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AIRSPACE MODELING FOR REENTRY AUTHORIZATION
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The August 13, 2025, White House Executive Order 14335, “Enabling Competition in the Commercial Space Industry,” includes a focus on reentry specifically to determine “*whether to expand the conditions that demonstrate reliability for a reentry vehicle, sufficient to protect against a high-consequence event on reentry.*” Mitigating risk of a high consequence event can involve both space operators and airspace planners. NASA’s Air Traffic Operations Lab (ATOL) is uniquely positioned to facilitate the modeling, analysis, and visualization of both controlled and uncontrolled reentry effects on air traffic for more than 29 million square miles of airspace, including the North Atlantic and Pacific Oceans. The lab is connectable to space operators through its Aviation Sim Net for operational feasibility assessments. Its application with partners will facilitate the development of system level requirements for performing safety analysis and streamlining the reentry approval process.

This paper highlights foundational capabilities needed to model the airspace, air traffic, and aspects of air traffic control to enable research of space traffic reentry through active airspace to land at spaceports. It also highlights why these simulation capabilities are needed to inform policy decisions by providing a repeatable evidence-to-authorization pipeline to facilitate decision making regarding reentry policy, licensing, and airspace management enabling support for Executive Order 14335. The foundational capabilities reside at NASA Langley Research Center and are poised to be integrated in assessments with partners.

Keywords: *Controlled Reentry, Airspace Modeling, Airspace Closures, Integration of Air and Space Operations, ATOL, ATOS*

1. Introduction

The August 13, 2025, White House Executive Order (EO) 14335 [1] “Enabling Competition in the Commercial Space Industry” includes a focus on reentry specifically to determine “*whether to expand the conditions that demonstrate reliability for a reentry vehicle, sufficient to protect against a high-consequence event on reentry.*” The December 18, 2025 Executive Order (EO) 14369 [2], “Ensuring American Space Superiority” further elevates this issue by explicitly directing policy reforms to increase national launch and reentry cadence, providing decision-grade airspace information, a practical prerequisite for scalable authorization. The generic term “reentry” is used to describe the breadth of diversity of reentering space objects. It includes space vehicles associated with a launch, like reusable rocket stages, discarded stages, and fairings; objects reentering Earth’s atmosphere after mission completion, including spacecraft returning humans to Earth; and emerging use cases of reentering objects containing material mined or manufactured in space. This paper focuses specifically on the impact to airspace operations of reentering space objects. The breadth of requirements set forward in Chapter III, Subchapter C (licensing) in Title 14 of the Code of Federal Regulations are outside the scope of this paper but are an area of interest for future study.

Efforts to protect against a high-consequence event (e.g., collision with an aircraft) consider multiple factors, including airspace demands, and should be sufficiently agile to consider a variety of mission profiles. Considerations for high-consequence events of a space reentry include the safety of people on the ground and aboard aircraft, disruption to the airspace, and balancing the interests of a diverse airspace user community. Mitigating the risk of a high consequence event must involve both space operators and airspace planners. This paper addresses the opportunities in airspace planning and management to streamline the reentry licensing process via improved airspace risk modeling. The dramatic increase in the commercial launch industry has already created strain and imposed additional costs on the commercial aviation industry and the traveling public [3] [4]. Current efforts to protect against high-consequence reentry events are informed by previous airspace planning experiences and have been studied since the breakup of Space Shuttle Columbia in 2003 [5].

Existing U.S. Government resources can be leveraged to support these efforts, including NASA’s Air Traffic Operations Lab (ATOL), located at the Langley Research Center in Hampton, Virginia and two Federally Funded Research & Development Centers operated by the MITRE Corporation: the Department of Commerce’s Center for Government Effectiveness and Modernization (CGEM) and the FAA’s Center for Advanced Aviation System Development (CAASD).

The ATOL is uniquely positioned to facilitate the modeling, analysis, and visualization of both controlled and uncontrolled reentry effects on air traffic for more than 29 million square miles of airspace, including over the North Atlantic and Pacific Oceans. In addition, the lab can connect to space operators through its Aviation Sim Net to conduct operational feasibility assessments and facilitate the development of system level requirements that can inform safety analysis in support of efforts to streamline

the reentry approval process [6]. ATOL turns reentry uncertainty into measurable risk and disruption envelopes, enabling policy to be set on analytical evidence rather than just precedent.

The sections that follow enumerate ATOL's relevant airspace modeling and operational assessment capabilities. This paper's central claim is that **these capabilities should be leveraged not only for technical analysis, but as a repeatable evidence-to-authorization pipeline that converts operational data and uncertainty into decision-grade products for reentry policy, licensing, and airspace management**. In practical terms, ATOL enables regulators and mission owners to evaluate competing approaches to reentry reliability and airspace protection using a common set of scenarios, metrics, and decision thresholds, thereby reducing policy set by ad hoc judgment and increasing decision velocity without compromising safety.

