74th International Astronautical Congress (IAC), Baku, Azerbaijan, 2-6 October 2023

IAC-23–D6-1-1

Airspace Integration of U.S. Commercial Space Launches and Reentries

Mr. Kelvin B. Coleman
Federal Aviation Administration Office of Commercial Space Transportation (FAA/AST), United States, kelvin.coleman@faa.gov
Mr. Timothy Arel
Federal Aviation Administration Air Traffic Organization (FAA/ATO), United States, timothy.arel@faa.gov
Ms. Hannah Browne
Federal Aviation Administration Air Traffic Organization (FAA/ATO), United States, hannah.browne@faa.gov Ms. Brooke Teferra
Federal Aviation Administration Office of Commercial Space Transportation (FAA/AST), United States, brooke.teferra@faa.gov
Ms. Emily Sisneros
Federal Aviation Administration Office of Commercial Space Transportation (FAA/AST), United States, emily.sisneros@faa.gov
Mr. John Sloan
Federal Aviation Administration Office of Commercial Space Transportation (FAA/AST), United States, john.sloan@faa.gov

Abstract

The increase in commercial space transportation operations has shed light on the need for airspace systems to modernize practices related to the integration of these operations to ensure the safety of all users and the non-participating public and maximize efficiency. In the United States, commercial launches/reentries and spaceport operations are regulated by the Federal Aviation Administration's (FAA) Office of Commercial Space Transportation, and airspace integration of space operations is coordinated and executed by the FAA Air Traffic Organization's (ATO) Space Operations group.

The purpose of this paper is to describe FAA's current process to regulate, coordinate, and integrate commercial space transportation operations into air traffic systems, and to identify opportunities for standardizing efficient procedures for operations affecting international airspace systems. Common themes include increasing collaboration and situational awareness between commercial space providers, range and spaceport personnel, air traffic control, and other relevant stakeholders.

This paper will cover commercial launch and reentry licensing and the required letters of agreement. The paper will further discuss the coordination of Notices to Air Missions (NOTAMS); airspace management procedures and techniques; the application of aircraft hazard areas into airspace systems; mission planning including international coordination; and how the FAA coordinates real-time mission support. Areas for future work include efforts to streamline Air Navigation Service Provider (ANSP) to ANSP coordination through data dissemination to key stakeholders such as air traffic personnel for safety-critical decisions.

The paper will be useful to space agencies, State Space Regulators[1], Civil Aviation Authorities, air navigation service providers, and industry as a model to evaluate and consider for the efficient integration of commercial space transportation operations into airspace systems. In particular, the paper will be useful for countries modifying or developing new, national frameworks to address domestic and international space launches and reentries.

[1] For the purpose of this paper the State Space Regulator (SSR) refers to the government entity responsible for authorizing commercial space transportation operations (launch and reentry) to ensure public safety.

1. Introduction

As commercial launches and reentries have increased and more countries participate in space activity, interest has also increased in how to efficiently manage the integration of commercial space transportation activity into airspace systems.

During 2022, approximately 54 percent of a record 186 global space launches were commercially-operated with the remaining launches operated by governments. [1] In the United States alone, the Department of Transportation's Federal Aviation Administration (FAA) has experienced steady growth in licensing U.S. commercial launches from 11 in 2015 to 79 in 2022.[2] (See Annex 1, Table 1 for FAA-licensed operations 1989-2022 that includes launches and reentries.)

Since beginning in the 1980s, global commercial launch rates have been relatively low compared to government launch activity. Although there have been surges with increased market demand such as during the late 1990s when 40 percent of launch activity was commercial, the importance of integrating commercial space transportation into airspace systems attracted less attention. Recent activity has changed this perspective. The emergence of low cost small satellites and large satellite constellations with increased private sector investment has driven commercial demand for launches. This demand has been met with the growth of new, operational launch and reentry vehicles, and new launch and reentry sites (spaceports) internationally.

This paper will discuss how the United States addresses airspace integration for commercial space transportation as a model for countries to consider.

