Integration of Commercial Space Vehicle Traffic into the National Airspace System

Research Contract Data

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Table of Contents

Mission Statement

Air Traffic Control Project

[The Air Traffic Control Project was not authorized until April 8, 2011. The modified requirements were specified in the Research Grant Task Analysis - Revision III - 6-9-11. These tasks were to be carried out beginning after April 8, 2011.]

The current ATC system employs both terminal control (ATCT) and En Route control (ARTCC) systems to safely manage air traffic up to 60,000 ft. (FL 600). In order to safely integrate atmospheric traffic with transitional aircraft (atmospheric to space, and space to atmospheric), concepts and procedures for integration need to be developed. This task seeks to identify problems that the FAA must explore in the creation of additional ATC procedures and airspace structures to safely integrate commercial space operations into the existing NAS architecture.

Introduction

This document is divided into five basic sections:

1. The essential contract information.
2. The research mission statement.
3. A brief introduction to the history of airspace development to include concepts and definitions.
    - Ancient concepts which still affect modern airspace development and management.
    - Historical review of the NAS architecture and its control.
    - Examination of the current airspace structure.
4. A detailed analysis of the pertinent sections of the three primary FAA documents that define, direct and control the National Airspace System (NAS). The analyses seek to ask questions regarding the fine details of airspace design and operations, pilot responsibilities and air traffic control (ATC) that must be addressed in the safe integration of commercial space vehicles (CSV) into the NAS.
    - Federal Air Regulation (FAR) Part 91.
    - Airman's Information Manual (AIM).
    - FAA Order 7110.65T (ATC Handbook).
5. Attachments of some key documents that report on past efforts to address the integration of CSVs into the NAS. These documents may be referenced within this report in order to clarify specific points or concepts. These documents take a macro look at the integration problem, while this research effort addresses the problem from a micro point of view.

Professional airspace managers, current ATC specialists and individuals who have completed formal courses in Terminal Instrument Procedures (TERPS) development or Traffic Control and Landing System (TRACALS) training may want to go directly to Section 4 of this document.

However, Section 3 of this document places today's NAS integration problems into context and may assist the reader in understanding the complexity of the integration task. I recommend most reviewers read this section before proceeding to the technical questions in Section 4.

History of Airspace

NATIONAL AIRSPACE SYSTEM STRUCTURE BACKGROUND

The National Airspace System (NAS) is a common network of the following:

All airspace above US territory from the surface to infinity.

All aviation related navigational aids (NAVAIDs).

All aviation related support equipment for navigation.

All aviation services for navigation.

All aeronautical related cartographic products.

All aviation related information both technical and general in regards to navigation.

All aviation related rules regulations and procedures.

All the manpower necessary to support aviation activity in the NAS.

All material and money required to support aviation activity.

Early theory and law

The original concept was that the airspace belonged to everyone. Tradition held that no single entity restrict its use. Eventually, however, balloon flights by the French and glider flights by both the United States and Germany changed airspace concepts. National boundaries and sovereignty were threatened by the new reality of aircraft being able to transit international borders.

There had been no precedent available for the control and use of airspace. As a result, sovereign nations fell back on ancient maritime law and began using the basic principles of maritime law to govern operations in the world's airspace. One of the prime concepts in maritime law was the right of all users to innocent passage through the oceans of the world. Nations began to use this same concept for the transit of air machines to include balloons, aircraft, kites and almost anything else that we now considered aircraft through the airspace. Under this concept, all users of the airspace had the right to innocent passage as long as they did not threaten a sovereign nation. The concept mirrored the maritime concept of a movable sovereign state in which seagoing vessels were considered part of a sovereign state as long as they were clearly identified. In aviation, the international community adopted the same concept and decreed that aircraft properly identified were movable sovereign states that had the right to innocent passage. Just as ships were restricted from the protected waters of a sovereign state by a boundary so too was the airspace restricted to a sovereign nation from the surface to 1000 feet. This became the basis for international airspace operations.

The concept of innocent passage in restricted airspace up to 1000 feet continued as aviation developed. However, World War I brought significant airspace management changes and problems. The belligerent states involved in the World War I conflict declared complete sovereignty over airspace with no upper limit over the national territory. After World War I this concept became international law and stated that each country's airspace belonged to that nation. In addition, the sovereign nation could prohibit passage of any aircraft over its territory. Any aircraft trespassing through the airspace of a sovereign territory could be seized by the sovereign nation or, failing the seizure of the intruder, the sovereign nation could destroy the intruder. These basic concepts continue to form the foundation of modern international airspace law.

International airspace and aviation law began to gel with the International Air Navigation Conference of Versailles, France, in 1919. This conference confirmed and granted nations complete airspace sovereignty over the airspace covering their territory. However, even though the conference granted the right of innocent passage to all nations, some restrictions were placed on the innocent passage. First, airworthiness certificates could be required by the sovereign nation. Second, crew competency could be required in order to transit the sovereign nation's airspace. Third, aircraft had to carry national documents declaring that they were sovereign movable states of the registered country. Fourth, cabotage rights were validated. Fifth, a sovereign nation could require a monetary deposit or bond for the right to transit its airspace.

The international Air Traffic Association (IATA) was formed and met at the Hague in 1919 and continued to meet until 1939. The association had as its goal the promotion of international aviation. In addition, it had the power to resolve technical difficulties in disputes between nations over airspace and aviation related problems. Note that the IATA ceased to exist after 1939 when Germany invaded the lowland countries of Europe, and it has never been regenerated in its original form.

In the United States, airspace development took its lead from the IATA and developed its aviation industry into the world leader of airspace operations through modern times. However, prior to the IATA, no formal airspace definition was needed in the United States. That began to change in 1920 when the US Post Office Department established four aeronautical stations using bonfires as navigational aids (NAVAIDs) for airborne aircraft. These four stations used wood fired bonfires to light up the sky in relatively remote areas so that aircraft could fly from light to light at night. These fires were the beginning of NAVAIDs in the United States, and development has proceeded steadily ever since. In 1923, natural gas fires and electric arc lights were introduced to replace the bonfires and expand the aeronautical station system, and in 1925, the Air Mail act of 1925 gave aviation a financial boost. This act was the first major financial incentive to develop aviation throughout the country, and at this point, commercial aviation interests began controlling traffic in the airspace.

The introduction of air traffic control (ATC) produced conflict between the commercial interests of the United States and its military aviation operations. As a result, a committee was formed in 1925 to resolve the conflict. That committee produced a report, commonly known as the Morrow Report, which split the responsibility for United States airspace operations into two parts. Responsibility for parts of the airspace remained under federal control in the Department of Commerce while the ranges and other airspace essential to air operations pertinent to the military flights, remained under the War Department. This committee report is significant because it split responsibility for airspace in the United States into two distinct parts under two different controlling organizations. The split in airspace responsibility remains today.

In 1926, the Air Commerce Act was passed which regulated and promoted aviation. Perhaps the most significant part of this act was that it authorized airways and NAVAIDs for the first time. In addition, the science of radio transmission and receiving had developed to the point where airborne communications by radio were now possible. In 1928, the first aviation radio chain was established for the specific purpose of controlling aircraft, and the chain was a direct result of the increased traffic caused by the transportation of mail. The amount of traffic in the airspace began to grow at an astounding rate.

