FEDERAL AVIATION ADMINISTRATION

CONCEPT OF OPERATIONS FOR COMMERCIAL SPACE TRANSPORTATION IN THE NATIONAL AIRSPACE SYSTEM

ADDENDUM 1: OPERATIONAL DESCRIPTION

SPACE and AIR TRAFFIC MANAGEMENT SYSTEM (SATMS)
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS

012505 INDD

CONCEPT OF OPERATIONS FOR COMMERCIAL SPACE TRANSPORTATION IN THE NAS

ADDENDUM 1: OPERATIONAL DESCRIPTION

FOREWORD

In May 2001, the *Concept of Operations for Commercial Space Transportation (CST) in the National Airspace System (NAS), Version 2*, was published by the FAA's Office of Commercial Space Transportation, Space Systems Development Division. AST, in collaboration with the FAA Air Traffic Organization, has developed this document — Addendum 1 to the Concept of Operations — to provide an additional level of detail regarding the operational integration of space and aviation traffic within the NAS. To that end, this document addresses those aspects of CST operations that directly involve NAS air traffic controllers and traffic managers, and the supporting functions required for space vehicles to conduct real-time air traffic operations.

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CONCEPT OF OPERATIONS FOR COMMERCIAL SPACE TRANSPORTATION IN THE NAS

ADDENDUM 1: OPERATIONAL DESCRIPTION

1.0 INTRODUCTION

In May 2001, the *Concept of Operations for Commercial Space Transportation (CST) in the National Airspace System (NAS), Version 2*, was published by the FAA's Office of Commercial Space Transportation (AST), Space Systems Development Division (AST-100). As described there, CST and aviation traffic will be fully integrated through capabilities provided by a Space and Air Traffic Management System (SATMS). The Concept does not propose SATMS as a system separate from the NAS, but rather as a vision for expanding NAS capabilities so as to integrate space vehicles into NAS operations while equitably sharing the airspace with conventional air traffic. The resulting integration of space and air transportation operations will provide the foundation for routine and affordable access to space. This in turn will facilitate accelerated scientific discovery, enhance quality of life through technological innovation, and foster economic growth through new commercial activities in space.

AST, in collaboration with the FAA Air Traffic Organization, has developed this document, Addendum 1 to the CST Concept of Operations, to reflect industry developments that have occurred since 2001. The scope of the current Concept encompasses various aspects of space vehicle design and operation, in addition to the integration of those vehicles into the NAS. This Addendum provides an additional level of detail regarding the operational integration of space and aviation traffic within the NAS. As a result, this document excludes topics such as certification, launch licensing, and vehicle dispatch and servicing, in order to concentrate on the functions involved in daily NAS operations.

The time frame of interest extends from the present to 2025. Because of the recent success of Mojave Aerospace Ventures (MAV) SpaceShipOne, interest in CST activities is presently centered on suborbital operations of reusable vehicles. However, AST expects that the NAS must be prepared to support a wide range of orbital CST operations by 2025, and possibly even earlier. This document therefore describes 1) those aspects of suborbital and orbital CST operations that directly involve NAS air traffic controllers and traffic managers, and 2) the supporting functions that are required for space vehicles to comply with the requirements of real-time air traffic operations.

1.1. CST INDUSTRY ENVIRONMENT

Today's commercial space-access market focuses primarily on the placement of uninhabited satellites in Earth orbit. The international launch rate required to satisfy the market demand remains at 15 to 20 operations per year, because comparatively few uninhabited satellites are needed in space, and because they remain in service for long durations. The industry continues to rely on expendable launch vehicles (ELVs) because the low launch rate and the inanimate nature of the payloads provide no business case for the costly development of more advanced systems. Furthermore, the launch rate requires only a small number of spaceports, while ELV operational characteristics require that those spaceports be at coastal or sea-based locations. Finally, with the exception of a few operations per year by the Space Shuttle fleet, there are no reentries from space. As a result of these factors, the scope of the CST industry remains limited, and the impact of commercial space-access operations on the NAS remains comparatively minor.

This constrained industry environment will be radically altered in the near future by the emergence of human-centered space-access operations. Unlike the limited number of uninhabited satellites needed in space, potentially millions of people will desire to go there for both business and pleasure. Also unlike uninhabited satellites, humans will remain in space for fairly short stays, and human payloads will provide the business rationale to develop systems that will provide advanced vehicle reliability and efficiency.

Public reaction to the X-Prize competition in October 2004 showed that this popular craving for human access to space does indeed exist — and the flights of SpaceShipOne showed that the capability to serve that potential market is rapidly emerging. As a result, suborbital space tourism may significantly increase the commercial launch rate within the near term. Developments in other concepts, such as inflatable space habitats, indicate that destinations in orbit may also become feasible, which will provide the economic rationale to develop advanced human-centered launch systems for orbital operations.

To accommodate these human-centered markets, a large fleet of reusable launch vehicles (RLVs) will yield a vastly increased rate of operations. This rate will be supported by the proliferation of spaceports throughout the U.S., including inland locations. The increased rate of operations, distribution of spaceports across the NAS, and occurrence of RLV reentries from space will result in a new traffic population that will need to be integrated into NAS operations. To provide background on the evolving industry environment that the NAS will need to support, the balance of this paragraph outlines the operational capabilities and the space applications that may exist at various stages in the coming decades.

1.1.1. Commercial Space-Access in 2025 and Beyond

The following discussion describes a far-term CST environment that could potentially evolve over the coming decades. This far-future vision is not presented as a prediction, but only as an illustration of the scale of progress that could occur if the CST industry achieves the rapid rate of change that the air transportation system underwent upon emerging from its infancy in the mid-20th century.

In this vision, the American CST industry will provide all of the space transportation services that the U.S. will need to secure its place as the world's leading space-faring nation. To that end, the industry's suborbital and orbital operations will support a wide range of economic and scientific activities in 2025 and beyond. For example, suborbital point-to-point transportation will provide extremely fast intercontinental movement of passengers and cargo. In addition, routine orbital operations will facilitate a wide range of human activities in space, including leisure travel, medical care, space science, and exploration.

Since orbital activities will emerge as the industry's primary market in the future, the NAS will handle the majority of the world's space travelers on the first and last 100 miles of their extraterrestrial journeys. To that end, the CST industry will provide hub-to-hub services between numerous U.S. spaceports and a constellation of 'earth/space transfer facilities' in the lowest of sustainable Earth orbits. These services will use a large fleet of highly conventionalized, single-purpose 'space-ferry RLVs' for the transport of people and goods between the surface and the orbiting transfer facilities. In space, pure spacecraft operating independently of the NAS will transport these payloads between the transfer facilities and destinations elsewhere. Thus the overall Earth/space transfer system will consist of:

- Numerous public spaceports throughout the U.S., with ELVs operating from coastal and sea-based locations, and RLVs operating from inland and coastal locations.
- Numerous orbiting Earth/space transfer facilities, each with several docks. Some of these facilities will represent destinations, while others will serve merely as way stations for the space-to-space component of the system.
- Hundreds or thousands of comparatively small space-ferry RLVs for transporting passengers and small cargo to and from the transfer facilities.
- Hundreds of large RLVs and ELVs, for ferrying large objects (facility structures, satellites, pure spacecraft) into space, and for hauling bulk supplies to the orbiting facilities.

This hub-and-spoke approach will enable the CST industry to concentrate demand on discrete Earth-to-space and space-to-space transportation modes. Thus the two modes will develop into highly specialized activities, with Earth-to-space operations being a fully integrated NAS domain. ELVs will continue to be used for many applications, but the majority of Earth/space transfer operations will rely on RLVs that will use conventional runways for takeoff and landing.