2. Airspace Systems

Airspace systems worldwide are charged with maintaining the safe, orderly, and expeditious flow of traffic, balancing capacity, and demand within their area of responsibility. Airspace systems refer to the physical and regulatory infrastructure governing the use of this resource. These systems incorporate air traffic control services, navigation aids, communication systems, and airspace use regulations. With the growing number of airspace users and an array of operational profiles, airspace systems will need to evolve to accommodate all users to maintain system efficiency and maximize utilization for all users.

International law identifies airspace as a global common. The guiding philosophy suggests that the resource be held in trust for future generations to be protected by individual nation-states. Historically, access to the airspace system has not been scarce. However, in recent years, the increased demand for resources for navigation and flight has proliferated due to advancements in science and technology. The consensus within the international community is to conserve the airspace domain for development and human well-being, and several conventions and treaties have been adopted to govern the global commons.

3. United Nations Organizations and International Treaties

The International Civil Aviation Organization (ICAO) is a United Nations (UN) specialized agency, established to create harmonized international aviation standards. ICAO was created by the Chicago Convention of 1944, primarily to "achieve sustainable growth of the global civil aviation system." ICAO assists 193 Contracting States to the Chicago Convention as they adopt standards, practices, and policies for international civilian flight. ICAO's role in the safe operation of international civil aviation means that it has a role in the airspace integration of commercial space transportation operations. In practice, this involves the publication of hazard areas, and ensuring non-participating aircraft do not enter the published areas, further discussed as Aircraft Hazard Areas (AHAs) through processes laid out in various ICAO Annexes.

The space race began decades after aircraft first took flight, meaning the development of airspace systems stemmed from the needs of the civil aviation community and predominately outweighed input from other stakeholders, such as launch and reentry operators. Although space operations began more than 60 years ago, compared to aviation, they have low flight rates, and at the time, most operations were state or government-sponsored, so efficiency was not a priority. Additionally, mission profiles have changed rapidly in the last decade, requiring the integration of new technologies, influencing the overall impact on today's modern airspace systems.

The UN Committee on the Peaceful Uses of Outer Space (UN COPUOS) was established in 1959 to govern the exploration and use of space for the benefit of humanity. It currently has 100 member states. The four main international space treaties developed in UN COPUOUS underpinning international space law are the Outer Space Treaty (1967), the Rescue Agreement (1968), the Liability Convention (1972), and the

Registration Convention (1976). Article 6 of the Outer Space Treaty states, "The activities of non-governmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty." The U.S. addresses this obligation through domestic laws and regulations.

Currently, there are no international forums on launch and reentry activities. The U.S. is committed to fostering this conversation at UN COPUOS. Legal authority does not currently exist for any international entity to create binding regulations for commercial space launch and reentry activities, although the U.S. is promoting the use of best practices around the world to promote safety and global interoperability for the space industry. As countries establish legislative frameworks for space, they can seek to develop a top-level scheme that considers the following elements: safety, international obligations, and established norms of behavior for space-based activities. UN COPUOS can provide an entry for countries seeking to develop their own national regulatory framework.

4. Technical Application of ICAO Annexes

When discussing constraints and usage of airspace systems, it is imperative to distinguish between sovereign and delegated airspace. Delegated airspace could be characterized as a global common, meaning it is a shared resource that everyone can use and is owned by no one. ICAO recognizes in Articles 1 and 2 that States have complete and exclusive sovereignty over the airspace above their sovereign territory, i.e., the airspace directly overlying and adjacent territorial waters. This disbars sovereign airspace from being a global common because it is an excludable resource.

The airspace over the "high seas," referred to in Article 12 of the Convention, says sovereignty does not apply, and "the rules in force shall be those established under the Chicago Convention" (Annex 2, Rules of the Air). Per the United Nations Convention on the Law of the Seas (UNCLOS), the high seas, and the air above the high seas are a global common. The U.S. is not a signatory to UNCLOS but considers its navigation provisions customary international law. Although UNCLOS is titled "Law of the Sea', its provisions also affect airspace and the management of airspace systems by defining sovereign and delegated airspace.

In delegated airspace, ICAO SARPs are considered binding. Annex 11 and Annex 15 of the Chicago Convention outline the procedures for arranging activities potentially hazardous to civil aircraft. This includes NOTAM promulgation and cancellation procedures, notification timelines of seven days, and NOTAM formatting requirements[3].