Certain areas of the United States proved to be high focal points for air traffic. Some of these are obvious. For example, Chicago, New York, St. Louis, Denver and Los Angeles were natural aviation hotbeds. However, one of the busiest and most logical landing places in the United States was considered a gateway between East and West and was saturated daily with transient traffic. This location was the airfield at St. Louis, and St. Louis had a serious air traffic problem as flights used it to refuel, make repairs and re-provision. As a result, the airfield hired what is generally considered to be the first air traffic controller in order to increase safety. The controller hired was Archie W. League, and his job was to communicate to ground and air traffic specific clearances for landing and takeoff. To accomplish the task, he proceeded to the center of the field with a wheelbarrow filled with colored flags, an umbrella, liquid, food and a chair. He used the colored flags to communicate clearances via Morse Code where each flag represented some activity. From a historical point of view, this is the beginning of terminal air traffic control (ATCT) with the first facility being a wheelbarrow with an umbrella and the first communication devices being Morse Code flags. As time progressed, the flags were replaced by light guns which directed colored light at landing or ground-based aircraft. Light guns are still used in ATCTs as a backup.

Eventually, radios replaced both the flags and lights as the primary communications device with lights being retained as a backup method of communication. The first air traffic control tower constructed specifically to control air traffic at an airfield was built in Cleveland, Ohio and was designed to house large radio transmitters and receivers. The first ATC radios had a power of approximately 15 Watts and a range of up to 15 miles. The communications from these facilities was relatively poor and lacked standardization. Pilots were not required to use the system or contact the airport but were encouraged to do so. Air traffic controllers of the time were airport employees.

As technology developed, navigational aids supplemented radios and lights and all weather navigation became possible. However, flying and navigating in inclement weather under instrument conditions greatly complicated the control of aircraft, and by 1934 a new government organization was created to regulate traffic along the airways that had been authorized previously. The Federal Government justified its intervention into the regulation of traffic along airways based upon article 1, Section 8, Clause 3 of the United States Constitution. This is commonly called the interstate commerce clause or ICC clause.

In 1936 the Bureau of Air Commerce issued the first rules for instrument meteorological conditions (IMC) or more commonly called instrument flight rules (IFR) flight. (Both IMC and IFR are equivalent terms with older written work using IFR and more recent work using IMC.) These rules specified the equipment required by the aircraft, the training of the pilot and the weather conditions for flight under instrument control. This is the beginning of positive control of all aviation by what is eventually going to become the FAA.

Many of the "legacy" airlines such as Trans World Airlines, American Airlines, Eastern Airlines, and United Airlines formed air traffic control units (ATCU), to control specific aircraft in the airspace during instrument meteorological conditions. The controllers were airline employees, and military and noncommercial aviation aviators were not required to participate in the ATCU operation. The legacy airlines developed flight plans, coordination procedures and separation standards using radios controlled from large rooms containing relief maps manned by employees. The controllers moved symbols representing the various airborne aircraft along routes marked on the map. These operations were commonly known as "Shrimp Boat Control" because the symbols used to identify participating aircraft resembled shrimp boats. The legacy airline pilots reported their position over a specific point in the airspace to a ground radio station which relayed that information to the ATCU. The ATCUs are the forerunners of today's Air Route Traffic Control Centers (ARTCC).

The ATCU developed internal procedures for the control of aircraft to and from various airfields. The work load was divided into three distinct parts. These positions were labeled as A, B, C positions. The Alpha controller ensured separation of aircraft. The Bravo controller maintained the symbol positions on the map. The Charlie controller calculated the aircraft's future path and positions based on the reported airspeed and altitude of each flight. The concept of positive control was being established, and these operating positions still carry the original designations even though many of the duties have changed.

The federalization of air traffic control proceeded quickly. By 1937 the Department of Commerce had acquired the ATCUs and staffed them with federally certified air traffic controllers. In 1938, the Department of Commerce was authorized to regulate and license ATC operations. It abolished and replaced the Civil Aeronautics Authority (CAA) that had been in place up until that time. However, even though the CAA was deactivated, the new organization took over the CAA's charter. That is important because the CAA had contained several important items that were to form the basis for future FAA operations. It had been given independent authority and was directed to promote and regulate aviation. In addition, it was authorized to establish and operate an ATC system and investigate accidents involving ATC. By 1941 the air traffic control division formed, and it ran the newly formed organizations known as Air Traffic Control Centers (ATCCs). At the beginning of World War II (1941) the Civil Aeronautics Board was formed from the CAA and began to issue civil air regulations (CARs) which became the basis of the legal authority for air traffic control. Under these CARs, the board could require IFR certification for flight in weather. It could also require a specific configuration for aircraft that were going to fly in weather and required the filing of a flight plan. By the end of 1941, some 23 ATCCs controlled 100% of the IFR operations, and the federal airway system was formalized. The new system connected all major US cities, but all other airspace was considered to be uncontrolled.

After World War II, the interstate communications stations were placed at key points in controlled airspace. These stations provided en-route communications, and they eventually became what we now know as flight service stations (FSS). The US military on the other hand, retained its independence and set up its own air traffic control system which consisted of 23 air traffic control units under the direction of military controllers. In 1947, the Provisional International Civil Aviation Organization (PICAO) formed under the United Nations umbrella, and after the United Nations was chartered, that organization became the International Civil Aviation Organization (ICAO) we know today. The ICAO and most of the developed nations used the CARs, known as the Federal Air Regulations(FARs) after the war, as the basis for their own rules for regulating aviation.

Immediately after WW II, the airspace became very crowded, and the system began to grow. The President of the United States appointed a committee commonly known as the special committee 31 (SC31) to study the problems and come up with some solutions. The committee looked into the future and suggested that the nation develop a common air traffic control system, a common navigational system and that the navigational system should be based upon the Very High Frequency Omni Range (VOR) plus Distance Measuring Equipment (DME), surveillance radar (ASR), Air Traffic Control Radar Beacon Systems (ATCRBS), Instrument Landing Systems (ILS), Precision Approach Radar (PAR) and Tactical Air Navigation Systems (TACANs). This plan was, indeed, an excellent blueprint for the National Airspace System (NAS) of the future. However, due to politics and financial considerations, it was delayed for nine years, and by the time it was adopted, most of the plan was obsolete.

President John F. Kennedy recommended that the old plan be revised. The new project was given the name “Project Beacon,” and it was directed to investigate the entire aviation system. Unfortunately the research was not focused. It did recommend the installation of the ASR system, directed the activation of the ATCRBS and the development of the Flight Data Entry Printout (FDEP) system. It also recommended on-screen displays for radar scopes and the development of advanced radars. Unfortunately, this project was never adopted.

The Department of Transportation (DOT) act of 1966 created the Department of Transportation, changed the name of the Federal Aviation Agency (FAA) to the Federal Aviation Administration (FAA), placed the new FAA under the Department of Transportation and provided for the formation of the National Transportation Safety Board (NTSB). The Department of Transportation act of 1966 is the governing act for almost all current aviation related activity and remains in effect.