To minimize the inefficiencies that result from hybrid aircraft/spacecraft, these single-purpose space-ferry RLVs will have the ability for only brief independent operations outside the atmosphere. To reduce RLV design complexity and to minimize launch mass, these vehicles will not carry the structures, systems, or supplies needed for extended independent missions in space. Instead, they will spend the majority of their time in space being docked to an Earth/space transfer facility, and will be supported by that facility's systems and supplies. As a result, the fleet of space-ferry RLVs will provide the specialization, standardization, and economy of scale needed to offer routine and affordable access to low Earth orbit.

1.1.2. Space Applications

Today's emerging ability to provide affordable human access to space promises to open a large new market for space transportation. Competition to capture that market will increase space vehicle production and hasten technological advancement as the competitors strive to expand the services they can offer. The resulting economies of scale and technical capabilities will then make it feasible to branch out to new, non-human-centered niche markets that by themselves would not be worth pursuing. Table 1-1 presents a few examples of the space applications that may emerge in the coming decades as space-access operations become increasingly routine.

Table 1-1: Commercial Space Applications

2005 & Beyond		By 2025	2025 & Beyond	
Suborbital Applications	**Space-Based Utilities**	**Resource & Threat Management**	**Long-Duration Zero-g Exploitation**	**Colonization & Science**
Adventure Travel High-Speed Research Hardware Qualification High Altitude First Stage to Orbit	Communications Navigation & Positioning Power Generation Imagery	Asteroid Detection & Negation Hazardous-Waste Disposal Space Debris Management Natural Resource Acquisition	Space Tourism Zero-G Medical Care Manufacturing Agriculture Movie Production	Near-Space Settlements Solar System Exploration Space Science

New suborbital applications are now emerging with the development of numerous RLV concepts. The other applications shown on Table 1-1 are derived from the *Commercial Space Transportation Study* commissioned by NASA in 1994 and conducted by the multi-corporation Commercial Space Transportation Study Alliance (which was led by the Boeing Defense and Space Group).[1] Of these applications, space-based utilities are the major component of today's launch market, and this market will likely expand throughout the foreseeable future. The majority of applications in the remaining three categories must await development of affordable human access to Earth orbit, and the presence of permanent facilities from which those applications can be pursued.

Suborbital Applications. Adventure travel will initially drive the development of suborbital RLV capabilities. As suborbital flight becomes commonplace, technology advancements and economies of scale will reduce costs, which will enable an expansion into non-human-centered services such as research, hardware qualification, and high-altitude launch of small payloads to orbit. Suborbital point-to-point transportation capabilities will then evolve for the intercontinental movement of passengers and cargo. Suborbital adventure travel will begin in earnest within the next few years, and will come to dominate the commercial launch market until human-centered orbital capabilities become available. Thereafter, adventure travel may decline, but demand will continue to increase through the foreseeable future for the non-human-centered applications and for point-to-point transportation.

Space-Based Utilities. The space-based communications, positioning, and imaging systems of today will continue to expand through the foreseeable future. In addition, orbital power generation may also evolve for space-to-space and space-to-ground distribution.

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[1] http://www.hq.nasa.gov/webaccess/CommSpaceTrans/

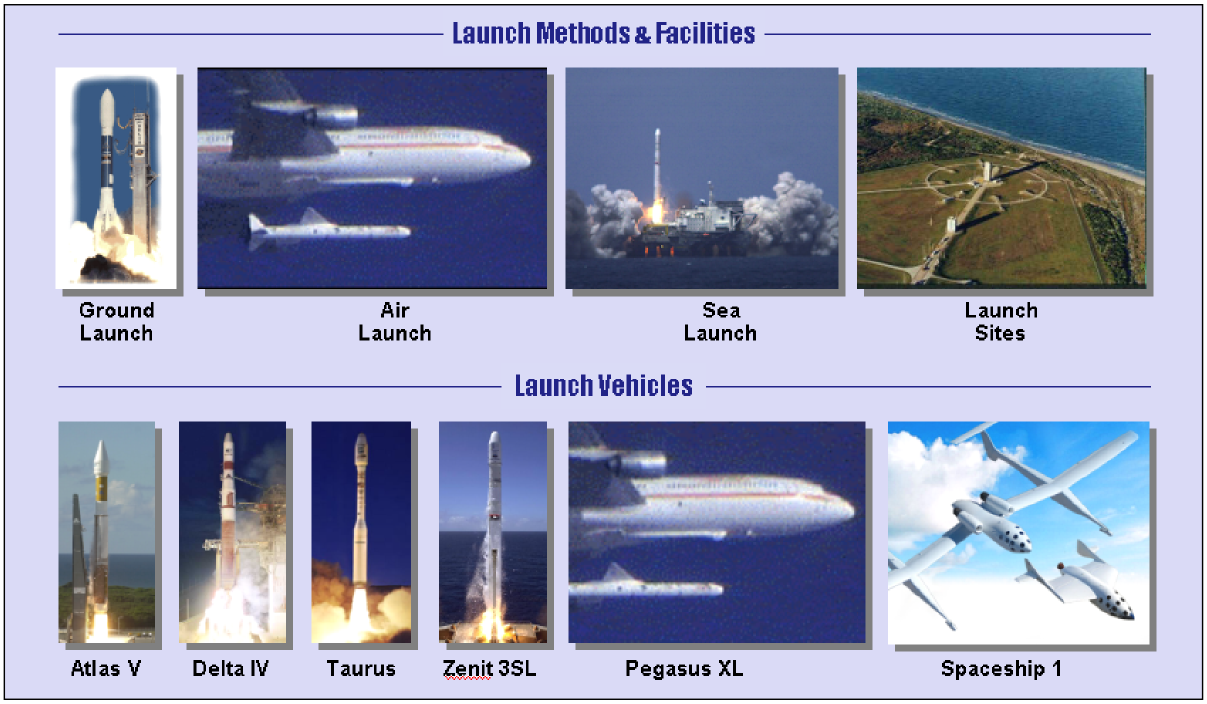
Resource and Threat Management. From the present to 2025, government and commercial enterprises will increasingly provide human access to orbit to conduct a wide range of military, scientific, and (to a limited degree) tourism applications. As a possible medium-term spin-off from these developments, non-human-centered capabilities will be developed for asteroid negation, hazardous waste disposal, space debris management, and natural resource acquisition.

Far-Term Applications. In 2025 and beyond, a CST system such as described in paragraph 1.1.1 will support an increasingly wide range of human activities in space. In addition to the orbital transfer facilities that will enable highly conventionalized access to orbit, other permanent stations will be used as tourist attractions, medical facilities, manufacturing and agriculture facilities, business parks, and movie production studios. In addition, the same Earth-orbit infrastructure will provide bases from which to develop space settlements, conduct space science, and support solar system exploration.

1.1.3. Emerging Regulatory and Operational Environment

One of the primary responsibilities of AST-100 is to help identify requirements for the integration of CST operations in the NAS. Other AST divisions are involved in the licensing of space vehicles and spaceports. Thus the scope of AST's overall responsibility encompasses the licensing and operation of launch/reentry vehicles and facilities. Figure 1-1 depicts some of the operational methods, facilities, and vehicles that are within AST's scope of responsibility.

Figure 1-1: AST Areas of Interest.



The CST regulatory environment is rapidly evolving to keep pace with industry developments. Currently, the primary regulatory framework governing CST activities is provided by Title 14 Code of Federal Regulations (CFR) Chapter 3, Commercial Space Transportation, Federal Aviation Administration, Department of Transportation. Within this Chapter:

- Paragraph 420.31, Launch Site Air Traffic Requirements, specifies launch site operator requirements for launch and reentry site use agreements, and for agreements regarding notices to airmen and mariners.
- Paragraph 431.75, Launch Vehicle Air Traffic Requirements, specifies vehicle operator requirements for agreements regarding notices to mariners, and for agreements with relevant Air Traffic Control organizations.