This paper highlights capabilities needed to model the airspace, air traffic, and aspects of air traffic control to enable research of space traffic reentry through the National Airspace System (NAS)¹ to land at spaceports or other NAS locations. Specifically, it highlights how available simulation capabilities can be leveraged to inform policy decisions regarding spacecraft reentry and thereby supports implementation of Executive Order 14335. These Langley capabilities can be used as a part of assessments with partners and industry stakeholders. Scaling commercial reentry requires moving from bespoke analyses to institutionalized evaluation pipelines; ATOL is the testbed where that pipeline is proven and iterated.

2. Current Reentry Use Cases

The mission profiles of reentering space objects vary dramatically, ranging from a clearly defined flight path of a reentering space plane to the completely uncontrolled and difficult to predict reentry of a large component that has been in space for decades. The latter may contain hazardous material, the composition and characteristics of which may not be known, which makes these efforts critical to mitigating the risks of high-consequence events. Although different approaches to airspace management may be necessary for adequate risk mitigation, at the same time, we can make considerable progress over the current state by understanding the different challenges, applying existing resources, and identifying where new research is needed. Three types of reentries are considered in the following subsections: (a) launch-related reentry, (b) reentry from orbit, and (c) disposal from orbit.

a. Suborbital Reentry Included in Launch License

As the cadence of commercial space launch has increased, the Federal Aviation Administration (FAA) has made dramatic progress in both the reduction of the amount of airspace needing to be closed to accommodate a launch, and its ability to respond to off-nominal events. The implementation of increasingly dynamic airspace

¹ "The NAS is a network of both controlled and uncontrolled airspace, both domestic and oceanic. It also includes air navigation facilities, equipment and services; airports and landing areas; aeronautical charts, information and services; rules and regulations; procedures and technical information; and manpower and material", https://www.faa.gov/air_traffic/nas

management tools can be leveraged to respond to suborbital reentry profiles. This paper uses the description of suborbital reentry to cover those reentering objects that are contained in the launch license, like boosters and fairings, and includes suborbital vehicles with space flight participants aboard. This can provide a model for commercial reentry from orbit to share telemetry information in near real time with the FAA's prototype Space Data Integrator (SDI) Tool (Figure 1). The same simulation campaign that protects against high-consequence events can also accelerate approvals by pre-validating decision thresholds and operational playbooks.

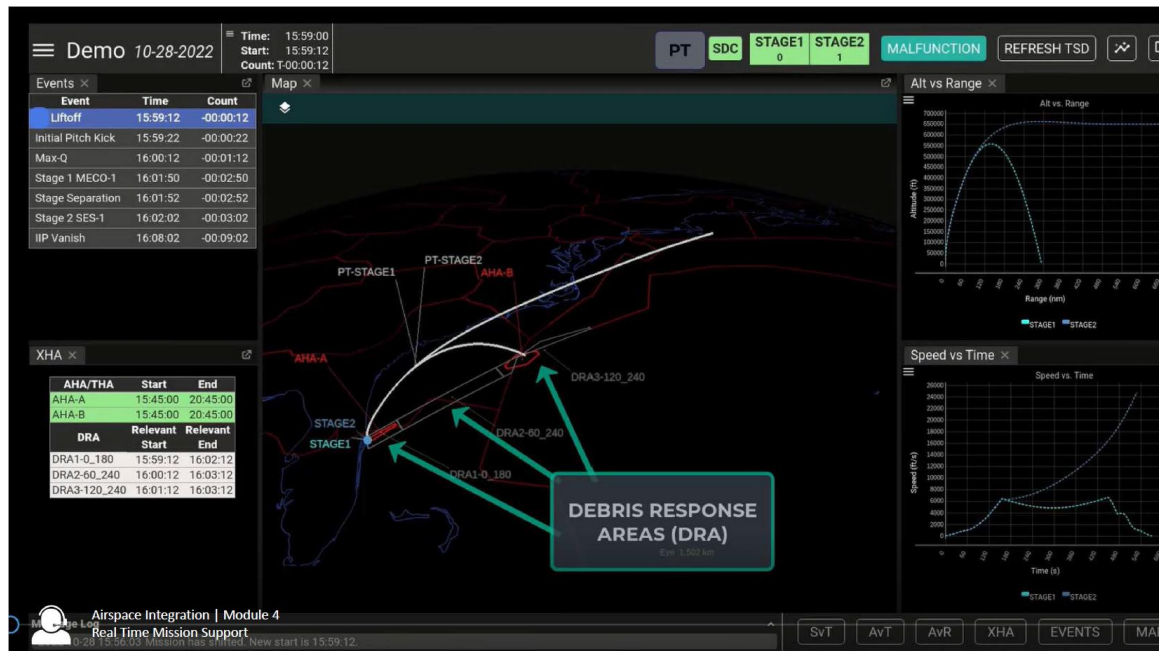


Figure 1: FAA Space Data Integrator (Source: FAA [7])

Reusable launch vehicles create an opportunity to precisely plan for both the airspace necessary to accommodate the reentry and the contingency plans that reflect the reliability of the individual vehicles.