Federal Aviation Regulations (FARs)

Originating from the Code of Federal Regulations (FARs) authorized by Congress under Title 14, Aeronautics and Space, Chapter 1 concerning the FAA and the Department of Transportation, there are 11 volumes of FARs. Each volume addresses a different aspect of aviation. Three volumes are directly related to airspace management and air traffic control. All the other volumes are involved, but these three are essential to the overall operation of the airspace. Volumes VI, IX, and XI contain most of the information required for management of the NSA. Each volume is divided into specific parts, and each part is numbered. There are numerous examples of the process in the regulations and in this document. For example, volume VI, Part 91 is a detailed description of the general operating procedures for flight in the NAS and contains such items as flight rules and standards. Volume VI Part 93 is an analysis of special air traffic control rules and airport traffic patterns, while Part 99 involves air traffic control security. These regulations can become quite detailed. For example, Volume VI Part 101 addresses tethered balloons, kites, unmanned rockets and both manned and unmanned free balloons while Part 103 details the transportation of dangerous articles and magnetized materials. The list of regulated tasks in these volumes and Parts is extremely long, and a study of all the FARs would take a normal lifetime.

Analysis of all these regulations is well beyond the scope of this research. However, some of the FARs and some of the Federal Orders are deeply concerned with the airspace operations which might affect commercial space vehicle (CSV) activity. This research effort examines Part 91 of the Federal Aviation Regulations and both the Airman's Information Manual (AIM) and FAA order 7110.6 5T (Air Traffic Control Handbook). These detailed analyses are an effort to identify the exact requirements of integrating CSVs into the daily operation of the NAS.

Airspace Physical Structure

Continental Control Area

All airspace over the 48 contiguous states of the United States, the District of Columbia and Alaska, except that airspace over the Alaskan Peninsula west of longitude 160° 00 min. 00 seconds West above 14,500 feet mean sea level (MSL), constitutes the Continental Control Area of United States. This area does not include airspace less than 1000 feet above ground level (AGL), prohibited or restricted areas.

Class A airspace is positive control airspace. All airspace above 18,000 feet MSL up to 60,000 feet (FL600) MSL is considered to be class “A” airspace. Operations in this airspace are restricted to IMC operations only, requires an ATC clearance, an instrument rated pilot, an aircraft with a two-way radio and all aircraft are separated by ATC.

Class “B” airspace generally surrounds terminal airport areas and extends from the surface up to an altitude depicted upon the appropriate aeronautical chart. Both IMC aircraft and VMC aircraft flying in this airspace must have an ATC clearance, a pilot with a valid pilot's license, or a valid student pilot's license, a two-way radio and all VMC aircraft must have at least three statute miles of visibility. All VMC aircraft in this airspace must remain clear of all clouds and all aircraft will be separated by ATC.

Class “C” airspace surrounds airports serviced by radar. The airspace extends from the surface to an altitude depicted on the appropriate aeronautical charts. Both IMC and VMC aircraft must have an IMC clearance to fly in the airspace. The aircraft must remain in contact with ATC, and the pilot must have either a pilot's license or student pilot certificate. All aircraft must have a two-way radio, and if the aircraft is VMC, it must have three statute miles of visibility and must remain 500 feet below, 1000 feet above and 2000 feet horizontally from all clouds. Separation is provided for all participating VMC aircraft, SVFR aircraft and aircraft on or about the runway.

Class” D” airspace is all the airspace surrounding the runways from the surface to 2500 feet AGL and is generally five statute miles in circumference. Both IMC and VMC aircraft may fly in this airspace provided IMC aircraft have an ATC clearance. All VMC aircraft must remain in radio contact with ATC. Only certified pilots and student pilots may operate in this airspace, and the aircraft must have a two-way radio. If the aircraft is VMC, it must have three statute miles of visibility. All VMC aircraft must remain clear of clouds by 500 feet below, 1000 feet above and 2000 feet horizontally from all clouds and separation is provided for all IMC and SVMC aircraft.

Class “E” airspace is general controlled airspace and extends from 700 feet AGL up to 18,000 feet MSL. In some cases, approach or departure airspace may require an alternate airspace designation from 1200 feet AGL up to 18,000 feet MSL. All aircraft both IMC and VMC may fly in this airspace, but IMC aircraft must have an ATC clearance. A pilot or student pilot certificate is required to operate the aircraft, and the aircraft must have a two-way radio installed. All VMC aircraft must have three statute miles of visibility and must remain clear of clouds by 500 feet below, 1000 feet above and 2000 feet horizontally from clouds. While in the airspace, separation is provided for IMC and SVFR aircraft.

Class “G” airspace is uncontrolled airspace, and it extends from the surface to the base of any controlled airspace above it. All aircraft, both VMC and IMC, may fly in this airspace. No ATC clearances are required. The pilot must be a certified pilot or student pilot. No radio is required, and a VMC visibility of one statute mile is required. Aircraft which are flying VMC must remain clear of clouds and no separation services are provided.

Special Use Airspace

Special Use Airspace is airspace wherein activities must be confined or wherein limitations are imposed on aircraft operating within that airspace.

Types of Special Use Airspace:

Prohibited Areas. Flight within these areas is prohibited due to security and or national welfare. For example, in Washington, DC the White House and Congress are prohibited areas. Nuclear test sites and sensitive military installations are also often prohibited areas. Prohibited areas are depicted on aeronautical charts and are clearly marked and numbered.

Restricted Areas. Flight within these areas is subject to a restriction of some sort due to the area containing an unusual and often invisible hazard. Examples of restricted areas might be a missile firing range, aerial gunnery range, or flight test areas. Restricted areas are depicted on aeronautical charts as “R” plus a number and the name of the controlling agency. A pilot must have prior permission to enter these areas.

Warning areas. Warning areas contain hazards in international airspace and are always beyond the three-mile limit from the coastal United States. These areas are often used as extensions of restricted areas on land and frequently entertain hazardous aeronautical activity such as air to air combat maneuvers, test firing of rockets and gunnery practice.

Military operating areas. (MOAs) These areas separate specific military activity from other IMC fights. These areas are often used for flight training in aerobatics, formation training and combat maneuvers practice. Flight under VMC conditions is allowed, but the pilot must proceed with extreme caution and contact the nearest flight service station or controlling agency within 100 nautical miles of the area. These areas are depicted on Sectional charts, VMC Terminal Area charts and En-route Low Altitude charts.

Military training routes. (MTRs). These routes are designated low-level, high-speed military training routes. Both IMC and VMC flight is possible on these routes, but they are designed with the following limitations. First, VMC routes extend from the surface up to 1500 feet AGL and are labeled as VR routes since all activity is conducted under VMC. Second, the IMC routes begin at 1500 feet AGL and extend up to 10,000 feet AGL and are designated as IR routes since most flight are conducted under IMC rules. Both MTR routes may have aircraft travail at speeds in excess of 250 knots indicated airspeed (KIAS). These routes are used to train military pilots in high-speed, low altitude combat tactics. They are depicted on VMC Planning Charts and Area Planning Charts. Flight in or along these routes is not prohibited, but extreme caution is required and a pilot must contact the closest flight service station for information regarding activity along these routes. The routes are labeled and numbered on the charts.

Ranges. Ranges are special military operating areas that have specific altitudes and parameters designated and are used for complex military training and testing. Ranges are scheduled for activation and once activated may contain very hazardous activity. Ranges are depicted on most aeronautical charts and entering the range requires prior permission from the closest flight service station or controlling agency.