Furthermore, the U.S. continues to hold the view that there is no need to seek a legal definition or delimitation for outer space.[4] The current framework has presented no practical difficulties for integrating launch and reentry operations into airspace systems and activities in outer space are flourishing. Given the lack of consensus on where such a boundary would exist and the benefits of defining one, an attempt to define or delimit outer space could unintentionally complicate existing activities for all airspace users and may not be able to adapt to future technological developments. Until there is a demonstrated need and scientific consensus, the U.S. believes systems should continue to operate under the current paradigm.[5]

Launch and reentry operators must traverse multiple types of airspace before reaching the extraterrestrial domain. Navigable airspace is a limited natural resource, and it is the responsibility of the respective Air Navigation Service Provider (ANSP) to ensure efficient and safe usage.

5. Defining Airspace Systems

There are four types of airspace: controlled, uncontrolled, special use, and "other" airspace. The categorization of these volumes is based on the complexity or density of aircraft movements, the nature of the operations, the level of safety required, and the national public interest.

Discerning between controlled and uncontrolled airspace is necessary because airspace users are required to follow different rules based on the classification of the volumes they are attempting to access. The FAA defines controlled airspace as "all airspace over the territory of the United States extending 12 nautical miles from the coastline of U.S. territory; any airspace delegated to the United States for U.S. control by other countries or under a regional air navigation agreement; or any international airspace, or airspace of undetermined sovereignty, for which the United States has accepted responsibility for providing air traffic control services[6]."

Controlled airspace requires ANSPs to have adequate communication, navigation, and surveillance equipment to provide separation services to participating users of the airspace system. Class A, B, C, D, E, and G airspaces exist in the contiguous United States[7].

Special Use Airspace (SUA) is designed for activities needing to be confined based on their nature, where limitations are imposed upon non-participating aircraft. SUA is defined with vertical, horizontal, and time parameters. Types of SUA include Prohibited areas, restricted areas, Warning areas, Air Traffic Control Assigned Areas (ATCAA), Military Operations Areas (MOA), Alert Areas, Controlled Firing Areas, and National Security Areas. "Other airspace areas" refer to remaining airspace.

Temporary Flight Restrictions (TFR) are versions of "other airspace areas" designated through a Notice to Air Mission (NOTAM) publication. The purpose of establishing TFRs varies from National Security (99.7 TFR) to Space Operations (91.143 TFR). Altitude Reservations (ALTRV) are also designated through the publication of NOTAMs and are frequently used to define aircraft hazard areas, the volume representing the risk introduced into systems during the integration of space operations.

The various types of airspace can be activated during launch and reentry operations representing the aircraft hazard area. It is up to the ANSP and other relevant stakeholders to determine which types are used in support of such operations.

6. Key Roles of State Space Regulator and Air Navigation Service Provider

As countries establish their own national regulatory frameworks, governments are delegating roles of processing and integrating operations into airspace systems to various organizations within their country. This includes the State Space Regulator (SSR), the Air Navigation Service Provider (ANSP), and in some capacities, the Civil Aviation Authority (CAA).

In the United States, the SSR is the U.S. Department of Transportation's Federal Aviation Administration (FAA) Office of Commercial Space Transportation (AST). AST has the authority to regulate commercial space transportation. AST licenses U.S. commercial launch and reentry activities and the operation of launch and reentry sites in the United States or outside the United States when carried out by U.S. citizens. Under national law, AST is to exercise its authorities consistent with public health and safety, the safety of property, and the national security and foreign policy interests of the United States.[8]

Since 1989, the FAA has licensed over 580 commercial launches and 39 commercial reentries.[9] The FAA currently has 23 active launch and reentry vehicle licenses, and 14 active licenses for the operation of non-federal launch or reentry sites (spaceports). The FAA has already surpassed 100 commercial space launch and re-entry operations for fiscal year 2023. This will be the highest annual launch rate in U.S. history for the commercial space industry.

In some cases, the SSR may organizationally be within the CAA as is the case in the U.S. However, these two entities perform vastly different functions and require specialized expertise to perform job functions due to space and aviation operations being disparate in nature.