While expendable launch vehicles may not have the same pinpoint precision as reusable use cases, the inclusion of the reentry profile in the launch license provides appropriate airspace planning information. ATOL simulations can consider the different levels of precision in the airspace modelling.

b. Intact Reentry from Orbit

There is a distinction between objects that intend to return to Earth intact after spending a period of time in space, and reusable launch vehicles that return to Earth as part of the launch activity. This distinction reflects the different manner in which the airspace is managed to accommodate both types of reentry. Capsules and space planes can be crewed or uncrewed. The presence of humans aboard creates a higher safety threshold for reentry planning and affects airspace modeling.

In general, returning capsules do not rely on atmospheric lift to shape the nominal descent profile. Capsules rely on drag devices to slow the rate of descent prior to contact with land or water. The Space X Crew Dragon performs splashdown and

recovery in the ocean, while the Blue Origin New Glenn performs surface landing like that demonstrated in the New Shepard suborbital reentries. Uncrewed capsules, like the commercial Varda or NASA's OSIRIS-Rex, where the interest is in recovering the payload, are smaller than human rated capsules but also return on land.

Space planes, like NASA's Space Shuttle, Virgin Galactic's Unity, Sierra Space's Dream Chaser and Boeing's X-37B, utilize atmospheric lift to control reentry and land on runways. While maneuverability may be limited when compared to conventional aircraft, once the spaceplane has reached navigable airspace, the vehicle can be tracked, in real time, through the airspace and to the ground.

c. Post Mission Disposal subject to Atmospheric Disintegration

These types of reentries can include spent rocket bodies, defunct satellites, and other types of space debris. Unlike launch-related debris, these objects have been in orbit around the Earth, and the detection and prediction of the time and location of effect on the airspace is imprecise. In addition to reentry point, the amount and pattern of debris that survives atmospheric burn can be difficult to predict for both controlled and uncontrolled reentries.

i. Uncontrolled Reentry

Uncontrolled reentry presents a more significant challenge for reentry prediction. In its 2023 Report to Congress, the FAA noted that "*Despite guidelines recommending purposeful reentry, large space objects reenter the Earth's atmosphere roughly once a week. Some are recently launched, and many more were launched prior to any agreed-upon disposal strategies* [8]." Large rocket bodies, like the Long March 5B uncontrolled reentries in May 2020, July 2022, and November 2022 created international concern and highlighted the difficulty in predicting where debris may impact navigable airspace (Figure 2).

The prediction uncertainty for the November 2022 reentry over the south-central Pacific Ocean led to different responses by those responsible for airspace management. France and Spain closed sections of airspace, other European countries issued advisories, and yet other responsible States took no action [9]. In other instances, objects that were designed for demise or otherwise expected to burn up upon reentry well above navigable airspace have survived reentry and impacted the Earth. Detection and tracking of these objects are limited, and often no information is available until after the impact with the earth is detected. For example, on March 9, 2024, debris that had been jettisoned from the International Space Station three years earlier crashed into a house in Naples, Florida causing considerable damage [10].

Reentry Prediction

Predicted Reentry Time	04 Nov 2022 11:20 UTC $\pm$ 3 hours
Orbit Epoch	03 Nov 2022 19:58:06.668 UTC

Prediction Ground Track

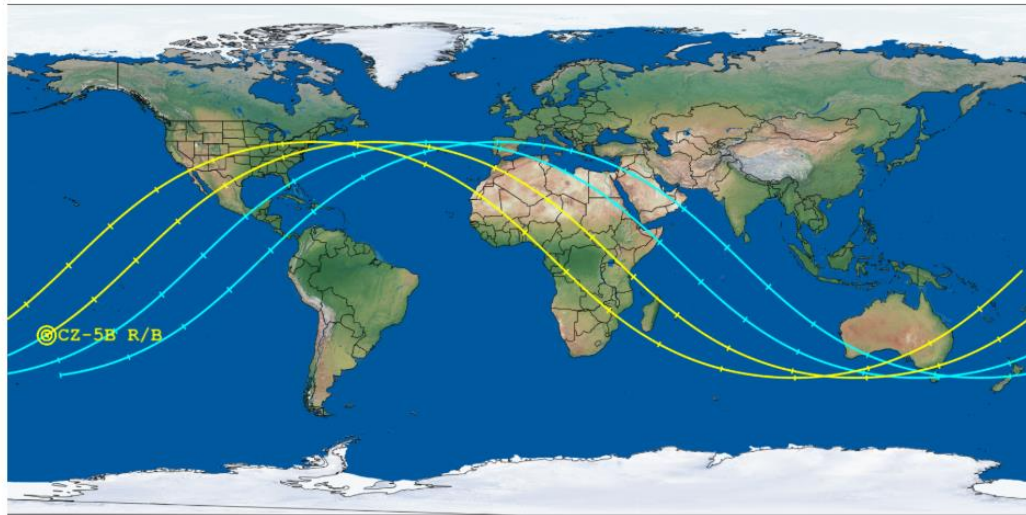


Figure 2: Reentry Prediction for CZ-5B November 4, 2022 [11]