Navigational Aids (NAVAIDS)

Radio Beacons. Radio beacons are generally described as low or medium frequency navigational aids and are designated as non-directional radio beacons (NDB) NAVAIDs. There are several types of NDBs:

"MH" designates beacons broadcasting less than 50 Watts of power and having a 25 nautical mile range.

"H" designated beacons generate between 50 and 1999 Watts of power and have a Range of 50 nautical miles.

"HH" designated beacons produce 2000 or greater Watts of power and have a range greater than 75 nautical miles.

"L" designated beacons generate up to 2 Watts of power with a varying range of from a few hundred feet to 1 nautical mile. These Navigational Aids are used as Locator Beacons for approaches to an airfield. They are also used as Outer Marker (OM) Beacons for similar approaches to an airfield and are frequently known as Compass Locator Beacons on Instrument Landing Systems (ILS).

Those beacons generating 50 Watts to greater than 2000 Watts are identified by a three letter identification code and have voice capability. Those beacons designated as Low Beacons are commonly designated as LOM and carry a two letter identification code.

Instrument Landing Systems (ILS)

The instrument Landing System (ILS) is a three element system consisting of a localizer, a glide path and course markers and is designed to place aircraft at a specific point on a runway after the aircraft executes a predetermined flight path.

Ground Equipment

Localizer. The localizer is a radio broadcasted course which furnishes directional guidance (azimuth) on a horizontal plane to a runway surface. The antennas for the localizer radio are located on the extended centerline of the IMC runway 1000 feet beyond the departure end of that runway. The broadcast operates on a VHF of 108.10 to 111 .9 MHz. Centerline definition is produced by the broadcast of two radio waves on either side of the runway. The right side of the transmission is broadcasted at 150 Hz, and the left side is broadcast at 90 Hz. A properly tuned ILS localizer is extraordinarily accurate. The broadcast is normally curtailed on either side of the centerline of the runway at 35° left or 35° right. However the centerline as defined by the broadcast is always within 10° of the centerline of the runway in use. The signal is only 7° high in the vertical plane and 10° wide in the horizontal plane. The pilot's instrument landing equipment will indicate a full-scale deflection when the aircraft is outside of 3° of the centerline.

Unfortunately, there are some problems with the system. Buildings, trees, large rocks, man-made obstructions, etc., can deflect the localizer signal and give the pilot a false course. In addition, harmonic wavelengths may cause false courses.

The glide slope portion of the instrument landing system is a simultaneous radio broadcast of two frequencies, one on top of the other, and provides a slope at the intersection of the two broadcasts that is received by the pilot's equipment. The antennas for this broadcast are located approximately 500 feet from the runway centerline and 1000 feet from the approach end of the runway. Just like the localizer, the glide slope operates on two frequencies. One frequency is 90 Hz and is broadcast above the other which is 150 Hz. Properly tuned, the system will provide the pilot with a 3° glide slope from a predetermined point in the airspace, designated by a low-frequency beacon, to a touchdown point on the runway.

Unfortunately there are some problems with this system as well. The antenna height for this broadcast is normally much too high for the safety of aircraft approaching the airfield. Therefore, the height of the antenna is drastically reduced, and in order to achieve the proper glide slope signal, the broadcast is bounced off the ground in front of the antenna. The angle of the broadcast can be adjusted to achieve the desired glide slope. In some cases poor maintenance of the ground surrounding the glide slope antenna may produce false glide slopes and is the result of a poor quality reflective surface. The signal is also affected by large amounts of water, particularly groundwater, as well as grass, weeds, etc.

Along the final approach course to the instrument Landing system are low powered NDB radio's that generate two Watts at 75 MHz. These beacons are usually located between four and seven nautical miles from the approach end of the IMC runway and are often called "Fan markers". Additional markers are located at approximately 3500 feet from the approach and of the runway, and these are normally designated as middle markers. Operational errors generated by the instrument landing system will trigger warning lights in the cockpit of the approaching aircraft that the system is unreliable.

Very High Omnidirectional Ranges (VOR)

The omnidirectional range is a radio NAVAID which is used to provide course guidance to airborne aircraft. A string of VOR stations across the United States constitutes the backbone of the airway system in the NAS.

A VOR consists of radio waves broadcast through a 360° pattern. Each degree broadcast is a radial and extends from the antenna of the VOR outward from its center to infinity. Two different radio waves are sent out at the same time. One wave is commonly referred to as the reference phase is radiated equally throughout the 360° circle. The second wave is known as the variable wave and varies with each degree broadcast as the antenna rotates. The radio antenna rotates at exactly 1800 RPM and provides azimuth information to any receiver that receives both the reference and the variable signals and compares the two. The reference point for the signals is always Magnetic North for both of these signals. Both the reference and variable signals are exactly the same when the antenna rotates through Magnetic North.

In practice the system is relatively simple and easy to understand from the pilot's point of view. Unfortunately, the signals broadcast from a center point began to spread with distance, and eventually a receiver may receive the broadcast well outside the center line of the broadcast. Therefore, the reliability of this system decreases with distance. In order to make up for the errors generated by the distance from the antenna, the usable distance is prescribed by FAA, and another station is placed along the route to complete the route segment. In designing the route, the error is calculated and must remain within a specified parameter for use by an aircraft, and a mark is made on the aeronautical charts to tell the user to change to the next VOR in the series. The flight, by tuning in each successive VOR, can navigate from radio beacon to radio beacon across the United States and always remain within a very narrow corridor defined by the signals from each radio station. These tracks are the airways that lace the nation's airspace together.

In conjunction with the VOR airway system, a separate set of radios broadcast signals which can be measured. By calculating the time between the broadcast and reception of a radio signal and comparing it to the known speed of radio waves, distance from the broadcast station can be determined. These highly specialized radios are collocated with VOR radios, and an aircraft having both the VOR and timing equipment aboard can determine not only its azimuth from a particular point but its distance from that point. The specialized radios which broadcast distance information are known as distance measuring equipment (DME).

The VOR/DME equipment is currently the primary navigational system in the United States. It has many advantages, but as traffic numbers increase, it has significant disadvantages. The advantage is that an aircraft can navigate from point to point throughout the United States without outside assistance, and it is very accurate and reliable. The disadvantages are that it tends to funnel traffic to a specific point and traffic congestion then becomes a dangerous situation. By channeling aircraft to specific routes and specific points, vast sections of airspace have very few if any aircraft participation, but those stations along the route of an airway have great congestion and, therefore, great conflict. One of the reasons that NEXTGEN is being developed is to alleviate the congestion problem and use more of the airspace in a safer manner. A brief discussion of NEXTGEN follows this discussion on NAVAIDS.

Since normal navigational radios and beacons can be accessed by anyone with the proper equipment, the US military determined that the normal navigational system in the United States could be accessed by an enemy of the United States and used to target specific areas of the country. The military also determined that aircraft defending the United States needed some navigational system to assist in navigating, not only the airspace, but in targeting incoming belligerent forces. Therefore, the US military developed an independent navigational system which could only be accessed by classified codes to be carried by military aircraft performing national defense duties. The system developed provides the same basic information as the VOR/DME system, but is coded in such a manner that only military aircraft can use it. This system is called the Tactical Air Navigation system (TACAN). Normally, these systems are co-located with the VOR/DME systems for convenience. However, during a national emergency, the VOR/DME is deactivated while the TACAN remains active for use in the nation's defense.