The FAA Air Traffic Organization (ATO) serves as the U.S. ANSP. The ATO is the focal point for the coordination and dissemination of any hazard mitigation requirements to affected Air Traffic Services facilities and affected stakeholders during space operations. The ATO ensures the safe and efficient integration of the operations into the airspace system, consistent with applicable policies and regulations.

Additional functions of the ATO include coordinating international NOTAMs for launch and reentry operations occurring from the U.S., maintaining letters of agreement between license holders and FAA facilities, developing strategic solutions for tactical operations, including routing considerations and airspace management tools. The ATO is also responsible for monitoring, evaluating and disseminating information regarding the status of the operation to stakeholders, including air traffic facilities and support units, and facilitating real-time communication during the operations.

During operations, the ATO integrates AST-approved hazard areas into the airspace system and works with Launch and Reentry Operators (LROs) and AST to minimize impacts of operations on the airspace systems when possible.

7. Letters of Agreement

Letters of Agreement (LOA) are developed with Air Traffic facilities, federal and regional airspace authorities, companies, and other relevant stakeholders. Generally, the LOAs encompass the responsibilities of each party related to missions, and procedures to execute during missions including the scheduling of activities, notification channels, flight operations, hotline procedures, and any other relevant information.

LROs and launch and reentry site operators are required, by U.S. regulation, to maintain an LOA with the ATO outlining procedures and expectations of all applicable stakeholders.[10] AST validates the methods used to determine the Aircraft Hazard Areas (AHAs) and approves final AHA results produced by LROs prior to operations. Both are required for a launch or reentry to take place.

LOAs must contain procedures for the issuance of NOTAMs, procedures for the closing of air routes during launch and reentry windows, and for any other measures the FAA deems necessary to protect public health and safety. LOAs also contain operational timelines and requirements for scheduling SUA, and responsibilities of the ATC facility or ANSP when supporting a launch or reentry[11].

LOAs are started during the pre-application process of licensing with the LRO. AST facilitates a meeting between the operator and ATO Space Operations for introductions and discussion about mission specifics and how the operations will integrate into the National Airspace System (NAS) in addition to the development of the LOA.

Additionally, LOAs have been developed between the ATO and commercial space operators to facilitate international NOTAM coordination. Through extensive trial and error, the FAA determined that it was significantly more efficient for the coordinating ANSP (the ATO in the case of launches occurring from the United States) to conduct international coordination with impacted ANSPs rather than relying on commercial operators to independently procure international NOTAMs. This is primarily due to the lack of practical ways for commercial space operators to request NOTAMs from foreign ANSPs without support from a sponsoring ANSP. ANSPs may utilize existing mechanisms such as the Aeronautical Message Handling System to send a NOTAM request in accordance with the international coordination LOA between the originating ANSP and the LRO. Information within this LOA includes notification timelines, data format requests, and relevant information.

8. Licensing and the Development of Aircraft Hazard Areas

During the licensing process a flight safety analysis is conducted by the operator and submitted to AST for validation that any risk to the public falls under the necessary safety criteria (14 CFR§ 450.115)[12] for air, land and sea. The thresholds of each vary, but for airspace the analysis is computed at 10^{-6} probability of impact with debris capable of causing a casualty in addition to the 97% probability of containment of all debris resulting from normal flight events capable of causing a casualty.[13]

For airspace impacts, the outcome of this analysis produces an AHA, which defines the boundaries of the airspace closure. An AHA is a volume of airspace used by ATC to segregate air traffic from a launch vehicle, reentry vehicle, amateur rocket, jettisoned stages, hardware, or falling debris generated by any of these activities. Unless otherwise specified, the vertical limits of an AHA are from the surface to unlimited.

Additionally, debris response areas (DRA) are volumes of airspace that encompass the AHA and are slightly larger. These are calculated to 10^{-7} where emergency procedures can be applied in the case of an off-nominal occurrence. However, in the U.S., procedural responses to DRAs are only executed in adequately surveilled airspace with radio coverage.

In the case of nominal launches and reentries, airspace closure times are determined using trajectory information including the time required for planned jettison items to pass through the airspace system. Debris fall times are calculated during the licensing process and will define airspace closure times in the case of a malfunction event.