ii. Controlled Reentry

Controlled reentry requires active intervention to manage the descent of orbital objects. An operator will execute a maneuver to enter the atmosphere at a steep angle to limit the area of debris fallout and ensure the reentry occurs over an unpopulated or sparsely populated area [12]. Controlled reentry is focused on the object reentering the Earth's atmosphere and is not synonymous with controlled deorbit, which is intended to remove an object from its current orbit by lowering the orbital altitude to initiate orbital decay [13].

3. Emerging Trends and Opportunities

Over time we have seen repeated patterns in the space industry where long periods of speculation about technological breakthroughs receive attention, but it is not until the technologies demonstrate economic value that a rapid growth period occurs. For example, a technology breakthrough for space tourism occurred in 2004 when the Ansari X Prize was awarded to Scaled Composites for the first non-government organization to launch a reusable crewed spacecraft twice within two weeks. However, it was not until 2023 that the first space tourism flight was authorized, and within a year, three different companies, Virgin Galactic, Space X, and Blue Origin, were conducting space tourism flights.

The pattern of long development followed by rapid growth is apparent in both the commercial use of Global Positioning System (GPS) and in the commercial launch industry (Figures 3 and 4):

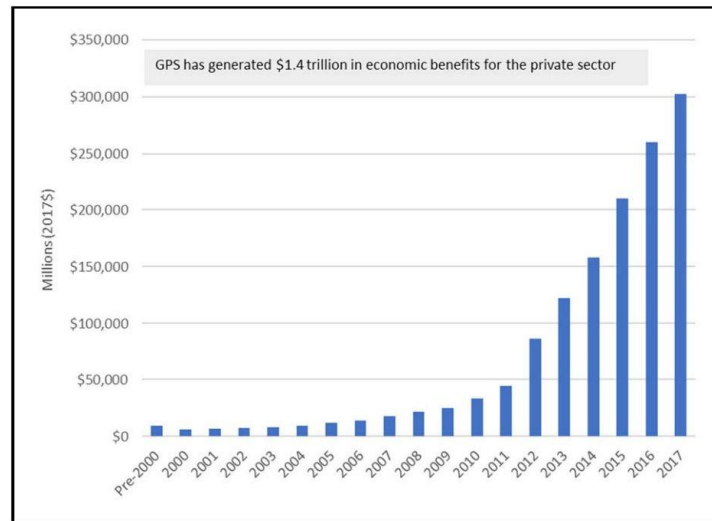


Figure 3: GPS Economic Benefit for the US Private Sector [14]

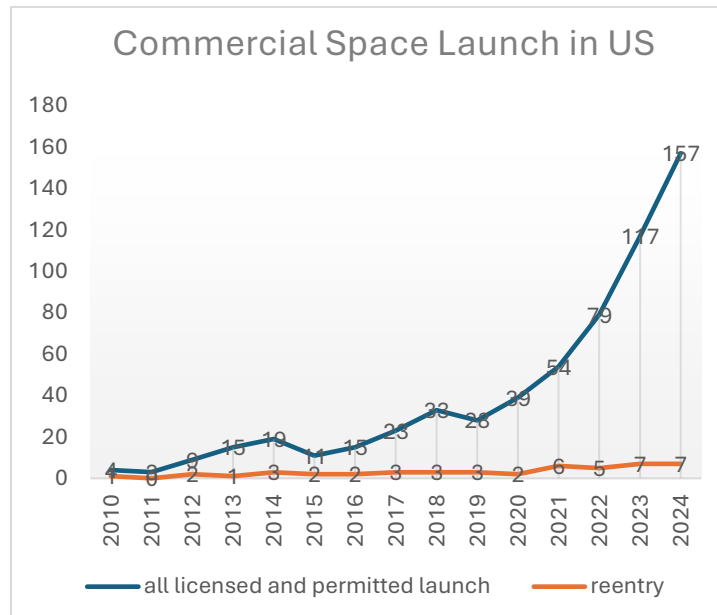


Figure 4: Growth of Commercial Space Launch ²

The rapid growth in commercial space launch created tension with the commercial aviation industry, as the frequency of launches increased the number of flights rerouted and delayed to accommodate the launch airspace [4]. The increase in space

