles for Development of the CSINAS ConOps*** – describes the set of guiding principles used in developing the ConOps
- ***Remaining Document Organization*** – lists the remaining sections of the ConOps and provides a brief description of each

1.1 Background

Historically, launch/reentry operations occurred infrequently and were typically segregated from other operations by containing them within special activity airspace (SAA). These missions were also conducted almost exclusively by federal agencies (e.g., NASA and DoD). The operations historically originated from coastal sites, and air traffic was routed around the SAA to ensure public safety. Given their infrequency and national priority, there was little incentive to make these complex operations more efficient with respect to their effects on NAS efficiency and capacity.

NASA and the DoD are no longer the only participants in space launch/reentry operations. Leading commercial space is a priority objective for the United States. Private companies are now launching an increasing number of government and commercial industry missions into space. New launch sites are being licensed on the coasts and inland locations across the United States, including dual-use airports (i.e., facilities that host both space and traditional aviation operations).

As the commercial space transportation industry evolves and becomes more efficient and economical, the tempo of commercial launch/reentry operations will continue to increase. The expansion of the industry and operations leads to an increased demand for NAS resources. Today's mission segregation approaches are quickly becoming less feasible. Fully integrating the operations into the NAS while meeting other user and stakeholder needs requires a more equitable approach for allocating NAS resources.

Additionally, as the commercial space industry continues to mature and evolve, new vehicle types with a variety of unique flight capabilities and characteristics will continue to emerge. In the Commercial Space Integration Concept of Operations, we consider both today's launch/reentry vehicles and other emerging vehicle types. The reader should note that not all operational concepts presented in this document will apply universally to all of these vehicle types, or to all phases of vehicle flight, and in fact it is likely the case that most of the concepts and ideas presented in this document will be better suited to one type or phase more than others. For example, presenting vehicle tracking data information to the controller may not be useful or feasible in some cases, particularly for very fast moving vehicles that spend little time in the airspace, however it may prove to be very useful in the case of more maneuverable vehicles. As the industry matures and new technological advancements emerge, the engagement of the FAA and its partnership with industry will also evolve.

1.2 Challenges of Integrating Launch/Reentry Operations into the NAS

The FAA does not currently have the capabilities in place for meeting the anticipated growth in launch/reentry operations created by industry commercialization. The FAA relies on non-integrated, operational systems not designed for launch/reentry operations. The capabilities of existing systems and procedures are used to the extent possible, to establish and maintain situational awareness. Situational awareness allows the FAA to ensure that plans developed in advance of the mission are safety implemented, executed as efficiently as possible, and that safety nets are in place in the event of a contingency. Current systems and procedures require data to be communicated by voice or other non-automated systems (e.g., memos, email, etc.). This process is time consuming, labor-intensive, and leads to an increased probability of human error (e.g., transposition of safety data points). As a safety measure, intentional duplication of effort is used to reduce the potential for human error in manual data entry and transcription.

Additionally, current airspace management strategies for balancing the needs of all users during launch/reentry operations are not optimized, therefore limiting NAS efficiency, effectiveness, and capacity. Since the vehicles traverse NAS boundaries quickly due to their speeds and flight profiles, segregated airspace techniques are used. This airspace is characterized by large volumes of airspace that extend from the surface to an unlimited altitude, and long-time windows that span from before the mission begins until after it has completed. This method does ensure the protection of other NAS users from the hazards associated with potential off-nominal events. This approach is standard NAS wide during launches due to the small number of operations and existing gaps in capabilities, preventing more dynamic and efficient approaches. Examples of these gaps include a reliance on manual interfaces, a lack of integrated safety and capacity/efficiency evaluation processes, a lack of standardized planning and real-time processes, a lack of surveillance and communication capability. There is also limited capability for ATC to maintain situation awareness and manage other NAS users more dynamically in the oceanic environment.

Finally, there is a limited ability to archive, analyze, and disseminate data and information gathered post-launch and reentry, inhibiting the continual evaluation and improvement of the FAA's integration approach. Without the capability to quickly share accurate, assimilated data across the FAA and amongst the stakeholders, the FAA will continue to be challenged in keeping pace with the space transportation industry.

The FAA and its partners are developing new technologies and capabilities to improve NAS efficiency, and to assist with mission planning and execution. Many of the technologies and capabilities are expected to improve overall system and mission performance during launch/reentry operations while ensuring safety, efficiency, and predictability for all NAS users.

1.3 Primary Development Organizations

This ConOps is a collaborative effort that spans multiple agency lines of business (LOBs). The primary development team includes the Office of NextGen (ANG), the Office of Commercial Space (AST), the Air Traffic Organization (ATO), and the Office of Airports (ARP). The following subsections provide brief descriptions of each of these organizations.

1.3.1 Federal Aviation Administration's Office of NextGen (ANG)

ANG provides leadership in planning and developing the Next Generation Air Transportation System (NextGen). The NextGen Office coordinates NextGen initiatives, programs, and policy development across the various FAA LOBs and staff offices. The office also works with other U.S. federal and state government agencies, the FAA's international counterparts, and members of the aviation community to ensure harmonization of NextGen policies and procedures.

1.3.2 Federal Aviation Administration's Office of Commercial Space (AST)

AST was established to:

- Regulate the U.S. commercial space transportation industry, to ensure compliance with international obligations of the U.S., and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States;
- Encourage, facilitate, and promote commercial space launches and reentries by the private sector;
- Recommend appropriate changes in Federal statutes, treaties, regulations, policies, plans, and procedures; and

- Facilitate the strengthening and expansion of the United States space transportation infrastructure.

AST manages its licensing and regulatory work, and varying programs and initiatives, to ensure the health and facilitate the growth of the U.S. commercial space transportation industry.

1.3.3 Federal Aviation Administration's Air Traffic Organization (ATO)

ATO is the operational arm of the FAA. It is responsible for providing safe and efficient air navigation services to 30.2 million square miles of airspace. The ATO is the body within the FAA that contains the nation's air traffic management and control workforce and is responsible for keeping aircraft safe, separated, and on-time[3]. It operates several various service units whose functions range across safety monitoring, workforce training, information technology, operational performance metrics, weather observation and interface with the DoD.

1.3.4 Federal Aviation Administration's Office of Airports (ARP)

ARP provides leadership in planning and developing a safe and efficient national airport system to satisfy the needs of the aviation interests of the United States, with consideration for economics, environmental issues, local proprietary rights, and safeguarding the public investment. As part of its central mission, ARP supports a broad range of goals focused on maintaining and optimizing airport and runway safety, capacity, efficiency, financial responsibility, and environmental sustainability. ARP is responsible for all airport program matters pertaining to standards for airport design, construction, maintenance, operations, safety, and data, including ensuring adequacy of the substantive aspects of FAA rulemaking actions relating to the certification of airports. ARP also supports airport planning and environmental review and permitting processes, Airport Improvement Program (AIP) grants, property transfers, and the Passenger Facility Charge (PFC) program administration.

1.4 Guiding Principles for Development of CSINAS ConOps

The following are the guiding principles used in developing the CSINAS ConOps. These principles are consistent with the FAA's approach to other operations such as small Unmanned Aircraft System (UAS) and Operations above Flight Level 600 (FL600), the expectation is that:

1) Launch/reentry vehicles that can meet the flight characteristics and performance requirements of operating aircraft in the airspace being transited will be integrated into normal operations and within the Communication Navigation & Surveillance (CNS)/Air Traffic Management (ATM) procedures and infrastructure.

    a. Class A domestic – Automatic Dependent Surveillance – Broadcast (ADS-B), Airborne Collision Avoidance System (ACAS), direct voice and data communications with controller. If on board piloted launch/reentry vehicles,

[3] ATO Website: "We are the 35,000 controllers, technicians, engineers and support personnel whose daily efforts keep aircraft safe, separated and on time."

then some type of voice communication or an optional controller-pilot data communication; if ground operations direct ground communications to the FAA network demarcation.

2) Launch/reentry vehicles that are not integrated will have operations conducted in a cooperative environment with required information provided by the operator to the FAA network demarcation. Communications, Navigation and Surveillance (CNS) capabilities are operator provided.

3) To support this cooperative airspace management environment, the FAA will work with the launch/reentry operator community to develop standards for information exchange of surveillance, and intent with associated Adaptive Risk Envelope (ARE).

4) There will be different levels of access resulting from risk-based assessments that consider vehicle/operator capabilities (e.g., CNS capabilities), the manner of operation, and the airspace transited.

The Guiding Principles and Philosophies assume that any attempt to integrate launch and reentry vehicles into the NAS would need to be accomplished incrementally as part of a phased approach. Likewise, any strategies developed to address launch and reentry operations would need to be flexible and readily adaptive to rapid advancements in technology.

Given the growing number of stakeholders involved with launch and reentry vehicle operations, collaboration with industry, other governmental agencies, and international bodies is a necessary component of this concept. In future implementation plans for this concept, the FAA will seek to ensure the safety of the NAS and minimize impacts on other NAS users and the environment.

1.4.1 Phased Approach to Integration

The concept embodies that the FAA will take a phased approach to integration, using risk-based decision-making to efficiently respond to the growing operational needs, and technological evolution of the NAS and that of the launch and reentry vehicles and operations. The pace of launch and reentry vehicle integration is determined by the combined ability of industry, the operator community, other government agencies and the FAA to overcome technical, regulatory, and operational challenges; it will be a shared environment.

1.4.2 Flexibility

In fulfilling its commitment to industry to integrate launch and reentry operations into the NAS safely and efficiently, the FAA will be flexible in addressing the changing needs and priorities of the industry. Risk-based decision-making and performance-based regulations are just two ways in which the FAA is already adapting more quickly to the rapidly advancing technologies and changing demands within the constraints of the Federal rulemaking process. This flexibility can reduce regulatory delays in the continuing evolution of technology, while maintaining an acceptable level of safety within the NAS.

1.4.3 Emphasis on Collaboration

Close collaboration with industry, state and local governments, other Federal Government agencies, international organizations, and foreign aviation authorities is a critical element of this concept and to successful integration of launch and reentry operations into the NAS. Because space vehicle technologies and community needs are expected to change rapidly, the FAA will need to leverage the research and knowledge of the space industry and research organizations in order to develop safety standards and regulations as well as policies and procedures more rapidly. Partnerships with the space community are key to implementation of this concept and successful development of standards for launch and reentry operations. Coordination and collaboration with organizations representing other airspace users will ensure that their views and changes in operations are also taken into consideration.

Coordination with other U.S. agencies, such as the DoD, Department of Homeland Security (DHS), NASA, and the Department of Commerce (DoC) will enable the FAA to leverage the technical and operational expertise of those stakeholders and ensure a consistent and comprehensive set of operational U.S. policies. The FAA will also collaborate with airports, state and local officials to support safe and efficient management of aircraft in their respective jurisdictions to ensure equitable access to the NAS and airport surfaces and facilities. Partnerships with international organizations and foreign authorities will enable the FAA to provide international leadership promoting a risk-based approach to permitting safe launch and reentry operations, and to encourage global industry standards and practices.

1.4.4 Minimized Impacts on Other NAS Users

Safety and airspace access for other NAS users is a central theme in this concept. As future launch and reentry sites and dual-use airports are licensed, and standards and policies are developed, NAS safety and efficiencies are at the forefront. This concept supports a common strategy for management of the NAS that seeks to minimize negative impacts imposed by launch and reentry operations on other NAS users such as commercial air carriers, general aviation (GA), and helicopters as well as future new entrants. The FAA will support safe space vehicle operations within airspace shared with other air traffic provided necessary safeguards are available to maintain safe separation among all aircraft.

1.4.5 Environmental Considerations

To achieve full integration of launch and reentry operations into the NAS the environment must be considered. As additional launch and reentry sites and dual-use airports are requested by industry, state and local governments, this concept considers the FAAs environmental review requirements. These requests include the review of the broad range of environmental categories covered by the National Environmental Policy Act of 1969 (NEPA)[4] and other special purpose environmental laws such as noise, air quality, visual effects, historical, architectural, archeological, tribal, and cultural resources.

1.4.6 Data Exchange and Information is Essential for Success

This concept relies on the continual development and deployment of many of the NextGen technologies, policies, procedures and capabilities to stay abreast of the momentum of the space industry. Secure data sharing and distribution by industry and government is key to collaborative decision-making and shared awareness of NAS status. By improving the data handling and network capabilities to securely record, archive, retrieve, and distribute data will:

- Improve shared awareness and interoperability among the FAA, commercial space operators, federal ranges, and other NAS users.
- Take advantage of common, standard protocols, and formats for inputting, processing, transferring, and coordinating data and information so it can be fully integrated and facilitate decision-making, information sharing, and improving common situational awareness.
- Leverage use of commercial-off-the-shelf systems allowing for the use of advanced data handling capabilities being developed and rapid changes in technologies.

Note, the term telemetry is used throughout the document. As telemetry is a broad term, we will work to define the actual elements of telemetry exchange through our concept development processes.

1.5 Remaining Document Organization

This ConOps describes a transformation in the approach to managing the NAS during commercial space launch/reentry operations. This transformation will improve NAS efficiency by:

- Integrating commercial space and other NAS operations where the degree of integration is commensurate with the potential benefit of increased system efficiency and capacity; safety will always be at the forefront
- Streamlining and standardizing processes for planning and executing commercial space operations

This ConOps focuses on launch/reentry operations occurring in the NAS, defined as the airspace in which the FAA provides air traffic control (ATC) services. Airspace management may be bounded by the limits of NAS automation.

The remainder of the ConOps is organized into six sections. These sections include:

- **Section 2: Current Operations and Capabilities** - This section describes the existing methods, tools, and procedures for managing launch and reentry operations.

[4] The National Environmental Policy Act of 1969, as amended, (Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258, § 4(b), Sept. 13, 1982)

- **Section 3: Need and Justification for the Concept** - This section identifies and describes shortfalls in the current system and introduces strategies to address these shortfalls.
- **Section 4: Future Operations and Capabilities** - This section describes the future operational environment and presents a path to integrating launch/reentry operations fully into the NAS.
- **Section 5: Operational Scenarios** - This section provides representative scenarios depicting how specific mission types will be conducted in an integrated environment.
- **Section 6: Impact of Concept** - This section summarizes the anticipated impacts of the concept on various stakeholder types.
- **Section 7** – **References** – This section lists the references used in the development of the ConOps.

2 – Current Operations and Capabilities

This section describes the existing methods for managing commercial launch/reentry operations. It includes the following subsections:

- **Stakeholders** - This section describes the stakeholders involved in managing launch/reentry operations.
- **Current Operational Environment and Infrastructure** - This section describes the current processes and tools used for managing commercial launch/reentry operations.
- **Description of Current Operations** - This section describes how commercial launch and reentry operations are currently conducted, including planning, real-time operations, and post-operations analysis.
- **Current Launch Sites, Reentry Sites, and Dual-use Airports** - This section describes the evolution and use of launch sites, reentry sites, and dual-use airports. It also discusses the current regulatory structure in place for their operation.
- **Environmental Review for Commercial Space License or Permit Applicants** - This section describes current processes that ensure compliance with the NEPA and the types of environmental reviews conducted by FAA.
- **Current Safety Procedures, Review, and Approval Considerations** - This section describes today's safety considerations associated with commercial launch/reentry operations.

2.1 –Stakeholders

Launch and reentry operations are currently supported by multiple operational stakeholders, each with tools that enable the responsibilities specific to their organization and function. For development of this concept, stakeholders involved in current operations were separated into NAS users and FAA support staff.

2.1.1 NAS Users

NAS users include commercial operations (e.g., air carriers, air taxis, cargo, charter, business jets, etc.), DoD, state aircraft, and general aviation operating under both Instrument Flight Rules (IFR) and Visual Flight Rules (VFR). The flight operator stakeholders most relevant to this ConOps include Flight Operations Center (FOC) personnel and flight crews. Under current operations, these users file flight plans consistent with published Notices to Airmen (NOTAMs) that avoid any airspace closures for the duration of the published closure. However, in some cases, the NOTAMs instruct IFR traffic to file their normal routes, and ATC uses tactical separation methods to manage the operation. Avoiding this airspace often requires flight operators to use longer routes than their preferred routes. This often results in additional fuel burn, loss of efficiencies, and therefore additional cost. They may also incur delays due to traffic management initiatives (TMIs) used to manage air traffic near the protected airspace.

A growing group of NAS users, referred to as launch and reentry operators, represent many organizations with varying degrees of sophistication in their internal analysis, planning, logistical capabilities, and mission requirements. Members of this group include private organizations such as research colleges launching small rockets. However, most of the operators are commercial companies. Commercial companies performing launch/reentry operations receive licenses or permits from the FAA and coordinate with launch/reentry sites, dual-use airports, or federal ranges where the operation could take place. The operations of commercial launch/reentry sites are licensed by the FAA. Federal ranges are operated by the U.S. government, and include sites such as Cape Canaveral Air Force Station, Vandenberg Air Force Base, and NASA's Wallops Island. Commercial launch/reentry operators may enter into contracts with a host range to receive launch/reentry services, such as range safety and ground safety services. As with any other NAS user, they consider the effects of their operations on the NAS and consider alternatives to minimize those effects to the extent possible.

2.1.2 FAA Organization Support

Various entities within the FAA are responsible for distinct aspects of integrating commercial launch/reentry operations into the NAS. These entities include AST, AVS, ARP, and the ATO. AST executes its licensing and permitting functions, evaluates applications, and makes authorization determinations. AVS and AST work closely together in the licensing and permitting of "hybrid vehicles" that can operate under airworthiness certificates and licenses, ensuring operators use consistent safety procedures under either authorization to the extent possible. ARP and AST work closely together in the licensing or permitting of operations that occur at or near existing airports, ensuring that any effects of launch/reentry operations on airport safety, efficiency, and capacity are addressed. Within the ATO, personnel at air traffic facilities and the Command Center participate in the licensing process through the development of agreements. These include facility airspace and procedures specialists, members of the Operations Support Groups at the Service Areas, the Central Altitude Reservation Function (CARF) at the Command Center, and members of the Joint Space Operations Group (JSpOG).

The JSpOG is comprised of representatives from AST and the Air Traffic Control System Command Center Space Operations Group (ATCSCC SOG). The JSpOG was established in 2014 as part of the answer to the FAA Administrator's Strategic Initiatives to develop the methods and processes for integrating launches and reentries into the NAS. For operations with national traffic management implications, the JSpOG manages the tactical decision-making of the airspace management planning process by assessing the proposed operation and alternate strategies for safely and efficiently accommodating the missions. The results of these assessments and a final strategy are captured in an Airspace Management Plan (AMP) as described in Section 2.3.1.

On the day of the launch/reentry operation, at least one JSpOG representative monitors and evaluates the status of operations in real-time, distributes necessary notifications and information, and remains prepared to respond to off-nominal events. Post-launch or reentry, the JSpOG evaluates the effectiveness of the AMP, gathers lessons learned, maintains historical launch/reentry information, and prepares operations reports for FAA management.

AST coordinates directly with launch/reentry operators and assists ATC facilities in developing agreements. Furthermore, as part of its licensing and permitting evaluation processes, AST computes or evaluates the Aircraft Hazard Areas (AHA)[5] for operations that do not take place from federal ranges and validates an applicant's information. The coordinates for these AHAs are provided to Air Traffic personnel and provide the basis for what airspace must be segregated from live traffic. Currently, Altitude Reservations (ALTRVs) and Temporary Flight Restrictions (TFRs) are used for this.

Although the JSpOG is typically the lead for operations occurring from a federal range, they have not been historically involved in operations occurring at licensed launch/reentry sites, dual-use airports, and private sites. In these cases, the local ATC facility assesses the proposed operation for conflicts and constraints. The JSpOG/ATCSCC has recently become more involved in coordination and operations from these sites to ensure a national-level perspective.

The ATC facility that controls the airspace in which the launch/reentry operation occurs has a significant role in planning and managing the airspace. The affected facilities review the proposed activity and the effect on the facility's airspace, and if necessary, identifies and proposes alternative strategies. Traffic managers and airspace and procedure specialists work with AST and ATCSCC SOG to coordinate and implement the operation through various means, including TFRs and ALTRVs, and communicate this information to operational staff and other impacted facilities. Traffic managers and controllers provide operational direction (e.g., ground delays, reroutes, etc.) to affected aircraft and traffic flows to safely manage the airspace and avoid the constraint areas.

2.2 – Current Operational Environment and Infrastructure

The FAA process for managing the NAS during launch/reentry operations continues to evolve through experience and repetition. The process relies on human experience, judgement, collaborative decision making and decision-support tools, mission objectives, and varying priorities. Each stakeholder uses tools specific to their role in the operation. The following subsections describe current processes and tools used for managing the NAS when commercial launch and/or reentry operations are occurring.

2.2.1 – Types of Launch and Reentry Operations

Launch operations begin well before liftoff, with planning the mission and preparing the vehicle and any cargo. Planning activities can begin weeks, months, or even years in advance of the proposed launch date. Customer requirements dictate many fundamental aspects of the operation, including the type of vehicle to be used, available launch sites, the path that the vehicle will take along its mission (i.e., its trajectory), and the timing of the operation (i.e., its launch window). Mission planning typically begins with the operator addressing these requirements, and each addressed requirement tends to limit the trade space of options

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[5] Airspace defined as an area to protect nonparticipating aircraft from a launch vehicle, reentry vehicle, amateur rocket, jettisoned stages, hardware, or falling debris generated by failures associated with any of these activities. Unless otherwise specified, the vertical limits of an AHA are from the surface to unlimited.

available for future requirements to some degree. As plans mature, additional constraints are incorporated in the form of regulatory authorizations, the availability of necessary infrastructure and commodities, and the performance of specialized analyses (e.g., on-orbit collision avoidance analyses).

A suborbital launch is typically designed to reach a predetermined altitude, based on the customer's mission needs. These launches include suborbital space tourism and research flights designed to expose space flight participants or cargo to the space environment for brief periods of time. Since peak altitude (i.e., apogee) is a key mission design parameter, these operations will typically originate and end from the same location. In the future, "point-to-point" suborbital launches will originate from one location and transport people and/or cargo to another location. Suborbital launch operations typically take from 20 minutes to one hour to complete, depending upon many factors.

Suborbital launches can depart horizontally from a runway or vertically from a launch pad. However, not all launches occur from the ground. For example, a captive carry launch operation uses a carrier vehicle, most often an airplane, to transport a rocket-powered element of the launch system to a particular altitude. Once the carrier aircraft is at launch altitude, the vehicle in carry position is released, ignites its rocket engines, and continues the mission. The released vehicle may follow a suborbital trajectory and return to land on the surface, or it may continue to orbit.

Launches to orbit require significantly more performance than suborbital launches, so the launch vehicles are typically larger and more complex than suborbital launch vehicles. Although captive carry launches to orbit do occur today, most launches to orbit depart from ground launch pads. Within seconds after liftoff, the vehicles begin slowly turning from the vertical direction to a more horizontal direction, accumulating the horizontal velocity required to achieve an orbit at altitude hundreds, or even thousands, of miles above the Earth. As the vehicles climb under rocket power, most of them intentionally jettison hardware in the form of spent stages, fairings, and other components. These components fall through the airspace to the surface. Some operators recover these components for reuse through various means, including flying them back under rocket power to surface location. A typical launch to orbit takes about 10 minutes, from liftoff to orbital insertion.

Phases of launch include preflight, flight, and post flight activities. Preflight processing activities include stacking vehicle stages, loading propellants, stowing cargo, arming safety systems, and boarding crew. Preflight operations for a captive carry launch include taxiing. The flight phase can include jet-powered flight (for captive carry operations), rocket powered flight, and unpowered flight. Unpowered flight can include gliding, descending under parachute, or just falling to the surface. Vehicles can be designed to land horizontally on a runway, or vertically by parachute or rocket powered landing. The post flight phase includes all activities that take place after the vehicle reaches its destination on orbit, or activities that occur after it returns to the surface that are required to make it safe to approach.

Reentries occur from Earth's orbit or beyond. The pre-reentry phase includes preparations to perform the deorbit burn that slows the vehicle down enough to allow it to begin falling. These preparations include vehicle health checks, vehicle orientation changes, stowing or jettisoning solar arrays, and similar activities. Rocket motors perform the deorbit burn, which can last several minutes. Once the burn is complete, some reentry vehicle concepts jettison components that are no longer needed, like service modules which carry the propellant used while on orbit and during the deorbit burn. Often these components are manufactured from materials with low melting points, allowing them to burn up in the upper atmosphere. Once the deorbit burn completes, the vehicle may fall or glide to the surface. Falling vehicles typically use parachutes to slow their descent. Some fire small rocket motors just above the surface to slow down. Gliding vehicles typically land horizontally on a pre-approved runway.

2.2.2 – Airspace Management

The primary method for protecting aircraft from commercial launch/reentry operation hazards is to isolate the operation from other NAS users. The FAA prevents other NAS users from entering or operating within the launch/reentry areas using some type of SAA such as ALTRVs, restricted areas, Air Traffic Control Assigned Airspace (ATCAAs) and TFRs, specifically 14 Code of Federal Regulations (CFR) §91.143. These airspaces are implemented before the mission starts to preemptively protect against hazards. They are sized according to 14 CFR §400 regulations, and extend from the surface to unlimited altitude. NOTAMS provide notification of planned activation of the areas. Aircraft operators avoid these areas through flight planning, in-flight deviation or ATC instructions.

Not all commercial launch/reentry operations take place in airspace defined by fixed, charted boundaries. For these situations, ALTRVs and TFRs are implemented. ALTRVs dictate airspace use under prescribed conditions, and are normally employed for the mass movement of aircraft or other special user requirements that cannot otherwise be accomplished. They are approved by the appropriate FAA facility (FAA JO 7110.65). TFRs are temporary regulatory actions that define dimensions of airspace to prevent aircraft from operating near events including VIP movements, air shows and sporting events, hazards, disaster relief, and space flight operations (FAA, 2014). The FAA uses ALTRVs for launch/reentry operations that are coordinated through the CARF. TFRs and ALTRVs for launch/reentry operations are published to the aviation community via either domestic or international NOTAMs before the scheduled operation and cancelled once the operation is complete.

The NOTAM includes a description or identification of the protected airspace involved, and the start and end times of the scheduled closure. The start and end times correspond to the operational window of the scheduled activity, which is generally based on mission requirements and vehicle performance. For launches, the window corresponds to the timeframe in which the launch could occur and still meet the mission requirements, plus an additional amount of time to address potential launch delays or failures. The requested time window may range from just a few minutes to several hours, based on constraints such as orbital mechanics and limitations in vehicle performance. Airspace closures to support the missions can result in reduced access to public-use airports and airspace located near the launch/reentry activity.

2.3 – Description of Current Operations

The following subsections describe how the FAA currently integrates commercial launch/reentry operations in the NAS. This involves three distinct phases of the operation: pre-operational planning, real-time operations, and post-operations review and analysis. The process by which the FAA currently licenses the operations of a launch/reentry site is discussed in Section 2.4.

2.3.1 – Pre-operational Planning (includes long- and short-term planning)

AST has the responsibility for licensing and permitting launch and reentry vehicle operations. For planning NAS access and vehicle operations within the airspace during the planning process, operators may plan for the use of an ALTRV, TFR or Special Use Airspace (SUA). An ALTRV is typically used for operations conducted from a federal range. Figure 1 illustrates the pre-operational planning process for launch/reentry licensed or permitted operations and is described in the following paragraphs. The launch/reentry and dual-use airport licensing process is described in Section 2.4.