1.2. DOCUMENT SCOPE AND PLAN

The preceding discussion has highlighted various considerations related to CST operations extending from the present day into the far future. The long-term vision described in paragraph 1.1.1 is presented as one example of an end-state goal that could help guide the evolution of CST capabilities over the next 20 years. The remainder of this document focuses on the near- to medium-term integration of the emerging generation of suborbital RLVs into NAS operations. In addition, since a reasonable likelihood exists that orbital RLVs will emerge in the medium term, this document addresses those operations as well. This document is structured as follows:

- Section 1. Introduction
- Section 2. Operational Overview.
- Section 3. CST Integration in the NAS.
- Section 4. Summary.

1.3. REFERENCES

- *2005 U.S. Commercial Space Transportation Development and Concepts: Vehicles, Technologies, and Spaceports*, AST, January 2005.
- *Suborbital Reusable Launch Vehicles and Emerging Markets*, AST, February 2005.
- *Commercial Space Transportation Study*, NASA, 1994. (http://www.hq.nasa.gov/webaccess/CommSpaceTrans/)
- *Title 14 Code of Federal Regulations, Chapter 3, Commercial Space Transportation, Part 400*.

CONCEPT OF OPERATIONS FOR COMMERCIAL SPACE TRANSPORTATION IN THE NAS

ADDENDUM 1: OPERATIONAL DESCRIPTION

2.0 OPERATIONAL OVERVIEW

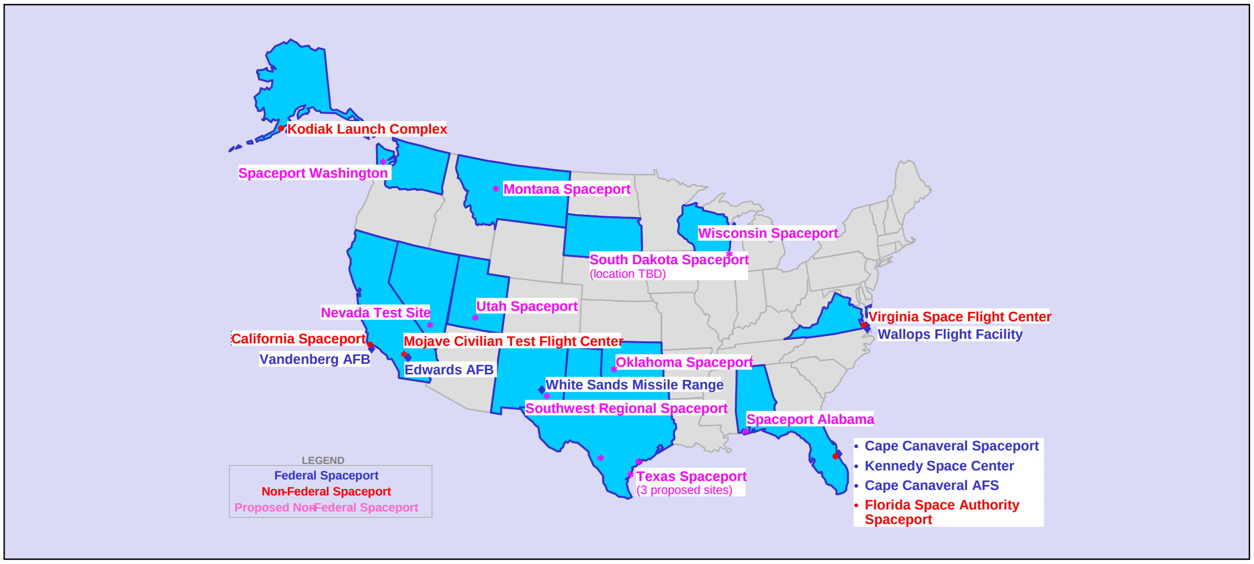
Space vehicle performance will require the NAS to handle most launch and reentry operations differently than conventional air traffic. The NAS already handles numerous kinds of special operations using procedures that can be adapted to the emerging CST concepts. The majority of these procedures involve the definition and scheduling of reserved airspace for use by the special operation. By establishing space vehicles in reserved airspace using such procedures, the role of the air traffic control (ATC) system will be limited to conformance monitoring to verify that the space vehicle remains within its reserved airspace, and airspace avoidance to ensure that opposing air traffic remains outside of the reserved airspace.

With the role of ATC thus simplified, the integration of CST operations in the NAS will be largely the dual process of airspace design and traffic flow management (TFM) planning. This process will begin by defining space vehicle trajectories based on spaceport locations, space vehicle performance, and prevailing traffic flows. Airspace will then be designed to encompass the trajectories. Appropriate airspace will then be scheduled for use on an as-needed basis, and the TFM system[2] will take action to aid the ATC system in diverting air traffic flows away from the reserved airspace. The balance of this paragraph describes the spaceports and space vehicles that the NAS will need to support, and outlines the major phases of flight that will be used by the various space vehicle concepts.

2.1. SPACEPORTS

The U.S. currently has ten spaceports to support commercial space flight operations. Because many of these sites are designed primarily for ELV launches to orbit, they are not well suited to the emerging generation of piloted RLVs. For these vehicles will generally not require the launch pads or range infrastructure of ELV launches to orbit, and the CST industry is also concerned about the cost and regulatory burdens of federal launch ranges and co-located spaceports. Therefore, several new spaceports specifically designed for commercial RLV operations have been or are being developed. Figure 2-1 depicts 22 spaceports in 14 states that are either in use or currently under development.

Figure 2-1: Current and Planned U.S. Spaceports.



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[2] As stated on the FAA's TFM Modernization web site, "The 'TFM system' minimizes airway and airport congestion by balancing flight demands with NAS capacity."

While all of these spaceports are being developed for the first generation of suborbital RLVs, many of them will evolve along with RLV capabilities to support orbital flight when that becomes achievable. East Kern Airport in California is the latest facility to obtain an FAA license to serve suborbital vehicles that take off and land horizontally. Operators in New Mexico, Oklahoma, and Texas are also seeking spaceport licenses, in addition to those already licensed in California , Florida, Virginia, and Alaska.

2.2. SPACE VEHICLES[3]

In addition to the emergence of RLV operations, the CST industry will continue to use ELVs through the foreseeable future. Because these ELVs will likely retain the basic operational characteristics of today's vehicles, they will continue to operate infrequently and from coastal spaceports. In contrast, RLV developers are proposing a wide range of design techniques. As a result, the integration of ELV operations in the NAS will likely use the same techniques as today, while the integration of RLVs will require operational innovation to accommodate a wide range of operating techniques.

2.2.1. Expendable Launch Vehicles

In 2004, the FAA licensed nine orbital launches out of 15 commercial orbital launches worldwide. Lockheed Martin launched five commercial Atlases and one Titan 4. Boeing launched seven Delta 2s and one Delta 4. Orbital Sciences launched one commercial Taurus, and Sea Launch performed three commercial Zenit-3SL launches. As the market for commercial launches expands in the future, so will the demand for inexpensive, innovative rockets. Thus a number of commercial ELVs are under development to serve smaller payloads. Small entrepreneurial companies focusing on specific market niches, such as small government payloads, are developing these ELVs. A number of key developments for these types of ELVs have emerged, thus assisting the pursuit of private investment.

2.2.2. Reusable Launch Vehicles

Historically, one of the enabling elements for new industries has been the development of common industry-wide standards, and this will inevitably occur in the CST industry. But that day has not yet arrived, as today's RLV concepts involve numerous and widely varied designs. These include vehicles that launch vertically, horizontally, from aircraft, or from balloons. Landing techniques include various combinations of wings, jets, rockets, rotors, and parachutes. It is not yet clear which of these techniques will survive to provide the design conventions of the future, but it is possible that a wide variety of vehicle concepts will initially be used to serve different markets.