RADAR

The acronym RADAR is commonly accepted as a word in today's world. However, it actually stands for Radio Detection and Ranging and is a type of radio which broadcasts signals and then waits for the signals to bounce back from a specific target. The development of radar allowed ground controllers to actually see the position of users of the airspace without the users reporting via radio. Radar greatly enhanced the control of traffic by allowing a ground-based controller to broadcast instructions to participating pilots and assisting them in maintaining separation from other aircraft. Modern radar augmented, by computers, provides the aviation community with a great many options for transit in the NAS. These systems allow a controller to track specific aircraft, determine its altitude, determine its airspeed, determine an aircraft's location in relation to other systems, and assists in landing at a suitable destination. Radar has many, many advantages and some disadvantages. However, a detailed discussion of those advantages and disadvantages are well beyond the scope of this research.

NEXTGEN

Currently, the national airspace system is being managed using ground-based systems composed of radar, a variety of cartographic publications, global positioning satellites, and both verbal and electronic instructions. In an attempt to better use the airspace and facilities available in the United States, the FAA has begun developing a complex system using modern radios, airborne computers and GPS systems to improve air transport. This effort is commonly known at the next generation of airspace management and is abbreviated NEXTGEN.

NextGen Integration

(The following is condensed from an introduction to NEXTGEN by the FAA.)

NextGen is a comprehensive overhaul of our National Airspace System to make air travel more convenient and dependable, while ensuring your flight is as safe, secure and hassle free as possible.

In a continuous roll-out of improvements and upgrades, the FAA is building the capability to guide and track air traffic more precisely and efficiently to save fuel and reduce noise and pollution. NextGen is better for our environment, and better for our economy.

NextGen will be a better way of doing business. Travel will be more predictable because there will be fewer delays, less time sitting on the ground and holding in the air, with more flexibility to get around weather problems.

NextGen will reduce aviation's impact on the environment. Flying will be quieter, cleaner and more fuel-efficient. We'll use alternative fuels, new equipment and operational procedures, lessening our impact on the climate. More precise flight paths help us limit the amount of noise that communities experience.

NextGen will help us be even more proactive about preventing accidents with advanced safety management to enable us, with other government agencies and aviation partners, to better predict risks and then identify and resolve hazards.

NextGen boils down to getting the right information to the right person at the right time. It will help controllers and operators make better decisions. This data will assist operators in keeping employees and passengers better informed.

Our nation's economy depends on aviation. NextGen lays a foundation that will continually improve and accommodate future needs of air travel while strengthening the economy with one seamless global sky.

NextGen will help communities make better use of their airports. More robust airports can help communities attract new jobs, and help current employers expand their businesses. By doing this the U.S. will strengthen its economy and help communities realize all the benefits that aviation can bring.

NextGen will allow us to meet our increasing national security needs and ensure that travelers benefit from the highest levels of safety.

Integrating New Capabilities

NextGen capabilities aren't turned on all at once. Before the FAA can deliver each new capability, a myriad of activities has to be accomplished, some of which include: safety management system and risk assessments; environmental management systems and impact assessments; demonstrations to ensure the capability delivers its intended benefits; tests to determine how the capability affects the workload of FAA technicians, air traffic controllers and pilots; training so that controllers and operators know how to use the capability; identification, development and installation of needed infrastructure and software; development and installation of new aircraft equipment, if needed; and changes to orders and policies to conform to federal and international standards.

The development of NextGen capabilities is not carried out in a vacuum. Throughout the process, the FAA collaborates with aviation community stakeholders, including operators, equipment manufacturers, academia and other federal agencies.

We work with the international community, including air navigation service providers, to make sure that equipped aircraft can take advantage of similar capabilities around the world. And we carefully plan how to integrate new capabilities into the airspace, which is active around the clock.

Two teams of FAA executives, the NextGen Management Board and the NextGen Review Board, constitute a governance structure that works to ensure that the capabilities that grow out of the NextGen portfolio are delivered in a timely, coordinated and cost-effective manner.

The NextGen Management Board is chaired by the deputy administrator, the federal official with overall responsibility for NextGen. Composed of the heads of the FAA lines of business with primary responsibility for delivering NextGen, the Management Board provides executive oversight of NextGen progress and performance metrics, and makes strategic policy decisions that drive implementation forward. The Management Board is supported by the NextGen Review Board, which resolves cross-agency implementation issues and identifies and formulates positions on critical policy issues.

While we have crafted our governance structure to ensure our NextGen plans remain on track, we have also built in flexibility and adaptability commensurate with the challenges posed by the breadth and magnitude of the NextGen transformation, including varying maturity among interdependent systems and operator equipage rates. A deeper examination of these challenges can be found in (other FAA documents.). As new information emerges, and alternative solutions arise from our various aviation community collaborations, our governance structure allows for course shifts as necessary to ensure the most timely, cost-efficient delivery of NextGen capabilities and benefits.

The NextGen progress made by the FAA, the goals the agency has set for itself, and the work plan we have committed to in pursuit of those goals are summarized in the document you are reading now, the NextGen Implementation Plan, which is updated annually. The Plan pulls together NextGen information from a number of other key FAA documents. The result is a high-level overview of all the FAA's NextGen planning and execution efforts in a plain-language document intended to inform a wide audience of NextGen stakeholders.

(The following information is condensed from AvidyneLive, Posted: 24 Jun 2010.)

ADS-B or Automatic Dependent Surveillance – Broadcast, is an airspace control system for separation of airborne aircraft. In an ADS-B environment, an aircraft will broadcast its position using GPS technology. Included in that broadcast will be the heading, altitude, geographical position, speed and altitude. The broadcast will be processed by ground based receivers and fed into the ATC system. The ATC system uses ADS-B information to assist in participating aircraft. Aviation vehicles that broadcast the ADS-B information are designated as ADS-B Out aircraft.

If other aircraft that are ADS-B equipped can receive the broadcast and display that information in the cockpit, then the receiving aircraft is designated as ADS-B In.

Where the ADS-B ground stations re-transmit position target information so that all equipped aircraft can be seen on cockpit traffic displays, the system is designated as an ADS-R. (Where "R" stands for rebroadcast.)

ATC controllers can use the ADS-B information to assist in the separation of participating aircraft and allow them to let ADS-B In vehicles employ separation efforts on their own. The combined system will improve situational awareness and allow more aircraft to be served.

Originally, the FAA was directed to implement ADS-B Out by 2020 for class B and C airspace above 10,000 ft. The FAA could have most of the ADS-B ground infrastructure in place by 2013.

In addition, a Flight Information System (FIS-B) – Broadcast can be linked to ADS-B In. If the ADS-B equipped aircraft is in the broadcast range of a ground station, a lot of information can be transmitted to the participating aircraft. Such vital information as weather and NOTAMs can be received and displayed in the cockpit. Data is such as AIRMETs, SIGMETs, METARs, NEXRAD, NOTAMs, TFRs, PIREPs, TAFs, and Winds/Temps Aloft is available

A Traffic Information System – Broadcast (TIS-B) involves ADS-B ground stations sending Secondary Surveillance Radar (SSR) targets to aircraft with ADS-B In. TIS-B targets will be updated at least every 2 seconds on the surface, 6 seconds in the terminal area, and 12.1 seconds in the en-route airspace.