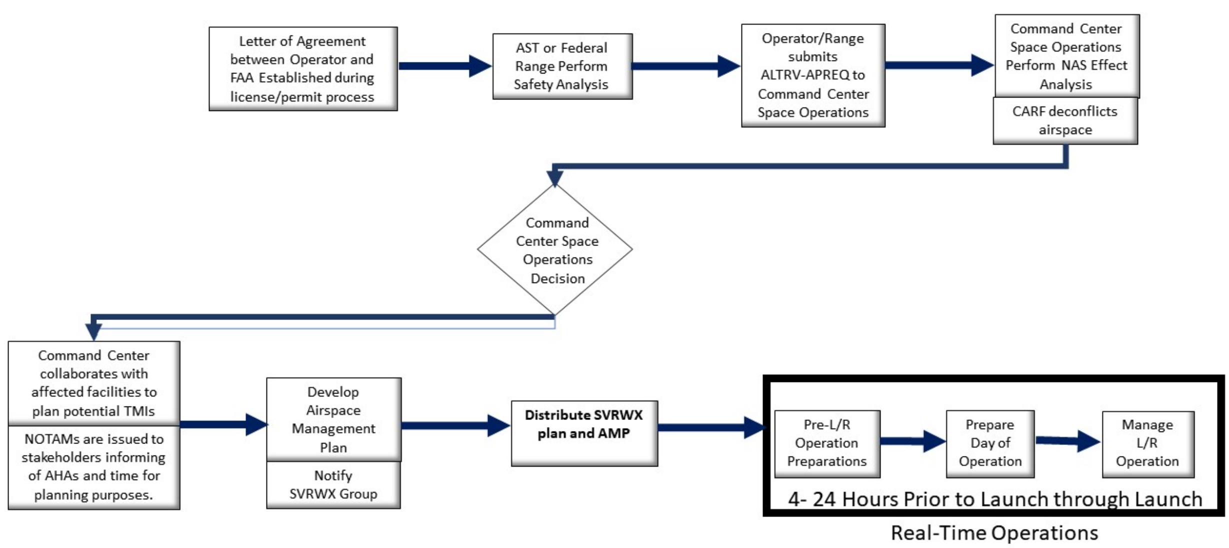

Figure 1 - Pre-mission Planning Process

The first step in any commercial launch/reentry operation is the licensing and permitting application process. The launch/reentry operator applies to AST for a license or permit to conduct one or more operations. The application includes a Letter of Agreement (LOA) between the operator and the FAA ATC facility with jurisdiction over the airspace to be used, that establishes procedures for each operation such as notifications, communication, and response to contingencies. The application includes data about the proposed mission, such as mission timing, mission type, payload, and the operator's plans and processes for ensuring public safety. As the application and evaluation processes may occur over months or even years, this information may change. AST receives updates from the applicant and coordinates with other FAA LOBs, as necessary. Once AST grants a license or permit, the operator and the FAA begin specific planning for the mission including scheduling for specific days and times, developing or evaluating AHAs, and assessing the effects of the required AHAs on the NAS. For some of these activities, a federal range may act on behalf of the operator, as described in the operator's license or permit.

Since local processes have evolved differently over time, notifications may take different forms depending on the location (e.g., federal range, private site, dual-use airport), whether it requires an ALTRV, TFR or SUA, and if there are any unique notification requirements defined in the LOA. As a result, the notification may be received first by the ATC facilities or by the JSpOG. For operations conducted from a federal range, the JSpOG receives the notification in the form of a safety letter and a Ready or Return Minus 15 (R-15). By regulation, an operator submits the R-15 to AST no later than 15 days in advance of the operation to support the execution of a collision avoidance analysis for objects on orbit. The R-15 contains operational window information that the JSpOG uses to verify the date and timing of the mission, along with backup dates and times. The JSpOG typically receives the safety letter 10 days in advance of the operation, and it contains the coordinates defining the boundaries of one or more AHAs and timing information that lists how long each airspace area should remain closed for both a nominal operation and if an off-nominal event were to occur. In these cases, AST reviews and verifies the AHA coordinates. For operations that do not take place from federal ranges, an operator may compute the AHA and coordinates, and provide the information to AST to review and verify. At other times, AST may compute them. For launches to orbit and reentries from orbit, the ATCSCC space operations group (SOG) distributes the expected airspace actions to the affected ATC facilities. For suborbital launches, the airspace actions are handled with a similar process and distributed by the affected ATC facilities.

If an ALTRV is required, the operator, or a federal range acting on behalf of an operator, submits an ALTRV Approval Request (APREQ) form to both the ATCSCC SOG and to CARF. CARF de-conflicts the ALTRV requests it receives from various entities. Either CARF or the applicable ARTCC may issue the required NOTAMs.

For operations led by the JSpOG, the ATCSCC SOG uses the mission and airspace data to identify other known activities that may cause potential conflicts. Furthermore, the ATCSCC SOG works with ATC facilities potentially impacted by the operation to identify location-specific issues or constraints. For operations led by an ATC facility, the facility performs these functions and coordinates the results with ATCSSC and other affected entities.

Once the airspace for the proposed launch/reentry operation is deconflicted from other activity, the lead facility conducts a NAS effect analysis to predict the effects that the operation may have on system capacity and efficiency. For operations led by the ATCSCC, the JSpOG performs this assessment. For operations led by the local ATC facility, the facility may perform this assessment. This process involves evaluating the airspace against historical air traffic data for the area of interest, identifying the affected routes, estimating the number of aircraft affected, and calculating the reroute mileage or delay time required for each flight to avoid the activity during the NOTAM times. Using this data as a baseline, the lead facility evaluates the launch/reentry mission constraints against available airspace management strategies and may coordinate refinements to planned or existing TMIs.

If the evaluation indicates that the FAA cannot support the operation as planned, the lead facility works with the operator to identify and assess alternative plans that reduce the effects on other NAS users. In some cases, the mission constraints may not allow for any alternatives to be exercised. The process can take days or weeks to complete, depending on the complexity of the request and the availability of required data.

For operations led by the ATCSCC, the ATCSCC SOG develops an AMP once a decision is made to proceed with the mission. The AMP documents the factors considered in making the decision, including the effects on NAS efficiency and the operator's constraints. Once the AMP is complete, the JSpOG distributes it to the stakeholders involved in the operation (e.g., affected ATC facilities, AST, other NAS stakeholders, etc.). ATCSCC SOG then reviews the launch/reentry operational information with traffic management (TM) personnel, the Severe Weather (SVRWX) unit, the DoD Liaison, the ATCSCC Advanced Planning Team (APT), and the Strategic Planning Team (SPT). Once the TMIs and advisories have been developed, they are disseminated via the Traffic Flow Management System (TFMS). The ATCSCC APT sends the plan to other NAS users two days in advance of the operation, so they can file flight plans that comply with associated airspace constraints.

After NOTAMs are issued, the JSpOG verifies its accuracy. For operations requiring an Electronic System Impact Report (eSIR), the JSpOG verifies that the affected facility has submitted the required eSIR. Additionally, within 24 hours prior to the operation, NOTAMs inform the public about airspace restrictions. Airspace is activated by ATC according to the NOTAM and the planned TMIs and ATC advisories are implemented. If necessary, ATM personnel revise TMIs based on operational status and the mission information is briefed to the APT and on the SPT Telecom.

Leading up to the launch/reentry operation, the operator reports its readiness to proceed with the mission to the lead facility, as defined in the LOA.

The flow of information described in this section can vary for launches and reentries conducted by the U.S. Government (e.g., DoD or NASA) since AST does not regulate these operations. In this case, the federal range from which the operation will be conducted coordinates directly with both the affected ATC facilities and the JSpOG. The ATCSCC SOG supports coordination between multiple facilities (e.g., air traffic is affected in multiple ARTCCs) when necessary. As with commercial aviation operations, the ATCSCC SOG then assesses the expected effect of the operation on NAS traffic and determines appropriate traffic management measures to address the affected airspace. Negotiations that result in changes to the proposed operational parameters, such as the launch window, are rare. The process for preparing and publishing NOTAMS to notify other NAS users of the operation is the same as any other aviation operation notification.

2.3.2 – Real-Time Operations

The real-time operations phase begins 4-24 hours prior to the scheduled launch/reentry operation and ends when the operation has been completed or scrubbed.

ATC ensures that the protected airspace is clear of IFR and VFR traffic prior to the SAA start time. ATC begins to reroute traffic as the scheduled start of the operational window approaches. In the oceanic (non-radar) environment, the reroutes could start hours before the activation time. The launch operator provides the FAA with updated status of its readiness to perform the operation, in accordance with the LOA. This mission status is disseminated manually to all involved organizations via emails, phone calls, a hotline, or other communications media.

Currently, no capability exists to provide ATC with a live automated display or real-time knowledge of the vehicle's position or status. During the mission, the operator keeps contact with the vehicle, relaying required information and situational reports to the FAA in accordance with the terms of the LOA. These reports may come to the local ATC facility or the JSpOG via emails, phone calls, a hotline, etc. For licensed or permitted launches, AST safety inspectors stationed onsite at the operator's facility provide additional mission status information to the JSpOG. When the operation is complete or scrubbed, the operator contacts the responsible facility and the facility releases the airspace so normal operations (e.g., route use) can resume.

If an off-nominal event occurs, the operator contacts the lead facility in accordance with the terms of the LOA. For some operations, this response may include real-time AHA computation using the best available data at the time of the failure. For operations from a federal range, the range may provide this AHA. For operations conducted elsewhere, AST may provide it. The lead facility uses the refined AHA to determine if the airspace closed in advance of the operation remains sufficient, or if additional airspace must be closed to ensure public safety. The lead facility coordinates and implements the necessary contingency response.

2.3.3 – Post-operations Review and Analysis

The lead facility may perform a post-operations review and analysis of the data to verify that plans developed in advance of the operation were adequate, to capture actions and lessons learned, and to prepare for the next operation. For operations led by the JSpOG, the JSpOG enters a previously compiled list of aircraft call signs into the TFMS to determine if they are flying at the time of the operation and what route they are flying to avoid the NOTAM airspace. The JSpOG also examines aircraft flying during the operation and attempts to determine if it is likely that they were flying hazard area avoidance routes. If there are any questions on managing a launch/reentry operation, the JSpOG contacts the controlling ATC facility.

During post-mission analysis and review, the JSpOG also reviews the air traffic situation stored on the TFMS leading up to the actual launch time, during the active launch window, and immediately after the airspace was reopened to air-traffic. These reviews are conducted using the replay function of the Traffic Situation Display (TSD). The JSpOG captures any issues and compares the projected effects to air traffic (number of aircraft reroutes estimated and by how much) to the actual number of aircraft reroutes likely due to the launch/reentry operation. The JSpOG also evaluates relevant ATCSCC route advisories and documents them for any possible impact.

JSpOG personnel support a launch/reentry post operational analysis by performing the following:

- Compiling observational data to include screenshots of the operation
- Capturing aircraft hazard area computation data files
- Logging NOTAMs and ATCSCC advisories from operations
- Compiling observational data, including number of flights affected and reroute mileage
- Capturing and compiling a list of lessons learned
- Completing the operations report
- Assigning/executing/closing out actions

The results of the post-operations analysis are captured in reports and shared within AST, the ATO, and then archived. The post-evaluation also includes lessons learned and the tracking of action items as necessary. There is no central repository of these archived reports. Each organization maintains its own records and the information is shared as needed across the organizations.

With today's capabilities, the number of aircraft affected is difficult to quantify. Once the NOTAM messages are published, some pilots may file a reroute to avoid the published activity area even if the NOTAM directs them to file their normal routes. The actual number of aircraft affected or the reason for the reroute choice may not be known but is a "best estimate" given the situation and known information. Effectiveness of the applied strategies, such as the number of aircraft that use an opened air route or corridor, is assessed against historical data and predictions.

2.4 Current Launch Sites, Reentry Sites, and Dual-use Airports

Traditionally, launch sites were federally-owned and -operated locations, providing facilities and services for launching government rockets. NASA's Kennedy Space Center, Wallops Flight Facility, Cape Canaveral Air Force Station, and Vandenberg Air Force Base are the primary government locations that have regularly conducted launches from the U.S. for more than 60 years. In the past two decades, U.S. Congress passed several pieces of legislation that are steering the use of government assets for access to commercial launch/reentry, including commercial launch facilities, rockets, personnel, and missions. Legislation such as the Commercial Space

Launch Amendments Act (CSLAA)[6], NASA authorizations, and other initiatives have encouraged the use of commercial providers for launches. The President's National Space Policy (2010)[7] and National Space Transportation Policy (2013)[8] have also supported these initiatives. These policies also encouraged the U.S. government to offer excess capacity at its launch sites to commercial operators, providing even more opportunities for commercial launches from government ranges.

AST regulates the operations of launch/reentry sites and assists entities looking to apply for licenses through pre-application consultation. When an applicant applies to the FAA for a site license, they must specify a type or types of vehicles the applicant intends to operate from the location. Licensed launch/reentry sites may be operated by state or local governments through airport or aviation authorities. Some emerging locations are operated by private commercial entities. Some licensed launch sites are dual-use airports, in that they are both airports and launch/reentry sites.[9] As of 2018 the FAA has licensed the operations of 11 commercial launch sites.

2.4.1 –Definition of Launch Sites and Reentry Sites

Like today's airports, launch sites can vary in size, layout, and function. Much depends on the types of operations the applicant intends to host. The addition of commercially-owned and -operated launch sites to the list of formerly federal launch sites allows for diverse missions and users to gain more efficient access to space. To date, however, the FAA has overseen the operations of launch/reentry sites using a single regulatory approach.

2.4.2 – Dual-use Airports

A launch/reentry site that can support horizontal launch vehicles is typically co-located at an airport. A site that is co-located at a federally-obligated and/or 14 CFR Part 139 certificated airport is also referred to as "dual-use" because of additional regulatory or statutory requirements imposed on the airport. In addition to complying with 14 CFR Parts 420 and 433 and the terms and conditions of the launch/reentry site license, the operator of a dual-use airport must also comply with applicable ARP regulations, standards, AIP grant assurances, and oversight.

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[6] Commercial Space Launch Amendments Act of 2004, Public Law 108-492-Dec. 23, 2004

[7] The National Space Policy expresses the President's direction for the nation's space activities. Broadly, it recognizes the rights of all nations to access, use, and explore space for peaceful purposes; promotes international cooperation in space science and exploration, Earth sciences, and space surveillance; and emphasizes openness and transparency. Specific to U.S. activities in space, the policy recommends that the U.S. government use commercial space products and services in fulfilling governmental space and emphasizes the need for partnerships between NASA and the private sector. It highlights the need to invest in space situational awareness capabilities, orbital debris mitigation, and launch vehicle technologies, among other issues relating to national security. Finally, it states that the U.S. will accelerate the development of satellites to observe and study the Earth's environment, and conduct research programs to study the Earth's lands, oceans, and atmosphere.

[8] The National Space Transportation Policy 2013 includes guidelines applicable to the civil, national security, and commercial space transportation sectors. http://www.space.commerce.gov/policy/national-space-transportation-policy/

[9] An important distinction for a launch or reentry site is whether it is at a dual oversight facility (i.e., an FAA licensed launch/reentry site and a federally-obligated or Part 139 certificated airport) or not." This is not reflected in the discussion because the distinction involves FAA oversight, and not launch vehicle operations.

As of 2018, the FAA has licensed five launch sites that are dual-use: Cecil Spaceport in Jacksonville, Florida; Houston Spaceport in Houston, Texas; Mojave Air and Space Port in Mojave, California; Oklahoma Air and Space Port in Burns Flat, Oklahoma; and Midland International Air and Space Port in Midland, Texas.

Launch or reentry of horizontal flight vehicles is not limited to dual-use airports. A private or public use airport could apply for a launch/reentry site license for accommodating these vehicles. Similarly, purpose-built launch/reentry sites are designed specifically to support commercial launch/reentry operations. Only one purpose-built launch site for horizontal launch/reentry vehicles, Spaceport America in New Mexico, is currently licensed. While the facility looks like an airport, it is not subject to the same statutory or regulatory obligations as a dual-use airport.

Launch/reentry sites also vary with respect to the types of operations that may be supported. The types of vehicle operations that may be accommodated at a given site are determined by many factors such as:

- Destination/mission objective and the preferred launch/reentry trajectory
- Ability of the launch site to accommodate the vehicle operational, performance, and support requirements in a manner that meets public safety criteria
- Site scheduling assurance and range turn-around time (e.g., time to process successive operations)
- Environmental constraints (e.g., noise, air and water quality concerns)
- Economics (e.g., launch costs)
- Historical weather trends (i.e., the probability that weather patterns/trends will present a risk to the launch window)

2.4.3 – Dual-use Airport Regulation

Dual-use airports must comply with applicable ARP regulations, standards, and assurances. These apply to the planning, design, operation, and maintenance of any federally-obligated and/or 14 CFR Part 139 certificated airport. In some cases, these can place more complex constraints on the launch/reentry site operator's siting of propellant storage and loading areas, research and development activities, and propellant haul routes compared to other sites.

AST regulations were not written specifically to address launch/reentry activity in the airport environment. Similarly, ARP regulations and standards were not written to address commercial launch/reentry activities on airports. There are known gaps between AST and ARP regulations and standards. While that has not stopped the FAA from licensing dual-use airports, there are known issues that are being addressed to fully integrate these activities with traditional aviation uses:

- Propellant Siting and Oversight: AST regulations require applicants to identify propellant storage within their Explosive Site Plans (14 CFR §420.63) but do not require these storage facilities to be located within the launch site boundary (14 CFR §420.21). AST's public safety oversight authority is limited to the facilities or operations located within the launch site boundary or related to launch activities. ARP regulatory oversight is limited to aircraft fuel storage and handling. ARP's regulatory oversight and technical resources do not include propellant storage and handling.

- Propellant Loading Areas: AST regulations of pre-flight and post-flight activities (§417.411, §437.53) do not specifically preclude loading propellant on a runway or taxiway. ARP's current guidance is to locate propellant loading away from critical infrastructures such as runways, taxiways, safety areas, and navigational aids (NAVAIDs).
- Space-Related Activities: AST regulations do not apply to space-related activities that do not meet the regulatory definition of launch (§401.5), such as rocket engine testing. ARP standards and regulations do not provide specific guidelines on the siting and operation of these facilities on airports because there has not been a need for such guidelines until now.
- Regulatory Definitions: Existing regulation tends to focus on either traditional aviation or commercial launch/reentry operations but not both. For example, airport emergency planning and response requirements under 14 CFR Part 139 address aircraft incidents and accidents, passenger safety, and fuel hazards. These regulations do not specifically cover launch or reentry vehicles, space flight participants, or propellant storage and handling.
- Protection: AST regulatory requirements ensure protection of the public and impose insurance requirements to address the potential damage to property (14 CFR §440.9). ARP's regulations, standards, and assurances also protect the utility and efficiency of the public use airport.

As launch/reentry operations increase, airspace closures required to ensure public safety during a launch or reentry could prevent other stakeholders from using public use airports. Further, closures of airspace above or adjacent to an airport can also affect its utility and efficiency. The FAA's efforts to engage the airspace user community on airspace access and launch site definitions should provide some agency direction on these and other critical challenges.

2.5 – Environmental Review for Commercial Space License or Permit Applicants

Environmental review is a required part of the AST approval process for each license or permit application, as the issuance of a commercial space license or permit is a major federal action under NEPA of 1969, as amended (42 United States Code §4321, et seq.). The environmental review process begins as part of pre-application consultation and must be completed before AST issues a license or permit. 14 CFR §415.201 of the AST regulations requires applicants to provide sufficient information to analyze the environmental impacts associated with the proposed project and comply with the requirements of NEPA, Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*. In addition to FAA Order 1050.1F, there are other NEPA-implementing policies and procedures that may be applicable to a proposed project at federally-obligated or 14 CFR Part 139 airports, including FAA Order 5050.4, *NEPA Implementing Instructions for Airport Actions.*

2.5.1 National Environmental Policy Act

The FAA must comply with NEPA requirements and other federal environmental laws, regulations, and orders when issuing commercial space licenses or permits. In general, the NEPA process includes the following six steps:

1. Initial identification of issues and concerns
2. Coordination with other Federal, state, or local agencies to determine which entities should be included in the NEPA process
3. Identification of the appropriate type of environmental review (see *The Types of AST Environmental Review*, below)
4. Preparation of the draft NEPA document, and public involvement, as appropriate
5. Preparation of the final NEPA document
6. Issuance of the environmental determination

2.5.2 Types of Environmental Reviews

The primary types of AST environmental reviews are environmental assessments (EAs) and environmental impact statement (EISs). In limited situations, a third type of environmental review, categorical exclusion, is encountered. The types of reviews differ based on the FAA's determination of the potential for significant impacts. Although AST is responsible for these documents, they are often prepared by the applicant or by another Federal entity (such as a Federal range operator) and independently evaluated by AST.

During the NEPA process, AST analyzes the potential environmental impacts associated with proposed activities. After all environmental analysis requirements are satisfied, AST prepares a finding or decision document which becomes part of the license or permit evaluation for an application.

2.6 – Current Safety Procedures, Review, and Approval Considerations

2.6.1 AST Safety Review and Approval for Launch or Reentry Licenses

To obtain a license, an applicant must obtain approval from AST in accordance with regulations under 14 CFR Parts 400-460. AST issues a license or permit to an applicant if the applicant satisfies the regulations for the activity which it applies and can conduct the proposed operation without jeopardizing public health and safety of property. A launch/reentry operator is responsible for ensuring the safe conduct of the operation, and for ensuring public safety and safety of property during the operation. Explicit safety review and approval requirements exist for the following applicants:

Subject	Title 14 Part
(1) Obtaining a launch license	Part 415
(2) License to Operate a Launch Site	Part 420
(3) Launch and Reentry of a Reusable Launch Vehicle (RLV)	Part 431
(4) License to Operate a Reentry Site	Part 433
(5) Reentry of a Reentry Vehicle other than a RLV	Part 435
(6) Experimental Permits	Part 437

The evaluation of a launch site operator license application under 14 CFR Part 420 does not use the term “safety review” explicitly. However, a launch site location review requires the applicant to submit a demonstration that the collective risk to the public does not exceed the regulatory limit. Further, the applicant must describe how it will execute certain responsibilities of the launch site operator such as control of public access and explosive siting. The requirements for a reentry site operator are under 14 CFR Part 433 and are not specified in as much detail.

2.6.2 AST Safety Approvals Separate from Traditional Licensing

AST has the authority to issue a safety approval, separate from a license or permit, for one or more of the following safety elements in accordance with 14 CFR Part 414:

- Launch vehicle, reentry vehicle, safety system, process, service, or any identified component thereof, or
- Qualified and trained personnel performing a process or function related to licensed launch activities or vehicles.

A safety approval is an FAA document issued by AST that contains a determination that one or more of the elements listed above will not jeopardize public health and safety, or safety of property, when used or employed within a defined envelope, parameter, or situation. This safety approval also enables launch/reentry vehicle operators to use an approved safety element within the terms of the safety approval without having to go through a re-examination of the element's fitness and suitability for a proposed operation.

The safety approval allows the safety approval holder to offer a launch vehicle, reentry vehicle, safety system, process, service, or personnel to prospective launch/reentry vehicle operators, including RLV mission operators. Once an approval is granted, the safety element may be used by launch service providers, launch site operators, or other licensed or permitted entities without additional review by AST if the operations are conducted within the limits of the safety approval.

3 Need for the Commercial Space Integration in the NAS ConOps

The future operational environment and infrastructure presented in this ConOps (see Section 4) provides a framework to address the shortfalls previously identified in the *Preliminary Shortfall Analysis Report for Integrating Launch and Reentry Operations into the NAS* (FAA, 2016).

3.1 System Shortfalls

A preliminary Shortfall Analysis Report (pSAR) of the current system (FAA, 2016) identified 14 operational shortfalls and over 50 contributing factors related to seamless integration of launch/reentry operations into the NAS. This analysis also considered factors identified in previously conducted shortfall analyses (FAA, 2014; FAA & MITRE Corp., 2014; & FAA, 2013). Three previously unidentified shortfalls that were beyond the scope of the original pSAR have been included in this document bringing the total number of shortfalls to 17. Table 1 (FAA, 2016) lists the 17 high-level shortfalls along with their major area of impact.

Table 1 - Identified System and Operational Shortfalls (*shortfall identified in pSAR 2016)

#	Shortfall	Impact Area
*1	Limited ability to efficiently receive and distribute data on launch and reentry operations.	Infrastructure
*2	Limited ability to accurately and reliably determine the current position and state of launch and reentry vehicles in all environments; and aircraft within the oceanic environment.	Infrastructure
*3	Inability to develop and distribute best practices and disseminate them among stakeholders.	Infrastructure
*4	Lack of policy and technical capabilities to address operations above Flight Level (FL) 600.	Infrastructure
*5	Lack of separation standards, procedures and/or techniques available to controllers to separate aircraft from launch and reentry vehicles.	Infrastructure
*6	Lack of complete, timely, and accurate data prevents the FAA from accurately quantifying the effect of a launch or reentry operation on the NAS.	Efficiency
*7	Ineffective processes to develop optimized plans for both the launch and reentry mission and the NAS which balance NAS stakeholders' access.	Efficiency
*8	Delayed or inefficient ability to develop and distribute tactical options to support decision-making during nominal and off-nominal events.	Efficiency
*9	Limited ability to proactively monitor vehicle health status and respond efficiently to off-nominal launch and reentry events.	Efficiency
*10	Inability to effectively address and adjudicate NAS impact concerns (beyond safety regulations) among FAA lines of business during the spaceport *[sic]* proposal process.	Policy and Procedures
*11	Lack of coordination between stakeholders who utilize and are affected by SUA/SAA availability.	Policy and Procedures

#	Shortfall	Impact Area
*12	Lack of policy defining FAA's obligation to notify foreign nations of potential hazards during planning and real-time off-nominal events.	Policy and Procedures
*13	Lack of policy defining the FAA's role and procedures in protecting aircraft from uncontrolled reentries of space debris.	Policy and Procedures
*14	A lack of NAS operational metrics that consider safety, efficiency, capacity, and performance during launches and reentries.	Policy and Procedures
15	Current regulatory approach to oversight of launch/reentry site operations is not flexible enough to address the variety of specific vehicle or mission types and activities.	Infrastructure & Policy and Procedures
16	AST regulations are not written to specifically address launch and reentry activities in the airport environment, and ARP regulations are not written to address launch and reenter operations. This leads to gaps between the two sets of regulations and standards. Examples areas where this is a known issue include propellant storage and loading, and regulatory definitions.	Policy and Procedures
17	Lack of common weather picture for FAA and launch and reentry operator to understand how weather will affect launch probability and projected NAS impact.	Efficiency

3.2 Addressing Shortfalls with the CSINAS Concept of Operations

Listed below are shared FAA strategies proposed by the CSINAS concept for mitigating or eliminating the operational shortfalls identified in the preceding section. Each mitigation strategy listed below is followed by a parenthetical list of shortfalls addressed by the strategy. These strategies include, but are not necessarily limited to:

- Developing a streamlined and standardized planning process between ANSP and operators to increase efficiency, effectiveness, situational awareness, and data sharing (addresses Shortfall numbers 1, 6, & 11)
- Developing automated tools to evaluate the impact of operations in the NAS (addresses Shortfall numbers 6, 7, & 10)
- Developing automated data sharing mechanisms among the relevant stakeholders (addresses Shortfall numbers 1, 2, 3, 6, 7, & 11)
- Developing a standardized set of data and format for data exchange between stakeholders (addresses Shortfall numbers 1, 2, 3, 6, 7, &11)
- Developing improved hazard analysis methodologies to decrease the required size and duration of the protected airspace (addresses Shortfall numbers 2, 8, 9, & 13)
- Realizing the benefits of planned improvements in air traffic surveillance and communication capabilities (addresses Shortfall numbers 2, 5, 8, 9, & 14)
- Developing tools and procedures that enable the ANSP to more efficiently plan for and respond to nominal and off-nominal operations (addresses Shortfall numbers 2, 5, 8, 9, & 13)

- Leverage or develop tracking capabilities for vehicles from surface to the NAS automation boundary and back to surface when needed (addresses Shortfall numbers 2, 5, 8, & 9). Such efforts will maximize technological advancements and developments in industry for space and other NAS users while meeting NAS requirements.
- Developing procedures and policies aimed specifically at integrating launch/reentry operations equitably into the NAS (addresses Shortfall numbers 1-7, 10-12, & 14)
- Establishing a set of defined criteria (based on vehicle type) for use in developing a method for tailoring regulatory approach at launch/reentry sites to the expected type of vehicle operation. (addresses Shortfall number 15)
- Identifying and addressing gaps in regulations covering launch/reentry operations between different lines of business. (address Shortfall number 16)
- Providing FAA, aviation, and launch/reentry operators with a common weather picture to understand how weather will affect launch probability and projected NAS impact for planning and increased NAS predictability. (addresses Shortfall number 17)

4 Commercial Space Integration Future Operations

This section describes in detail the tools, policies, and procedures proposed by the CSINAS concept. It includes the following subsections:

- **Assumptions and Constraints** – describes the assumptions underlying the ConOps and identifies constraints that could render the concept less effective than planned.
- **Stakeholders** – lists the primary stakeholders involved in the integration of launch and reentry operations.
- **Future Operational Environment and Infrastructure** – explains the airspace management methods introduced in this ConOps to more efficiently manage launch and reentry operations in the NAS, and describes the NAS infrastructure (e.g., facilities and automation) and support services (e.g., licensing, safety assurance, and information security) associated with integrating these operations.
- **Future Operations** – details launch and reentry operation management involving the operational stakeholders and methodologies.
- **Future Launch Sites, Reentry Sites, and Dual-use Airports /Airport Operations and Regulation** – describes the future processes and procedures for integrating a site into the NAS and its system of airports.
- **Future Environmental Considerations** - discusses Environment Services that allow sustained aviation and commercial space transportation growth with the new CSINAS concept. Topics include environmental considerations associated with launch and reentry such as noise, air quality, climate, energy, and water quality.
- **Future Safety Procedures, Review, and Approval Considerations –** describes safety considerations associated with commercial launch and reentry operations.
- **International Harmonization** - discusses current work in ICAO, including public safety approaches in international airspace.
- **Anticipated Benefits of the Concept** – enumerates the expected benefits of implementing this ConOps.
- **Areas for Future Concepts/Research** – identifies areas where further research is needed.