Although RLV development has been hindered in the past by a number of factors, the pace of development has recently accelerated in response to competition for the $10 million Ansari X Prize. Successful completion of that competition proved that private companies can develop ways to travel to space without the extreme expense of government-funded programs. Another positive result has been the attraction of capital to the CST industry. For example, Sir Richard Branson, founder of Virgin Airlines, has teamed with Mojave Aerospace Ventures to create a new company, Virgin Galactic, that will develop large RLVs to carry paying passengers into space.

Inventors other than X-Prize contenders are also developing commercial RLVs. For example, SpaceDev signed an agreement with the NASA Ames Research Center for technology collaboration in designing a commercial, manned, suborbital vehicle. In addition, the Space Exploration Technologies Corporation (SpaceX) Falcon 1, a partially reusable launch vehicle, was placed on the SpaceX launch pad at Vandenberg Air Force Base, California, and is currently undergoing final tests.

Finally, technologies that encourage development of commercially viable orbital RLVs are also under development. For example, Bigelow Aerospace is developing inflatable space habitats with assistance from the NASA Johnson Space Center. These modules will provide commercial destinations in space that will support an array of scientific, technical, business, and leisure activities.

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[3] Reference *2005 U.S. Commercial Space Transportation Development and Concepts: Vehicles, Technologies, and Spaceports*, AST, January 2005, and *Suborbital Reusable Launch Vehicles and Emerging Markets*, AST, February 2005.

2.3. SPACE MISSION ELEMENTS

As just discussed, ELVs and RLVs will apply a wide range of operational techniques to reach and return from space. The operational characteristics of the many emerging RLV concepts conform to no standard, and it is too soon to determine which of the concepts will actually enter service. Thus it is not feasible to address specific characteristics of the vehicles that the NAS will need to support. However, a survey of space vehicle concepts indicates that they all must use some combination of 12 general mission elements for the full range of suborbital and orbital operations. As shown on Table 2-1, these elements are in the areas of mission planning, launch operations, and reentry operations.

Table 2-1: Common Space Mission Elements.

Mission Planning	Launch Operations	Reentry Operations
▪ Strategic Mission Planning ▪ Flight Day Planning ▪ On-Orbit Reentry Planning	▪ Vertical Launch ▪ Horizontal Single-Stage-to-Orbit Launch ▪ Air Launch & Ferry Aircraft Return ▪ Vertical Ascent Through the NAS ▪ Upper Stage Separation	▪ Atmospheric Reentry ▪ Steep Descent Through the NAS ▪ Non-Conventional Return ▪ Conventional Return

The planning phase may begin weeks or months before a mission, while launch and reentry operations represent flight-day activities. Preceding all of these activities is a process in which airspace is designed to encompass any acceptable trajectory to and from all spaceports in the NAS. The balance of this paragraph describes the 12 common mission elements. Section 3 then discusses the airspace design, mission planning, and flight-day launch and reentry processes.

2.3.1. Mission Planning

Today's mission planning includes strategic planning that begins long before the mission, and short term planning on the day of the launch. In the future, commercial missions will also require on-orbit reentry planning. Today's planning process is time-consuming and extremely mission-centric. As CST operations become more routine, mission planning will continue to involve the same problem solving that is required today. However, the planning process itself will become increasingly shorter term, electronic, and operationally proceduralized. The objectives of the planning processes that will need to be accomplished throughout the foreseeable future are as follows:

Strategic Mission Planning. The objective of the strategic planning process is to develop an end-to-end mission profile that meets user requirements while being sensitive to TFM conditions and constraints. The overall process consists of mission profile development by the vehicle operator, and collaboration between the vehicle operator and the TFM system to integrate the mission into predicted traffic environment. The process includes planning for nominal mission implementation and for all abort modes and contingencies.

Flight-Day Planning. On the day of the launch, the mission profile developed in the strategic planning phase is validated based on prevailing weather and TFM constraints. In the case of suborbital and short-duration orbital flights, this validation will encompass the end-to-end mission profile. For long-duration orbital flights, the process will focus either on the launch or on the reentry, whichever is applicable. When weather or traffic requires it, the originally planned mission profile will be modified to accommodate the prevailing constraints.

On-Orbit Reentry Planning and Coordination. Orbital missions will not require a clearance to reenter the NAS, but they will provide timely notification of their return along one of the preplanned reentry trajectories. The strategic planning process will define the reentry trajectories that the space vehicle will use for its nominal mission profile, and for all contingencies. These plans will be continually updated with the NAS, and may be modified while on-orbit based on weather and traffic conditions.

2.3.2. Launch Operations

As shown on the upper panel of Figure 2-2 below, there are only four general ways for space vehicles to reach space. In all but one of these cases, the entire launch process will be integrated into the NAS using reserved airspace. Suborbital operations will use the same methods, but these flights will simply transition directly from the vertical ascent phase on the upper panel, to the steep decelerating trajectory on the lower panel.

Vertical Ascent Through The NAS. As shown in black on Figure 2-2, all concepts will use a nearly vertical trajectory through the NAS that will be entirely contained within reserved airspace. A variety of methods will be used before initiating the vertical ascent, as discussed in the following paragraphs.

Vertical Launch. The method shown in red on the Figure represents the launch technique used by ELVs. The vehicle leaves the ground vertically and proceeds directly to the vertical ascent phase through the NAS. This phase will be conducted within reserved airspace in all cases.

Horizontal Single-Stage-to-Orbit (SSTO) Launch. As shown in orange, the majority of SSTO concepts will take off horizontally from a conventional runway and transition immediately to the vertical ascent. These operations will be entirely contained within reserved airspace.

Horizontal Two-Stage-to-Orbit (TSTO) Launch. Some RLV concepts call for the vehicle to be taken to an airborne launch point by a ferry aircraft. Some of these first-stage aircraft are piloted, and some operate autonomously. As shown in blue on Figure 2-2, piloted ferry aircraft may operate outside of reserved airspace while en route to and from the airborne launch point. Autonomous first-stage aircraft (shown in green) would be required to remain within reserved airspace.

Upper Stage Separation. Most ELVs and possibly some RLVs will discard components late in the launch trajectory. This phase will be performed both within reserved airspace and over water.

2.3.3. Reentry Operations

The lower panel of Figure 2-2 illustrates the general means by which the various vehicle concepts can reenter the atmosphere and return to base. Three methods involve aerodynamic flight, and one that is a ballistic descent all the way from space down nearly to the surface. All but one of these flight phases will be conducted within reserved airspace.