Active Traffic Systems (including TAS and TCAS) use Mode-A, C, or S transponder interrogations to determine aircraft bearing and distance. Altitude is determined by reported Mode-C altitude. After the ADS-B is installed, aircraft will still be required to have a Mode-C or S transponder in airspace where it is currently required, thus Active Traffic Systems will continue to function.

Active Traffic Systems are still needed in an ADS-B environment. Not all aircraft will have ADS-B, and without an Active Traffic System, those unequipped aircraft would not be displayed on a cockpit traffic display even if you had ADS-B In. An Active Traffic System will display all aircraft independent of the type of ADS-B Out installed since all aircraft will still be required to have a Mode-C or Mode-S transponder. ADS-B is dependent on GPS signals, so during periods of poor satellite geometry or solar storms, GPS position and thus ADS-B will not be available. The FAA is keeping ATC radars as a backup and an Active Traffic System can act as a backup to ADS-B in the cockpit.

Regulatory Analyses for Commercial Space Vehicle Integration into the NAS

(Note: Questions generated in these analyses are in red font and numbered consecutively. Topics that do not appear directly to the integration of Commercial Space Vehicles into the NAS are noted as not applicable – NA.)

Federal Regulations (FAR) PART 91

GENERAL OPERATING AND FLIGHT RULES

Subpart A—General

91.1 Applicability - NA

91.3 Responsibility and authority of the pilot in command.

91.3(a) "The pilot in command of an aircraft is directly responsible

for, and is the final authority as to, the operation of that aircraft".

1. Question: In a piloted CSV, who is "directly responsible for and the final authority" for the operation of that vehicle?

91.3(b) "In an in-flight emergency requiring immediate action, the

pilot in command may deviate…"

2. Question: What will constitute an emergency that allows deviation from "contracted" trajectory?
3. Question: Do the "contracted" abort/ contingency plans provided by the operator and agreed to by TFM allow for deviations from that plan?
4. Question: Does the payload of the CSV restrict deviations if surface people and assets (SPA) are endangered by the potential of a catastrophic event?

91.5 Pilot in command of aircraft requiring more than one required pilot.

"No person may operate an aircraft that is type certificated for more than one required pilot flight crewmember unless the pilot in command meets the requirements of §61.58 of this chapter."

5. Question: What requirements will regulate certification of commercial space vehicles and pilot qualifications in order to transverse and operate within the national airspace system?

91.7 Civil aircraft airworthiness.

91.7(a) "No person may operate a civil aircraft unless it is in an airworthy condition."

6. Question: What are the requirements for a CSV to be considered to be in an airworthy condition?
7. Question: What additional criteria will constitute the operational worthiness for commercial space vehicles?

91.7(b) "The pilot in command of a civil aircraft is responsible for determining whether that aircraft is in a safe condition."

8. Question: Will the long-standing paradigm of the pilot in command determining the safe condition of flight of the vehicle change with commercial space vehicle operation in the National Airspace System?
9. Question: What additional criteria constitute an unworthy condition for operation of a commercial space vehicle in the National Airspace System?
10. Question: How will these criteria be integrated into the regulatory framework that defines a "worthy" condition for space travel?

91.9 Civil aircraft flight manual, marking, and placard requirements. (This Part defines requirements for civil aircraft flight manuals, markings and placards; these requirements are based upon certificated authority of the country of registry or, in the case of US registered civil aircraft, certificated authority from part 21.5.

11. Question: What "Part" will define "certificated authority" for CSVs?
12. Question: What are the requirements for CSVs to operate within the National Airspace System with regard to flight manuals, markings, and placards?

91.13 Careless or reckless operation. N/A

91.15 Dropping objects.

13. Question: What objects may be dropped from commercial space vehicles? (Jettisoned material, fuel dumping, etc.)
14. Question: Will the permitted objects that are allowed to be dropped be dictated by phase of flight?
15. Question: What will constitute "reasonable precautions" to avoid injury or damage to persons or property from permitted drops?
16. Question: Will the statement "reasonable precautions" be left to the operator of the CSV or will a formal approval authority determine "reasonable precautions"?

17. Question: What additional international regulatory framework will govern dropping objects which may penetrate international and foreign airspace from commercial space vehicles?

91.17 Alcohol or drugs. (This regulates the use of alcohol or drugs by crew members of aircraft within the National Airspace System, based upon physiological criteria.)

18. Question: What changes to this regulatory framework will occur based upon physiological considerations of crew members' performance in commercial space operations?

91.19 Carriage of narcotic drugs, marihuana, and depressant or stimulant drugs or substances. NA

91.21 Portable electronic devices.

19. Question: Will the present regulations, manuals, and research that are used to guide the use of portable electronic devices within the NAS be sufficient guidance for commercial space vehicles?
20. Question: If current guidance is not adequate, what changes to regulations and manuals need to be made?

91.23 Truth-in-leasing clause requirement in leases and conditional sales contracts. NA

91.25 Aviation Safety Reporting Program: Prohibition against use of reports for enforcement purposes.

21. Question: Does the basis for providing the prohibition against the use of safety reporting data for enforcement purposes remain for commercial space operations?

Subpart B—Flight Rules

General

91.101 Applicability. (This prescribes flight rules governing the operation of aircraft within the United States within 12 nautical miles from the coast of the United States.)

22. Question: Is the historic 12 nautical mile limit applicability scale sufficient for tracking, planning, and management of commercial space vehicle operations by air traffic management?
23. Question: What deployment of NAS resources will be required outside of the 12 nautical mile boundary to support increased regulatory oversight of commercial space vehicles?
24. Question: Can the "12 mile regulatory net" support the airspace "module" concept that may be necessary in the management of airspace resources to assimilate incoming and outgoing commercial space vehicles?

25. Question: Will the 12 nautical mile regulatory construct be appropriate for the additional resources and planning needed to acquire and respond to position and intent data such as trajectories and debris fields?
26. Question: If the 12 nautical mile limit is not adequate, what response will be required to accomplish deployment of required sensor and control resources?

91.103 Preflight action. ("Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight…")

27. Question: Is this traditional paradigm appropriate for commercial space vehicle operations, including contingency planning?

91.105 Flight crewmembers at stations.

28. Question: What particular restrictions will be made for flight crew member station requirements? (Consideration for platforms that require transfer of crew to and from ferry vehicles or movement within vehicles should be considered)

91.107 Use of safety belts, shoulder harnesses, and child restraint systems.

29. Question: In accordance with 91.107, what regulatory framework will govern the use of safety belts shoulder harnesses and child restraint systems?
30. Question: This regulation speaks of child restraint systems (age & weight criteria); what age and weight criteria will be applied to the use of restraint systems in commercial space vehicles?

91.109 Flight instruction; simulated instrument flight and certain flight tests. (Presently, flight instruction, simulated instrument flight and certain flight test are conducted in the National Airspace System in accordance with 91.109).