² Data source: FAA Office of Commercial Space Transportation

reentry is likely to follow a similar growth pattern. ***Given the lessons learned from airspace disruption due to launch, it is in the public interest to plan for and establish policy regarding the expected rapid growth in the number of reentering objects.***

For the United States, the FAA provides air navigation services for 29 million square miles of airspace, only 5 million of which is US domestic airspace (Figure 5). Large Flight Information Regions (FIR) over the Pacific and Atlantic oceans are delegated by the International Civil Aviation Organization (ICAO) Council to the U.S. as the State responsible to provide Air Navigation Services. ***It is imperative for the US to mitigate the airspace impacts from reentering space objects through policies informed by airspace modeling.***



Figure 5: Airspace for which US provides Air Navigation Services [15]

4. Modeling Reentry Impacts on the National Airspace

The Air Traffic Operations Laboratory (ATOL) is powered by a custom-designed simulation suite, the Airspace and Traffic Operations Simulation (ATOS), and it has been continuously matured through production research since 2002 [16]. ATOS possesses the capability to model at mid- to high-fidelity hundreds of aircraft simultaneously, including both background traffic and primary aircraft of interest (including those with special capabilities under research and development). These aircraft of interest operate in various modes: human-piloted, pilot-modeled, automated configurations, and integrated combinations thereof. Given this unique modal flexibility, ATOS provides an agile architecture for studying integration of emerging and novel use cases in the airspace.

For transport category operations, ATOS employs an aircraft simulation named Aircraft Simulations for Traffic Operations Research (ASTOR), which simulate Boeing-style aircraft. ATOS has significantly expanded its capabilities over decades of

research and development, and it now supports simulation of several hundred aircraft of interest concurrently, exclusive of background traffic, while maintaining connectivity with diverse simulation platforms [17].

ATOS flexibility is founded on two primary operational modes:

- Batch Mode Processing – automated simulation runs for large-scale scenario analysis without humans in the loop
- Human-In-The-Loop – Interactive simulation with real-time human operator involvement, complemented by automated background traffic

The system features an intuitive interface that enables the sim-operator to interactively define computer configurations and incorporate comprehensive data collection scripts. The scripts aggregate data from multiple distributed computers and compiles it into a centralized file directory. Output products include Keyhole Markup Language (KML) files compatible with Google Earth® for post-simulation visualization and analysis.

a. Simulation Architecture

An ATOS simulation architecture connecting with many different software tools is shown below in Figure 6:

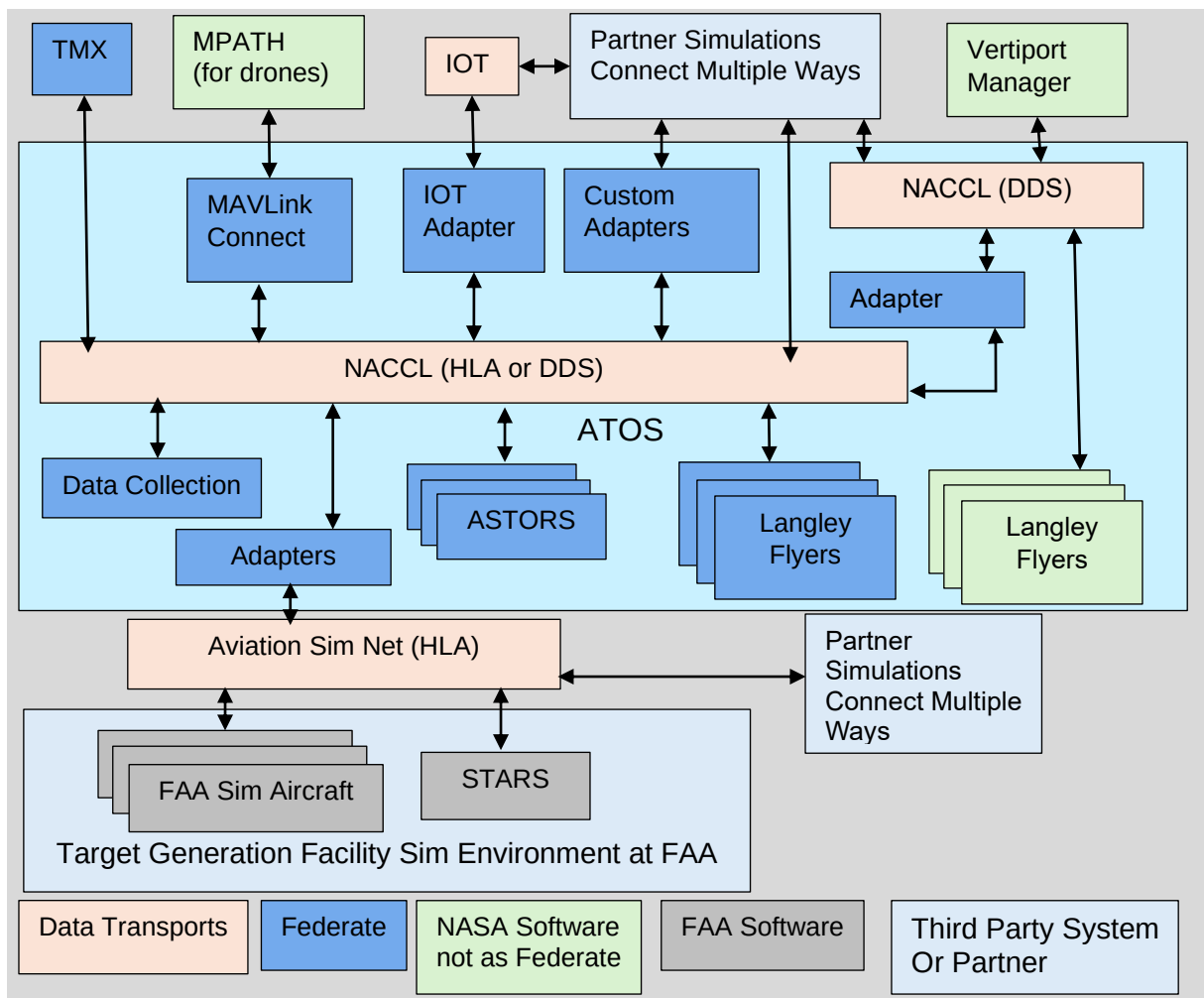


Figure 6. ATOS Simulation version showing hybrid HLA and DDS forms of communication

A standardized architecture with multiple ways of interacting with the simulation gives flexibility to adjust to a variety of requirements and produce full scale simulations quickly.

b. Connectivity

Central to the capabilities of scalability and interoperability of the ATOS simulation across diverse research applications are many methods of communication/Data Transport utilizing the NASA Air Traffic Management (ATM) Common Communication Library (NACCL). NACCL is a wrapper/interface to enable use of either High Level Architecture (HLA) or Data Distribution Service (DDS) as a communication backbone, or a hybrid setup of both.

Internet of Things (IOT) communication services are available that utilize publish/subscribe services. These interface with ATOS using a NACCL based connector that subscribes to needed information.

AviationSimNet is an HLA Federation Object Model (FOM) that has been used to connect with other aviation communities for simulation experiments to include FAA and MITRE.

MAVLink Connect enables conversion of information from NACCL format to QGroundControl recognized formats when working with drones.

Several other gateways have been developed to enable information exchange with other simulations. These can be updated to enable data exchange with other partners as needed.

c. Aircraft Simulations

Two simulation platforms, the ASTOR and the Langley Flyer, are used in ATOS for simulating aircraft of interest (those that employ advanced technologies to change path and direction according to the simulation events). Hundreds of aircraft of interest can be simulated at one time. Various other simulation platforms are used to generate the high volume of background traffic that generally fly recorded tracks and place constraints on how these aircraft of interest make decisions.

i. Aircraft Simulations for Traffic Operations Research (ASTOR)

ASTOR simulates a single, representative, transport-class aircraft implemented with a six-degrees-of-freedom aircraft performance model. Each ASTOR simulation includes the following components (see Fig. 7):

- Primary flight, navigation, and engine/alerting glass displays
- Multi-function control display unit
- Mode control panel
- Autopilot
- Auto-throttle system
- Flight management system
- Receiver/processor for Flight Information Services Broadcast (FIS-B)

- Receiver/processor for Automatic Dependent Surveillance-Broadcast (ADS-B) [17]
- Research-prototype automation for dynamic path planning, enabling operator-responsible conflict management (see Autonomous Operations Planner, below)

This component-level discrete systems modeling approach creates a realistic avionics environment for evaluating the capability of routine air traffic to respond to a reentry event under a variety of circumstances.



Figure 7. ASTOR Cockpit Display [18]

ii. Langley Flyers

The Langley Flyer is one of the most recent and versatile simulation platforms integrated with ATOS (see Fig. 8). This system provides simulation capabilities in a single platform capable of modeling diverse vehicle categories, including:

- Six different fixed-wing aircraft models of varying types and performance [19]
- Three distinct Urban Air Mobility (UAM) vehicle types
- Two different drone configurations
- High-Altitude Long Endurance (HALE) vehicle

Langley Flyers enable sophisticated distributed simulation scenarios that can incorporate any combination of the vehicle types simultaneously. This capability creates realistic NAS scenario representations specific to the challenges of a reentry event featuring:

- Operational environments specified by altitude range or airspace class
- Aircraft with diverse performance characteristics operating concurrently in the same airspace
- Complex interaction scenarios reflecting realistic mixed-traffic operations

The Langley Flyer has supported multiple high-priority research initiatives:

- NFLITE activities with FAA [6]
- Digital Flight research [19]
- Autonomous Operations Research [20] [21] [22]
- Human Autonomy Teaming studies

The Langley Flyers' ability to simultaneously model traditional aircraft alongside emerging aviation platforms (UAM aircraft, drones, and HALE systems) provides researchers with unprecedented capability to study airspace integration challenges for current and future scenarios. This multi-platform approach enables investigation of complex operational scenarios that will become increasingly relevant as the aviation industry evolves to incorporate diverse vehicle types across varying altitudes and performance envelopes. This is particularly valuable as emerging use cases for space operations are occurring concurrently with new aviation use cases that are increasingly dependent on automation and human-machine teaming. A holistic approach to airspace management must consider shifting demands from innovations in both aviation and space.



Figure 8. Langley Flyer

d. Vertiport Manager

The Vertiport Manager provides an example of how existing modeling tools originally developed for bespoke concepts like UAM can be applied to the space use case. The Vertiport Manager enables modeling of vertiports and scheduling reservations and timelines for the vertiport resources [23]. For purposes of the simulation environment described in this paper, the vertiport is a proxy for a spaceport or other common area used by spacecraft for landing in the ocean or on the land.

e. Autonomous Operations Planner (AOP)

The Autonomous Operations Planner is an advanced, highly capable, research prototype onboard automation system that analyzes detailed traffic data (e.g. from ADS-B) to enable operator-responsible conflict management. Its processing occurs through three core functions [24].

- Conflict Detection – Long-range predictions of aircraft-hazard separation loss
- Conflict Prevention – Trajectory planning to avoid conflict creation
- Conflict Resolution – Complex, multi-layered algorithms to ensure separation and optimize the flight

AOP monitors and modifies trajectories to be conflict-free while accounting for multiple operational factors:

- Weather hazards and static/time-variant airspace restrictions
- Aircraft performance, trajectory constraints, and prediction uncertainty bounds
- Required Time of Arrival (RTA) requirements
- Flight optimization of distance, time, and/or fuel
- Look-ahead horizons to prevent cascading effects

AOP in conjunction with vehicle simulations can be used to research and understand the impact of reentries on the NAS. AOP continuously monitors the predicted closest point of approach of traffic relative to the host aircraft (“ownship”). This closest point estimation is applicable to reentry objects as well and can determine when avoidance maneuvers or other mitigation strategies are warranted. Avoidance maneuvers are computed by AOP using a NASA-developed pattern-based genetic algorithm capable of accommodating diverse constraints and finding non-obvious trajectory solutions through 4D (space plus time) airspace [25].

AOP’s conflict-free maneuver processing leverages several different data exchanges of traffic state, various forms of intent, and avoidance polygons. The latter is representative of a dynamically defined debris response area. Various configuration parameters enable study of different separation criteria including uniform standards or performance-based criteria.

AOP data collection includes records such as [26]:.

- Loss of separation events
- RTA conformance [20]
- Closest point of approach error analysis
- Resolution success rates
- Fuel consumption
- Path length

AOP’s configurability and adaptability to different operating environments makes it an ideal tool for studying the impact of space reentry on NAS operations and for evaluating alternative approaches to hazard mitigation. It illustrates how the ATOL research infrastructure uniquely supports reentry policy decisions that account for full system effects including operator behavior, air traffic dynamics, and realistic traffic/weather patterns.

5. Using ATOS to Evaluate Reentry Policy

ATOS provides a simulation environment well suited to studying and defining policy for tighter integration of launch and reentry operations with both existing and emerging

NAS operations. The ability to accommodate hundreds of simultaneously operating aircraft in the vicinity of reentry events allows the study of large volumes of airspace that a space vehicle operation could impact. ATOS provides several levels of simulation fidelity, applying lower-fidelity modeling for aircraft not expected to be directly impacted by reentry but that constrain those that are, and applying higher fidelity modeling for aircraft that require active decision-making. Such aircraft operating near the affected airspace are simulated by an ASTOR or Langley Flyer and employ AOP for avoidance of dynamic, time-activated protected areas. This approach activates the core data-to-decision primitive for reentry policy: explicitly encode uncertainty, then test how alternative protected-area rules change both safety margin and NAS disruption.

Types of studies enabled by ATOS:

- Appraising the NAS impact of reentry to a particular landing site as a function of orbit inclination.
- Evaluating the impact of a reentry risk mitigation strategy on a specific airspace based on historic traffic patterns.
- Analyzing how the impact of a reentry risk mitigation strategy varies with the size of the protected areas to determine the impact reduction afforded by improved prediction accuracy.
- Assessing how time of day, day of week, or other factors related to common traffic patterns can be used to minimize the economic impact of space operations on other airspace users.
- Determining how much lead time would be required to clear the protected area as functions of affected airspace volume, size of the protected area, and excess time required to generate and disseminate protected area alerts and implement route modifications.
- Ascertaining how adjacent weather systems would influence or preclude moving flights out of the protected areas.