4.1 Assumptions and Constraints

4.1.1 Assumptions

In exploring the future state of commercial launch and reentry operations in the NAS for this ConOps, the FAA reviewed a set of key assumptions previously collected to set an agency-wide vision for integration[10]. Integration of commercial space into the NAS was defined as:

> *Evolving the FAA towards routine and predictable launch and reentry vehicle operations to ensure safe and efficient access in the NAS.*

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[10] CS EWG – A Vision for Integration of Commercial Space into the NAS, Characteristics and Assumptions, Version 1.0, July 28, 2017.

The assumptions supported this definition and provided a basis to compare the current state and the future vision for an integrated state.

The assumptions, listed below, also underlie the operational framework in this ConOps and are grouped into six categories: Industry Growth, Advances in Vehicle Design, Evolving Regulatory Approach, Advanced NAS Technologies, Standards Development, and Policy Development.

Industry Growth

- There will be an increase in mission proponents and advocates, including government agencies using commercial vendor services, commercial space launch and reentry operators, and private space launch and reentry organizations. As such, there is anticipated potential for additional launch and reentry sites and enabling infrastructure.

Advances in Vehicle Design

- There will be a greater variety of vehicle types and flight profiles operating much more frequently and from more locations throughout the NAS.
- Some vehicles will be capable of both space flight and controlled, powered operations in the NAS. For example, these vehicles will be capable of responding to ATC commands and be certified and equipped for integrated operations (e.g., maneuverability under ATC instruction, active transponder, etc.).
- The commercial space industry will continue to invest in technologies that will increase vehicle reliability and operational predictability. As these technologies mature and operational data is collected, the FAA's operational understanding and knowledge of flight characteristics will increase. Consequently, the FAA will evolve, manage and monitor the NAS and improve the overall predictability and efficiency of launch and reentry operations in the airspace.
- Launch and reentry operations will become increasingly safer and more reliable, with vehicle failures becoming increasingly rare.

Evolving Regulatory Approach

- The commercial space industry will mature along a path similar to commercial and cargo aviation. As that time approaches, and certain designs become mass-produced, the FAA will transition from only authorizing operations to also certifying designs of vehicles or categories of vehicles.
- The FAA's statutory authority should be expanded to allow for the eventual certification of launch and reentry vehicles, including the necessary authority to ensure the safety of vehicle occupants.
- The FAA will work across agencies to resolve any conflicts, duplications, or gaps in statutory authority to fully integrate commercial space launch and reentry operations.

Advanced NAS Technologies

- New advancements in air traffic control and management technologies supporting commercial space transportation (e.g., decision support tools for improved planning and real-time information sharing supporting launch and reentry vehicle operations) will be available.
- The FAA will continue its commitment to deliver new and improved NAS capabilities. Launch/reentry vehicle operational concepts will capitalize on these capabilities, directly and indirectly. Some launch and reentry vehicle operators may be able to incorporate these capabilities directly into their operations (e.g., mission planning, when vehicle is within altitude stratums populated in today's NAS – gliding reentry).
- The FAA and commercial space operators will continue to improve upon methodologies for analyzing NAS hazards from launch and reentry operations, using additional performance data to characterize vehicle failure probabilities, failure modes, and debris characteristics, thus reducing the analytical need to use conservative estimates in safety calculations.
- Real-time data sharing capabilities will exist between NAS stakeholders, including, but not limited to, flight plans and schedules, operational constraints, and weather data, to support tactical and collaborative decision-making.

Standards Development

- New launch and reentry site classifications will provide public awareness and enhance agency decision-making through the simplified and shared communication, coordination, and common understanding of launch and reentry site operations across the FAA.
- The FAA will publish data standards for performance level operational data (e.g. precision, latency, reliability, etc.) that will be required for launch and reentry vehicle operation approval. Launch and reentry operators will be expected to collect operational data and information per these standards and submit them as part of the approval process.
- Launch and reentry vehicle standards will be established and used to certify vehicle designs and demonstrate compliance with regulations.
- Fleets of launch and reentry vehicles will be produced according to established standards.
- The space industry is currently self-policing and the overall structure of standards bodies is not completely apparent. It is anticipated that as this industry matures, this will change to have a robust national and global standards presence, including for United Nations Article 6 compliance.

Policy Development

- The U.S. will maintain its leadership role in the international community, using its operational experience to propose and encourage international harmonization with U.S. approaches.

- Initially, the ATO will implement a common strategy to the management of the NAS during launch and reentry operations, with the Command Center as the lead but working closely with local ATC facilities. As the operational tempo increases and best practices propagate, the ATO will evolve to a more distributed strategy, where local ATC facilities will take the lead for local operations. The Command Center will maintain the lead for operations with national traffic management implications and assist local ATC facilities as necessary.
- The ATO will maintain the responsibility for identifying airspace at risk from a launch or reentry vehicle failure. Prior to an operation, the ATO will verify the results of any externally computed hazard areas (as they do today). The ATO will perform hazard analyses in real-time.
- The FAA does not plan to own or build dedicated tracking and navigation equipment (e.g., source infrastructure) to capture state (health, position, velocity, vehicle and mission status) data specifically for launch/reentry operations but will instead, where appropriate, leverage existing U.S. government and industry assets and add new capabilities as they emerge.
- The future operational environment for managing launch and reentry vehicles in the NAS will continue to ensure safety at all times while also improving NAS efficiency when it is feasible to do so. As launch and reentry operations become routine – more reliable, predictable and repeatable – and ATC systems become more responsive, the need to block, or protect, large volumes of airspace will decrease, facilitating the integration of launch and reentry operations into the NAS.
- Policy decisions regarding vehicle maneuverability and responsiveness as inputs to conflict resolution may be required as the operational environment evolves.

4.1.2 Constraints

The following constraints identify areas that could render the ConOps less effective:

- This ConOps depends on evolving technologies for tracking, collaboration, and data distribution.
- Processes used to manage operations must be applicable to existing operations, including current levels of vehicle and mission reliability, and future operations in which they are expected to operate with greater reliability.
- Success of the operational integrated system proposed in this ConOps depends on the participation of stakeholders. Quality of decisions, communications, and operations relies on the willingness of individual groups to invest resources and adopt enabling technologies, data sharing, and other practices recommended in this document.

4.2 Stakeholders

The following subsections identify the key stakeholders involved in integrating launch and reentry operations in the NAS.

4.2.1 NAS Users

The group of stakeholders labeled *NAS users* comprises of all vehicle operators that are operating in the NAS, including but not limited to traditional aircraft, launch and reentry vehicles, UAS, high-altitude balloons, and hybrid aircraft. They may include flight crews for manned and unmanned vehicles, and operations center personnel providing support functions such as flight planning and dispatch. Aircraft operators include commercial passenger carriers, cargo carriers, military, and GA operating via both IFR and VFR.

4.2.2 Air Navigation Service Providers

For the purpose of this ConOps, Air Navigation Service Providers (ANSPs) are defined as government departments (e.g., FAA, DoD), state-owned companies, or privatized organizations actively involved in managing air traffic and airspace within the NAS or delegated to the U.S. by ICAO (e.g., ATM, ATC, etc.).

4.2.3 FAA Aviation Safety Organizations

Aviation Safety (AVS) is the FAA organization responsible for the certification, production approval, and continued airworthiness of aircraft; and certification of pilots, mechanics, and others in safety-related positions. AVS will have a large role in shaping and defining safety regulations for launch/reentry operations as the FAA moves toward a more integrated approach.

In addition to AVS, the ATO's Safety Directorate (AJI-1) will have a bigger role in operational safety. AJI-1 is responsible for ensuring NAS safety through reporting, mitigating, and monitoring risks. They support ATO leadership and operations by collecting safety data for analyzing events affecting the NAS, identifying trends and non-compliance issues.

4.2.4 Non-FAA Federal Agencies

Other federal agencies will also have a stake in the integration of launch/reentry operations into the NAS. Most notably NASA, DoD, National Transportation Safety Board (NTSB), Office of Safety and Health Administration (OSHA), DHS, law enforcement, or other Federal and State agencies. Future processes and policies will ensure the highest level of cooperation and coordination possible between these agencies and the FAA to ensure safe and equitable access to all NAS users.

4.2.5 Foreign Entities

The FAA will also work with foreign counterparts to ensure the safety and efficiency of launch/reentry operations when these missions cross borders. Section 4.8 provides a brief overview of relevant international harmonization processes.

4.3 Future Operational Environment and Infrastructures

The future operational environment for managing launch/reentry vehicles will continue to ensure safety and improve NAS efficiency. As operations become routine (e.g., more reliable, predictable, and repeatable) and ATC processes become automated, system responses will become more agile. The need to block or protect large volumes of airspace will decrease, facilitating the integration of operations into the NAS. The degree of integration will be defined for each launch/reentry phase of flight, along with its associated characteristics, potential hazards to other NAS users, and the airspace management method(s) available for the ANSP to use. The level of conformance between planned and actual trajectories, the timing of key mission events, and the potential for vehicle failures to generate falling debris can vary by phase of flight and type of launch/reentry operation. Available airspace management methods may also vary based on the level of available automation, information sharing, communication, navigation, and surveillance capabilities present for both the launch/reentry vehicle and the affected air traffic, the class of affected airspace, and the extent of constraints that all operations are concurrently imposing on the system. Future NAS capabilities supported by NextGen advancements will increase and expand the opportunity for the ANSP to apply the best available methods.

4.3.1 Airspace Management Methods

Integration of launch/reentry operations will require providing the ANSP with new airspace management methods, tools, and procedures. There are three high-level airspace management methods that may be used individually or in combination for a given launch/reentry operation, including:

- Adaptive Risk Envelope (ARE)
- Space Transition Corridor (STC)
- Temporary Flight Restriction (TFR)

4.3.1.1 Adaptive Risk Envelopes (ARE)

This subsection describes the ARE and explains the theory behind it, including the NAS Automation Boundary Entry Time (NABET) requirement. Different implementations of ARE, depending on if the launch/reentry vehicle can respond to ATC instructions, are described.

With AREs, a defined protected volume of airspace encapsulates potential hazards associated with the vehicle location and moves in accordance with the vehicle's velocity, similar to the five-mile, 1000-foot envelope used for aircraft in the NAS (Colvin & Alonso, 2012) as shown in Figure 3. Actual separation may be larger than depicted separation, as envelope depiction is not absolute and can be enlarged based on a controller's judgement and known vehicle characteristics. The key differences between AREs and today's AHAs are their dynamic nature and sizing. AHAs are computed in advance of the operation and are not updated in real-time (see Section 2). The FAA will be able to update AREs in real-time based on changing conditions. AREs are also sized to account for ATC response time, and do not necessarily extend all the way to the surface as today's AHAs. They extend only so far as to address scenarios in which the response time is too short, even with advances in future automation accounted for.

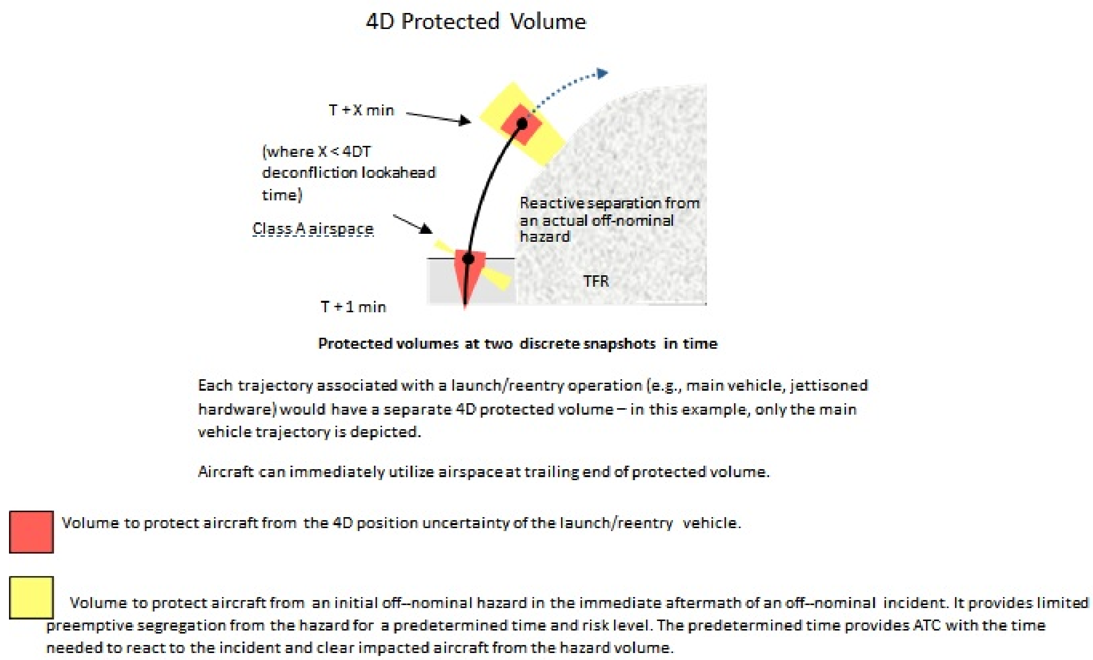


Figure 2 - ARE encapsulates vehicle trajectory variations and potential off-nominal hazards in the immediate aftermath of an off-nominal event

This aggregate volume is derived from two other volumes:

- The first volume protects against collisions and encounters between the launch/reentry vehicle (including separate volumes for hardware jettisons, hazardous plume, wake vortex, etc.) and other NAS users, using the vehicle position uncertainty of the nominal operation (red region in Figure 2).
- The second volume is a separate volume used to protect aircraft from a hazard (e.g., debris) in the immediate aftermath of the off-nominal event (e.g., breakup, explosion, or thrust-termination). This volume provides preemptive protection from the hazard and is determined by the time required for ATC to respond to the event and by acceptable risk level (yellow region in Figure 2).

During an off-nominal event, the preemptive protection will give ATC enough time to react to the event and clear at-risk aircraft from the hazard volume (identified by the gray region in Figure 3). The extent of this volume varies with time along the trajectory based on the changing risk of off-nominal events as a function of trajectory events (e.g., stage separation, maximum dynamic pressure), kinematics, the time required for ATC to react, and other variables. The number of dynamically changing variables illustrates the need for automated decision-support system functions and tools to assist ATC in determining changing volumes with enough lead time to clear at-risk aircraft. The predetermined time needed for the ANSP to react to off-nominal events is also highly dependent upon the scenario and requires decision support to implement.

AREs may exclude the hazard volume for some or all segments of a trajectory if high vehicle reliability for those segments can be established (e.g., the aircraft-ferried segment of a captive carry operations or the subsonic segment of a winged vehicle during landing). When the hazard volume is excluded for a trajectory segment, this is referred to as separation assurance-based AREs. Applicable hazardous plumes and wake vortex issues are covered implicitly by this term.

Separation assurance-based AREs are expected to be the dominant airspace management method in the far-term ConOps (see Figure 3), where launch/reentry operations have demonstrated high reliability and the goal is to provide separation assurance rather than to segregate operations to avoid potential debris hazards. Furthermore, in the far-term, when the likelihood of an operational hazard is low, mitigating risks through reactive separation from off-nominal events is no longer required, just as there is no requirement for reactive separation in today's aircraft operations. A key research question is how to compute the ARE volume so that the risk is acceptable to other NAS users in the event of a hazard, including the probability of fatality based on the real-time traffic density near the operation and the ability for other vehicles to maneuver out of a resulting debris field.

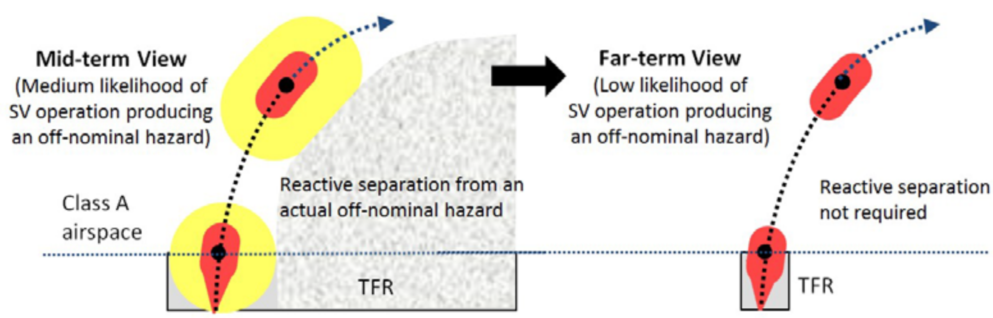


Figure 3 - Mid- and far-term views for using Adaptive Risk Envelopes (same legend as Figure 2)

<u>Detecting Conflicts</u>

Conflict detection look-a-head times of 15-20 minutes are typical for current ATC automation. Current look-a-head times are sufficient for controllers to contact the involved flight crews and safely implement one or more trajectory changes to solve a conflict in their control jurisdiction. A similar look-a-head time for launch/reentry vehicles (used for vehicle collisions and debris generated from off-nominal events), known as an ARE look-a-head, would likely mean that the distance between the vehicle's current position and the conflict location could be significantly larger for vehicles with a large horizontal component of velocity. In some cases, the vehicle could be several en route sectors away from the conflict point or even outside of the upper limit of the NAS. Off-nominal events for some space vehicle applications have a significantly wider range of impacted stakeholders than the typical aircraft so more time may also be necessary. In such a large distance, there also may be multiple identified conflicts.

NAS Automation Boundary Entry Time and Adaptive Risk Envelopes (NABET)

To apply AREs to a reentry operation, accurately predicting a new parameter called the NABET is required to minimize false conflict detection alerts. The NABET provides the time at which the vehicle will enter the NAS automation boundary (i.e., ground level or upper) with a high standard of accuracy (e.g., a launch time that is accurate to within 1 minute 95% of the time). ATM automation will use vehicle speed and trajectory to calculate the NABET or more likely, the NABET would be provided by the operator and verified by automation (e.g., the Space Data Integration capability described in Section 4.3.2.1).

The time at which the NABET is received defines the NABET lead time (NABET minus current time). For times prior to the receipt of NABET, but within the ARE look-a-head time, reentry time uncertainty may result in automation producing false alerts based on pre-defined AREs. NAS efficiency decreases if aircraft are maneuvered based on false alerts. Thus, deconfliction processes based on the ARE should not commence until the NABET is established to mitigate false alerts.

Once the NABET is received, the ARE and the associated envelope of protected airspace can be accurately probed for conflicts. For example, is a NABET is received at T minus 10 min [11] and a 15 min deconfliction look ahead time:

- At T minus 12 min, reentry time is still uncertain and probing the reentry envelope can produce false alerts if the time slips. Maneuvering aircraft to resolve the false conflict alerts is inefficient so it should be avoided by waiting until the time is certain.
- At T minus 10 min, the NABET is received and the time is now known with certainty. The first 5 min of the predicted reentry ARE, and associated envelopes are active (because the look ahead time = 15 min) and can be accurately probed for conflicts and resolved as necessary.

If a reliable NABET is not feasible for a given operation, the STC method with predetermined activation may need to be used instead. Furthermore, the NABET lead time needs to provide enough time for conflicts in the deconfliction horizon to be safely resolved before the operation starts. Both the NABET and the NABET lead time are unique to a given operation and influenced by multiple factors (e.g., location of operation, vehicle speed, etc.)

ARE automation will require research to address: 1) incorporating the dynamically changing envelopes into the deconfliction algorithm; 2) modeling time as a function of trajectory design; and 3) modeling performance characteristics unique to reentry vehicles such as velocity, trajectory, and phase of flight.

[11] Launch/reentry operation convention defines the parameter *T* to be the time at which an event of interest occurs. In this context, it is the time at which the launch/reentry vehicle enters the NAS automation boundary. For launches, it refers to the liftoff or rocket ignition time. For reentry, it refers to entering the upper NAS automation boundary.

Using AREs for launch/reentry vehicles capable of complying with minimal ATC tactical control instructions

If the launch/reentry vehicle can comply with ATC tactical control instructions during some or all of its mission phases, then it may be maneuvered based on ATC direction for separation purposes during those phases. For example, in the case of a powered, non-glider, winged vehicle that can accept and execute ATC instructions during reentry, a minor adjustment in the vehicle trajectory may resolve multiple conflicts. Therefore, it may be more efficient to maneuver the launch/reentry vehicle instead of multiple aircraft. This capability could enable operations in more congested airspace where compliance with TMIs would routinely be required. In the immediate future the ability to comply with ATC instructions would be minimal.

Vehicle type (maneuverability and responsiveness) is input into the ARE deconfliction automation. The vehicle's ability to comply with ATC instructions may be most limited by hazard analysis that determines how much deviation is acceptable in the vehicle's trajectory and resulting ARE (e.g., to avoid highly populated regions).

This method of integration depends on vehicle characteristics. For example, the speed of the vehicle and a steep vertical profile, coupled with current en route sector design, would result in a vehicle transitioning from a low to a high to a super-high sector in a very short time. The sectors controlling the launch/reentry would change too rapidly to allow ATC tactical control instructions to be issued by the controlling sector. In these situations, it may be more pragmatic to require changes to the aircraft trajectories for deconfliction or employ the STC method.

Using AREs for launch/reentry vehicles not capable of complying with ATC tactical control instructions

Other NAS users are maneuvered as necessary to resolve conflicts involving launch/reentry vehicles. This is a shift from today's Class A airspace operations where both aircraft in a conflict must be able to respond to tactical control instructions. The justification for this shift comes from the requirement that the launch/reentry vehicle must adhere to its filed trajectory within predetermined tolerances and thus stay within a reserved – albeit dynamic – volume of airspace.

4.3.1.2 Space Transition Corridors

This subsection describes STC, the second airspace management method. An STC is a type of SAA specifically designed for the unique characteristics of a launch/reentry operation. The three key distinguishing features of STCs are:

- The spatial protection provided by STCs is uniquely tailored to both the nominal and off-nominal characteristics of each individual launch/reentry operation (Bilimoria & Jastrzebski, 2013).
- STCs can be dynamically activated and deactivated on a just-in-time basis to enable launch/reentry vehicles to transition safely through the NAS while minimizing the effect on other NAS operations.

- Unlike AREs, the STC extends from surface to unlimited altitude (similar to today's AHA).

The following subsections explain the methodology of STC design and spatial protection within the NAS. The two types of STC activation are also described: 1) Just-In-Time STC Activation, used when an accurate prediction of launch/reentry time is available, and 2) Pre-determined STC Activation, used when there is uncertainty in the launch/reentry time.

<u>Space Transition Corridor Design and Spatial Protection</u>

During the planning phase for a launch/reentry mission, the STC is derived from:

- Trajectory analysis, which determines the volume(s) of airspace necessary to contain the vehicle trajectory and its normal variations (the red region in Figure 4), hazardous plume, any planned hardware jettisons, and any escape pod trajectories. Each of these components could have different time windows if deemed advantageous.
- Hazard analysis, which determines the volume of airspace necessary to ensure the protection of other NAS users from launch/reentry vehicle hazards.
- Effect on NAS efficiency and capacity, which determines the chosen STC configuration.

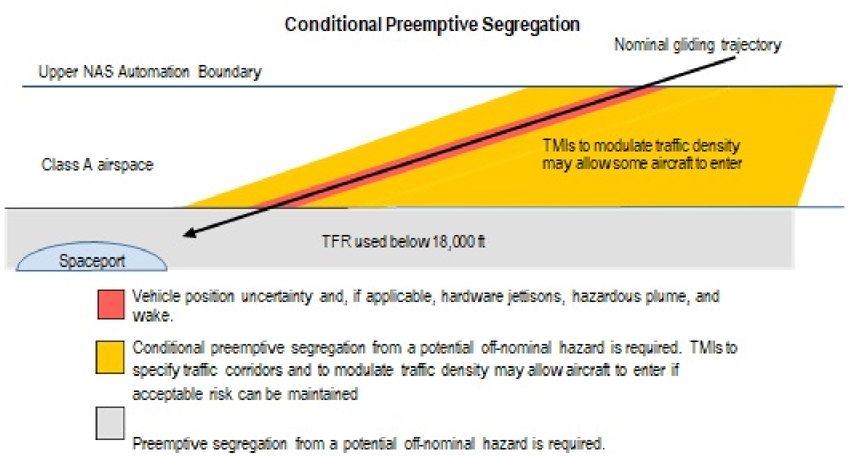


Figure 4 - Space Transition Corridor Conditional Preemptive Segregation

The volume of airspace included in the STC depends on the reliability of the launch/reentry vehicle, the methods available for protecting against hazards, NAS traffic, and other factors determined by the vehicle trajectory, potential hazard, and NAS performance impact analyses (Bilimoria & Jastrzebski, 2013). At a minimum, this will be a relatively small amount of airspace along the near-vicinity of the vehicle trajectory to address separation assurance. If the likelihood of debris is sufficiently high, it will also include a new type of conditionally segregated airspace (Wilde, 2013) for a potential off-nominal hazard (the orange region in Figure 4), which allows the density and organization of NAS traffic to be controlled to maintain acceptable levels of individual risk. This can be achieved by TMIs limiting aircraft traffic to specific corridors through the potential off-nominal hazard and modulating (e.g., metering) traffic to predetermined levels to maintain acceptable risk levels.