31. Question: What ATC control configuration will be required for CSVs operating under this Part?
32. Question: What will constitute "ensuring safe operation" in the NAS under this instruction?
33. Question: What qualifications will be required of the CSV crewmembers operating under this Part?
34. Question: What ATC displays will be appropriate for monitoring activity under this Part?
35. Question: What role and responsibility will ground support and ATC personnel have in regard to this training?
36. Question: What additional airspace will be required to ensure safe operations when CSV training is conducted?
37. Question: What planning and control protocol must occur prior to initiation of CSV training within the National Airspace System?

91.111 Operating near other aircraft.

38. Question: What regulatory adjustments will be necessary to allow for the operation of CSVs near other aircraft?
39. Question: How will the operator of the CSV judge hazardous "close" operations? (This question may be resolved when answering the questions on separation standards in FAA Order 7110.65T.)
40. Question: What regulations to prevent sightseeing of aircraft near commercial space vehicles will be necessary?
41. Question: Will special provisions be necessary for formation flight in the carriage of passengers for hire? (This may apply to "chase aircraft" required by some CSVs.)
42. Question: What provisions will be made for ferry aircraft operating near space vehicle?
43. Question: Will a concept similar to Military Assumes Responsibility for Separation of Aircraft (MARSA) be necessary for formation/chase flights with commercial space vehicles? (This question may be resolved when answering questions on Special Use Airspace as defined in the Airman's Information Manual –AIM.)

91.113 Right-of-way rules: Except water operations. (According to the concepts of operations for commercial space vehicles in the National Airspace System dated 2005, some platforms of commercial space vehicles will operate outside of restricted airspace due to the vehicle's ability to transition to a powered aircraft flight profile.)

44. Question: What will be the classification of an aircraft derived from a CSV?
45. Question: Will CSVs operating as powered aircraft be considered a commercial space vehicle with limited maneuverability or a fully functioning aircraft capable of responding to NAS issues?

(Issues that might affect traditional aircraft within the National Airspace System could be traffic advisories, go around instructions, missed approach procedures, in-trail spacing, and holding procedures.)

46. Question: Will mission profile and requirements, such as physiological demands, contracted trajectory agreements, limited fuel, restricted alternate options, security concerns, and hazardous payload render commercial space vehicles less maneuverable?
47. Question: If no such restriction to maneuverability exists, will there be a "perceived limited maneuverability" such as may be suggested under subpart 91.115 section (e), *Special circumstances,* cause controllers and other aircraft operators to proceed with inappropriate caution or unconventional maneuvers when encountering this type commercial space vehicle in unrestricted airspace?

91.117 Aircraft speed. (Subpart 91.117 specifies the maximum speed below 10,000 MSL to be no more man 250 knots indicated airspeed. Further this subpart restricts the speed of aircraft operation within four nautical miles of class C or D airspace to 200 knots indicated airspeed while below 2500 feet AGL. A similar restriction is applied below class B airspace

and within a VFR corridor through class B airspace. This subpart provides two provisions for operation of aircraft above this speed restriction; a) authorization by the administrator/ATC or b) if the minimum safe airspeed for any particular operation is greater than the max be prescribed in the section, the aircraft may be operated at that minimum speed.)

48. Question: Will aircraft, like commercial space vehicles, be required to maintain a standard minimum safe airspeed by regulation that defines certification?
49. Question: Is standard flight profile capability of CSVs provided for to ensure predictability in the TFM functions of the National Airspace System?
50. Question: Is there a potential that smaller airports, classified with class C or class D airspace, be used in the operation of commercial space vehicles outside of restricted airspace?
51. Question: If smaller airports are to be used, such airports may underlie class B airspace. If it becomes necessary to increase the indicated airspeed beyond 200 knots, does the National Airspace System have sufficient resources at smaller airports and TRACONS to manage aircraft operating at the greater speeds?
52. Question: What is the impact to abutting controlled airspace such as control zones and approach corridors if waivers to the airspeed restrictions are approved?
53. Question: What impact will the increased airspeeds have upon aircraft operating under VFR flight plans or within VFR corridors?

91.119 Minimum safe altitudes: General (Subsection 91.119 prescribes minimum safe altitudes with the guiding principle being safe operation of the aircraft and protection of people and property on the ground.)

54. Question: What CSV characteristic(s) will influence the minimum safe altitude determination?

91.121 Altimeter settings. (Subpart 91.121 states that altimeters will be set to 29.92" Hg at or above 18,000 feet MSL; this reference ensures altimeter setting ensures standardization to flight levels and that an aircraft that is operated at or above 18,000 feet MSL is maintained at its assigned flight level.

55. Question: At what reference point along the descent profile will a CSV be required to use the 29.92" Hg altimeter setting?

91.123 Compliance with ATC clearances and instructions. (Subpart 91.123 addresses compliance with ATC clearances and instructions.)

(With reference to the Traffic Alert and Collision Avoidance System (TCAS))

56. Question: Deviation from an ATC clearance is permitted under certain conditions including a traffic alert and collision avoidance resolution advisory. Will commercial space vehicles be equipped with TCAS?
57. Question: How will CSVs be expected to respond to a TCAS advisory?
58. Question: Due to the high performance profile of CSVs, what modifications to the TCAS need to be made to anticipate the challenges to the Closest Point of Approach (CPA) algorithms?

(With reference to Class A Airspace and VFR on Top airspace.)

59. Question: With the routine operation of commercial space vehicles, will the current altitudes and parameters defining class A airspace dimensions be adequate?
60. Question: Will commercial space vehicles be permitted to operate under VFR flight rules? (This question may arise if a commercial space vehicle elects to fly VFR on top, depart under VFR rules with the intent to later pick up an IFR clearance, contact or visual approaches, or cancellation of IFR flight plans.)
61. Question: Will CSVs be permitted to cancel an IFR flight plan?

91.123(b) "Except in an emergency, no person may operate an aircraft contrary to an ATC instruction in an area in which air traffic control is exercised."

62. Question: With the routine operation of CSVs, will the exercise of air traffic control be expanded beyond present airspace boundaries?

91.123(c) outlines the necessity of notification to ATC by an aircraft that has deviated from an ATC clearance or instruction.

63. Question: Under flight profiles of CSVs that require separation from other aircraft by using restricted airspace, what mechanism will allow for the adjustment (expansion or contraction) of the reserved airspace?

91.123 (d) specifies the requirement for a pilot in command, who is given priority by ATC due to an emergency, to submit a detailed report of the deviation within 48 hours to the manager of that ATC facility, if requested.

64. Question: Will CSVs have the same option of requesting ATC priority without declaring an emergency?
65. Question: If a deviation is requested, what will be the proper procedure and reporting requirements?

With reference to formation flight:

91.123(e) Unless otherwise authorized by ATC, no person operating an aircraft may operate that aircraft according to any clearance or instruction that has been issued to the pilot of another aircraft for radar air traffic control purposes …

66. Question: What formalized procedure will account for commercial space vehicles' that are operated in a manner that requires coordination with chase aircraft, ferry aircraft, or any other type of aircraft that will be operated according to the clearance of another aircraft?