An operator must perform a new analysis to generate AHAs for each operation. The approved AHAs are then provided to ATO Space Operations.

9. Coordinating Airspace Use for Launch and Reentry

When LROs attempt to coordinate airspace use with the ATO, they follow the agreed-upon procedures outlined in LOAs signed by air traffic facilities prior to operating. This process begins with LRO notification to the ANSP. Notification includes information about the coordinates, times, and days for the requested airspace.

Once ATO Space Operations receives a notice of intent to launch from an LRO, the ATO Space Operations office evaluates potential impacts to the airspace system. ATO Space Operations collaborates with multiple stakeholders of the airspace system to define operational mitigations a few days prior to the operations. Such mitigations are frequently achieved by collaborating with the LRO to reduce the time of the operation windows, adjust the time of day to minimize impacts during high traffic volume times,

and provide feedback on the size and placement of the AHA to the operator and AST for reductions where possible.

The following materials are examples of information disseminated by the ATO to airspace system stakeholders in preparation for launch or reentry operations: AHA NOTAM requests, real-time communication (e.g. hotline) information, Traffic Management Initiatives (TMIs), international NOTAM requests, Airspace Management Plans (AMPs), and Debris Response Areas (DRAs).

Airspace stakeholders may include international ANSPs that provide air navigation services to flight information regions (FIR) impacted by launch and reentry operations. In the U.S., ATO coordinates international NOTAMs on behalf of LROs. As noted earlier, through post operational evaluations, extensive learning, and outreach to ANSPs, FAA determined the model requiring operators to obtain NOTAMs from foreign ANSPs is not tenable for timely airspace coordination.

The AMP is developed prior to each operation detailing how Air Traffic facilities will safely manage the airspace. The AMP provides a broad overview of dates, times, and operational impacts including background information on the vehicle, proposed operational schedule, AHA information, DRA information, illustrations of the AHAs, and relevant TMIs.

Air Traffic facilities then take the information to develop their own launch packages with specific instructions for controllers at the air traffic sector level. The strategic and tactical coordination is disseminated days prior to the operation to all stakeholders enabling them to provide safe and efficient mission execution.

10. Integrating Launch and Reentry Operations into the NAS

The FAA implemented a new procedure in 2021 encouraging space operators to make decisions early before traffic management initiatives are implemented if there is a likelihood a space operation may be scrubbed or rescheduled. The Critical Decision Window (CDW) is typically three to six hours prior to scheduled airspace activation. This procedure allows air traffic facilities to stand down from implementing any relevant traffic management initiatives and minimize impacts on other airspace users and stakeholders.

The space operations hotline is hosted by ATO Space Operations on the day of operations using an audio conference system. The hotline is used to ensure the relevant stakeholders are kept up to date on mission status to ensure safe and efficient airspace management during launch and reentry activities. The notifications include airspace activation, status and health of the operations, mission milestones, and airspace return to the NAS. The hotline is also used to implement time-based launch procedures (TBLP), dynamic launch and reentry windows (DLRW), and modify traffic management initiatives. Utilizing this rudimentary capability has allowed a dramatic reduction of unnecessary airspace closures.

The purpose of the hotline is for real time situational awareness; stakeholders are able to disseminate accurate and timely information for both nominal and off nominal operations. During nominal operations, AHAs can be returned prior to the end time reflected in the published NOTAM after confirmation that risk no longer exists to non-participating users. Utilization of the hotline has allowed the U.S. to minimize impact to the airspace system and reclaim an average of 93 minutes per mission in heavily saturated and high-demand airspace rather than the historical paradigm of three-to-four-hour closures. [14] During off nominal events, the hotline is used to verify an anomaly has occurred; this triggers the implementation of DRA procedures where applicable. Additionally, the hotline is kept active until confirmation is received that the risk to non-participating users is negligible.

Generally an hour prior to airspace activation, a real-time communication hotline is activated including impacted air traffic facilities, the Air Traffic Control System Command Center units including Severe Weather (SVRWX), Central Altitude Reservation Function (CARF), and other operational entities. Non-FAA stakeholders include the launch and reentry operators, spaceport or federal range personnel, and in some instances North American Aerospace Defense Command (NORAD).