Multiple STC configurations are developed and analyzed in the planning phase to determine which method minimizes effects on NAS performance while meeting the launch/reentry mission objectives. To further reduce NAS impacts, minor STC modifications can be made in real-time prior to launch to account for current atmospheric conditions and disseminated to stakeholders. STCs may be tailored based on the individual mission characteristics to minimize NAS impact and provide flexibility.

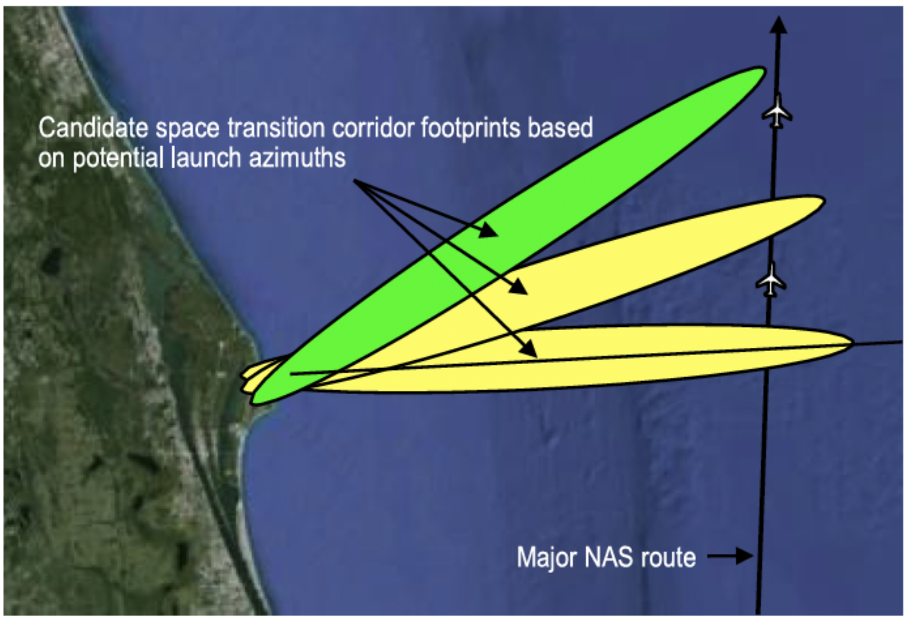


Figure 5 - During the planning phase, some operations have flexibility in determining launch azimuth, which can be selected to minimize impact to other NAS users. The top footprint would minimize NAS impact in this example

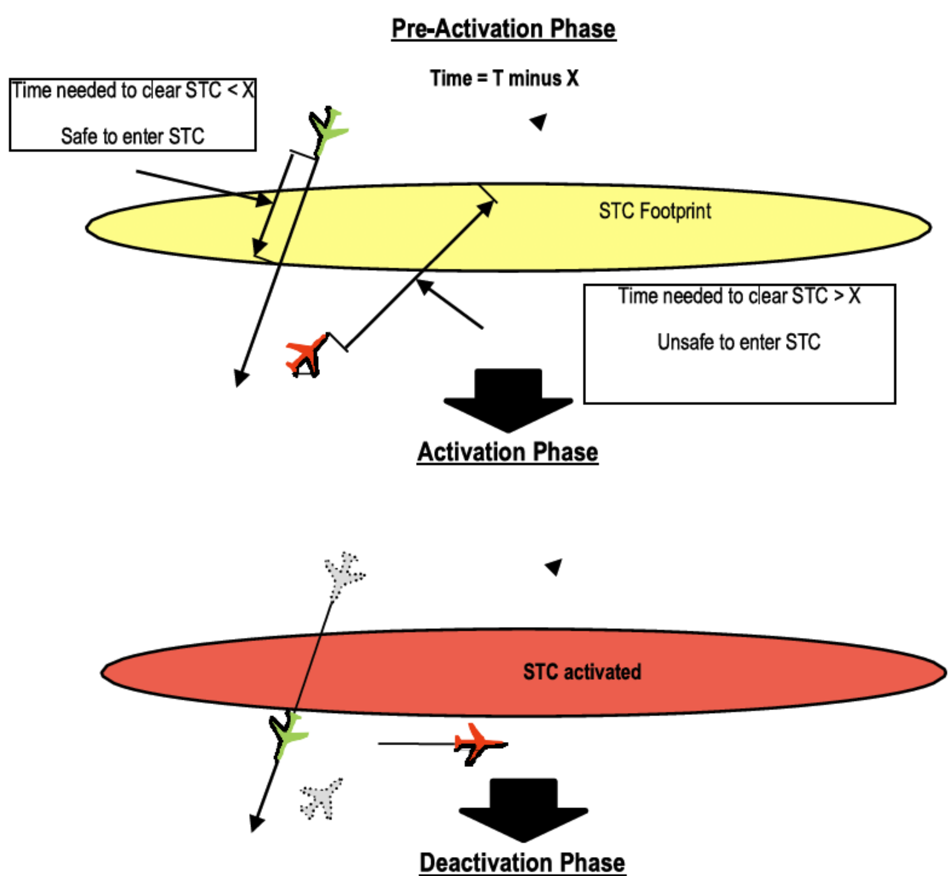
Space Transition Corridor Activation

The volume of airspace included in the STC is determined during the mission planning phase. Vehicle and operator characteristics also determine how the STC is activated and deactivated. A launch/reentry vehicle and operator that can provide reliable information about the time when the vehicle will enter the NAS automation boundary supports *just-in-time activation*, whereas an operation for which this information is not available requires *pre-determined activation*.

Just-in-time activation. Just-in-time activation and deactivation of the STC minimizes the impact to other NAS users by minimizing the length of time that the airspace is reserved for the launch/reentry operation. This precise temporal control requires the NABET, which enables the activation of the STC to occur as late as possible. For example, if it takes 5 minutes worst-case to clear the STC and the launch time is known with certainty at T minus 10 minutes, then aircraft can continue to enter the STC until T minus 5 minutes.

For this process to work seamlessly, the operator should provide the NABET early enough for the flight that will linger the longest in the STC to clear it. This supports the worst-case situation where an aircraft enters the STC at the exact time the launch/reentry vehicle reaches T minus the NABET lead time, such that the aircraft is able to clear the STC just prior to NAS automation boundary crossing. If the aircraft cannot clear the STC before the mission vehicle will enter the NAS, the aircraft may need to be rerouted or placed in an airborne hold while the STC is activated. The value of NABET lead time is expected to be mission-specific.

Prior to T minus the NABET lead time it is assumed that there is uncertainty in the launch time, resulting in the ANSP being unable to *efficiently* plan the STC activation. Rather than having aircraft avoid an STC that may or may not be activated, the ANSP delays the decision until there is certainty of the time at which the launch/reentry vehicle will enter the NAS, which occurs when the NABET is received. Before the NABET is available, the ANSP will receive updates of the expected launch time for situational awareness. However, the pre-activation does not start until the NABET is known.



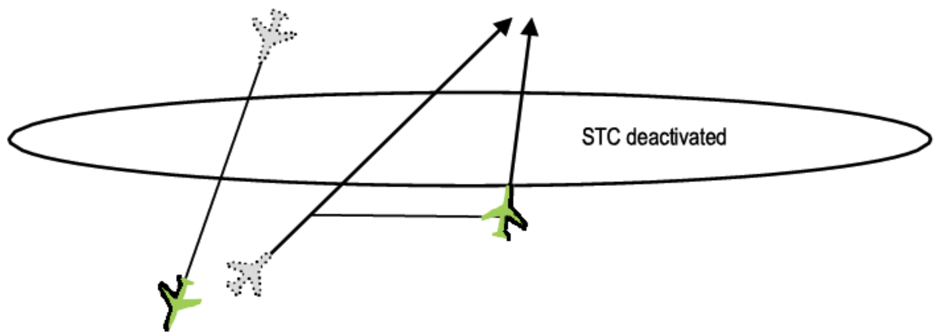


Figure 6 - Just-in-time activation of STC to minimize impact to other NAS users

Predetermined STC Activation. If just-in-time activation is not feasible due to large uncertainty in the launch/reentry time or a lack of adequate air traffic surveillance and communication to support it (e.g., the current oceanic, non-radar environment) then the predetermined activation method would be used. In this method, the STC activation time is determined during the planning phase based on the operator's best estimate of the time window needed for the mission (similar to today's operation). However, the deactivation notification is sent automatically based on collaborative tracking data coupled with automation as soon as the vehicle has cleared the STC (same as the just-in-time method). If a toxic plume or any other hazard exists, deactivation may be delayed as necessary.

The STC time window for a nominal vertical launch is expected to be less than 3 minutes, so the number of flights directly affected by the STC activation will be significantly smaller than today's approach to airspace closures. In that situation, using just-in-time activation rather than pre-determined activation implies that the STC time window is relatively small and does not impact individual flights any more than routine tactical control instructions. Thus, flight operators can perform trajectory and fuel planning as normal, making planning for a reroute and carrying extra fuel unnecessary. Conversely, if predetermined activation is used and the time window is large, the flight operator may require planning for reroutes and extra fuel.

Similarly, horizontal launches may require an STC with pre-determined activation, and a larger time window. However, this scenario is not expected to be normal since horizontal launches are more likely to be supported using AREs.

4.3.1.3 Temporary Flight Restrictions (TFRs)

This subsection describes the use of TFRs for launch/reentry operations. TFRs are used to manage the operations of other NAS users near launch/reentry operations outside Class A airspace (i.e., below 18,000 ft or above the Class A ceiling). There are three types of flights (IFR and VFR flight with and without access to a system wide data and information exchange capability) operating in this airspace.

VFR flights without the capability to access a system wide data and information exchange:
The protected airspace time is predetermined in the planning phase based on the maximum time window needed for the launch/reentry operation (same as legacy method used today) and

includes preemptive segregation based on full coverage of the potential off-nominal hazard. The boundary and time window of the protected airspace is issued via NOTAM. If a VFR flight that cannot access the system-wide data and information exchange capability is on frequency when automation determines that the mission has been completed, ATC is notified and can provide notice of deactivation in response to flight crew request for airspace status and the VFR flight can enter the protected airspace.

VFR flights with the capability to access system wide data and information exchange: Compared to the process for VFR flights unable to access the data and information exchange capability, those that can will require a smaller volume of protected airspace due to the capability for reactive separation. The smaller boundary and the activation time are provided via a system-wide data and information exchange capability. Once ANSP automation determines that the mission has been completed, notice of the deactivation is sent via this exchange capability (and via frequency, Flight Information Service Broadcast, etc.), at which time flights can enter the airspace. It is a research question as to whether these VFR flights need ATC services to be alerted to off-nominal events that require reactive separation or if the exchange capability alone would be capable of alerting the pilot to an off-nominal event.

IFR flights: These flights can be issued clearances to enter the protected airspace until the ANSP receives a NABET from the mission operator. This is similar to just-in-time activation of an STC. A smaller boundary of protected airspace is needed due to the capability for reactive separation. However, the protected airspace required for the VFR flights described above may be larger than the protected airspace for IFR flights since potential slower-moving VFR flights would require more time to clear the protected airspace in the event of an off-nominal hazard.

Figure 7 illustrates the difference between the smaller TFR used to manage IFR and system-wide data and information exchange capable VFR traffic near a launch/reentry operation and the larger TFR used to manage non-capable VFR traffic.

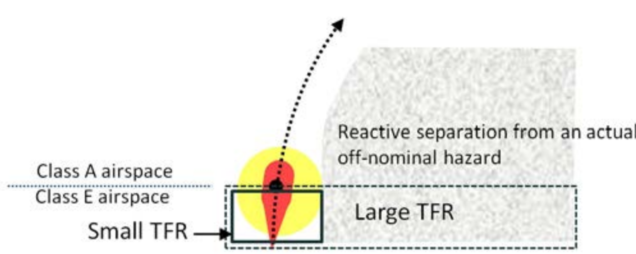


Figure 7 - Small and Large TFRs based on flight type and accessibility to system wide data and information exchange capability

4.3.1.4 Summary of Airspace Management Methods

The first two methods, ARE and STC, apply only to Class A airspace (see Table 2). The third method, TFR, applies to the VFR environment (typically Class E and G airspace) in domestic airspace.

Table 2 - Airspace management methods for managing launch/reentry operations

Airspace Management Method	Airspace Class	Description
Adaptive Risk Envelope	Class A	Launch/reentry operators and other NAS users are safely separated by an ARE -- a volume of airspace that encapsulates the hazards to other NAS users associated with the launch/reentry vehicle and moves according to the vehicle's velocity. The size/shape of the volume depends on many factors, including the vehicle's speed and altitude, and the potential risk. Launch/reentry operators that can receive and respond to control instructions may be expected to maneuver to resolve conflicts, including other NAS users.
Space Transition Corridor	Class A	STCs are volumes of airspace that are tailored to specific vehicle and mission characteristics, and span from surface to unlimited altitude. Launch/reentry vehicle capabilities and mission characteristics determine whether an STC is activated at a predetermined time or through just-in-time activation procedures.
Temporary Flight Restriction	Class E	A TFR is a volume of airspace that provides preemptive segregation for other NAS users from potential debris and other hazards. TFRs are applied to three types of flights (IFR, VFR with or without access to the system-wide data and information exchange capability). Each receives different information about the TFR to maximize NAS efficiency.

The ARE method is expected to provide the largest improvement in NAS performance but places the most stringent requirements on the launch/reentry vehicle and ANSP automation capabilities, and it cannot always be implemented. This method protects an adaptive, moving volume of airspace that encapsulates the potential hazards associated with launch/reentry vehicle and moves in accordance with the vehicle's velocity.

The STC method protects a larger volume of airspace than an ARE, for the entire time between the activation and deactivation time window. The STC includes a conditional preemptively segregated volume, which requires aircraft to operate on predefined routes through potential debris or other hazards. TMIs modulate the traffic to tightly control the number of aircraft based on maintaining acceptable levels of risk (Wilde, 2013). Different airspace management methods may be applied for different phases of an operation in which the vehicle has a larger or smaller likelihood of producing an off-nominal hazard.

In the far-term view of this ConOps the ARE method will be the rule, with negligible likelihood of in-flight breakup or explosion and increased system responsiveness to off nominal conditions. The goal of the method is to ensure separation similar to today's aircraft separation assurance methods (however not necessarily equivalent separation minima). In the mid-term view, while launch/reentry vehicles improve their reliability, operations become more predictable, and ATC develops and implements more responsive airspace management technologies, off-nominal events will play an important role in determining the size of the protected airspace due to their relatively high likelihood of occurrence (see Figure 8).

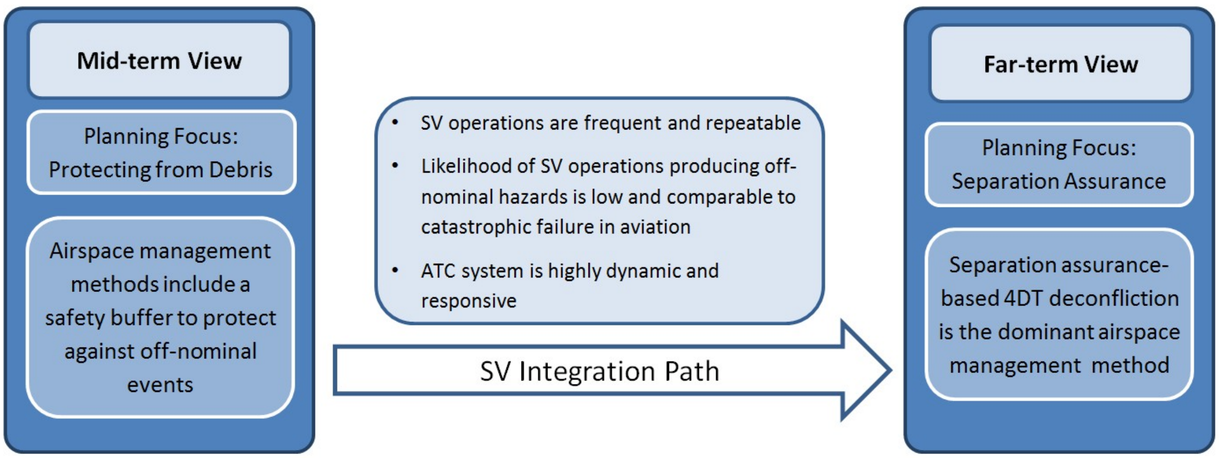


Figure 8 - Airspace Management Mid- and Far-term Views

The airspace management method employed depends greatly on balancing the risk to other NAS users (e.g., safety considerations) of a given launch/reentry operation (or phase of an operation) with NAS efficiency. This is defined as a spectrum of risk ranging from low (e.g., proven reliable vehicle operations) to elevated probability (e.g., experimental vehicles with no historical record) that the operation will produce a hazard, and is determined by a pre-mission risk-analysis.

Launch/reentry operations with low likelihood (as likely as a catastrophic event in today's aircraft operations) enable the operation to be fully integrated with other NAS operations. Launch/reentry operations that have an elevated likelihood of producing an off-nominal hazard must be protected from other NAS operations to achieve the required level of safety. The low and elevated likelihood cases are conceptually straightforward

Launch/reentry operations with medium likelihood refers to operations that can be partially integrated with other NAS operations by mission phase, vehicle configuration, or other differentiators. This partial integration, while complex, is a key aspect of this ConOps. Using these descriptors, the ConOps operational environment is summarized as follows:

- For launch/reentry operations that have low likelihood of producing a hazard to other NAS users, using AREs provides separation assurance and, if applicable, wake vortex separation between the vehicle and other NAS users.
- Launch/reentry operations that have an elevated likelihood of producing an off-nominal hazard are expected to be a small proportion of all operations. However, fully integrating these operations would produce a higher than acceptable risk. Instead of relying on traditional SAAs as in today's operating environment, using an STC will allow for improved efficiency by:
    - Minimizing the time the airspace must be protected through automation. The STC is activated and deactivated as soon as is safely possible.
    - Minimizing the volume of fully closed airspace in the STC by applying less conservative hazard analysis that tailors the overall volume to specific mission characteristics and conditionally allows other NAS users to operate during a launch/reentry operation.

To reduce the time that airspace is protected, ATC responsiveness must be increased by leveraging planned advances in technology, which will provide reliable air traffic surveillance and communication throughout the NAS environment at a level of precision and timeliness at least as high as is currently possible in today's surveillance environment.

The relationship between airspace management, likelihood of hazards to other users, flight type, and hazard management methods is presented in Figure 8, where interim and end-state timeframes are introduced. The interim timeframe denotes a stage of the ConOps where the ANSP will not yet have the procedures and automation to support reactive separation from off-nominal events (previously introduced in the FAA Space Vehicle Debris Threat ConOps [FAA, 2010b]) and yet the likelihood of vehicle failure is still relatively high. The end-state timeframe represents the complete ConOps when all enabling technologies are available.

A summary of the ARE and STC methods is shown in Table 3. The main difference between the two methods is that the STC protects a fixed volume of airspace (from surface to unlimited altitude) and ARE protects a volume of airspace that moves with the vehicle in real-time.

Table 3 - Comparison of airspace management methods in Class A airspace

Adaptive Risk Envelope	Vehicle Not Capable of Complying with ATC Tactical Instructions	Vehicle Is Capable of Complying with ATC Tactical Instructions
• Requires launch/reentry vehicle to adhere to its trajectory within required error tolerances. • NAS automation boundary entry time is known with high certainty to reduce false alerts. • Minimizes the effect on the NAS because the protected volume moves with vehicle trajectory in time, maximizing the airspace available to other NAS users. • The ANSP must support reactive separation until launch/reentry operators can demonstrate that their vehicles have low likelihood of producing an off-nominal hazard.	• Conflicts between launch/reentry vehicle and other NAS users always result in the NAS user being maneuvered for deconfliction.	• Vehicle can comply with some types of ATC instructions (e.g., heading changes) enabling vehicle operations in more congested airspace. • Vehicle that yields the right of way is a function of the ability for each of the vehicles involved to safely comply. • Trajectory changes for launch/reentry vehicles may be limited due to wider public safety concerns.
Space Transition Corridor	**Just-in-Time Activation**	**Predetermined Activation**
• Launch/reentry vehicle has an elevated likelihood of producing an off-nominal hazard and/or is not capable of adhering to an ARE, either temporally or spatially. ANSP does not support reactive separation, or sufficient reaction time for ATC system does not exist. • ATC may implement TMI to modulate traffic – conditional preemptive segregation. • STC is deactivated as soon as launch/reentry clears STC.	• Activate STC as late as possible based on NABET lead time	• Uncertainty in NAS automation boundary entry time or a lack of adequate air traffic surveillance and communication to support just-in-time activation requires STC to use a larger time window.

4.3.2 Supporting Capabilities, Tools and Procedures

This section describes the enabling capabilities that will be necessary to integrate future launch/reentry operations as described in this ConOps. While envisioning new technologies or capabilities is not the primary purpose of this ConOps, it is intended to describe new ways of operating with technologies or capabilities that are likely to exist in the future. Hence, this section describes technology areas and standardization approaches that address the technical challenges to enabling future spaceflight operations as envisioned.

4.3.2.1 Space Data Integration

The limited ability to efficiently receive and distribute launch/reentry operational data primarily results from two main issues. First, the FAA uses a set of non-interfacing systems that were not designed for launch/reentry operations. Secondly, launch/reentry vehicle operator tools were not designed to interface with NAS systems. It is expected that the operators will provide a defined set of data that complies with FAA requirements, to the FAA firewall for ingestion into FAA systems.

The capability to exchange data in real time between space operators and ANSPs provides ATC with visibility into the mission. It also provides a real-time capability to monitor vehicle location status, health, and automates the data sharing between the operators. This allows the FAA to respond more quickly to both nominal and off-nominal mission conditions.

Improving the data handling and network capabilities to securely record, archive, retrieve, and distribute data over the global network will:

- Improve interoperability among the FAA, commercial space operators, federal ranges, and other NAS users.
- Take advantage of common, standard protocols and formats for inputting, processing, transferring, and coordinating data and information so it can be fully integrated to facilitate decision-making, information sharing, and improving common situational awareness.
- Leverage commercial-off-the-shelf systems, allowing for the use of advanced data handling capabilities being developed.

Technology efforts in this area focus on leveraging ground and wireless network development efforts being pursued for commercial applications. Technologies to improve ground-based networks include data integration along with new protocols and next-generation Internet research that's already being pursued for a variety of commercial applications. Commercial advances in computing technologies should also be leveraged and pursued in parallel to enhance data handling and integration capabilities and enhance global network capabilities.

Technology will provide ANSPs with an automated means to process and display launch/reentry available operational data (e.g., vehicle health, planned trajectory etc.) that will not only reduce workload and increase overall system efficiency, but will increase safety to all NAS users. This automation could include the capability to provide launch/reentry vehicle conformance monitoring and alerting on the displays.

4.3.2.2 Capability for computing debris hazard volumes in real-time

Protecting against failure and resulting debris is an important aspect of mitigation. Modeling can be performed to predict the extent of airspace in which falling debris would result in unacceptable risk to aircraft.

Automation for computing real-time debris hazard volumes in the event of a catastrophic failure is necessary to maximize NAS efficiency and to ensure equitable access for launch/reentry operations and traditional NAS users. There are two key requirements that make the computation of real-time hazard volumes different from a typical pre-launch risk-based approach. First the calculation approach must be very quick to accommodate the total timeline available to reroute aircraft following a failure, which is usually only a few minutes. Second, the result must also be accurate—the worst situation would be to direct an aircraft into a more dangerous location.

The timeline constraint has several implications. First, the faster the calculation, the more time is available to ATC to move aircraft. The goal is for the automation to produce a result on the order of a few seconds. Second, the smaller the volume, the more likely it is that ATC will be successful in moving all affected aircraft away from the hazard. The calculation must account for uncertainty in a manner that does not increase the size of the resulting volume or the time required to compute it. The principal factor is often not the total size however, but the size of the smallest dimension. In many cases a long, thin hazard area can be much more efficiently sanitized than the same size circular area.

It is significantly challenging to account for all potential outcomes after failure identification, while avoiding the creation of excessively large volumes that are not actionable. There are three basic phases to consider after a vehicle has failed: 1) flight while still under powered or coordinated lift, 2) intact ballistic “fall”, and 3) post-breakup fall of debris. Each of these phases must be adequately characterized, accounting for the uncertainty in the data and the conditions which cause a switch from one phase to another. The failure response of the vehicle is critical, especially when the vehicle remains intact with thrust or controlled lift after real-time data ceases, as this behavior expands the at-risk region. Physics-based simulation of debris fall allows for accurate determination of the size and timing of the hazard volumes. In real-time, a pseudo-containment approach is possible, where the “debris list” is much smaller than is necessary for a probabilistic approach as is used in pre-launch. The resulting hazard volumes are small enough, so it is realistic to move aircraft out of them by the time the debris arrives.

There are also important data management issues for a real-time software to be effective. There must be connection to a space data integration capability for the best source data on the vehicle, so the last known position and velocity are available. Some mechanisms need to be in place to identify a failure or potential failure. When a failure occurs, the correct data needs to be associated with the modeling, so changes in vehicle configuration (e.g., staging or other hardware jettisons) and mission status (e.g., engine start or stop) need to be entered. The system also needs to be able to quickly disseminate resulting hazard areas to all involved stakeholders, and be able to update (if more data is available) or cancel (if the vehicle data stream recovers).

4.3.2.3 Common Weather Picture

Weather continues to be a major factor in launch/reentry integration challenges, and increasingly accurate products will fine-tune information on weather impacts to specific operations.

Quality, timeliness, coordination, and distribution of information is central to addressing an increased demand for launch/reentry system support. Air traffic service providers and users each have a different view of aviation information, creating an inconsistent portrayal of weather, traffic demand, and system constraints. Current NAS weather systems do not provide all weather data that launch/reentry vehicle operators require, and operators are often required to get their own data from their own sources. This can lead to issues where a launch/reentry operator comes to a very different conclusion regarding weather than other NAS users do, creating unpredictability and confusion. Together, these issues impede decision-making in a collaborative environment and diminish the effectiveness of the air transportation system.

Increasingly accurate weather data will be available to service providers and users, including hazardous weather alerts for wind shear, microbursts, gust fronts, and areas of precipitation, icing, and low visibility. Enhanced steps for avoiding convective weather are made as weather prediction capabilities are improved and integrated into decision support tools. Aircraft and spacecraft are both the consumers and sources of weather data. Improved weather 'forecasting' and 'now-casting' increases scheduling precision (for air traffic operations, space launches, and reentry operations) and overall NAS management. Detailed weather information from a collaborative multi-source system is available via a common weather platform and is selectively presented on sector displays and flight deck displays.

Enhancements in weather information and forecasting present a common picture that is shared with users via system-wide information management and will improve collaboration and decision-making efforts. This improved weather information is assimilated into all applicable decision-support tools to improve tool performance during weather events and to assist with adjusting routes and trajectories during launch/reentry operations. A common weather picture is shared amongst ANSP, pilots, launch/reentry operations centers, and other NAS users to improve collaboration and decision-making efforts to reduce delays.

Currently, space weather is not monitored by air traffic, but it can affect the predictability of a launch or reentry operation. As forecasting technology in space weather increases and the effects of space weather on launch/reentry operations are better understood, then sharing space weather information may be included in future collaboration/considerations.