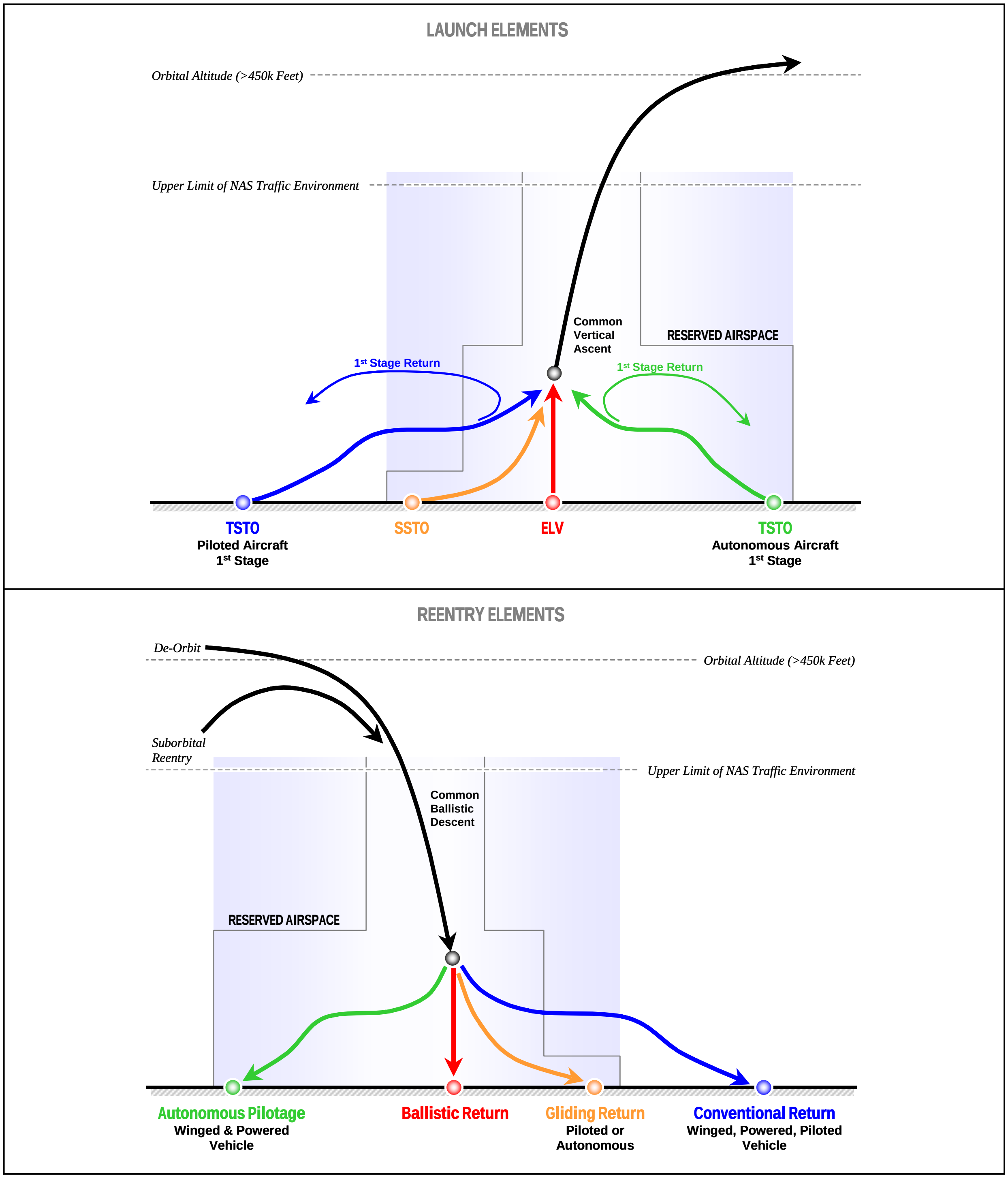
Atmospheric Reentry. All orbital and suborbital vehicles will exit the atmosphere during the launch phase. Upon reaching suborbital apogee or upon de-orbit, the vehicles will fall a great distance before reaching the air traffic environment. While the NAS will be involved in the planning of this maneuver, the maneuver itself will be conducted above NAS airspace structures.

Steep Descent Through The NAS. Upon initially entering the air traffic environment during reentry, all space vehicles will be traveling too fast to be tracked or controlled. This phase of flight (shown in black) will therefore be contained within reserved airspace.

Non-Conventional Return. Many RLV concepts propose some combination of unpiloted, *or* unwinged, *or* unpowered reentry vehicles (as shown in red, green, and orange). Because these vehicles cannot comply with the full range of ATC clearances, they will all be contained within reserved airspace.

Conventional Return. As shown in blue, some RLV concepts use piloted, *and* winged, *and* powered reentry vehicles that achieve normal performance characteristics at some point within a conventional altitude range. Because these vehicles will be able to comply with normal ATC clearances, they may depart reserved airspace and receive conventional ATC services for their return to base.

Figure 2-2: General Launch and Reentry Elements.



3.0 CST INTEGRATION IN THE NAS

The majority of CST launches to date have been conducted by ELVs from coastal spaceports that are co-located with federal space launch ranges. These over-water launches have used the Restricted Airspace structures and the airspace scheduling processes that have evolved since the 1950s to support federal launches. As a result of these legacy airspace designs and planning processes, air traffic is often excluded from massive airspace structures for extensive periods of time, both before and after the actual launch. The impact of these restrictions has remained acceptable due to the infrequency of launches, and because the restrictions have been limited to coastal and oceanic traffic flows.

However, major traffic flows will eventually be affected as the commercial launch rate increases, and as launches move to inland locations. Therefore, a major goal of SATMS will be to define ways to 1) reduce the amount of airspace that is restricted for each launch, 2) reduce the amount of time that the restriction needs to be in effect, and 3) schedule the restriction so as to accommodate conventional air traffic while still achieving the space mission objectives.

In this regard, airspace management techniques that are equally relevant to aviation and space traffic are being studied by the FAA's Joint Planning and Development Office (JPDO), in a concept of operations that describes the evolution to the Next Generation Air Transportation System (NGATS) by 2025. Since the CST industry today is still in its infancy, the emerging NGATS concept represents the target environment that will guide the long-term development of CST technologies and procedures. The chief NGATS concepts that will be relevant to CST operations are as follows:

- *'4-D Trajectory Contracts.'* Integrated NGATS flight planning and traffic management processes will be based on the use of precise 4-dimensional trajectories. Upon receiving a flight plan request, the NGATS will deconflict the requested trajectory against all other users. When conflicts exist, the user and the NGATS will negotiate a revised trajectory. Once a deconflicted trajectory is accepted, the user will be committed to achieve the trajectory precisely, and the NAS will be committed to reserve that trajectory for that user. This 'contract' paradigm is well-suited to the integration of CST operations, since launch and reentry operations will require the space vehicle to reliably conform to the planned trajectory in order to remain within the airspace that has been reserved for the vehicle.
- *Traffic Analysis Capability.* The NGATS concept calls for a comprehensive 'airspace evaluator' that will plan traffic flows based on all traffic, weather, and infrastructure constraints. This capability will assist in determining the optimum timing of CST operations within their launch and reentry windows, and in efficiently managing opposing traffic to protect those operations.
- *Dynamic Airspace.* The NGATS will greatly reduce its reliance on the static sector boundaries that characterize today's system. Instead, it will dynamically alter ATC sectors to support prevailing traffic conditions. Using this capability, ATC facilities will be able to resectorize their airspace to efficiently handle the airspace that is reserved for a given CST operation.

It currently appears likely that suborbital adventure travel will increase the CST launch rate well before these NGATS capabilities are achieved. Thus near-term CST operations will be handled using today's airspace design methods and operational procedures. The balance of this paragraph describes the considerations involved in CST operations in any time frame, in terms of 1) airspace design and scheduling to enable highly proceduralized mission planning, 2) strategic mission planning to develop mission profiles based on predicted operational conditions, and 3) flight-day activities that will effectively implement the mission profile under prevailing conditions.

3.1. TRAJECTORY DEFINITION AND AIRSPACE DESIGN

From the perspective of the NAS, strategic mission planning is primarily a function of identifying the airspace that needs to be reserved for the space mission, and planning traffic flows to protect that reserved airspace. Before this operational function can be performed, the trajectories that are feasible for the mission must be determined, and the airspace that will be reserved for the space mission must be designed. This paragraph outlines the trajectory and airspace design processes that precede the strategic mission planning phase.

3.1.1. Trajectory Definition

Spaceport and space vehicle operators have various requirements for defining space mission trajectories, as follows:

- In order for a non-federal entity to operate a launch or reentry site in the U.S., it is required to obtain a license from the federal government through FAA/AST. As part of this process, the proposed spaceport must define the general trajectories that will be used for launch and reentry.
- As part of their vehicle licensing process, space vehicle operators must define the trajectories they will use for individual missions. This highly mission-centric requirement will continue for some time, but as CST operations become more routine, launch and reentry trajectories will ultimately become more akin to airport arrival and departure procedures.