In certain cases Airspace Management techniques and procedures may be implemented to maximize efficiency without degrading system safety. The ATO has developed two primary procedures that have helped reduce NAS impacts from commercial space transportation operations. These procedures are Time Based Launch Procedures (TBLP) and Dynamic Launch and Reentry Windows (DLRW) and they allow for more timely and dynamic closing and re-opening of airspace.

The underlying theme of these concepts is cooperation. DLRWs use key mission triggers which may be specific to each operation or vehicle; this allows the ATO to limit excess airspace activation ensuring the most efficient use of airspace. Key mission triggers include but are not limited to loading of propellants, weather, orbital mechanics, etc. For example, if an operator has loaded a time sensitive propellant that has an hour's life span at 0900 then ATO is able to use that as a key trigger to notify ATCs that airspace will be returned by 1000 even if the original launch window may have been longer.

Time Based Launch Procedures (TBLP) are implemented for operations occurring near high-volume airspace (e.g. Cape Canaveral). TBLPs were developed to allow airspace users to plan to return to previously sterilized AHAs as soon as assurances are made via the operational hotline that risk to the airspace system will end by a certain time. This is accomplished by reprogramming traffic management initiatives and notifying stakeholders.

On the East Coast of the U.S., multiple streams of traffic that are traversing the Atlantic Ocean between south Florida and North Carolina via the Atlantic Routes (ARs) can be heavily impacted by AHAs. TBLP allow airspace users to return to previously sterilized airspace with minimal delay. With the inception of TBLP, the ATO is able to save 40 minutes on average per launch. Previously, airspace was not reutilized until 84 minutes post airspace release. Utilization of TBLP has saved us on average 124 minutes per launch. [15]

TBLP and DLRW allow LROs access to the required airspace for the duration of their mission, while also allowing other airspace users to return to previously sterilized airspace as soon as safely possible. These notification procedures allowing for better sharing of operational information, without significant time or cost to the ATO, LRO, or other airspace users.

Many ANSPs do not have a real-time communication hotline with launch and reentry providers, or other airspace stakeholders including neighboring ANSPs during operations; the lack of communication and situational awareness makes tactical airspace management impractical, especially with the increasing launch and reentry cadence. Promulgation of real time information sharing and time based notification procedures in the international environment would significantly decrease impacts of space operations on the global airspace system.

11. Future Areas of Collaboration

As launch and reentry activities increase, a number of new opportunities for collaboration are becoming evident. These include but are not limited to:

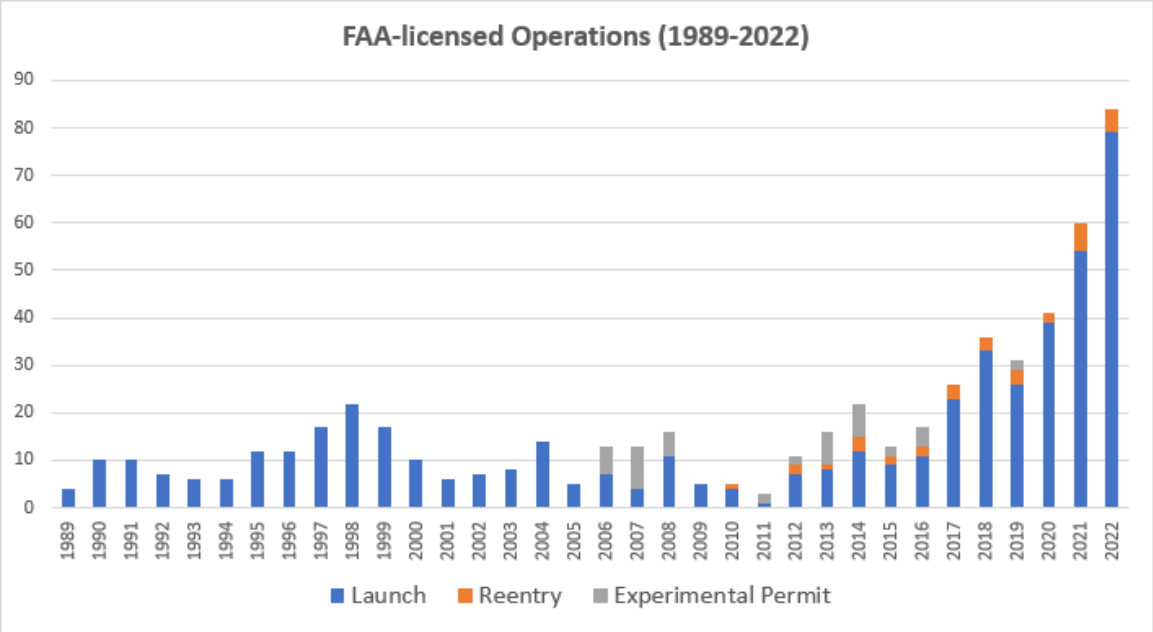
- Clear delineation of roles and interactions between the SSR, CAA, and ANSP for international space launch and reentry;
- Development of efficient, internationally recognized, standardized practices for access to airspace systems;
- Collaboration on new spaceport development, including those collocated with aerodromes;
- Procedures and international coordination for unplanned reentries (uncoordinated operations, reentry of space debris) ; and
- Development of operational channels for safety-critical data dissemination (critical events like operation start time, notification of off-nominal event, notification of end of risk posed to airspace system).