4.3.2.4 Planning Data Portal

The Planning Data Portal is a public data portal used to standardize an interface between the commercial space industry and the FAA. It would provide a flow of standardized planning data sets similar to the Obstruction Evaluation/Airport Airspace Analysis (OEAAA) portal currently in use today. Operators submit supporting planning data automatically and receive automated responses regarding the status of their request and the results of the FAA's assessment. A standard interface exists that encourages the operators to develop interfaces from their systems to this FAA system to realize optimal efficiencies in their processes.

Operators will also be able to conduct trial planning on mission design. They will be able to input one or more options for conducting a given mission (different trajectories and windows) and receive feedback allowing them to make comparisons between options and optimize their plans.

Requests and associated data are stored in a common repository where they can be retrieved by these entities and used to perform the necessary planning actions. This repository also serves as an archive, providing a centralized area for data, documents, and lessons learned. Common elements of past missions can also be retrieved, reused and manipulated as necessary to realize additional efficiencies and assist in ensuring consistency from mission-to-mission.

4.3.2.5 Modeling and Simulation Tools

Technologies to improve modeling and simulation apply to a variety of launch/reentry operational functions, but mostly focus on:

- Safety, as enhanced by automated decision-making analysis and support, relating to toxic, debris, and collision hazards;
- Weather-related constraints, including modeling of atmospheric and environmental parameters combined with the dispersal characteristics of leaking or exploding propellants and vehicle debris after breakup;
- Simulation of the reliability and failure modes of spaceport, range, and control center assets to support planning, scheduling, and coordination of assets for operational use and maintenance/repair; and
- Training, using sophisticated modeling and simulation capabilities.

4.3.2.6 Capability to provide improved planning of launch/reentry and NAS operations through information sharing.

As discussed previously (see Section 3) a process does not currently exist to efficiently collaborate with launch/reentry operators on reducing NAS impact. This is largely because of the time-consuming, manual, and inconsistent methods for the FAA and launch/reentry operators to share mission and NAS impact information. It is further compounded by the current lack of standardized data-sharing agreements documenting what information is to be shared and in what time frame.

Providing a standardized data-sharing capability that includes both a method for data input and retrieval and standardized agreements about types of data to include, will allow ANSPs and launch/reentry operators to send and receive information about mission readiness, frequency and timing, NAS status, projected NAS impacts and weather conditions. Providing this information that may affect the mission in a standardized electronic format that is accessible to authorized users.

Information sharing will improve planning and facilitate collaboration to help identify improvement opportunities in flight efficiency, demand/capacity. It will also increase predictability by providing better awareness for operational readiness on both a specific and NAS-wide level.

However, due to the complexity of each operation (rockets, fly-back boosters, captive carry operations, manned balloons, etc.), more analysis and research is required as to the viability of this capability.

4.3.2.7 Automated traffic management planning options for ANSPs based on changing NAS and/or mission conditions.

This capability will continuously monitor operational constraints and other NAS conditions to calculate and provide TMs options for dynamically adjusting planned TMIs in response to changing conditions. These options will be based on current conditions (e.g., weather, NAS status, vehicle/launch site readiness) and the presented options (e.g. reroutes, restrictions) will be adjusted as conditions change.

This capability will amend the current AMP process to reflect changing conditions and provide updates to stakeholders, who can then provide feedback. It will also improve flight efficiency by reducing aircraft delays and/or reroutes and reduce TM and SOS planning workload.

4.3.2.8 Decision Support

Providing controllers with decision support tools will enable them to more quickly identify aircraft currently, or about to be, exposed to potential hazards from launch/reentry operations. It will also suggest resolutions to controllers for maintaining safe operations that may be implemented via Data Comm or verbal direction. If a launch/reentry vehicle failure occurs, decision support will prioritize aircraft at risk by their risk exposure, allowing ATC to target their initial responses to the aircraft at highest risk. Aircraft that can be addressed through the same direction (e.g. turning on the same heading) will be grouped to allow ATC to address multiple aircraft at once. It will also improve safety by reducing the time needed to identify and resolve conflicts and improve flight efficiency by providing reroute suggestions.

Decision support will be essential in situations where large hazard volumes overlap multiple sector or facility boundaries, both laterally and vertically, as it will help align responses across these boundaries. It will also incorporate capabilities and limitations of the ATC environment (radar or non-radar) into the recommended response.

4.3.2.9 Post-mission repository of NAS, mission, and weather conditions for post-ops analysis.
This repository will provide a means to ingest, store, and analyze data about launch/reentry operations, NAS performance, and weather conditions pertinent to the mission. It will be able to differentiate NAS impacts related to the mission from those resulting from other NAS constraints. This will include a capability to reconstruct an entire operation to determine the efficiency of the operation.

Launch/reentry stakeholders will be able to identify reroute requests/refiles following the TMIs or conduct a comparative analysis of NAS effects from a non-mission event day to those of the mission day. This will reduce the post-operational workload required to find, store, and manage data, and to perform analysis and generate best practices.

4.3.3 New and Emerging Vehicle Concepts and Mission Types
While the boundaries of space flight are seemingly endless, small steps must be taken prior to achieving long-term goals such as flight to other planets or solar systems. Even this constraint leaves a wide array of possibilities as technology and capabilities continue to evolve. The following sections describe some new and emerging mission types that commercial space operators are planning over the next few years. This list is not inclusive but is used to illustrate the rapid growth of the industry and the continued goal of making space accessible to all. All these vehicles/operations types need to be planned for, and will likely have varying performance characteristics, which is why this work is so important.

4.3.3.1 Space Tourism
Space tourism is space travel for recreational, leisure, or business purposes. By 2007, space tourism was thought to be one of the earliest markets that would emerge for commercial spaceflight. However, as of 2018 this private exchange market has emerged slowly, and frequent commercial space flight is still in development. There are several different types of space tourism including orbital, suborbital, and lunar.

Orbital Space Tourism
During orbital trips, space flight participants will have the chance to visit the International Space Station (ISS) or other private on-orbit facilities. To date, orbital space tourism has been performed only by the Russian Space Agency carrying space flight participants aboard a Soyuz spacecraft to the ISS.

There are several ventures being researched and developed in the domain of orbital space tourism. For example, Boeing, SpaceX, Blue Origin, and Sierra Nevada are developing and testing vehicles and launch systems as part of NASA's Commercial Crew Development (CCDev) program. The following are examples of proposed orbital ventures being researched and/or developed and is not inclusive of all efforts currently in development.

Proposed Orbital Ventures

- Boeing is building the Commercial Space Transportation-100 (CST-100) Starliner capsule as part of the NASA CCDev. The CST-100 space capsule is being designed to carry NASA and international partner astronauts and supplies to the ISS. Additionally, the aerospace giant has also partnered with Space Adventures to sell passenger seats for future CST-100 flights. These trips would bring customers to the ISS, and perhaps one day to commercial space stations, or hotels, (e.g., Bigelow's inflatable space station).
- SpaceX's Dragon capsule currently ferries cargo and supplies to the ISS, but the Hawthorne, Calif.-based company is also working on a version of the Dragon that can carry humans into orbit.
- Sierra Nevada, based in Sparks, Nev., is developing a seven-person Dream Chaser vehicle for private spaceflight. The spacecraft is being designed to launch vertically on a rocket and land horizontally on conventional runways.
- Northrop Grumman Innovation Systems of Dulles, Va., already has a contract with NASA for its Cygnus freighter to carry supplies to the International Space Station. The veteran aerospace company which acquired Orbital ATK in 2018 also proposed a crew-carrying vehicle -- a winged space plane called Prometheus -- that could carry four to six astronauts into low-Earth orbit.
- Chicago-based PlanetSpace, Inc., is designing a space plane called the Silver Dart
- Blue Origin has plans for its own orbital space vehicle

Sub-orbital Space Tourism

To date, no sub-orbital space tourism has occurred. However, as these types of missions are projected to be more affordable, many companies view it as a viable business venture. Most are proposing vehicles that make suborbital flights peaking at an altitude of 327,000 feet. Space light participants would experience one to five minutes of weightlessness, and view the blackness of space, a thin blue layer of atmosphere, and the curvature of the Earth. The following are examples of proposed sub-orbital ventures currently being researched and/or developed and is not inclusive of all efforts currently in development.

Proposed Projects

- Blue Origin is developing the New Shepard reusable suborbital launch system specifically to enable short-duration space tourism.
- Virgin Galactic hopes to be the first to offer regular suborbital spaceflights to paying space flight participants, aboard a fleet of five SpaceShipTwo-class spaceplanes. The first of these spaceplanes, VSS Enterprise, was intended to commence its first commercial flights in spring 2015. However, the program suffered a considerable setback when the Enterprise broke up over the Mojave Desert during a test flight in 2014. A second spaceplane, VSS Unity, has begun testing.

Lunar Space Tourism

A final form of space tourism being considered is lunar space travel. These proposed missions typically involve space tourists flying on a trajectory that will orbit the Moon one time before returning to the Earth via a free return trajectory. A free return trajectory travels away from Earth where gravity from the Moon will cause the space vehicle to return to the Earth without the need for propulsion. Companies such as SpaceX and Space Adventures Ltd have proposed commercial lunar space tourism.

In February 2017, SpaceX announced plans for a Moon loop flight using a free return trajectory that could happen as soon as 2019. Additionally, Space Adventures Ltd. has announced that they are working on DSE-Alpha, a circumlunar mission to the moon. Space flight participants will be carried on a modified Soyuz capsule that will dock with a booster rocket in orbit and will send the vehicle on a free return trajectory that circles the Moon once before returning to Earth.

4.3.3.2 Point-to-point Missions

Point-to-point (PTP) is a category of sub-orbital flight in which a space vehicle provides rapid transport between two locations (e.g., Los Angeles to Sydney). This flight typically takes just over 15 hours, but with point-to-point suborbital travel the same flight could be completed in an hour or less.

In the future, since PTP markets will be near large cities, the FAA will not be able to confine NAS portions of PTP flight to existing, active restricted airspace. ANSPs, launch/reentry vehicle operators, and other NAS users will require communication and comprehensive situational awareness capabilities such as those discussed in Section 4.3.2. Additionally, the launch/reentry vehicle will require more trajectory control to prevent conflict as these vehicles will appear in rapid descents from extreme altitudes back into controlled airspace. Airspace entry will be specified by entry time, flight path, and assigned altitude. As weather and wind conditions change at the destination site, both individual reroutes and changes to the entire route structure will be managed via data linked communications. Precise trajectory control, communications, and shared situational awareness will be critical for PTP operation throughout the NAS.

Suborbital spaceflight over an intercontinental distance requires a vehicle velocity that is only a little lower than the velocity required to reach low Earth orbit. If rockets are used, the size required would be similar to an Intercontinental Ballistic Missile (ICBM). Any intercontinental spaceflight must surmount problems of heating during atmosphere reentry that are nearly as large as those faced by orbital spaceflight.

Currently there are no options for this type of travel, however, SpaceX has revealed it plans to provide such flights as early as the next decade. Virgin Galactic has also discussed the potential of using its Spaceship Two, or variations of it, to provide PTP services.

4.3.3.3 Microsatellites

Microsatellites are low mass, economical, and versatile spacecraft that are used in academic, commercial, and military markets. These satellites are typically used for scientific research, technology demonstrations, telecommunications, navigation, Earth imaging, and weather observation.

They are tracked and monitored by several government, U.S. Air Force, DoC and non-government organizations such as the NewSpace Global, SpaceWorks Enterprises, and The Tauri Group.

The projected market for microsatellites is somewhat inconsistent, however all projections reflect optimistic growth in the near term. There has been an average annual growth of 39% per year over the last five years with over a 40% average annual growth in the nanosatellite market. SpaceWorks Enterprises projects that approximately 3,000 satellites in the 1 to 50 kg range will be launched from 2016 through 2022.

By any estimate, the microsatellite market has strong projected growth that will likely exceed the available launch capacity as auxiliary payload. This will create an ancillary market for microsatellite launch capacity.

Commercial launches of microsatellites are currently occurring in limited numbers, which is mostly due to economic considerations concerning access to space[12]. Commercial users are limited by the availability of rideshare options, which dictate the launch schedule and final orbit of their satellite. With the development of commercially available microsatellite launch vehicles, the number of commercial launches is expected to increase to fill a variety of commercial applications.

The Northrup Grumman Innovation Systems Pegasus provides dedicated launches for microsatellites to low earth orbit as has conducted 42 missions since 1990[13]. The following is a representative list of companies that are developing small launch vehicles to meet the launch demands for microsatellites.

- ARCA Space Corporation is developing the Haas 2C small launch vehicle designed to accommodate 400 kg into low earth orbit (LEO).
- Boeing is currently developing the XS-1 Experimental Spaceplane, a small launch vehicle for DARPA.
- CubeCab, intends to begin launch operations in 2018. Initial plans will include air launch from an F-104 aircraft.
- Generation Orbit is developing the GOLauncher family, designed to launch from conventional aircraft.
- MISHAAL Aerospace is developing ground-based launchers for both suborbital and delivering microsatellites to low earth orbit.

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[12] O'Connell, Dan. "AIAA/USU Conference on Small Satellites." *DigitalCommons@USU*. 8th Annual AIAA/USU Conference on Small Satellites, n.d. Web. 18 Oct. 2016.

[13] Orbital ATK. *Pegasus Fact Sheet.* (2015) Retrieved from https://www.orbitalatk.com/flight-systems/space-launch-vehicles/pegasus/docs/FS002_02_OA_3862%20Pegasus.pdf

- Rocket Crafters is developing a ground-based launcher with the goal to be the world's first mass-producible "launch-on-demand" microsatellite launcher.
- Vector Space Systems is developing a ground-based mobile launcher scheduled to begin launching satellites in 2018 from Cape Canaveral, Florida.
- Virgin Orbit, is developing LauncherOne (a two-stage orbital launch vehicle designed to deploy small payloads into Sun-synchronous orbit) to be air launched at high altitude from a Boeing 747.

4.4 Description of Future Operations

The following subsections describe the management and integration of launch/reentry operations in the NAS. This involves three distinct phases of the operation: 1) pre-operational planning (includes both long- and short-term planning), 2) real-time operations, and 3) post-operations review and analysis. For suborbital operations that both launch and land in the NAS, it is expected that the real-time operation phase will last for the duration of the flight.

4.4.1 Pre-Operational Planning

In the future environment, the overall planning and coordination process will involve some parallel processes and independently acting stakeholders to coordinate and exchange information. Once a license or permit is granted, the operator and the FAA will begin specific planning for the mission, just as in today's operating environment. This planning includes scheduling for specific days, times and airspace requirements for the mission, developing and evaluating hazard areas, and assessing effects on the NAS. For some of these activities, a federal range may act on behalf of the operator, as described in the operator's license or permit.

In the current environment these processes are largely manual and both labor and time-intensive with communications taking place in disparate forms such as written notes, phone calls, emails, etc. This presents an increased opportunity for error (e.g., miscommunication, transposing data entries, etc.) and an inability to accommodate late changes in dynamic conditions. Advances in automation capabilities will help to streamline the overall licensing, planning, and coordination processes involved in launch/reentry missions, reducing planning timelines from weeks or months in the current environment, to days or hours in the future environment.

4.4.1.1 Mission Scheduling

Prior to any mission, a commercial space operator must receive a license or permit from the FAA to conduct an operation at the proposed launch site or spaceport. The license or permit application includes scheduled launch dates and an acceptable risk analysis. It also includes an LOA between the operator and the FAA, establishing procedures for each operation such as procedures for notification, communication, and response to contingencies. The application includes vehicle type, spaceport location, mission profile, payload, a prioritized list of multiple launch/reentry windows, and the operator's ability to ensure public safety.

For each launch the operator also submits a flight plan and scheduling request via ANSP automation, built on existing TFMS automation. ANSP automation supports traffic managers in balancing tradeoffs to ensure that NAS and mission goals are met with the required levels of safety. The submitted schedule request includes operator preferences and mission constraints (e.g., any conditions under which the launch or reentry must be conducted that may affect the time), are processed by ANSP automation, and are compared with other NAS user scheduled and requested operations.

ANSP automation analyzes the data for potential resource conflicts with other scheduled NAS operations for each proposed operational window and follows defined practices for balancing competing operations. The specific content of these guidelines involves future resolution of policy questions (e.g., first-come, first-served vs. better equipped better served).

ANSP automation uses available and historical NAS schedules, forecast weather, the airspace management method, and the debris hazard avoidance method selected to determine the effect the proposed operational windows will have on the NAS. As in the case of other system constraints, the effect on the NAS is assessed by evaluating whether NAS performance goals (measured in terms of system efficiency, capacity, and safety) are met. This analysis process may be iterative as different potential operational plans are evaluated and feedback is provided.

ANSP automation considers a variety of tradeoffs between NAS effects and the operator's list of operational preferences to generate a schedule. Factors considered include available NAS resources, effects on NAS performance and capacity, mission requirements, and hazard models.

If the mission cannot be supported in the manner required for mission success, the JSpOG provides an explanation and recommendations to the operator for modifying their requests. The schedule request process may also need to consider international agreements and cooperation for international operations (see Section 4.8).

4.4.1.2 Airspace Selection

During the mission planning phase, the operator and the ANSP work together to identify a region of airspace compatible with the planned mission. More experienced operators may be able to make this selection without much input from the ANSP, but less experienced operators may need to work closely with the ANSP to select the most appropriate airspace. They also need to satisfy the operational restrictions associated with the region where the operations are performed. Examples include:

- Risk: the likelihood and consequence of an off-nominal event posing danger to other vehicles in the area, population on the ground, etc.
- Trajectory uncertainty: the ability to operate in a predictable manner that enables proximity to other aircraft
- Maneuverability: the ability to respond to/comply with ATC instructions

The airspace profile allows the ANSP to set requirements for operations. For example, near a congested area, the ability to comply with the proposed trajectory must be precise enough so that the vehicle can avoid certain sectors. However, it does not preclude experimental vehicles from operating in appropriate locations where large protected volumes can be accommodated with minimal effect on the NAS (i.e., segregated airspace).

4.4.1.3 Integrated Safety and NAS Effect Analysis

Prior to a launch, results of the hazard analysis (conducted during the licensing and permitting processes) are used as inputs to a process that determines viable methods for airspace management and off-nominal hazard required to support the mission and associated effects on NAS efficiency and capacity. This process is expected to be iterative as it seeks to produce an optimized solution that meets safety standards and is efficient as possible. Some airspace management methods require more capabilities from the operator or ANSP than others. For example, if the ANSP supports reactive separation from off-nominal hazards, then the ARE method is a viable option.

Regardless of method, the volumes are defined by the most efficient solution meeting the highest degree of safety possible. In some cases, there is a trade-off between maximum efficiency and safety of the solution. An optimization capability for maximizing efficiency while maintaining acceptable safety standards as a hard constraint is needed to ensure NAS operations are optimal. This capability evaluates multiple options concurrently that meet the required level of safety.

4.4.1.4 Coordinating the Mission

Commercial space operations planning information will be available to authorized stakeholders to support their planning needs via a data sharing portal (see 4.3.2.4). Like data sharing via Collaborative Decision Making (CDM) today, stakeholder access to this planning information will be based on their level of involvement in the planning process, need to know, and other considerations such as proprietary data and export control.

Since local processes have evolved differently over time, notification may take different forms, depending on if an operation is planned to take place from a federal range, a private launch or reentry site, or a dual-use airport, and if there are any unique notification requirements defined in the LOA. As a result, the notification may be received first by the ATC facilities or by the ATCSCC.

4.4.2 Real-Time Operations

After the pre-launch planning and scheduling steps discussed above are completed, real- time operations can begin. Real-time operations include the following phases:

- NAS User Trajectory Planning
- Flight Authorization
- Launch and Ascent

- Reentry, Descent, and Landing

4.4.2.1 NAS User Trajectory Planning

ANSP automation is continuously updated as mission parameters are developed or refined to provide the most up-to-date information on the planned airspace management method, boundary, and time window. NAS users can access this information as needed to plan for an operation and determine any adjustments to normal operations planning. Table 4 lists the airspace management methods proposed in this document and indicates the flight operator trajectory adjustments required by each.

Table 4 - Trajectory planning adjustments (based on airspace management method)

<table>
<tr><th>Airspace Management Method</th><th>NAS User Trajectory Planning Adjustments</th></tr>
<tr><td>ARE (Class A airspace)</td><td>Launch/reentry operation effect on other NAS users is minimal, if any</td></tr>
<tr><td>STC with just-in-time activation
(Class A airspace)</td><td>NAS users plan trajectories assuming operations would not need to be rerouted around the STC because just-in-time activation generally results in very small-time windows (equivalent to tactical delays routinely encountered in the NAS). However, for the larger time windows, extra fuel may be needed.</td></tr>
<tr><td>STC with predetermined activation
(Class A airspace)</td><td>If affected by the STC time window, the nominal trajectory plan is adjusted to include a reroute around the STC and fuel is increased accordingly. If STC is deactivated early, the flight can follow direct routing (shortcut) through the STC.</td></tr>
<tr><td rowspan="3">TFR (below 18,000 ft)</td><td>Non-system-wide data and information exchange capable VFR:
Same as above, but the direct routing is only possible if the flight is on ATC frequency</td></tr>
<tr><td>System-wide data and information exchange capable VFR:
Same as above, but volume of STC is smaller</td></tr>
<tr><td>IFR:
Same as STC with just-in-time activation since ATC can clear IFR flights to enter TFR in the same manner that ATC can clear IFR flights to enter the STC</td></tr>
</table>

4.4.2.1 Flight Authorization

During the flight authorization phase, the appropriate ATC facility coordinates with the launch/reentry operator and provides updates about key pre-launch events that reduce

4.4.2.1 Flight Authorization

During the flight authorization phase, the appropriate ATC facility coordinates with the launch/reentry operator and provides updates about key pre-launch events that reduce uncertainty in the launch schedule. Affected ATC facilities are informed of updates to the schedule as needed to manage other NAS users for anticipated operations. Affected ATC facilities confirm that STC or TFR information was disseminated via NOTAM. ATC issues flight authorization, and automation disseminates mission and launch status to relevant organizations. Figure 9 specifies data exchange for orbital missions.

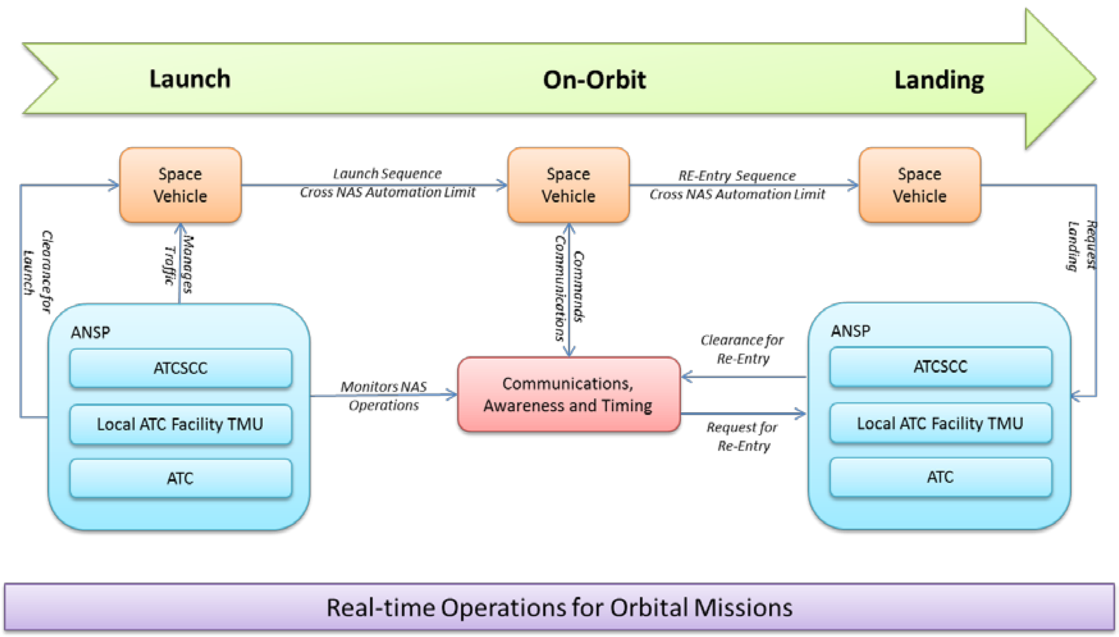

Figure 9 - Real-time Information exchange and communications between operational stakeholders

For the STC method with just-in-time activation, the launch/reentry operator or its designee notifies the ATC when the NABET has been received, which initiates the STC pre-activation phase. Before the NABET is available the ANSP will receive updates of the expected launch time for awareness, but the pre-activation does not start until the NABET is known. ATC monitors all other NAS users potentially affected by STC activation to ensure that if a flight enters the STC, it has sufficient time to exit prior to launch. Under rare circumstances, a flight in the STC may not be able to exit by launch time (e.g., due to an emergency or lost communications), in which case the controller notifies the Traffic Management Unit (TMU). The TMU initiates a contingency plan that would typically involve a launch delay.

For the ARE method, once the NABET is received, ARE deconfliction commences based on the launch time identified by the NABET. ATC begins resolving NAS user conflicts with the predicted vehicle trajectory. In the case where there are conflicts that cannot be safely resolved by launch time (e.g., high traffic levels near the ARE caused by unexpected delays leading to a number of conflicts that cannot be safely solved by the conflict resolution tool), the FAA will work with the operator to modify the mission plan so as to ensure the mission can occur under the safest possible conditions as timely as possible.

If a launch/reentry vehicle can adhere to a standard Call for Release time window and separation assurance can be maintained with the amount of notice provided by the Call for Release time window, a Call for Release process can be used. In this case, the operator requests a release time in lieu of providing a NABET. Local TMUs coordinate the release time for the vehicle just as they would for an aircraft requiring release into an overhead stream. The vehicle must launch within a small time window (e.g., 5 minutes), just as aircraft utilizing a Call for Release process must take off within a small time window. The key difference between the Call for Release for launch/reentry vehicles and aircraft is that the launch/reentry vehicle is being released into airspace managed using one of the above methods (e.g., an STC) instead of an overhead stream of aircraft traffic. As a result, the vehicle will often require a larger gap in operations to ensure adequate separation is maintained between it and other NAS users.

4.4.2.1 Launch and Ascent

The launch/reentry vehicle's real-time trajectory is distributed to relevant parties, including affected ATC facilities and aircraft operating nearby. Automation monitors any operational stages for a successful return to the surface.

- For the ARE method, ATC will continue separating any flights in conflict with an ARE until the protected envelope clears the upper NAS automation boundary.
- For the STC method, automation determines when the vehicle has successfully cleared the STC, applies necessary time buffers, and then deactivates the STC. ATC can then clear flights affected by the STC to enter it.
- Automation (FAA or operator) continues to monitor the mission for off-nominal events such as a vehicle breakup until the hazard no longer exists.

4.4.2.1 Reentry, Descent, and Landing

Any trajectory or schedule variance from the planned mission (above acceptable tolerances), including but not limited to adjustments (within the scope of constraints), changes in reentry time or location, cycle/orbit delay, etc. will require the operator to work with ATC and the landing facility to schedule an exit from orbit and a reentry profile update. The launch/reentry operator uses the original schedule and planned landing area as the starting point for discussions with ATC and any affected facilities to coordinate the final landing area and descent/landing operational sequence. The lead time required for this depends on scheduled NAS operations including flight durations of other operations plus flight planning lead time (i.e., deadline for submitting a flight plan before departure), but will need to occur well in advance of the operation.