Specific trajectory definitions for nominal and contingency operations will be affected by the following factors:

- Each type of space vehicle will have unique performance characteristics that will define that vehicle's launch and reentry trajectories.
- The space mission objective will significantly affect the desired 4-D trajectories. For example, suborbital flights will operate on defined paths over the ground, so mission timing will not be limited to strict launch or reentry windows. In contrast, orbital operations will often be time-constrained, and the path flown over the ground may vary based on the time of the operation.
- Each spaceport will have unique constraints limiting the areas that space vehicles can use for launch and return. Chief among these are the air traffic flows in the spaceport vicinity, which will necessitate extensive FAA involvement in the definition of space mission trajectories. Other constraints, such as public safety criteria, will also affect the definition of acceptable trajectories.
- Environmental factors, such as noise and emissions, will place some limitations on the launch and reentry trajectories that can be used.

3.1.2. Airspace Design

The dual purpose of a space mission's protected airspace is to segregate the vehicle from other air traffic, and to protect people and assets on the surface. Once the spaceport and space vehicle operators have defined their launch and reentry trajectories, they will collaborate with the FAA in the design of airspace structures that will encompass them. Two major factors affecting the design of the reserved airspace are:

- *Vehicle Safety.* The potential for catastrophic failure by the space vehicle will affect the size and shape of the reserved airspace. For example, vehicles carrying large fuel loads and structures will pose more risk and require more protected airspace than smaller vehicles carrying less fuel. To assure air safety, some vehicles will require airspace that prevents air traffic from operating underneath the vehicle. To assure public safety, the airspace for some vehicles will need to encompass the predicted debris pattern on the surface.
- *Navigation Performance.* Vehicles that can precisely conform to their planned trajectories will require less reserved airspace than those that cannot. Thus the ability to conform to planned trajectories will be determined primarily by the vehicle's flight characteristics and the accuracy of its navigation and flight management and control systems.

New airspace-reservation techniques dedicated to CST operations will likely emerge to regularize the airspace design process. For example, the SATMS Concept of Operations describes the use of Space Transition Corridors (STCs) to segregate space missions from aviation traffic. In the near term, however, three airspace-reservation techniques that are commonly used today will be applied to CST operations, as follows:

- *Restricted Airspace.* Some of today's spaceports have existing Restricted Airspace that is routinely used for space launches. For operations at these spaceports, this airspace may be reserved for any altitude block from the surface upwards, in order to sterilize the vicinity around the space vehicle trajectory of all other air traffic. However, this type of airspace will not be developed at all spaceports because of the extensive design process that is involved.
- *Altitude Reservations (ALTRVs).* Space missions that only require reserved airspace at Flight Level 180 or above may use an ALTRV. However, ALTRVs do not suit the purpose at altitudes below FL180 because they can not exclude Visual Flight Rules traffic.
- *Temporary Flight Restrictions (TFRs).* The airspace for most CST operations will likely be reserved using predefined TFRs that will be activated as needed. TFRs can be rapidly defined and scheduled, and they exclude all air traffic at all altitudes as specified. Therefore, TFRs will be used when suitable Restricted Airspace does not already exist, when the low-altitude airspace around the space mission must be sterilized, or both.

3.2. STRATEGIC MISSION PLANNING

Strategic planning by the vehicle operator for a specific mission encompasses the full range of activities related to vehicle and payload preparation, and end-to-end mission profile development. This overall process is conducted in collaboration with various FAA regulatory and certification organizations. However, operational mission planning by the NAS consists primarily of an airspace scheduling and notification process that focuses on the end-to-end mission profile. This profile will define trajectory and reserved-airspace requirements for the nominal mission, and for all abort modes and contingencies.

Today, this process is roughly analogous to the flight plan filing process used by conventional NAS users, but it is conducted weeks and even months in advance (versus hours in advance for aviation operators). As CST operations become routine, the mission planning process will become shorter-term and more operationally proceduralized. But regardless of the procedures used or the planning time frame, the objective of the process will remain the same — i.e., to schedule the airspace needed to protect the space mission, and to notify the public and relevant government entities of the activities that will occur to support the mission.

3.2.1. Airspace Scheduling

For the foreseeable future, airspace scheduling for the majority of launch/reentry operations will be performed before the flight-day. For orbital operations, strategic reentry planning will continue throughout the time the vehicle is on-orbit. Thus the strategic planning process will be based on fairly long-range predictions of weather, traffic, and NAS infrastructure conditions. In this process, the vehicle operator will collaborate with the local ATC facility and the Air Traffic Control System Command Center (ATCSCC) to balance the launch and reentry requirements of the space mission against the needs of the interacting traffic flows. The products of this collaboration will be 1) an end-to-end mission profile (including abort modes and contingencies) that addresses the needs of aviation users, 2) the identification and schedule of the predefined airspace structures to be reserved for the operation, and 3) a plan for managing traffic flows to protect that reserved airspace.

3.2.2. Information Distribution

Once the airspace needed to protect the CST launch and reentry operation is identified and scheduled, the following entities will be notified:

- *Central Altitude Reservation Facility (CARF).* Required airspace closures will be communicated to CARF, which will develop and disseminate Notices to Airmen (NOTAMs).
- *U.S. Coast Guard (USCG).* Maritime areas that will be affected by CST missions will be communicated to the USCG, which will develop and disseminate Notices to Mariners.
- *U.S. Strategic Command (U.S. STRATCOM).* Space mission launch and reentry trajectories will be communicated to U.S. STRATCOM, which will perform a space-traffic collision avoidance (COLA) analysis.
- *ATC Facilities.* Traffic management personnel at all towers, approach controls, and air route traffic control centers that will handle either the CST operation or the interacting traffic flows will be notified of the mission profile and the TFM plans.
- *Airline Operations Centers.* Airline industry representatives at the ATCSCC will be involved in the collaborative airspace scheduling process. Once the process is complete, the AOCs of affected airlines will be notified of airspace closures and TFM plans.

3.3. FLIGHT-DAY OPERATIONS

On the day of the launch/reentry operation, the mission profile and TFM plans developed in the strategic planning phase will be validated based on prevailing traffic, weather, and NAS infrastructure conditions. In the case of suborbital and short-duration orbital flights, this validation will encompass both the launch and reentry. For long-duration orbital flights, the process will focus either on the launch or the reentry, whichever is applicable. Once the mission profile and associated trajectory and airspace requirements are finalized, the TFM system will finalize and distribute the relevant 'Traffic Management (TM) Initiatives.' The ATC system will then implement TM Initiative actions as required to support the space mission and to manage the interacting traffic flows.

3.3.1. Trajectory and Airspace Validation

The strategic mission planning process will determine the optimum space vehicle trajectory, airspace allocation, and traffic flows, based on *predicted* weather, traffic, and NAS infrastructure conditions. As *actual* conditions become known on the flight-day, the strategically planned mission profile and the planned TFM responses will either be validated or modified as required. Thus on the flight-day (but well prior to the launch/reentry operation), the space vehicle operator will evaluate the mission profile in view of emerging weather conditions, and other factors related to the vehicle and payload. In coordination with the local ATC facility and the ATCSCC, the operator will either continue implementation of the existing mission profile, or modify its trajectory and airspace requirements to accommodate the changing operational conditions.

3.3.2. TFM Operations

Today's system requires on-going TFM manipulation of the traffic situation as unforeseen traffic interactions occur. As conceived in the JPDO's NGATS vision, integrated flight planning and TFM processes in 2025 will resolve all traffic problems when the users' flight plans are filed. Both today's system and the NGATS vision implement a similar problem-solving process, with the main distinction being that NGATS will complete the process much further in advance than is feasible today. The balance of this paragraph describes the general TFM problem solving process that will occur both now and in the future.