12. Conclusion

Commercial space transportation activities are increasing in the U.S. and globally. This increase necessitates new mechanisms and processes that provide efficient management of the airspace system for all users. The U.S. has over 30 years of experience integrating over 580 commercial launches into the U.S. NAS. In particular, the U.S. has developed procedures for implementing AHA's that minimize the duration of airspace closures and promote efficiency for integration of commercial space transportation activities into the airspace system. [16] Activating unnecessary airspace wastes a valued resource for all users. The processes and procedures outlined in this paper are intended to foster international cooperation and consistency for airspace integration of commercial launch and reentry activities. Consistency for airspace integration promotes global interoperability and benefits for all airspace users. Better global cooperation will help solidify international norms for integration of commercial space transportation activity.

Annex 1

Table 1. FAA-Licensed Operations 1989-2022



[1] "2022 Orbital Launches Year in Review," Bryce Tech, February 3, 2023. https://brycetech.com/reports

[2] FAA, AST, 2023, https://www.faa.gov/data_research/commercial_space_data/

[3] "Aeronautical Information Management (Doc 10066)." n.d. ICAO. Accessed August 29, 2023. https://store.icao.int/en/aeronautical-information-management-doc-10066.

[4] Statement by Emily Pierce, U.S. Department of State, to the Legal Subcommittee of UN COPUOS, Agenda Item 6(a) Definition and Delimitation of Outer Space March 21, 2023, U.S. https://vienna.usmission.gov/the-usa-at-the-62nd-session-of-the-copuos-legal-subcommittee-march-2023/

[5] Ibid.

[6] See 14 CFR § 187.3

[7] "Aeronautical Information Manual - AIM - Controlled Airspace." 2020. Faa.gov. 2020. https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap3_section_2.html.

[8] See 51 USC Chapter 509., available at https://www.faa.gov/space/legislation_regulation_guidance

[9] Federal Aviation Administration, Office of Commercial Space Transportation, as of September 5, 2023. https://www.faa.gov/data_research/commercial_space_data/

[10] Regulations (14 CFR Parts 420 and 450) require Launch/Reentry Site and Vehicle Operators to obtain a Letter of Agreement (LOA) with the FAA ATO or other applicable air navigation authority.

[11] Operators proposing to launch or reenter within the boundaries of active special-use airspace must obtain an agreement with the SUA Using Agency. If that agency already has an existing LOA with the FAA for airspace use, that agreement can be used in lieu of developing a new one. This is also applicable for operators launching from a federal range.

[12] See 14 CFR§ 450.115

[13] Relevant requirements for commercial operators are 14 CFR § 450.133(d) and 14 CFR § 417.107(b)(4) and §417.223. In addition, Space Force has a similar requirement in AFSPCMAN 91-710 Vol 1 Attachment 5.

[14] Statistics are pulled from the Air Traffic Organization's (ATO) internal metrics.

[15] Ibid.

[16] Federal Aviation Administration. (2023). Airspace Integration of Launch and Reentry Operations. YouTube. https://youtu.be/92ixki92fqw