STC Method

For the STC method, uncertainty in the position and time of reentry can result in large uncertainties in both the STC volume and the time to activate it. As more reliable trajectory information is collected and processed, and as the operation commencement time nears, this uncertainty decreases. The STC volume is updated in real-time to reflect the increased accuracy of the predictions. When the uncertainty decreases below some threshold, the landing time and trajectory through the NAS are known with enough certainty that the STC pre-activation phase begins. In this phase, ATC begins to monitor all other NAS users potentially affected by STC activation to ensure that if a flight enters the STC, it has sufficient time to exit prior to the actual STC activation. The NABET lead time requirements for reentry operations are critical and must be sufficient, since postponing the operation is not an option and the lead time needs to ensure that ATC has enough time to safely clear the STC of any traffic. When the hazard associated with the mission no longer exists, automation deactivates the STC and ATC can then clear flights through the formerly restricted corridor.

Adaptive Risk Envelope

For the ARE method, deconfliction commences while the launch/reentry vehicle is suborbital and the detection look ahead time begins to penetrate the NAS automation boundary. As this penetration reaches lower into the NAS where flights are typically located, ATC begins resolving conflicts against the vehicle's associated protection envelope.

4.4.2.2 Operations above 60,000 feet

Launch/reentry vehicles (current and emerging) will often be operating in the airspace above FL600. However, these operators are not the exclusive users of this airspace and the FAA must balance their needs with that of other users, including State aircraft and UAS operations.

The FAA designates the airspace above FL600 as controlled airspace, Class E. In Class E airspace, VFR aircraft do not require ATC approval and do not need to be in communication with ATC. Separation services are provided between IFR aircraft; however, separation services are not provided between IFR and VFR or between VFR aircraft.

Recent increases in development of aircraft types to provide telecommunications or earth-sensing services from high-altitude platforms and forecasted growth in space launch activity, is likely to result in a rapid increase in demand for this airspace.

Additionally, research and development activities may bring new operational types into this airspace, including suborbital hypersonic or supersonic aircraft, space tourism, and balloons as launch platforms. Use of the airspace above FL600 should be flexible enough to accommodate new types as they emerge, however, it should not constrain current operators in anticipation of future operational characteristics that are currently unknown.

Neither ICAO nor the FAA precludes the development of standards and procedures that are specific to this airspace. An evolutionary approach that accommodates existing operators, including military and State aircraft, and provides flexibility for launch/reentry vehicles will allow the FAA to support the emerging industry and continue to promote U.S. leadership while protecting the safety of the airspace for all users.

4.4.3 Post-Operations Review and Analysis
This subsection describes the post-operation process during which the AST, ATCSCC, the launch/reentry operator, and other stakeholders review the process used to plan and manage the operation to identify elements that worked well and areas for improvement.

Data is collected during planning and real-time operations to support post-operations analysis and lessons learned. Each stakeholder is responsible for reporting data for their operation that supports the ATCSCC and facility TMUs in tracking NAS performance including vehicle operations. Such performance data includes:

- Overall NAS delays.
- Costs (e.g., delays) to specific flights/operations/organizations, including the launch/reentry operator, and airspace management methods employed in the NAS. This includes all methods and associated TMIs employed in the NAS.
- Vehicle and operator reliability, including structural, trajectory compliance, adherence to NABET, etc.
- Planning system effectiveness, including duration of planning process and planning functions supported.

Additional metrics may be identified and included with the items above. It is assumed that the ANSP will develop metrics for comparing operational cost to aircraft operators with operational cost to launch/reentry operators.

4.4.4 Off-nominal Events
The ATC and NAS user response to a launch/reentry off-nominal event depends on the hazard management method determined during the planning phase and described in section 4.4.1 Pre-operational Planning. For reactive separation from a hazard, the process begins when surveillance, onboard sensors, or other communication from the launch/reentry vehicle mission system indicate an off-nominal event that will prevent the vehicle from adhering to its planned trajectory.

ANSP automation dynamically calculates and shows off-nominal hazard volumes on controller and traffic manager displays within a minimal amount of time from the event. In the case of a breakup, vehicles equipped with breakup transmitter technologies broadcast their positions, so the actual off-nominal hazard volume can be more accurately predicted.

Off-nominal events can require an alternate landing location. There will be a pre-designed hierarchy of potential landing sites based on the abilities of the vehicle at the time, and the automated scheduling and information flow architecture would be able to update and direct the space vehicle.

4.4.4.1 Reactive Separation Methods for Off-nominal Events
This subsection describes two concepts for reactive separation to protect other NAS users from actual off-nominal hazards:

- Reactive Separation for IFR flights; and
- Reactive Separation for VFR flights

In general, other NAS users operating in potential hazard regions (e.g., below a launch/reentry operation) is the rule rather than the exception. When an off-nominal event does occur, methods to safely and dynamically separate other NAS users from the hazard are needed.

Reactive Separation for IFR Flights

At any point in time along a nominal trajectory, ANSP automation can calculate and display hazard volumes in response to an off-nominal event. The hazard volumes are propagated as a function of time and altitude (see Figure 10, re-drawn from the FAA Space Vehicle Debris Threat ConOps [FAA, 2010b] for consistency with terms used in this ConOps) to identify where risk to aircraft and/or human casualty exceeds some threshold. If an off-nominal event occurs at some point, ANSP automation provides the following to the controller:

- Calculation and display of hazard volumes based on pre-defined input variables associated with the off-nominal event (e.g., the hazard volumes for a thrust-terminated vehicle would be different than the hazard volumes for a breakup).
- Trajectory solutions that prevent flights outside the hazard volume from entering it.
- Ranked trajectory solutions for clearing affected NAS traffic from the hazard volumes. These solutions are based on giving priority to flights with the highest risk while ensuring that none of the solutions compromise separation or the safety of any NAS user.

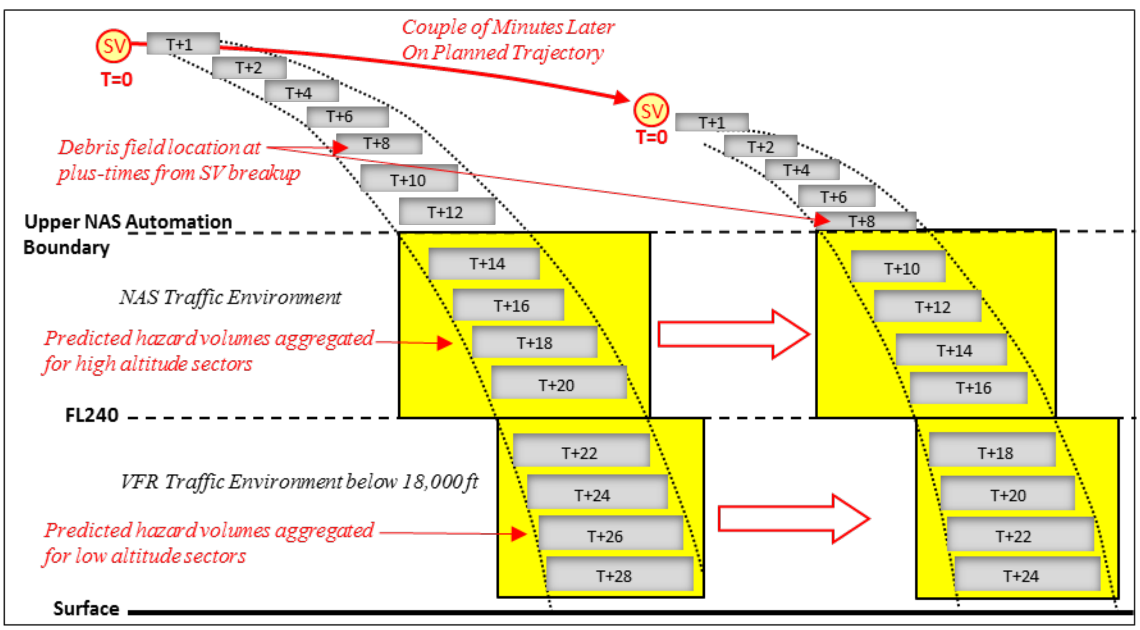

Figure 10 - Predicted hazard volumes shown at two distinct times along the vehicle nominal trajectory

The levels of risk to IFR flights are identified graphically (e.g., through a plan view display (see Figure 11)) as a visual confirmation to the controllers and traffic managers of the ranked trajectory solutions.

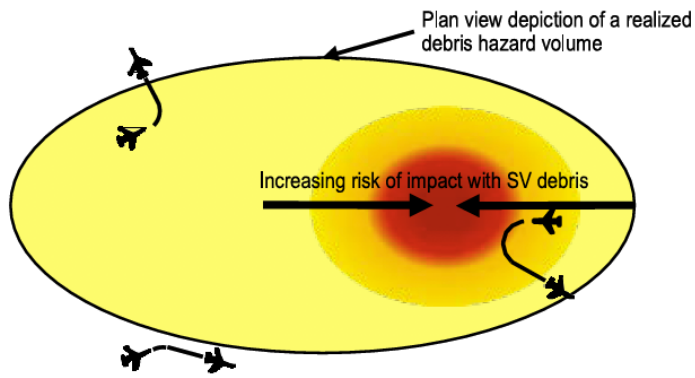

Figure 11 - Notional information to display to controllers and pilots in real-time in the event of a breakup with a gradient showing areas of higher risk of collision with debris

<u>Reactive Separation for VFR Flights</u>

Reactive separation for VFR flights requires the aircraft to have real-time access to hazard data and optionally be on an ATC frequency. In terms of displaying the predicted off-nominal hazard volume in the case of an off-nominal event, the VFR flights would have access to the same information as the IFR flights in the previously described method. However, VFR flights not receiving flight following, and are in voice communication with ATC, are responsible for determining the necessary path to clear the off-nominal hazard volume rather than being directed by ATC as with the IFR method.

4.5 Future Launch Sites/Reentry Sites and Dual-use Airports

4.5.1 Overview

As winged commercial space vehicles development increases (for horizontal takeoff/ landing), so will the need for enabling infrastructure and a regulatory framework at launch/reentry sites. Airports may look to capitalize on existing infrastructure to expand their business models and integrate commercial space operations and support services into their aeronautical portfolios. Alternatively, sites may be proposed for specific types of launch/reentry operations. These sites can be built to support horizontal or vertical launches, or both. Spaceport America in New Mexico is an example of a purpose-built site that supports both horizontal and vertical launches.

4.5.2 Site Selection, Planning Integration, and Design Standards

To realize routine integration of commercial space operations on dual-use airports in the future, airports need to include all potential users into their long-range plans. Applicants assessing new launch/reentry sites will be introduced to the concept of assessing site feasibility and NAS integration requirements. Site assessment is a critical step that needs to be carefully considered before proceeding with the planning process. Airport sponsors will identify proposed commercial space-related development and land use needs following the same process required for any planned development at NPIAS airports. Proposed facility development will be documented in Airport Master Plans and Airport Layout Plans[14] and be evaluated using the Obstruction Evaluation/Airport Airspace Assessment (OE/AAA) process to assess development feasibility. Applicants will be required to use such methods to streamline integration and align with FAA processes and requirements.

4.5.3 Evolution of Regulations

Dual-use locations will also find seamless regulatory oversight through blended regulations that bridge gaps between protecting public safety and protecting infrastructure. FAA will update common framework and regulatory definitions after gaps in statutory authority are resolved through legislation.

Standards will identify common infrastructure needs and offer guidance on the design, siting, safety capabilities, and integration of launch/reentry sites. Dual-use airports will be able to refer to these standards to integrate propellant storage, loading, and ground operations into existing infrastructure and operations. These standards will also cover necessary rescue and firefighting capabilities, techniques, and equipment.

Vehicle operators and the FAA will focus on the compatibility of airports or sites and types of commercial space operations when considering where to conduct their operations. The FAA will encourage commercial space operators and manufacturers to work with the FAA early in the design phase to identify any integration constraints to resolve compatibility issues before manufacturing begins.

4.5.4 Industry Trends and Evolution

As technology changes and more information is known about operation types and vehicle performance, FAA will develop or update design and operating guidance, so site operators are able to plan, design, and build facilities that safely integrate new operations. The result should be the establishment of a viable, balanced, and integrated system of launch/reentry sites.

4.6 – Environmental Review for Commercial Space License or Permit Applicants

Environmental review is required in the AST approval process for each license or permit application, as the issuance of a commercial space license or permit is a major federal action

[14] United States Code (USC) 47107(a) (16) requires that an airport owner/sponsor maintain a current ALP that ensures the safety, utility, and efficiency of the airport. The FAA must approve the plan and any revision or modification to the ALP before the plan, revision, or modification takes effect.

under NEPA of 1969, as amended (42 United States Code §4321, et seq.). The environmental review process begins during pre-application consultation and must be completed before AST issues a license or permit. 14 CFR Part 415.201 of AST regulations requires applicants to provide sufficient information to analyze the environmental impacts associated with the proposed project and comply with the requirements of NEPA, Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*. In addition to FAA Order 1050.1F, there are other NEPA-implementing policies and procedures that may be applicable to a proposed project at federally-obligated or 14 CFR Part 139 airports, including FAA Order 5050.4, *NEPA Implementing Instructions for Airport Actions.*

4.6.1 National Environmental Policy Act

The FAA must comply with NEPA requirements and other federal environmental laws, regulations, and orders when issuing commercial space licenses or permits. In general, the NEPA process includes the following six steps:

1. Identifying initial issues and concerns
2. Coordinating with other Federal, state, or local agencies to determine which entities should be included in the NEPA process
3. Identifying the appropriate type of environmental review (see the *Types of Environmental Review*, below)
4. Preparing the draft NEPA document, and public involvement, as appropriate
5. Preparing the final NEPA document
6. Issuing the environmental determination

4.6.2 Types of Environmental Reviews

The primary types of FAA/AST environmental reviews are EAs and EISs. In limited situations, a third type of environmental review, categorical exclusion, occurs. The types of reviews differ based on the FAA's determination of the potential for significant impacts. Although AST is responsible for these documents, they are often prepared by the applicant or by another Federal entity (such as a Federal range operator) and independently evaluated by AST.

During the NEPA process, AST analyzes potential environmental impacts associated with proposed activities. After all analysis requirements are satisfied, AST prepares a finding or decision document which becomes part of the license or permit application evaluation.

4.7 Future Safety Procedures, Review, and Approval Considerations

Central to this concept is recognizing that integrating launch/reentry vehicles is a major operational transformation for the FAA. The challenges from a safety perspective are significant, but the benefits to handling more launch/reentry operations, adding efficiency and capacity, and integrating environmental and security needs are worth the challenge.

Future NAS operations see the integration of launch/reentry vehicles and other new entrants into the NAS as just one of many users. The safety objective for all NAS users is to maintain safety given the increase in NAS traffic. Innovative ways of thinking about NAS safety may allow planned reduction in separation standards (e.g., vehicle/vehicle and vehicle/airspace) using automation assistance.

Safety management services evolved from that described in Section 2.6, for integrated historical and prognostic evaluation and management of hazards, and their potential risk to prevent future accidents or hazards. As technologies and procedures develop and more data is available, safety risk assessments are performed at every step in the planning and implementation process. Safe implementation and operation of increased launch/reentry vehicle traffic and other new entrants incorporate enhanced FAA capabilities for safety risk management and safety assurance. Safety assurance, as the regulatory authority, continuously measures and assesses the effectiveness of stakeholder safety management systems through joint audits and trend analysis.

Addressing the shortfalls contained in this document supports the safe evolution of integrating space vehicles by providing enhanced safety assessments, assurance methods, and procedures for airborne and ground systems. Advanced, predictive safety assessment capabilities accelerate previously unrecognized safety risk detection and contribute to safer operational practices. Improved verification and validation (V&V) processes ensure that systems are certified to be reliable enough to perform automated operations, including critical failure recovery without compromising safe NAS operations. Advanced training concepts assist users and service providers in maintaining proficiency to safely conduct operations when automation degrades or fails. Tools that extract relevant knowledge from data sources throughout the NAS enable the FAA and aviation community partners to monitor the effectiveness of NAS enhancements.

The enhancements described above ensure the operational capabilities required to increase capacity, efficiency, and environmental benefits. They do not introduce additional risks to the system, and safety issues are properly identified and managed. Improvements in system-wide risk identification, integrated risk analysis and modeling, analytical processes that link together existing data and databases, shared expert knowledge, results of research, experimentation and modeling capabilities continually assess the safety performance of the NAS. The future ensures an increase in safety to match increases in NAS operations, reductions in separation, and greater use of automation for operations, benefiting all stakeholders and the traveling public.

4.8 International Harmonization

The mission of the FAA is to provide the safest, most efficient aerospace system in the world. The FAA accomplishes its mission by facilitating compliance and enforcing aviation regulations through responsible LOBs including ARP, ATO, AVS, AST, and Security and Hazardous Materials Safety (ASH) with support provided by Centers and Staff Offices (SOs) including Policy, International Affairs and Environment (APL) ANG. The FAA’s global leadership is critical to achieving U.S. aviation goals and supporting broader national priorities. Through international engagement, the FAA increases the safety, efficiency, and environmental sustainability of the global aviation system while also helping to ensure that U.S. industry can participate in the global marketplace.

Within FAAs Global Leadership Initiative (GLI), the U.S. aims to improve safety, air traffic efficiency, and environmental sustainability across the globe. An integrated, data-informed approach helps shapes global standards, enhances collaboration and harmonization, and better targets FAA resources and efforts. FAA advocates for and shares U.S. best practices for commercial launch/reentry operations and emerging technologies that support operations in navigable airspace. FAA continues to work with ICAO and an increasing number of partner countries in each region. FAA's involvement also provides leadership to international safety and standards bodies and the UN Office of Outer Space Affairs, to promote U.S. commercial space transportation regulations and facilitate standards development and interoperability between national regulatory bodies.

4.8.1 ICAO Leadership & Influence
As a key member of ICAO, FAA coordinates the U.S. technical civil aviation activities. FAA's active engagement provides the opportunities for the Agency and the U.S. industry to share best practices, provide global leadership, and have strategic influence on worldwide aviation issues and standards development.

As global aviation sees more companies entering the space initiatives and increased launch requests in the U.S. NAS that potentially involve other countries, the FAA is actively engaged in developing processes through the GLI, so safety and efficiency are at the forefront of the discussions. The FAA will also continue its active participation in these global forums to ensure collaboration and harmonization within the space community.

4.8.2 Global Leadership in Launch and Reentry Operations
FAA leads in the development and implementation of innovative technologies and practices that improve aviation safety, efficiency, and sustainable growth. A large part of the U.S. space initiative is the introduction of best practices and standards as well as shared technologies that are required for crosscutting international engagements. This helps to ensure interoperability and global ATM infrastructure, including standardized safety parameters.

In addition to close engagement through ICAO, the FAA works with a range of government and industry stakeholders and regional groups through the ICAO Planning Implementation Regional Groups (PIRGS) and Regional Aviation Safety Groups (RASGs) on emerging technologies and practices of strategic interest to the global launch/reentry operators.

4.9 Anticipated Benefits of Implementing the CSINAS Concept
Implementation of the CSINAS concept is expected to yield several operation and system benefits. Among these expected benefits are:

- Improved NAS response to off-nominal operations that pose a threat to other NAS users, allowing a broader availability of NAS management options so that all achieve the required level of safety.
- Improved NAS efficiency (smaller delays, reduced fuel burn and emissions, increased launch/reentry opportunities) due to:
  - Hazard analysis methodologies that decrease the size of hazard volume for both nominal and off-nominal operations
  - Enables traffic to enter/transit potential hazard volumes when modulated by TMIs
  - Time required for protecting mission operations is as small as possible
  - Ability to reactively separate other NAS users from an off-nominal hazard, typically debris, allows aircraft to utilize more airspace below mission operations
  - More efficient planning process for the ANSP, mission operators, and NAS users
  - Improved shared situational awareness among stakeholders in the CSINAS operations planning process

4.10 Areas for Future Concepts/Research

This following is a list of areas identified that may benefit from future research to realize the full benefits of implementing the CSINAS concept. These areas include:

- Requirements for specific ANSP automation, tools/displays, and integration of the various automation systems needed to achieve the vision outlined in this ConOps.
- The upper limits of surveillance/tracking connectivity to NAS automation needs to be examined in concert with current/evolving technologies, operational considerations and other issues.
- Specific coordination and informational needs across the various CSINAS stakeholders
- The trajectory error tolerance requirement for ARE deconfliction.
- The optimal time needed to give ATC enough time to react to an off-nominal event and maintain safety
- The best approach for conveying conflict information to ATC automation
- Existing deconfliction automation will need to be researched to address: 1) incorporating the dynamically changing ARE into the deconfliction algorithm; and 2) modeling performance characteristics unique to launch/reentry vehicles such as high acceleration and deceleration (Section 3.3.2.1)
- The best approach to computing the ARE based on acceptable risk level and ability for ATC to respond to an off-nominal event
- International coordination procedures
- Improved and established real-time data exchange between operators and ANSP
- Data exchange and information requirements
- Operator requirements for providing telemetry data to the ANSP
- Required tracking and automation performance to achieve the ConOps objectives
- Data sharing bandwidth, capabilities/limitations, roles/responsibilities
- Best method for ingesting operator provided data set into the FAA firewall
- The conditions that constitute a volume conflict, given the much higher speeds and

subsequent distances than the equivalent problem with subsonic aircraft

- The best approach for conveying volume conflict information to ATC personnel, given potential levels of complexity and the speed at which events may evolve

5.0 Operational Scenarios

This section contains a set of scenarios that highlight several examples of commercial space launch/reentry operations along with one example of the future vision or Licensing a Launch/reentry Site at a Federally-Obligated Airport (Section 5.9).

Each scenario consists of an operational context that offers a high-level description of what the scenario entails, and a scenario description that details the specific example and how it may be handled operationally.

In addition to scenarios, a set of assumptions pertaining to all scenarios is presented in Section 5.1 to provide context for the operational environment these scenarios occur in.

5.1 Scenario-wide Assumptions

The following set of assumptions apply to all the subsequent scenarios. All license and pre-mission planning activities are successfully completed prior to the beginning of each scenario.

- **Reactive Airspace Configuration**
    - Immediate notification of a vehicle failure triggers ATC to identify affected flights and direct them as necessary.
    - Hazard areas can be calculated, modified, and displayed in real-time.
- **Vehicle Profile**
    - Captive carry operations are not considered to be specialized operations prior to release of the carried vehicle from the standpoint of access to the NAS.
    - Vertical launches will continue to require isolated airspace however, CNS requirements are placed on the vehicles allowing for decreased volume of this airspace.
- **Weather Considerations**
    - There is a common weather picture integrated into automation and available to all involved stakeholders for planning and managing missions.
- **Technologies and Automation Support**
    - ATM/ATC have the capability to monitor vehicle positioning and speed in real time.
    - File and fly capability is operational.
- **Policy and Procedures**
    - A single safety standard will be used for managing both commercial and federal space operations.
    - Policy and procedures are in place to enable the scenarios described in this document.

5.2 Reentry of Capsule under Parachute

5.2.1 Operational Context

From a service delivery perspective, if a vehicle cannot accept and execute an ATC clearance, integration into the ATC system is more difficult. However, there are methods that can be employed to ease integration and mitigate negative impact on the NAS. This scenario illustrates one such method, a reentering capsule under parachute that provides ATM/ATC with vehicle state data (e.g., positioning, altitude, and speed) via telemetry in real time.

Figure 12 - Splashdown of reentering capsule under parachute

5.2.3 Scenario Description

The commercial space operator is planning for the reentry of its vehicle, a capsule returning under parachute. The capsule is expected to touchdown off the east coast of the United States. The planning and execution of this mission includes the vehicle reentry and requires passive segregation where the reentry is confined inside a scheduled, pre-defined volume of airspace that extends well out across the Atlantic Ocean. The date and time window of the reentry and splashdown have been pre-planned and organized, and the reentry is within the predetermined window. The potential for the vehicle to suffer a failure that generates falling debris dictates the size of the airspace and expected duration of the closure. Weather conditions and wind patterns offer no unplanned conditions during the capsule reentry (i.e., all operations are progressing as planned). When the capsule reaches its commitment point, it is handled as a priority vehicle since it does not have the option of deviating from its landing plan.

The airspace requirements are identified in a NOTAM and published in advance of the scheduled reentry. The NOTAM informs other air navigation service providers and non-participating aircraft to potentially expect a delay or other traffic flow restriction to remain clear of the area (i.e., ALTRV and SAA).

ATC has the information about the vehicle and the fly-back profile. This was part of the provided data and the subsequent training provided to the ATC facility. The required information is contained in the airspace management plan. Additionally, developments in safety and improvements in operators relaying vehicle data (location and altitude) allow for ATM/ATC to monitor the reentering capsule in real-time. This improved capability allows the time and volume of airspace closures required to be reduced, and, if a failure were to occur, an increased ability to respond. This capability also allows ATC to provide other NAS users access to the altitudes cleared in the segregated airspace once the vehicle reports clear of those altitudes. This frees up those altitudes for use as soon as the vehicle reports descending through those altitudes rather than waiting for the notification that the operation is complete.

Typically, these vehicles with ballistic returns free-fall to a predefined altitude, and then use a parachute or other mechanism to slow the vertical velocity for landing. Positive ATC is not an option for handling these returns since the vehicle has no ability to comply with ATC clearances. Due to the relatively slow vertical descent, airspace must be reserved for a longer time, requiring more extensive planning and collaboration among users and service providers. In addition, ballistic returns are constrained to landing at ports that can support the unique descent profile with minimal impact to arrival and departure traffic. Once the vehicle deploys a mechanism to slow its descent rate, narrower airspace boundaries are dynamically reserved and released. ATC provides horizontal and lateral separation of aircraft from this airspace. When the vehicle touches down, the mission controller issues notification that the mission has been completed, and this notification is disseminated via the NAS-wide information dissemination systems.

After mission completion and the NAS has returned to normal operations, a post-operations analysis is performed. The vehicle operator coordinates a debrief with FAA and other involved organizations (all involved in the mission). This allows further learning and refinement of mission profiles and other changes that may be required for the type mission to continually strive to improve NAS efficiency, safety and predictability. This information and data collected is stored in a shared repository and access is provided as appropriate to cleared personnel. Information stored may be de-identified where appropriate to enhance shared awareness.

5.3 Vertical Launch with Flyback

5.3.1 Operational Context

Air-launched vehicles, vertical launches, and controlled fly-backs receive NAS services that integrate their operations to the extent possible for the protection of other aircraft and personnel on the ground. This scenario describes a vertical launch with flyback operation.

Figure 13 - Traditional vertical rocket launch. Photo of SpaceX Falcon Heavy Test Flight.

5.3.2 Scenario Description

A commercial space operator is planning a traditional vertical rocket launch from a launch facility on the east coast. The actual launch from their ground platform is still yet undetermined because of weather conditions, but planning, procedures, and launch requirements and approvals are the same. Planning and executing this mission includes the controlled reentry of components of the vertical launch rocket and requires passive segregation where the launch operation is confined inside a scheduled, pre-defined volume of airspace that extends well out across the Atlantic Ocean. The potential for the vehicle to fail in a way that generates falling debris dictates the size of the airspace and expected duration of the operation. Launch preplanning, coordination, and approvals are completed in the hours leading up to the scheduled launch. The airspace requirements are identified in a NOTAM and published prior to launch day. The NOTAM informs other air navigation service providers and non-participating aircraft to potentially expect a delay or other traffic flow restriction to remain clear of the area. Developments in safety and vehicle reliability data allow the time and volume of airspace to be reduced. Air traffic control and air traffic management automation is available that depicts the segregated airspace and the airspace management plan. Collaborative air traffic management tools for shared awareness are leveraged to improve vehicle flight and operations planning as well as awareness for air traffic control and NAS users.