TFM Objectives and Methods. In any era, the aim of the TFM system will be to prevent localized traffic problems from propagating through the NAS. Each TFM problem presents a unique combination of traffic, weather, and NAS infrastructure conditions. But even with this variability, the general problem set and the set of actions available to resolve those problems are fairly limited, as follows:

- Three TFM problems that routinely occur are 1) airport demand/capacity imbalances, 2) airspace demand/capacity imbalances, and 3) emergence of unusable airspace.
- Two TFM techniques that can be applied to any of the three problems are 1) airspace-avoidance techniques that remove demand from impacted sectors, fixes, runways, and 2) demand modulation techniques that spread out the demand to produce a workable traffic flow.

CST launch and reentry operations will frequently render airspace unusable to aviation traffic. Airspace-avoidance techniques will provide the most common solution to this problem, using either altitude revisions or reroutes. Minor altitude revisions are simpler and place the least impact on the user. But reroutes will likely be most frequently used because the vertical extent of the CST airspace reservation will often make it infeasible to divert opposing traffic flows above or below it.

Either of these airspace avoidance techniques can cause airspace demand/capacity imbalances in the sectors that receive the diverted traffic. When this secondary problem occurs, any of several demand modulation techniques may be used to spread out the traffic flow entering the affected sector. These techniques include miles-in-trail or metering restrictions, Call For Release, Ground Delay Programs, ground stops, and airborne holding.

Flight-Day Space Mission Coordination. Traffic managers and the space vehicle operator will coordinate to validate the strategically planned mission requirements. In addition to this coordination, the ATCSCC will conduct a collaborative decision making (CDM) process that will include the Traffic Management Units (TMUs) at affected ATC facilities, NAS users, and relevant DoD organizations. Through this collaboration, the TFM system will balance the needs of the space mission and other airspace users when modifications to the mission plan are required.

TM Initiative Development. The TFM role in flight-day planning is largely completed by developing TM Initiatives that reflect the actions identified in the CDM process, and by communicating those Initiatives to the ATC system for implementation. Each TM Initiative represents a specific TFM action required to resolve a given problem. For example, the closure of airspace to aviation traffic might be resolved by rerouting several aircraft. If this action creates a demand/capacity imbalance in the sector receiving the diverted traffic, a metering requirement might be placed on aircraft in that sector's traffic flow. In such case, the action to reroute the selected flights will be implemented by one TM Initiative, while the metering requirement will be implemented by another.

3.3.3. ATC Services

As previously discussed, the role of ATC in the majority of launch/reentry operations will be limited to maintaining awareness of the airspace that is reserved for the space mission, and implementing the TM Initiatives defined by the TFM system to ensure that all other air traffic avoids that airspace. This paragraph describes the ATC services provided to interacting traffic flows, and those provided to the space vehicles themselves.

TM Initiative Implementation. The majority of the actions required by a CST-related TM Initiative will be taken against the traffic flows that could potentially interact with the space mission. Based on CDM in the TM Initiative development process, AOCs can reflect TM Initiative requirements in the flight plans that they initially file with the system. But because the TFM system does not communicate with aircraft, TM Initiative requirements affecting flights that are already active (or soon-to-be active) must be implemented by the ATC system.

To that end, TM Initiatives will be communicated by various means to the TMUs in the affected ATC facilities. TMU traffic managers will then communicate TM Initiative requirements to the appropriate ATC positions in the facility. These requirements will typically describe the mission's airspace reservation, and the actions to be implemented on aviation traffic flows.

- *Predeparture Aircraft.* Tower positions at departure airports can revise the proposed flight plans in order to change the clearances that the predeparture aircraft will initially receive. Route changes in the flight plan will ensure avoidance of the airspace that is reserved for the space mission. If the reroutes needed to protect the space mission create a sector overload, another TM Initiative may direct the tower to impose ground delays, ground stops, etc.
- *Airborne Aircraft.* Terminal and en route controllers at sectors in the vicinity of the space mission will maintain awareness of the airspace reserved for the mission, and ensure that no air traffic enters it. Sectors further away will implement TM Initiative requirements affecting aircraft that are bound for the vicinity of the mission by issuing the altitude and route revisions specified in the Initiative. And again, if the reroutes needed to protect the space mission create a sector overload, these controllers will take the control actions needed to implement TM Initiative requirements for mile-in-trail or metering restrictions, airborne holding, etc.

Space Vehicle Support

Towers, approach controls, and centers will interact directly with space vehicles as follows:

- *Clearance Delivery and Surface Movement.* RLVs will receive conventional flight plan clearances from the ATC facility having control responsibility over the spaceport. RLVs operating from controlled airports will also receive conventional taxi instructions and takeoff clearance.
- *Airborne Situation Awareness and Conformance Monitoring.* Today, controllers will maintain awareness of the mission's reserved airspace, and ensure that no other traffic enters it. For many missions, ATC situation awareness may be constrained by communications and surveillance capabilities that could make it infeasible for a sector to track the positions of space vehicles, or to communicate with them. The reserved airspace for these missions will be large enough to encompass any feasible deviation from the planned trajectory, and controllers will rely on reports relayed from the vehicle operator through the TFM system to monitor conformance of the vehicle to its planned trajectory.

  In the future, launch/reentry activities will continue to operate in reserved airspace, because their ultra-high performance will always render them 'uncontrollable' in the ATC sense of the word. But advanced technologies may make it possible for a sector to track vehicle position, and thus monitor conformance to the planned trajectories. This would allow a reduction in the size of the reserved airspace, enable more flexible handling of interacting traffic, and expedite and improve the ATC response to contingencies.
- *Conventional Advisory and Separation Assurance Services.* Two modes of launch/reentry can be provided the same separation assurance and ATC advisory services that conventional traffic receives. These are 1) the departure and return of conventional aircraft that ferry the space vehicle to an airborne launch, and 2) the conventional return to base by a powered, winged, and piloted RLV that can assume normal aircraft performance characteristics.
- *Contingency Operations.* The TFM and ATC systems will collaborate in the detection of abnormal operations and in the implementation of preplanned contingency responses. All foreseeable contingencies will be included in the overall mission plan. Vehicle operators will coordinate with the TFM system when abnormal conditions occur, and identify the appropriate contingency response. The TFM system will then coordinate with the appropriate ATC facility to implement the response. In most cases, these responses will be in the way of changes to the size, location, and scheduling of the airspace that will be reserved for the space mission.

3.4. EMERGENCY PLANNING AND RESPONSE

Planning and implementing responses to CST emergencies will include extensive planning by the vehicle operator, and expanded detection and response capabilities by the NAS. This paragraph describes the general emergency and alerting functions that will support CST operations.

3.4.1. Emergency Planning

Operators are required to submit a mishap investigation plan (MIP) containing procedures for reporting and responding to launch and reentry accidents, incidents, or mishaps that may occur during an RLV mission. They also submit an emergency response plan (ERP) that contains procedures for informing the affected public of a planned RLV mission.

Mishap Investigation Plan

The MIP defines requirements for the immediate response to a mishap, and for investigating and reporting the mishap, as follows:

- *Mishap Response Plan.* The MIP defines procedures to 1) contain the consequences of the event, 2) ensure data and physical evidence are preserved, 3) coordinate with National Transportation Safety Board and FAA investigations, and 4) identify measures to avoid recurrence of the event.
- *Investigation Plan.* The MIP 1) defines procedures for investigating the cause of an event, 2) defines procedures for reporting investigation results to the FAA, and 3) delineates responsibilities for personnel assigned to conduct investigations.
- *Reporting.* Regulations currently require notification to the FAA Washington Operations Center in case of a launch or reentry accident, incident, or mishap involving a fatality or serious injury. Notification to AST is required within 24 hours of a mishap that does not involve a fatality or serious injury. And within five days, a preliminary report to AST is required to specify 1) identification of vehicle, payload, and mission plan, 2) description of the event, 3) action taken to contain the event, 4) number and description of fatalities and injuries, 5) estimate of property damage, and 6) potential consequences for other vehicles of similar type and proposed operations.