For any of the above studies, ATOS is instrumented to record and analyze such metrics as:

- Number of flights affected.
- Extra distance flown to avoid protected areas.
- Number of secondary maneuvers required to remain clear of non-impacted but nearby aircraft while avoiding protected areas.
- Number of flights failing to avoid protected areas.
- Extra fuel burn.
- Flight-time for affected aircraft.

The policy value of these studies is that they produce comparable evidence across reentry profiles, thereby enabling decisions about conditions that demonstrate reliability to be updated as performance improves. Decision velocity can improve

without safety erosion when the decision thresholds are validated against realistic scenarios and tracked metrics.

To translate ATOL's modeling capacity into a repeatable input to reentry authorization and airspace policy, NASA is positioned to define a **data-to-decision reference architecture for reentry operational impact on the NAS**, co-developed with the CGEM and CAASD operated by The MITRE Corporation.

At the front end, the architecture ingests operator-provided reentry trajectory intent (including near-real-time telemetry and uncertainty predictions), together with NAS background traffic, weather hazards, and time-activated protected-area constructs. Using the ATOL, powered by the ATOS simulation engine, NASA and MITRE in coordination with space industry/policy partners then execute a simulation campaign that leverages scalable traffic representations and higher-fidelity controller/vehicle interactions in the affected airspace. This approach enables systematic comparisons of alternative protected-area rules, lead-time requirements, and decision thresholds under realistic operational complexity. The resulting outputs are packaged as decision products, dynamic protected-area sizing guidance, recommended lead times, and quantified NAS impact metrics suitable for validating conditions that demonstrate reliability as commercial reentry scales.

The architecture will include governance and traceability in all aspects of the simulation campaign: assumptions, scenario definitions, uncertainty representations, and outputs, all of which are logged and reproducible. The impact of each simulation campaign will be decision thresholds that are defensible, threshold guidance updated as performance improves, and reentry approvals accelerated without eroding public safety. The NASA ATOL lab powered by ATOS will serve as a practical policy reform enabler by producing repeatable evidence that supports higher reentry cadence while maintaining safety objectives, an outcome directly called for in Executive Order 14369.

6. Conclusion

NASA Langley's advanced airspace modeling capabilities are positioned to rapidly advance the understanding of impacts of various space reentry policies on the U.S. National Airspace System. Ensuring safety throughout the rapid growth of space reentries in U.S. airspace as envisioned in Executive Order 14335 relies on effective modeling to inform policy and investment decisions. A commercially centered, mission-first posture depends on faster, clearer, and more repeatable decision pathways, and the NASA ATOL lab will supply the evidence base to do that. This NASA-MITRE initiative operationalizes commercial-first safety: it shortens time-to-authorization and converts uncertainty into measurable, auditable decision products. Such effective and informed modeling will balance the competing demands of aviation and space users of common resource of navigable airspace to ensure the public interest is preserved.

NASA Langley's capacity to model emerging and complex airspace at the intersection of commercial flight operations and reentry use cases represents immediate payback of significant prior public investment in air traffic management

research that now also supports emerging space applications. Airspace complexity is reflected in the diversity of aircraft types and use case scenarios. However, the airline model is only one of many user types that must be considered in the evaluation of reentry impacts. Different altitude bands, aircraft performance capabilities, mission profiles, weather patterns, and time of day are a few of the many factors that affect how a spacecraft reentry can affect airspace operations. The ability to evaluate impacts and mitigations at a realistic level of complexity is essential to the development of policy and licensing frameworks that ensure the safety of the flying public while still encouraging a competitive commercial space sector. Using existing resources, like the NASA ATOL lab, to model these activities can accelerate the evaluation of various strategies and risk mitigations to inform national policy for reentry authorization.

The mission- and safety-first approach to policy analysis described in this paper also aligns with emerging administrative priorities: of rebuilding a mission-first culture with urgency, ownership, and accountability, while recalibrating risk frameworks to keep safety foremost without stalling progress. A commercial centered posture, supported by a consolidated “front door” for external engagement and modernized mission operations, requires government to provide faster, clearer, and more repeatable decision pathways. Leveraging ATOL as an evidence-to-authorization pipeline is a concrete step toward those ends: it preserves public-interest safety while increasing decision velocity through standardized scenarios, metrics, and decision thresholds. Executive Order 14369’s revision of Space Policy Directive - 3 (SPD-3) toward Space Traffic Management (STM) services “for commercial and other relevant use,” alongside directed revisions to the National Space Transportation Policy (PPD-26), indicates a near-term policy window where decision-grade evidence on airspace impacts and reliability thresholds will be particularly actionable.

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