On the day and time of launch as designated in the NOTAM and mission documents, a successful launch takes place with the planned fly back and landing of rocket components. The jettison of non-reusable components takes place over international waters, approximately 60 miles off the coast. The controlled fly-back stage contains a propulsion system that requires the use of segregated airspace as with the rocket during launch.

ATC has a shared awareness of the operation through CNS standards in place that require position and altitude information be reported from the stage (booster). This allows for the potential earlier release of the segregated airspace. This portion of the operation is included in the NOTAM and includes landing or impact with the Earth (below Class A). As the returning stage provides position and altitude information, ATC can provide other NAS users access to the altitudes cleared in the segregated airspace once the vehicle components report clear of those altitudes. This frees up those altitudes for use as soon as the fly-back component reports descending through those altitudes rather than waiting for the notification that the operation is complete.

After mission completion and the NAS has returned to normal operations, a post-operations analysis is performed. The vehicle operator coordinates a debrief with FAA and all involved organizations. This allows further learning and refinement of mission profiles and other changes that may be required for the type mission to continually strive to improve NAS efficiency, safety and predictability. This information and data collected is stored in a shared repository and access is provided as appropriate to cleared personnel. Information stored may be de-identified where appropriate to enhance shared awareness.

5.4 Balloon Operations

5.4.1 Operational Context

For this mission, the vehicle operator is requesting a seven-hour window which to conduct its operation. The company intends to conduct its launch at the beginning of the window and requires roughly five hours for the operation to from takeoff to the touchdown of the parasail/capsule combination. The additional two hours were requested by the vehicle operator to work any issues that arise in the preparation for the release of the balloon, including technical issues such as navigational performance or telemetry communications issues from the capsule. The capsule will ascend under the balloon to a peak altitude, where it will remain roughly for about two hours, during which time the space flight participants are free to move about the cabin and take in the view. The separation of the capsule from the balloon could occur as late as six hours after the opening of the launch window. After separation, the capsule and parasail become a paraglider and the pilots control the vehicle to the land at a predetermined designated landing site. Figure 14 illustrates the balloon's flight profile.

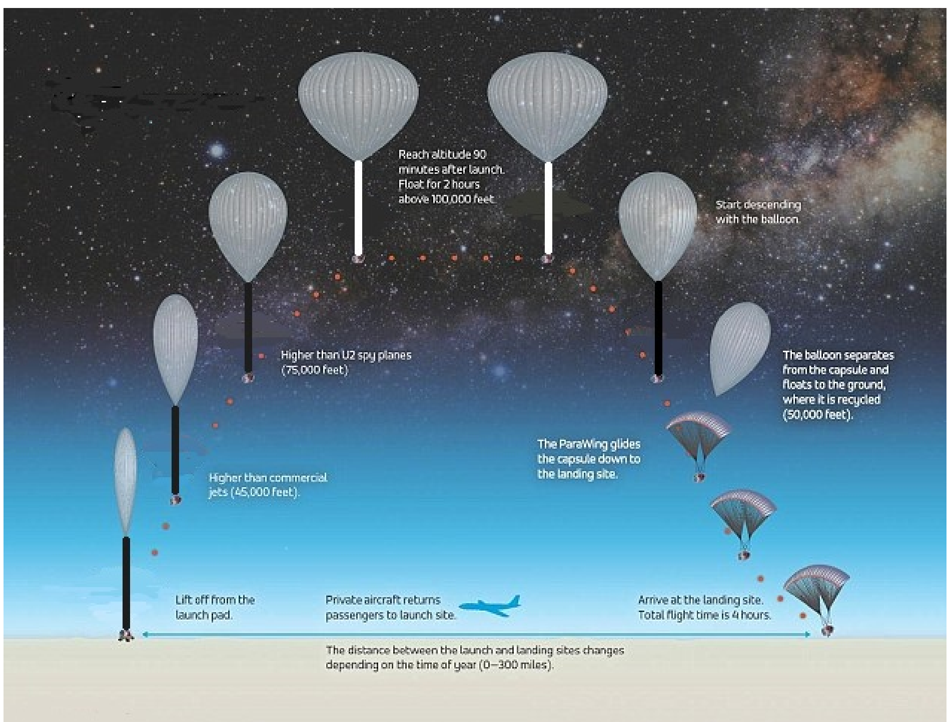

Figure 14 - Reusable High-Altitude Manned Balloon Flight Profile

5.4.2 Scenario Description

As the scheduled time for a flight approaches, the reusable high-altitude manned balloon operator contacts the FAA at specific intervals to provide status on its readiness level per its LOA. In the meantime, air traffic above FL180 continues to flow through the area.

The vehicle operator identifies the actual liftoff time and ATM begins to clear the area that corresponds to the TFR of air traffic. Unlike other launch operations, this AHA is sized to prevent collisions with other NAS users. The potential for the capsule to fail in a way that generates falling debris is so small that it does not require an AHA to address. Similarly, the aircraft approaching the area are contacted and rerouted as necessary to avoid the TFR. The vehicle operator confirms that the capsule has been launched over automation.

At this time, the mission is progressing nominally, and ATM/ATC continues to monitor the mission. The high-altitude manned balloon's present position and altitude continues to be transmitted to ATC and controllers continue to monitor the balloon's ascent. The present position of the vehicle is also displayed on the traffic management display for ATC situational awareness only.

As the mission transpires, incoming telemetry data allows ATM/ATC to continuously monitor the mission status and confirm mission conformance with expectations (e.g., vehicle position relative to the planned route). In this case, the planned route of flight is dependent on the winds aloft and the traffic management displays are monitored for any significant deviations in lateral direction. The state vector information is used to calculate any refined TFRs that could arise from an earlier than planned separation of the capsule from the balloon or a similar failure that could lead to a collision if necessary.

Due to the lack of winds during the ascent and flight at altitude, ATM does not see any significant deviations from the projected flight path and direction. The corresponding movement of the vehicle position on the traffic management displays also shows no significant change.

Once at the targeted altitude of 130,000 feet, the balloon and capsule loiter for approximately two hours. The anticipated drift of the capsule due to winds aloft are continuously monitored by the ATM using real-time telemetry data.

After two hours, the pilots initiate the return to a predetermined landing site by starting to vent helium gas from the balloon. The vehicle operator confirms over automation that the gas is being vented and the vehicle is descending. ATM/ATC continue to monitor the decent of the capsule and balloon in real-time.

At approximately 90,000 feet, the pilots initiate the action to release the balloon from the capsule and the parasail deploys. The parasail slides out of its stowed position in a sleeve similar to a parachute and deploys mechanically using a spring. As the parasail starts to inflate with air, a tether connected between the parasail and the balloon unzips a major seam to expedite the deflation of the envelope. The separation of the balloon from the capsule is confirmed by the vehicle operator and that information is passed to ATM/ATC. ATM/ATC continue to monitor incoming telemetry data, and all indications being received show that the balloon is not drifting as it falls and is expected to land in the planned area.

Once the notification is received that the capsule has separated from the balloon, automation begins to compute a refined TFR as a precautionary measure in the event of an off-nominal event occurring. The automation returns the coordinates of the AHA and they are displayed on the traffic management automation. ATM reviews the location of the proposed TFR with respect to this data to decide if it is correct. Once the TRF is deemed correct, the traffic management automation distributes it to the other NAS systems for display. This refined TFR is then shared with other facility Air Traffic Controllers so that proper arrangements can be made to segregate the airspace from other air traffic.

With the parasail fully inflated, the pilots start to fly the capsule back to the designated landing site. As the capsule descends, ATC continues to receive and monitor state vectors via automation for both the vehicle and the falling envelope. The vehicle operator confirms the event via automation.

Once both the capsule and envelope have landed, the vehicle operator confirms, over automation, that the mission is complete. The TFR is released once these actions are completed.

5.5 Point-to-point Operations

5.5.1 Operational Context

This scenario describes the planning and operation of a suborbital launch vehicle executing a horizontal takeoff and horizontal landing between two certified dual-use airports. The flight is a routine operation, occurring in the morning hours.

The vehicle is a high-speed, transcontinental transport carrying 50-100 space flight participants. It launches from the Northeastern United States and travels to the west coast, landing at a dual-use airport. Upon completion of fuel burn, and preparations are made for reentry, the vehicle glides back to Earth and performs a conventional runway landing.

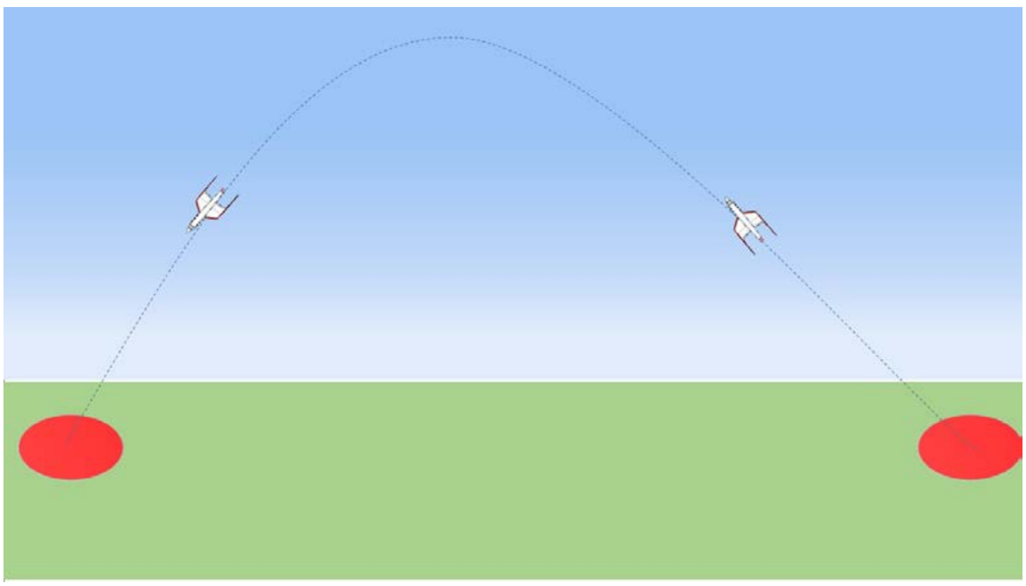

Figure 15 - Illustration of a point-to-point sub-orbital flight

5.5.2 Scenario Description

5.5.2.1 Pre-mission Planning and Coordination

Prior to launch, in accordance with current policy, the operator files a flight plan for the daily itinerant trip complete with the necessary mission characteristics such as vehicle data, flight profile, and launch and landing time windows to ANSP automation. The same flight plan is used every day. The daily launch has previously received a license from the FAA for the mission, which included aircraft hazard area analysis results as well as other necessary information such as communication and surveillance plans.

Once the intent is filed, ATM automation begins to factor the intent into its calculations and provides feedback to the operator that the predicted traffic levels are acceptable for accommodating the launch/reentry at the proposed times (i.e., there are no events going on in the system that would require the use of an alternate plan). The fully detailed flight plan is filed prior to departure, and ATM provides feedback of any time or route modifications that are necessary to accommodate the operation.

The operator collaborates with the ANSP and other NAS users to optimize the operational time windows, airspace use, and other mission parameters. The nature of the operation and results of the flight safety analysis required for license have demonstrated that an STC is appropriate for its takeoff and an ARE is most appropriate for its arrival and horizontal landing.

The ANSP automation makes mission information available to authorized stakeholders. FAA ATM facilities and flight operators whose operations are affected by the launch/reentry operation participate in the negotiation. The ATCSCC considers all parties' input by using ANSP automation to support balancing tradeoffs among competing requests and decides on a plan that minimizes the effect on the NAS while allowing for successful completion of the mission.

5.5.2.2 Real-time Operations – Launch and Ascent

Before the start of operations each day, launch personnel consult updated weather forecasts and other operational data to plan the operations for the day. The operator uses this information to update the planned vehicle trajectory for each mission expected for the day.

The operator's mission operations center files an updated trajectory plan with a scheduled launch time for the operation. The launch crew contacts the local control tower and requests a departure clearance. Tower controllers clear the flight as filed.

The launch crew contacts the local control tower and requests a departure clearance via a standard Call for Release procedure. The Air Traffic Control Towers (ATCT) requests a departure release time from the TMUs the local Terminal Radar Approach Control Facilities (TRACON) and ARTCC. TMU personnel use automation to plan a release time for the vehicle using a time-based metering timeline. TMU personnel issue a release window for the launch. The vehicle must depart within the assigned window or the release is void and must be re-coordinated.

ANSP automation meters local air traffic to ensure that the STC is not occupied by aircraft during the time it will be active for the operation. ARTCC and TRACON controllers ensure that affected NAS traffic is routed via automation-generated trajectories that do not conflict with the STC for the launch and ascent phases of the operation.

The vehicle receives a taxi clearance from Ground Control and taxis for departure. Once the vehicle is cleared for takeoff, the vehicle departs and initiates near-vertical ascent. The vehicle departs and initiates ascent. While still within automation boundaries of the NAS, ANSP automation maintains continuous tracking and telemetry of the flight, allowing controllers and traffic managers to view the real- time location of the vehicle, the status of the vehicle, as well as the locations of aircraft operating near the STC on appropriate displays. When the vehicle crosses the NAS automation boundary, automation notes its exit from the NAS and releases the STC to other NAS users.

5.5.2.3 Real-time Operations – Descent and Touchdown

The vehicle begins its descent from FL2000. ANSP automation receives telemetry and tracking information throughout the flight to process the projected trajectory and associated ARE for display to TMUs in affected facilities, and to continuously probe for trajectory conflicts with the relevant look ahead times.

Continuous tracking and telemetry of the flight, would allow controllers and traffic managers to know the location of the vehicle, the current status of the vehicle (nominal/off-nominal), and the potential hazard volumes, all while continuously probing for potential conflicts based on the appropriate look ahead time. The ARE is released behind the vehicle as it proceeds along its trajectory, allowing other NAS traffic to use that airspace. The vehicle touches down at the arrival facility and automation informs the ANSP that the operation has completed.

5.6 Suborbital Space Tourism

5.6.1 Operational Context

This scenario describes the planning and operation of a suborbital launch vehicle executing a future captive carry takeoff and horizontal landing at a dual-use airport serving both commercial space and traditional aviation operations. KXYZ (a federally-obligated and 14 CFR Part 139 certificated airport) is approximately 40 miles from a large hub airport.

5.6.2 Scenario Description

Mission Planning and Coordination

Prior to launch day, in accordance with current policy, Space Tours coordinates with ARTCC to submit a mission plan for four suborbital operations per day. Space Tours submits the necessary mission characteristics, such as vehicle data, flight profile, and launch and landing time windows to the ANSP Automation. Space Tours has previously received a license from the FAA for the mission, which included debris mitigation analyses (development of necessary ARE, STC, etc.) results as well and other necessary information such as communication and surveillance plans.

Space Tours collaborates with ATC/ATM and other NAS users via automation to optimize the operational time windows, airspace use, and other mission parameters. The nature of the operation and results of the flight safety analysis required for the license have demonstrated that an STC is appropriate for its takeoff and an ARE is most appropriate for its arrival and horizontal landing. Airspace near the facility is designed to support the ARTCC, local TRACON, surrounding large hub airport, and the site in managing the protected airspace volumes, coordinating airport and spaceport configurations, and providing separation assurance during Space Tours operations.

ATM automation makes mission information available to authorized stakeholders. The site, ARTCC, TRACON, the ATCSCC, and flight operators whose operations are affected by the Space Tours operation participate in the negotiation. The ATCSCC considers all parties' input by using the ATM automation to support balancing tradeoffs among competing requests and decides on a plan that minimizes the effect on the NAS while allowing Space Tours to carry out its mission.

Airport Operations

Prior to the mission, Space Tours works with airport administration to verify that the locations it plans to load propellant, load passenger, and conduct pre-flight activities comply with the locations identified in the site licensing documents. If there are differences, the airport must request a modification of its license prior to the mission.

Space Tours coordinates with the airport operator to identify the taxi route and preferred runway for launch and landing. Space Tours schedules its ground operations and launch window with the airport operator and notifies other airport users or tenants once approved by the airport. Scheduling is necessary to ensure reasonable access to the airfield environment by all aeronautical users. During certain hazardous activities such as loading of propellant, areas of the airport may be temporarily inaccessible by other users to ensure proper separation distances are maintained. Preflight activities including duration of propellant loading and engine testing are all coordinated in advance so that airport operations staff are aware and have sufficient plans in place.

Prior to mission, Space Tours notifies airport rescue and firefighting (ARFF) personnel of expected hazardous materials onboard, including propellant types, quantities, and any special vehicle conditions that may require additional training, tactics, or fire suppressant than are typically used for ARFF responses.

On the day of the mission, airport operations work closely with Space Tours Mission Operations Center personnel, escorting personnel on the airfield as appropriate. Airport operations verifies that NOTAMS identify locations and times when the airfield will be in use for the commercial space operation and follows the procedures identified in its FAA approved Airport Certification Manual (ACM) and Airport Emergency Plan (AEP).

ATC Operations

Before the start of operations each day, Space Tours Mission Operations Center personnel consult updated weather forecasts and other operational data to plan the operations for the day. Space Tours Mission Operations Center uses this information to update the vehicle's trajectory plan for each mission expected for that day, and files an updated trajectory plan with a scheduled launch time for the vehicle, SPT123.

The pilot of flight SPT123, a suborbital reusable horizontal takeoff and landing vehicle, contacts the site's Control Tower and requests a departure clearance. The Control Tower clears the flight as filed. The pilot of SPT123 requests a departure release from the Control Tower via a standard CFR procedure. The Control Tower requests a departure release time from the TMUs at the TRACON and ARTCC. TMU personnel use automation to plan a release time for SPT123 using a time-based metering timeline. TMU personnel issue a release window for SPT123 launch. SPT123 must depart within the assigned window or the release is void and must be re-coordinated.

ANSP automation meters local air traffic to ensure that the STC is not occupied by aircraft during the time it will be active for SPT123. ARTCC and TRACON controllers ensure that affected NAS traffic is routed via automation-generated trajectories that do not conflict with the STC for the launch and ascent of SPT123.

SPT123 receives taxi clearance from Ground Control and taxis from the terminal to the runway for departure. Local Control clears SPT123 for takeoff. SPT123 departs. As long as SPT123 is operating within the automation boundaries of the NAS, ATM automation maintains continuous tracking and telemetry of the flight, allowing controllers and traffic managers to view the real- time location of the vehicle, the current status of the vehicle, as well as the locations of aircraft operating near the STC on appropriate displays.

SPT123 initiates near-vertical ascent through the NAS automation boundary. ATM automation notes the exit of SPT123 from the NAS and releases the STC to other NAS traffic.

Descent and touchdown

SPT123 begins descent from 200,000 feet. ANSP automation receives telemetry and tracking information throughout the flight to process the projected trajectory and its protected areas for display to TMUs in the affected ATC facilities, and to continuously probe for trajectory conflicts with the relevant look ahead times.

SPT123 crosses and reenters the NAS automation boundary. Automation maintains continuous tracking and telemetry for the flight, allowing controllers and traffic managers to view the real-time location of the vehicle, the current status of the vehicle, and the potential hazard volume on appropriate displays, while continuously probing for potential conflicts based on the look ahead time. The protected airspace volume areas for SPT123 are released behind the vehicle as it proceeds along its trajectory, allowing other NAS traffic to use that airspace. SPT123 touches down at the site and ATC is notified that the mission is complete.

Ground personnel are standing by at a pre-designated location within the movement area of the airport and are escorted by airport operations to the vehicle once it comes to a stop on the runway. Ground support equipment is used to immediately tug the vehicle back to Space Tours hangar.

Airport operations staff perform a full runway and taxiway inspection prior to the resumption of airport operations to ensure the airfield meets standards for pavement, signage, lighting, and marking and that no foreign object debris is on the runway, taxiway or safety areas.

5.7 Off-nominal Event – Unplanned Upper Stage Reentry

5.7.1 Operational Context

A multi-stage commercial launch vehicle is being launched under an FAA license into orbit from a coastal launch site located in Florida. This multi-staged launch vehicle consists of two side boosters and a center core booster that comprise the first stage and a single segment that comprises the second stage. The payload is attached to the second stage and is encapsulated in a disposable payload fairing, which is comprised of two half shells.

5.7.2 Scenario Description

The multi-staged vehicle described above launches under an FAA license from a coastal commercial launch site in Florida. During the ascent, the first stage core booster suffers a loss of thrust during the final few seconds before staging. Discussions with the vehicle operator over automation indicate that the second stage burn can supplement this lack of velocity to obtain the target orbit. However, the vehicle will have less fuel available than had been planned to complete the deorbit burn for a controlled reentry of the upper stage. Therefore, once the second stage starts its deorbit burn, it exhausts its fuel supply thereby causing it to land further down range than expected. The surviving debris from the second stage will not fall as intended in the designated AHA in the South Pacific Ocean, but now over the Western United States.

The first stage core booster continues to burn but the engines shutdown prior to the pre-planned time. As the core booster MECO indication is received by ATC automation, the automation stops decrementing the first stage main engine timer, but the comparison with the predicted time indicates the event has occurred early, outside the predefined tolerance, which signifies an off-nominal event. Automation indicates to the JSpOG that the event has occurred early. The JSpOG confirms this early shutdown of the core booster with the vehicle operator over automation. The vehicle operator verifies that the core booster has shut down early but assures the JSpOG that the second stage can make up the difference in velocity to obtain the target orbit as anticipated. However, the vehicle operator indicates that their analysts are working to determine if this additional burning of the second stage will affect its deorbit burn.

The stage separation also occurs earlier than planned. Automation stops the associated countdown timer and indicates nonconformance to the mission plan. The JSpOG also confirms the early stage separation with the vehicle operator over automation, but no additional action is necessary.

After coasting for a few seconds, the second stage ignites and continues for another 12 minutes and ten seconds instead of 12 minutes as expected to place the second stage and payload into the target orbit. Automation receives the second stage engine cutoff indication, stops the associated countdown timer, and alerts the JSpOG that the event did not occur as anticipated. This off-nominal event is provided to the JSpOG as described above. The vehicle operator confirms that the event occurred late over automation with the JSpOG.

During this off-nominal event, the JSpOG selects two additional parameters to be displayed as a trace on the automation's display. This new trace shows the conformance of the predicted velocity versus altitude to the actual values received from telemetry. The trace clearly shows the discrepancy between the actual velocity produced by the first stage versus the predicted values and the gradual convergence of the second stage velocity to obtain orbit. The discrepancy provides an additional early indication of a potential issue with the reentry of the upper stage.

All boosters and first stage landing events associated with the mission occur as anticipated. In addition, the payload is separated as expected from the second stage. The JSpOG continues to monitor the second stage and automation continues using real-time telemetry data to decrement the countdown timer associated with the deorbit burn.

As the deorbit burn time approaches, the vehicle operator announces over automation that its analysts have determined that sufficient propellant should be available to complete a deorbit burn that will place the debris in the anticipated AHA, but that there is a degree of uncertainty in their calculations. Once the deorbit burn of the second stage starts, automation receives the indication that the event has occurred from incoming telemetry data and this is conformed via a message from the vehicle operator. The automation stops decrementing the second stage deorbit burn start event countdown timer and compares the time received in the data message against the predicted time plus or minus the tolerance. Indications are provided to the JSpOG as specified above for the nominal case that the actual event time is within tolerance of the predicted time, confirming normal operations that no additional action is necessary.

Using telemetry data, automation begins sending each incoming state vector to the AHA generator software so that a refined AHA can be calculated, and the results returned for display depending upon operator preference. A trace of the vehicle's predicted impact point also appears and updates with each incoming data message. At roughly the same time, the commercial operator announces over that the vehicle is committed to reentry. The predicted impact point starts to move across the map from a point out ahead of the vehicle's present position (i.e., downrange, which is to the east for this mission) to the expected landing site (i.e., a motion that is east-to-west for this mission).

However, the deorbit burn stops abruptly due to an exhausted fuel supply. Automation receives the indication in the data message and stops decrementing the deorbit burn stop event countdown timer. The time received in the data message is compared against the predicted time (i.e., zero tolerance for the event) and displays the resulting non-conformance to the mission plan as explained above. When the off-nominal indication is seen on the traffic manager's display, an information exchange takes place between the JSpOG and the vehicle operator to confirm the off-nominal event.

Once the vehicle operator confirms that the deorbit burn has stopped early from its designated time and that the vehicle will land further down range than the predicted area, automation sends the last state vector to the AHA generator software which computes the refined AHA.

The refined AHA coordinates are received and displayed based on the last state vector along with a trace of the vehicle's current position and the predicted impact point on the map. The resulting AHA calculations show that the surviving debris from reentry will now land over parts of the Western United States instead of the South Pacific Ocean as anticipated.

Once a refined AHA is calculated for the proposed area of debris, the JSpOG distributes it to the affected ARTCC facilities (i.e., Los Angeles and Oakland ARTCCs) via NAS systems to prepare for the potential falling debris. As expected, the second stage segment disintegrates as it hits the atmosphere; however, some larger pieces of debris do survive and pose a hazard to NAS users. The incoming data messages from the second stage continue to drive the vehicle position relative to the proposed route on the traffic management display until breakup.

The affected ATC facilities prepare for the off-nominal TFR by issuing a NOTAM message using the refined coordinates while the ATCSCC issues any necessary NAS advisories. Controllers who are controlling the sectors where the debris is expected start rerouting or delaying aircraft to prevent them from entering the area. The airspace closure is activated as soon as possible since the debris is expected to be in the airspace within ten minutes. During this time, any aircraft presently in the area will have sufficient time to exit the area.

5.8 Off-nominal event – Catastrophic Failure on Launch

5.8.1 Operational Context

This scenario represents a vertically launched rocket that experiences a catastrophic failure two minutes after lift-off from Cape Canaveral, leading to a Stage 2 explosion and an uncontrolled off-nominal flight of Stage 1, which is subsequently destroyed by an autonomous flight termination capability. The hazard areas discussed in this scenario are generated by future automation based on the last known state-vector of the vehicle. These areas include all airspace where debris can reach within a pre-determined amount of time from the end of the controlled flight (i.e., the last known position prior to break-up).

New automation capabilities allow controllers and traffic managers to respond to actual off-nominal events in near real-time. Improvements deployed under NextGen increased access to SAA for launch/reentry vehicle operations. Both active SAA volumes that protect aircraft from the trajectory of the launch vehicle, and the associated aircraft hazard area SAA created to protect aircraft from debris in the event of a catastrophic launch or reentry event are displayed to show the airspace that must be cleared. This real-time off-nominal response capability allows nominal hazard areas to be smaller and active for shorter time durations, reducing NAS impacts.

Figure 16 - Image of a catastrophic failure on launch

5.8.2 Scenario Description

In future operations, the launch of the mission still occurs in segregated airspace, but the degree of segregation is minimized due to the integration of new capabilities aimed at maximizing NAS safety and efficiency. Among these new capabilities are the ability to react to off-nominal events in real-time, the ability for ATC to actively monitor the operation in real-time through operator or vehicle provided data, increased data sharing between the vehicle operation and the FAA, and the ability to reopen airspace in a timelier manner once a threat has cleared, and the ability to redraw, activate, and deactivate hazard areas in real-time.

As above, the launch is conducted, and the rocket experiences a catastrophic failure two minutes after lift-off leading to a Stage 2 explosion. This explosion also leads to a brief uncontrolled trajectory of the remaining Stage 1 components. This uncontrolled trajectory is minimized by the inclusion of an autonomous flight termination capability onboard the vehicle.