Emergency Response Plan

The ERP describes the processes to be used for notification to local officials in the event of an unplanned landing so that vehicle recovery can be conducted safely, effectively, and with minimal risk to public safety. The plan must provide for the quick dissemination of up to date information to the public, and for doing so in advance of reentry to the extent feasible. A public information dissemination plan is also required for informing the affected public, in advance of a planned reentry, of the estimated date, time, and landing location of the activity.

3.4.2. NAS Emergency and Alerting Services

The NAS emergency and alerting service monitors the system for distress situations, evaluates the nature of the situation, and provides an appropriate response. When a user is overdue or missing, a communications search is initiated to determine when the aircraft last contacted an ATC facility. Emergency assistance ranges from information and advice, to alerting rescue agencies of the situation. CST operations will impose new emergency and alerting requirements in the two following areas:

- *Emergency Detection.* The majority of emergencies today are detected through controller/pilot communications (or through their loss). Since most CST operations will not involve direct controller/pilot communications, information relays from the vehicle operators will be required to inform appropriate NAS personnel of mission emergencies.
- *Response Organization Alerting.* Most NAS emergencies today are handled by domestic response organizations. Because emergencies may force orbital CST operations to be aborted anywhere in the world, the alerting function will need to be expanded globally to include relevant domestic, international, and foreign response organizations.

CONCEPT OF OPERATIONS FOR COMMERCIAL SPACE TRANSPORTATION IN THE NAS

ADDENDUM 1: OPERATIONAL DESCRIPTION

4.0 SUMMARY

The *Concept of Operations for Commercial Space Transportation (CST) in the National Airspace System (NAS), Version 2* encompasses various aspects of space vehicle design, licensing, and operation. This Addendum focuses on the functions involved in daily NAS operations, in order to reflect industry developments that have occurred since the Concept of Operations was last revised. The scope of this document extends from the present to 2025, and includes 1) those aspects of suborbital and orbital CST operations that involve NAS air traffic controllers and traffic managers, and 2) the supporting functions that are required for space vehicles to comply with the requirements of real time air traffic operations.

4.1. CST INDUSTRY ENVIRONMENT

Today's commercial space-access market focuses primarily on the placement of uninhabited satellites in Earth orbit. By the nature of this market, the scope of the CST industry remains limited, and the impact of CST operations on the NAS remains comparatively minor. But the recent success of SpaceShipOne indicates that suborbital space tourism may substantially increase the commercial launch and reentry rate within the near term, and will require spaceports throughout the U.S. mainland. The increased rate of operations, the distribution of spaceports across the NAS, and the frequent occurrence of RLV reentries will result in a new traffic population that will need to be integrated into NAS operations.

Far Future Vision. In 2025 and beyond, a mature CST industry will provide hub-to-hub services between U.S. spaceports and a constellation of 'Earth/space transfer facilities' in the lowest of sustainable Earth orbits.

Emerging Applications. The mature CST system will evolve through the emergence of various space applications, including suborbital adventure travel and point-to-point transportation, in addition to orbital applications such as communications, positioning, imaging, asteroid negation, hazardous waste disposal, space debris management, and natural resource acquisition.

Operational Overview. The growth in CST operations will involve an expanding system of spaceports and space vehicles. The U.S. now has ten spaceports, and new spaceports in 14 states are being developed. In addition to the emerging RLVs, the CST industry will continue to utilize ELVs through the foreseeable future. A survey of vehicle concepts indicates that they all will use some combination of 12 mission elements in the areas of mission planning, launch operations, and reentry operations.

4.2. CST INTEGRATION INTO THE NAS

The NAS will handle the increased number of CST launch/reentry operations through existing procedures that define and schedule reserved airspace for use by special operations. By establishing space vehicles in reserved airspace using such procedures, the role of the ATC system will be limited to conformance monitoring to verify that the space vehicle remains within its reserved airspace, and airspace avoidance to ensure that opposing air traffic remains outside of the reserved airspace.

The integration of CST operations in the NAS will then be largely the dual process of airspace design, and TFM planning. The major goals of these SATMS processes will be to define ways to 1) reduce the amount of airspace that is restricted for each launch, 2) reduce the amount of time that the restriction needs to be in effect, and 3) schedule the restriction so as to accommodate conventional air traffic while still achieving the space mission objectives.

Trajectory and Airspace Design. From the NAS perspective, mission planning is primarily a function of identifying the reserved airspace for the mission, and planning traffic flows to protect that airspace. Before this operational function can be performed, trajectories and airspace must be designed as follows:

- *Trajectory Definition.* Each spaceport will have unique constraints limiting the areas that space vehicles can use for launch and reentry. Chief among these are the air traffic flows in the spaceport vicinity, public safety criteria, noise, and emissions.
- *Airspace Design.* The dual purpose of a space mission's reserved airspace is to segregate the vehicle from other traffic, and to protect people and assets on the surface. Three current airspace-reservation techniques will be applied to CST operations are Restricted Airspace, ALTRVs, and TFRs.

Strategic Mission Planning. In collaboration with the local ATC facility and the ATCSCC, airspace scheduling for most CST operations will be performed before the flight-day, based on fairly long-range predictions of weather, traffic, and NAS infrastructure conditions. Once the airspace needed to protect the CST launch/reentry operation is identified and scheduled, various entities will be notified.

Flight-Day Operations. On the day of the launch/reentry operation, the strategically planned mission profile and TFM actions will be validated, and TM Initiatives will be defined and implemented as follows:

- *Trajectory and Airspace Validation.* The vehicle operator will evaluate the mission profile in view of emerging weather conditions, as well as other factors related to the vehicle and payload. In coordination with local ATC and the ATCSCC, the operator will either continue implementing the existing mission profile, or modify it to accommodate the changing operational conditions.
- *TFM Operations.* Traffic managers and the vehicle operator will coordinate to validate the strategically planned mission. In addition, the ATCSCC will conduct a CDM process that will include TMUs, NAS users, and relevant DoD organizations, to balance the needs of the space mission and those of other airspace users when modifications to the mission plan are required. The TFM role in flight-day planning is largely completed by developing TM Initiatives, and by communicating those Initiatives to the ATC system for implementation.
- *ATC Services.* The TMU will communicate TM Initiative requirements to the ATC positions in the facility. These requirements will typically describe the mission's airspace reservation and the actions to be taken on aviation traffic flows. ATC facilities will also interact directly with space vehicles for 1) clearance delivery and surface movement., 2) airborne situation awareness and conformance monitoring, 3) conventional advisory and separation assurance, and 4) contingency operations.

4.3. EMERGENCY PLANNING AND RESPONSE

Space vehicle operators are required to submit a Mishap Investigation Plan (MIP) that contains procedures for reporting and responding to launch and reentry accidents, incidents, or other mishaps. They also submit an Emergency Response Plan (ERP) that contains procedures for informing the affected public of a planned RLV mission. In real time operation, NAS emergency and alerting services are generally provided in the areas of:

- *Emergency Detection.* Most CST emergencies will be detected through information relays between the vehicle operators and the TFM system.
- *Response Organization Alerting.* Since emergencies may force orbital CST operations to be aborted anywhere in the world, a global alerting function will include all relevant domestic, international, and foreign response organizations.