While monitoring telemetry, ATC is notified by automation that a catastrophic Stage 2 explosion has just occurred. Automation immediately draws a precise debris field airspace closures based on the known position and trajectory of the vehicle at the point of the explosion and the prevailing wind patterns. This area is immediately overlaid on ATC's display along with the durations they will remain active. These durations are computed by automation and account for the effects of, wind patterns, etc. ATC then ensures via the tools available to them (e.g., reroutes, holding patterns, etc.) that all other NAS users are kept clear of the areas for the total duration of the closure.

As a result of the explosion, a brief uncontrolled trajectory of the remaining Stage 1 component follows. The vehicle is equipped with an autonomous flight termination capability and upon recognition of the explosion and subsequent loss of control this capability activates. The Stage 1 component is then destroyed and the same processes for developing AHAs and ensuring the safety of other NAS users is followed through the duration of the threat.

Unlike today's operations, the size and volume of airspace closure is constrained to the threat only and can be modified in real time once the threat has cleared. For example, if the explosion occurs at 60,000 feet, all airspace from the ground up to FL600 is immediately closed off to protect against falling debris. However, once the risk of falling debris passes through an altitude this altitude can be reopened (depending on FAA mandated vertical separation standards for space operations) even though there may still be a threat of debris below. This will allow for normal NAS operations to resume in a timelier fashion minimizing the impact of the event on other NAS users. Additionally, due to the capability to constrain the total volume of the AHA, and readjust in real time, the number of impacted users can also be mitigated thus improving overall system efficiency while maintaining all required levels of safety in the NAS.

Upon completion of the event, data is stored by automation so that FAA personnel can replay and evaluate the off-nominal event and use the data to develop and improve response to similar events in the future.

5.9 Licensing a Launch/reentry Site at a Federally-Obligated Airport

5.9.1 Operational Context

Airport officials at KXYZ have announced their intention to expand their business model by providing service to both commercial space operations (horizontal takeoff/landing) and traditional aviation operations. This scenario provides an illustrative narrative describing the steps to coordinate with the FAA on planned commercial space development and the site licensing process, including: preliminary planning, pre-application, site license application submission, application review and evaluation, and official licensing decision. See Figure 17 for a graphical depiction of the major process elements.

Title 14 CFR Part 420, prescribes the official requirements for applying and approving license applications. A license to operate a launch site does not guarantee that a launch license will be granted for any launch proposed for the site. All launches are subject to separate FAA review and licensing (see Sections 2 and 4).

A dual-use airport must also comply with airport-related regulations and requirements. When taking federal financial assistance or surplus or non-surplus government property, a federally-obligated airport agrees to comply with statutory requirements identified in grant assurances or conveyance documents. Airports that hold an Airport Operating Certificate must also comply with the regulatory requirements under 14 CFR Part 139.

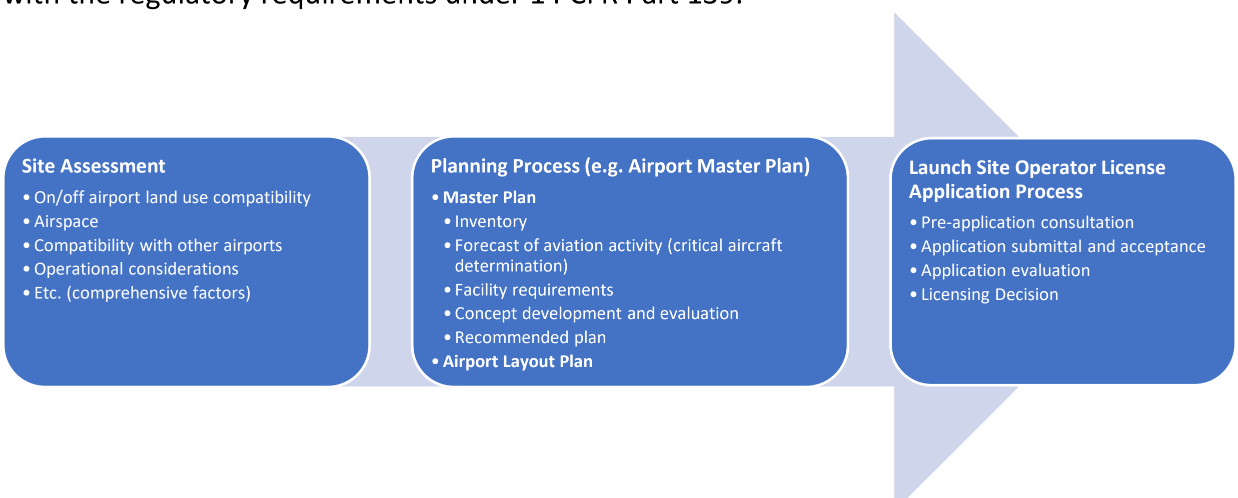

Figure 17 – Notional diagram of site assessment, planning process and launch site operator license application process. *Note – An airport master plan (or master plan update) is not required by strongly encouraged. An Airport Layout Plan update and FAA approval are required before any physical changes can be made to aviation infrastructure.*

5.9.2 Scenario Description

<u>*Site Assessment*</u>

The first step of the process for an airport that is looking to accommodate a commercial space development is to assess the basic feasibility of a site at airport KXYZ. The airport (or potential launch site operator, if different than the airport owner) would assess factors such as; on-airport land use compatibility, on-airport land availability, infrastructure compatibility, airspace compatibility, proximity to other airports, compatibility with airport operations, compatibility with nearby airports, off-airport land use compatibility, environmental impacts, operations, development cost, topography, natural and man-made obstructions, etc. Through this process, the proponent could identify which types of operations are better suited than others for their particular site, and what factors could prove challenging for particular types of operations. It is essential to screen whether the commercial space operation could feasibly be accommodated at the particular site of interest.

Planning

Once the proponent determines what type of commercial space development are compatible with the airport, they will incorporate reviewing integration of commercial space development as part of on-going airport planning, typically an airport master plan[15]. Following this process helps ensure streamlined compatibility and integration with existing facilities and other planned development at the airport. See Figure 17, for a graphical depiction of the major planning process elements.

For a commercial space development at a dual-use airport, airport sponsors will identify proposed commercial space operations, related development and land use needs, and any preliminary environmental findings, following the same process required for any planned development at NPIAS airports.

In this future scenario, the airport will apply appropriate design standards and setback distances (updated to specifically address commercial space development) and depict all facilities necessary for launch/reentry operations. The proposed facility development will be documented in their airport master plan report and on their approved airport layout plan.

Submitting licensing and oversight documentation

Dual-use airports interact with multiple FAA offices during their licensing process. AST serves as the agency lead on licensing activities and coordinates with the applicable FAA and other government agency offices as applicable to ensure coordination of licensing documents and other oversight documentation (e.g., airport layout plan approval, environmental review).

Officials at KXYZ prepare the information required for their application as outlined 14 CFR §420.15. This information package is organized into five categories: General, Environmental, site-specific, explosive site plan, and launch site operations.

In gathering and preparing this information airport officials designate primary Points of Contact (POCs) who will be responsible for working with the FAA throughout the licensing process. The licensing team prepares the information necessary to satisfy the general information requirements outlined in §420.15. This includes information related to:

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[15]An airport master plan is a comprehensive study of the airport to establish an organized framework for future facility development. The outcome of a master plan describes short-, medium-, and long-term development timeframes, which establishes what is depicted on the airport's Airport Layout Plan, which establishes what is depicted on the airport's Layout Plan, which all federally-obligated airports are required to maintain.. See AC 150/5070-6B for additional information.

- Launch site operator:
    - the team identifies the names and addresses of the applicants, and
    - the names, addresses, and telephone numbers of any person to whom inquiries and correspondence should be directed (e.g., POC).
- The launch site itself:
    - the team provides the name and location of the proposed launch site and includes the following required information:
        - A list of downrange equipment;
        - A description of the layout of the launch site, including launch points;
        - The types of launch vehicles to be supported at each launch point;
        - The range of launch azimuths planned from each launch point; and
        - The scheduled operational date.

In addition to the general requirements, the team from KXYZ also gathers the necessary information the FAA will require to perform an environmental analysis associated with operating the proposed launch site. The information provided by KXYZ is sufficient to allow the FAA to comply with National Environmental Policy Act of 1969, as amended (NEPA; 42 United States Code 4321, et seq.), Council on Environmental Quality NEPA implementing regulations (40 Code of Federal Regulations Parts 1500 to 1508), FAA Order 1050.1F, Environmental Impacts: Policies and Procedures, and FAA Order 5050.4, National Environmental Policy Act (NEPA) Implementing Instructions for Airport Actions.

An explosive site plan is developed for inclusion in the application package. This plan includes information that complies with the requirements outlined in regulations.

Finally, the team also provides the FAA with the information necessary to demonstrate compliance with all requirements listed in 14 CFR §420.53, Control of Public Access; §420.55, Scheduling of launch site operations; §420.57, Notifications; §420.59, Launch site accident investigation plan; §420.61, records; and §420.71, Lightning protection.

The dual-use airport team also prepares and submits an updated airport layout plan to depict the launch/reentry site boundary (including propellant storage area(s) and other hazard areas), new facilities related to commercial space operations (e.g., buildings and related structures, aprons, site access infrastructure, airfield access infrastructure, engine test pads), transit routes for launch and/or reentry vehicles or other equipment, hazard areas, and areas necessary to “safe” the vehicle upon landing). The FAA will review the ALP submission taking into consideration safety, environmental, planning, and compliance aspects.

Newly proposed launch, reentry, and pre-flight location and infrastructure are submitted to the FAA for obstruction analysis and FAA coordination.

As a part 139 airport, XYZ must also submit an update to its FAA-approved Airport Certification Manual and Airport Emergency Plan. The ACM and AEP must address items like procedures for self-inspection, airport condition reporting procedures for launch/reentry site activities, hazardous materials, aircraft rescue firefighting training and firefighting tactics and agent. The Accident Investigation Plan prepared for the site licensing application may have some of the information necessary to develop the supplements to the ACM and AEP.

Application review and evaluation

Following receipt of a completed application package, AST reviews the license application to determine whether it presents any issues affecting U.S. national security or foreign policy interests, or any international obligations of the United States.

Additionally, the FAA considers the environmental impact of the proposed facility. AST is the lead FAA office for environmental documentation for launch/reentry site operator licenses. ARP also reviews and concurs with draft and final documents. NEPA requires the FAA to integrate environmental values into its decision-making process. Under the Environmental Review for Licensed/Permitted Commercial Space Transportation Activities, AST analyzes the environmental impacts of proposed licensed and permitted actions, including the licensing of launch/reentry activities, the operation of launch/reentry sites, and the issuing of permits for suborbital reusable rockets. It then takes the appropriate action required under NEPA.

Other aspects of the proposed facility are evaluated to ensure compliance with 14 CFR Part 420.

Licensing Decision

Once the review process is completed and the proposed site has satisfactorily met or exceeded all requirements for acceptance, AST issues KXYZ a license to operate launch/reentry site. This license authorizes KXYZ to operate in accordance with the representations contained in their licensee's application, with terms and conditions contained in any license order accompanying the license, and subject to the KXY's compliance with 51 U.S.C. Subtitle V, chapter 509 and 14 CFR Part 420.

For a dual-use airport like XYZ, the FAA also approves the ALP (usually simultaneous with license issuance). ARP offers feedback on the ACM and AEP updates but does not approve those document addendums until such time as the facility has a viable operator seeking a launch/reentry license through AST. Once the FAA approves the ACM and AEP addendum, they become a requirement of the airport's AOC and must be implemented.

Oversight

Dual-use airports then receive oversight from multiple FAA offices. As a part 139 airport, XYZ receives annual inspections by the Office of Airports. AST also conducts annual licensing inspections. The FAA coordinates inspection activities and relays relevant findings with each other.

6.0 – CSINAS Impacts

The following subsections present the expected impacts on NAS operations in a variety of areas, including potential impacts on NAS Key Performance Areas (KPA), other NAS concepts, NAS users, and the ANSP.

6.1 – Impacts on NAS Performance Areas

Access and equity: Commercial space operators, aircraft operators, and other NAS users have safe and equitable access to the NAS and the impact on each other is minimized.

Organization and staffing: Existing FAA personnel will perform the roles defined in this ConOps.

Capacity: Dynamic activation and deactivation of protected airspace, computation of the airspace based on expected aircraft exposure to hazard as a function of changes in time, and procedures for dynamic response to off-nominal events (i.e., changing times required for a response to be implemented) reduce the time and volume of airspace that is unavailable to NAS traffic, increasing NAS capacity during commercial space operations.

Cost effectiveness & efficiency: Standard practices for managing operations allow rapid deployment of updates of changing information, a uniform understanding of process, and standard method for interaction. Such standards streamline operators' interactions with the ANSP and support other NAS users through improved predictability. In addition, automation support for the planning process and improved data sharing streamlines the planning process.

Environmental impact: As new technology is implemented, NAS traffic delays and miles flow to avoid protected airspace for launch and reentry operations will decrease. This will result in less environmental impacts that are experienced during today's launch and reentry operations.

Global interoperability: Automation support for publishing commercial space launch/reentry operations schedule data supports international coordination of operations near boundaries between ANSPs. As the only nation with operational experience in integrating commercial launch/reentry operations with other airspace users, the FAA's successful implementation of technologies, procedures, and standards will expedite global interoperability through other nations adopting these same approaches.

Reliability & maintainability: Standard processes for managing operations reduce uncertainty and inconsistency in procedures that can lead to errors for ANSP personnel, operators, and other NAS users, ensuring safety and increasing the reliability of the NAS.

Safety: ANSP has improved situational awareness of launch and reentry events which decreases the time required/increases the time available for ATC to respond to changing conditions during both nominal and off-nominal operations. Procedures for defining, activating, and deactivating protected airspace and dynamically responding to off-nominal events support the FAA in maintaining the safety of the NAS.

6.2 – Impact on ANSPs

Roles and responsibilities: The commercial space operations planning, and coordination functions described in this document exist in part in the FAA AST, ARP, and ATO and in many commercial space operator organizations.

Automation requirements: This ConOps identifies the need for increased capabilities for tracking, communications, and debris hazard projections resulting from commercial space launch and reentry operations that may result from FAA and industry partnerships. ANSP automation and controller displays may require some modification to accommodate operational data, hazard volume data, data distribution, new decision support features, and enhanced probing capability.

Training needs: ANSP personnel (traffic management, and controllers) will require training on standardized procedures for managing airspace during operations, including procedures associated with hazards that may occur. Flight operators may also require adequate training on procedures for operating near commercial space launch/reentry operations.

Policy changes: The policy aspects of this ConOps, including data sharing and coordination, may require changes to interagency agreements, including those between the FAA and international participants, U.S. DoD, DoC, and other U.S. government agencies.

6.3 – Impact on NAS Users

Other NAS users will be responsible for incorporating available operational data into their planning processes to reduce the number of aircraft requiring ANSP action (e.g., delays or reroutes) and to respond to off-nominal events.

Commercial space operators and *mission stakeholders* will be responsible for providing the FAA timely and accurate operational data and incorporate other NAS operator information in their planning processes. It will be a shared environment.

6.4 – Impact on other NAS Concepts

Implementing the CSINAS ConOps may impact other NextGen capabilities. NextGen emerging capabilities may require additional considerations to accommodate commercial space operations and emerging vehicle concepts.

7.0 References

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Acronyms

ACAS	Airborne Collision Avoidance System
ACM	Airport Certification Manual
ADS-B	Automatic Dependent Surveillance - Broadcast
AEP	Airport Emergency Plan
AHA	Aircraft Hazard Area
ALP	Airport Layout Plan
ALTRV	Altitude Reservation
AMP	Airspace Management Plan
ANSP	Air Navigation Service Provider
ANG	Office of NextGen
AOC	Airport Operating Certificate
APL	FAA's Office of Policy, International Affairs and Environment
APREQ	Approval Request
APT	Advanced Planning Team
ARE	Adaptive Risk Envelope
ARFF	Airport Rescue and Firefighting
ARP	FAA Office of Airports
ARTCC	Air Route Traffic Control Center
ASH	FAA's Office of Security and Hazardous Materials Safety
AST	FAA’s Office of Commercial Space Transportation
ATC	Air Traffic Control
ATCAA	Air Traffic Control Assigned Airspace
ATCSCC	Air Traffic Control System Command Center
ATCT	Air Traffic Control Tower
ATM	Air Traffic Management
ATO	FAA’s Air Traffic Organization
AVS	FAA Office of Aviation Safety
CARF	Central Altitude Reservation Function
CCDev	NASA's Commercial Crew Development
CDM	Collaborative Decision Making
CFR	Code of Federal Regulations
CNS	Communication Navigation & Surveillance
ConOps	Concept of Operations
CSINAS	Commercial Space Integration into the NAS
CSLAA	Commercial Space Launch Amendments Act
DHS	Department of Homeland Security
DoC	Department of Commerce
DoD	Department of Defense
DST	Decision Support Tool
EA	Environmental Assessment
EIS	Environmental Impact Statement

ERAM	En Route Automation Modernization
eSIR	Electronic System Impact Report
FAA	Federal Aviation Administration
FEA	Flow Evaluation Area
FL	Flight Level
FOC	Flight Operations Center
GLI	Global Leadership Initiative
ICAO	International Civil Aviation Organization
ICBM	Intercontinental Ballistic Missile
IFR	Instrument Flight Rules
ISS	International Space Station
JSpOG	Joint Space Operations Group
KPA	Key Performance Area
L/R	Launch and Reentry
LEO	Low Earth Orbit
LOA	Letter of Agreement
LOB	Line of Business
NABET	NAS Automation Boundary Entry Time
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NextGen	Next Generation Air Transportation System
NOTAM	Notice to Airmen
NPIAS	National Plan of Integrated Airport Systems
NTSB	National Transportation Safety Board
OEAA	Obstruction Evaluation/Airport Airspace Analysis
OSHA	Office of Safety and Health Administration
PIRG	Planning Implementation Regional Group
POC	Point of Contact
pSAR	preliminary Shortfall Analysis Report
PTP	Point-to-point
RASG	Regional Aviation Safety Group
RLV	Reusable Launch Vehicle
SAA	Special Activity Airspace
SDIEC	System-wide Data and Information Exchange Capability
SO	Staff Office
SOG	Space Operations Group (ATCSCC/SOG)
SOS	Space Operations Specialist
SPT	Strategic Planning Team
STARS	Standard Terminal Automation Replacement System
STC	Space Transition Corridor
SUA	Special Use Airspace
SVO	Space Vehicle Operations
SVRWX	Severe Weather Area or Unit

TFMS	Traffic Flow Management System
TFR	Temporary Flight Restriction
TM	Traffic Management
TMI	Traffic Management Initiative
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach Control Facilities
TSD	Traffic Situation Display
UAS	Unmanned Aircraft System
V&V	Verification and Validation
VFR	Visual Flight Rules
VHF	Very High Frequency

Glossary of Terms

Term	Definition
Air Navigation Service Provider (ANSP)	A public or a private legal entity providing Air Navigation Services.
Airport Certification Manual (ACM)	The requirements of what goes in an Airport Certification Manual (ACM) are found in 14 CFR 139.203.
Airport Emergency Plan (AEP)	A concise planning document developed by the airport operator that establishes airport operational procedures and responsibilities during various contingencies. (AC 150/5200-31C, Airport Emergency Plan, 6/19/09)
Air Traffic Control Clearance	Air traffic clearance means an authorization by air traffic control, for the purpose of preventing collision between known aircraft, for an aircraft to proceed under specified traffic conditions within controlled airspace. (FAA Federal Aviation Regulations (14 CFR Part 1)
Aircraft Hazard Area (AHA)	Used by ATC to segregate air traffic from a launch vehicle, reentry vehicle, amateur rocket, jettisoned stages, hardware, or falling debris generated by failures associated with any of these activities. An AHA is designated via NOTAM as either a TFR or stationary ALTRV. Unless otherwise specified, the vertical limits of

	an AHA are from the surface to unlimited.
Airport Layout Plan	Airport Layout Plan (ALP): The ALP is a set of drawings that depicts both existing facilities and planned (future) development for an airport. The ALP is a key output of the typical airport planning process.
Altitude Reservation (ALTRV)	Airspace utilization under prescribed conditions normally employed for the mass movement of aircraft or other special requirements which cannot otherwise be accomplished.
ATC Assigned Airspace	Airspace of defined vertical/lateral limits, assigned by ATC, for the purpose of providing air traffic segregation between the specified activities being conducted within the assigned airspace and other IFR air traffic
ATCSCC Space Operations Group (SOG)	Co-leads the JSpOG, and through its role as the commercial space point of contact defined in FAA Order JO7400.2L, serves as the single point of contact within the ATO for space and rocket activities. In this role, ATCSCC Space Operations manages the process by which notification of a space launch or reentry is distributed throughout the ATO, by working directly with AST to gather and distribute data and information to ATC facilities, FAA Headquarters ATO, and representatives of other NAS stakeholders.
Air Traffic Control System Command Center (ATCSCC)	An Air Traffic Tactical Operations facility responsible for monitoring and managing the flow of air traffic throughout the NAS, producing a safe, orderly, and expeditious flow of traffic while minimizing delays.
Central Altitude Reservation Function (CARF)	Responsible for coordinating, planning, and approving special user requirements under the Altitude Reservation (ALTRV) concept. CARF is located at the ATCSCC.
Contingency Hazard Area (CHA)	Used by ATC. Areas of airspace that are defined and distributed in advance of a launch or reentry operation and are activated in response to a failure.
Debris	The parts of a launch vehicle, satellite, missile, or reentry vehicle that are either jettisoned, broken off, or a result of flight termination.

Dual-use airport	A launch or reentry site whose boundaries include an area that is also included within the boundaries of a public-use airport that is (a) included in the National Plan of Integrated Airport Systems, (b) certificated under 14 CFR Part 139, or (c) Federally-obligated.
Electronic System Impact Report (eSIR)	A process where AT facilities coordinate with their Traffic Management Unit (TMU) or overlying TMU for all planned outages/projects/events that could cause a significant system impact, reduction in service, or reduction in capacity (for example, air shows, major sporting events, business conventions, runway closures, and procedural changes affecting terminals and/or ARTCC facilities).
Federal Ranges	Provide range safety and operational services to space vehicle operators operating from Federal ranges. Through agreements and the acceptance of common standards, range safety services provided by a Federal range meet the 14 CFR Parts 400-460 regulations for public safety. For operations occurring within a federal range, federal ranges compute the Flight Hazard Areas FHAs needed to ensure safe separation from aircraft and coordinate the results with ATC facilities and the JSpOG.
Flight Vehicles	Can be manned or unmanned and they rely on secondary launch systems to help them reach their operational altitude or orbit. They have limited propulsive capability.
Flow Control Area	The defined region of airspace, flight filters, and time interval used to identify flights subject to a constraint.
Flow Evaluation Area	The defined region of airspace, flight filters, and time interval used to identify flights.
Haul Routes	Ground routes for propellant/equipment, etc. those transit routes on the airfield that will be traversed either by a loaded vehicle or propellant fueling vehicles.
Instrument Flight Rules (IFR)	As defined from by the FAA Instrument Flying Handbook: Rules and regulations established by the FAA to govern flight under conditions in which flight by outside visual reference is not safe. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signs. It is also a term used by pilots and controllers to indicate the type of flight plan an aircraft is flying, such as an IFR or VFR flight plan (Aeronautical Information Manual).

Integration	Incorporation of space vehicle operations as NAS Users, utilizing available airspace management techniques to ensure safe and equitable access with other users in order to maximize the efficiency and capacity of the NAS.
Joint Space Operations Group (JSpOG)	A team of FAA specialists from Air Traffic Organization (ATO) System Operations (AJR) and AST which works collaboratively with launch and reentry vehicle operators on a mission-by-mission basis. The JSpOG team was established in 2014 as a result of the FAA Administrator's Strategic Initiatives, to collaborate to safely integrating increased launch and reentry operations into the NAS, including developing the methods and processes needed for launches and reentries.
Launch Site	The location on Earth from which a launch takes place (as defined in a license the Secretary issues or transfers under this chapter) and necessary facilities at that location. (14 CFR §401.5 definition)
Launch Vehicle	Means a vehicle built to operate in, or place a payload in, outer space or a suborbital rocket. (14 CFR §401.5 definition)
National Airspace System (NAS)	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.
NAS User	Civil, commercial organization, government agency, military organization that makes use of NAS services and/or facilities.
Negotiation	A process for back-and-forth communication and information exchange between space vehicle operators and the air navigation service provider to establish a mutually acceptable schedule, timing, and location for a particular space vehicle operation. Note that the simplest negotiation, where the proposed changed is accepted, does not require back and forth communication.
Notice to Airmen (NOTAM)	A notice filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route or at a location that could affect the safety of the flight.

Off Nominal Event	An event that is unplanned or abnormal that the system must detect and react to when it occurs, or the situation exists.
Reentry Site	The location on Earth where a reentry vehicle is intended to return. It includes the area within three standard deviations of the intended landing point (the predicted three-sigma footprint). (14 CFR §401.5 Definitions**)**
Refined Hazard Area (RHA)	Used by ATC. Airspace that is defined and distributed after a failure of a launch or reentry operation to provide a more concise depiction of the hazard location than a Contingency Hazard Area.
Reusable Launch Vehicle	(RLV) means a launch vehicle that is designed to return to Earth substantially intact and therefore may be launched more than one time or that contains vehicle stages that may be recovered by a launch operator for future use in the operation of a substantially similar launch vehicle. (14 CFR §401.5 Definitions**)**
Special Activity Airspace (SAA)	Any airspace with defined dimensions within the National Airspace System 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.
Space Operations Specialist (SOS)	Designated FAA personnel performing launch and reentry operations duties (e.g., AJR-1100, MOS, Facility POC, etc.)
Strategic Planning Team (SPT)	A focal point for the development of collaborative Strategic Plans of Operation. Their goal is to provide advanced planning information for system users and air traffic facilities in order to maximize the utilization of the NAS in an organized and equitable manner.
Telemetry	The process by which a measurement of a quantity is transmitted from a remote location to be recorded, displayed, or processed.
Temporary Flight Restriction (TFR)	An area temporarily restricted to air travel due to a hazardous condition, a special event, or a general warning for the entire FAA airspace.
The FAA Office of Commercial Space Transportation (AST)	AST ensures the safety of the public, property, and the foreign policy and national security interest of the United States during commercial space launch and reentry operations. AST also encourages, facilitates, and promotes

	the commercial space transportation industry. Through its regulatory role, AST facilitates the development of letters of agreement (LOAs) between launch and reentry operators, launch and reentry site operators, and ATC facilities, as described in FAA Order JO7400.2L. AST evaluates these agreements to ensure that they meet the requirements of 14 CFR Parts 400-460 regulations.
Traffic Management Initiative (TMI)	Techniques used by air traffic control to balance demand with capacity when conditions are not ideal, either at an airport, or in a section of airspace.
U.S. Notice to Airmen (NOTAM) Office	Responsible for collecting, maintaining, and distributing NOTAMs for the U.S. civilian and military, as well as international aviation communities. U.S. NOTAM Office is located at the ATCSCC.
Virtual Private Network (VPN)	An extension of a private network across a public network that enables users to send and receive data across shared or public networks as if their computing devices were directly connected a private network.
Visual Flight Rules (VFR)	Rules that govern the procedures for conducting flight under visual conditions. The term "VFR" is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, it is used by pilots and controllers to indicate a type of flight plan.