91.125 ATC light signals. NA

91.126 Operating on or in the vicinity of an airport in Class G airspace. (Cross Reference: AIM 3-3-1)

67. Question: Will commercial space vehicles be prohibited from operating in class G airspace?
68. Question: If commercial space vehicles will be permitted to operate in class G airspace, will current aeronautical information dissemination (NOTAM) be sufficient to ensure the safe separation and safety of the CSV and other participating traffic?

Subpart 91.126 also describes the prescribed direction of turns in the vicinity of an airport without an operating control tower.

69. Question: If commercial space vehicles are permitted to operate in class G airspace, what regulatory provision will be made to ensure operationally required maneuvers of the CSV's flight profile can be completed?

Subpart 91.126 also prescribes communication requirements with control towers within four nautical miles from the airport and up to 2, 500 feet AGL.

70. Question: If CSVs are authorized to operate in class G airspace, will the 4 nautical mile/2500 feet AGL dimensions provide sufficient time for ATM functions?

91.127 Operating on or in the vicinity of an airport in Class E airspace.

Part 91.127 specifies the communication requirements of operating "an aircraft to, from, through, or on an airport having an operational control tower.

71. Question: Based upon the stated operating criteria within class E airspace, will CSVs be allowed to operate within this class airspace?

91.129 Operations in Class D airspace. (See questions on Class E airspace.)

91.129 (e) Minimum altitudes when operating at an airport in Class D airspace.

72. Question: Will commercial space vehicles be classified as a large airplane or turbine powered airplane that must maintain the applicable distance -from -cloud criteria?
73. Question: Will CSVs be required to enter the traffic pattern altitude of 1500 feet above the elevation of the airport, and at least 1500 feet AGL until further descent is required for safe landing?

74. Question: If commercial space vehicles are classified as a large or turbine powered airplane that is "approaching to land on a runway served by an instrument approach procedure with vertical guidance"—what will constitute "if the airplane is so equipped"?
75. Question: Are the restrictions placed upon large and turbine powered airplanes in this regulation regarding approaches and landing sufficient or appropriate for commercial space vehicles?
76. Question: If a commercial space vehicle's flight profile requires a lower or higher approach glide path than the visual approach slope indicator, calculated dissent point from the IAP, or navigational guidance—what clearance criteria must be examined and what guidelines must be published in order to ensure safe and efficient use of this type of airport by CSVs?
77. Question: In light of the criteria for approaches to class D airspace, the flight and mission profiles of a CSV, in which category will each particular commercial space vehicle be placed?

(Although the FAA has established formal runway use programs as a part of the noise abatement program, the pilot in command may deviate from the use of that runway in the interest of safety.)

78. Question: Will CSVs and/or ferry vehicles be permitted to use this exception as part of routine operations?
79. Question: Will noise abatement procedures be enforced during CSV operations?
80. Question: What speed restrictions will be placed on CSVs and/or ferry vehicles within class D airspace?

91.130 Operations in Class C airspace.

81. Question: What minimum equipment will be required of CSVs to operate in class C airspace?
82. Question: If a CSV or ferry vehicle is departing a satellite airport within class C airspace, will additional communication, notification, and procedural requirements be placed upon its operations?

91.131 Operations in Class B airspace.

83. Question: Will CSVs and/or ferry operations be permitted within class B airspace to include satellite airports underneath class B airspace floors?
84. Question: If some commercial space vehicle operation is desirable in class B airspace, what limits, constraints, or criteria will guide the use of this airspace?
85. Question: What will be the equipment requirements (VFR vs. IFR) is CSVs operate in class B airspace?
86. Question: What will the definition of "training" be for CSV operations in this airspace?
87. Question: Will CSVs and/or ferry vehicles have a requirement to be piloted by a person possessing a particular (Unspecified) level of certification in this airspace?
88. Question: Will the FAA have "currency requirements" for the operation of CSVs within class B airspace?
89. Question: What speed restrictions will be placed on commercial space vehicles and/or ferry vehicles entering into, operating in, operating beneath, and exiting class B airspace?

91.133 Restricted and prohibited areas. NA

91.135 Operations in Class A airspace.

(Class A airspace includes a variety of airways, control areas and general airspace. Class A airspace generally begins at 18,000 feet MSL and extends to FL600. Special aircraft, pilot, operator and clearance requirements are needed to use this airspace.)

90. Question: Will CSVs require a separate set of clearances to operate in class A airspace?
91. Question: What specific communication equipment and procedures will be required for CSVs operating in class A airspace?
92. Question: What specific navigation equipment and/or procedures will be required for CSV operation in class A airspace?
93. Question: What specific surveillance equipment and procedures will be required for CSV operation in Class A airspace?
94. Question: Will CSVs be compatible with NextGen equipment and procedures? (This question should be paired with NextGen information contained elsewhere in this document.)
95. Question: What specific coordination will be required between Terminal ATC, EnRoute ATC and the appropriate space control organizations?

(At a minimum, questions regarding ATC letters of agreement (LOA) between controlling ATO divisions will have to be resolved. Such resolutions are well beyond the mission requirements of this document.)

96. Question: What new policy and procedures will govern the strategic traffic flow management of CSV operations?
97. Question: What will be the effect of CSVs on tactical air traffic control?
98. Question: How will airspace security (identification zones) be enforced during CSV operations?
99. Question: How will differential target identification be accomplished between civil, military and space traffic?
100. Question: Will ATC be tasked with dynamic trajectory management of CSVs in order to effect separation?
101. Question: What specific ATC authorizations will be required for CSVs operating in Class A airspace?

91.137 Temporary flight restrictions in the vicinity of disaster/hazard areas.

102. Question: What will be the limitations on commercial space vehicles operating in disaster/hazard areas?
103. Question: Will permissions, constraints, and restrictions enumerated in this subsection apply to a particular commercial space vehicle or ferry vehicle based upon that vehicles flight or mission profile?

91.138 Temporary flight restrictions in national disaster areas in the State of Hawaii. (See questions in 91.137.)

91.139 Emergency air traffic rules.

104. Question: What constraints and limitations will be placed on CSV operations during the implementation of emergency air traffic rules?

(Conventional ATC operations may have to be revised substantially. Suggesting modifications to the system is well beyond the mission of this study.)

105. Question: What specific notification mechanisms will provide CSVs with sufficient notification of emergency air traffic operations in order for the CSVs to execute appropriate maneuvers in a timely manner?

106. Question: Will CSV operations in affected or abutting airspace sectors affect emergency air traffic operations require additional monitoring, coordination, tracking, and communication between FAA and the DOD?

91.141 Flight restrictions in the proximity of the Presidential and other parties.

107. Question: Given the unique characteristics of CSV operations, such as high-altitude operations, contingency maneuvers, catastrophic breakup—what additional considerations must be given to CSVs "over or in the vicinity of any protected area"?

91.143 Flight limitation in the proximity of space flight operations.

108. Question: What changes to this regulation need to be made to support normal and routine commercial spaceflight operations while providing for efficient, safe, and secure civil and commercial aircraft operations?

109. Question: What will be FAA's specific definition of the term ***"integration"*** when it is applied to CSVs within the NAS?

110. Question: Does the concept of operations provide for concomitant operations of commercial space vehicles and aircraft within close proximity to each other?

111. Question: If concomitant operations of CSVs and aircraft within close proximity to each other are desirable, what mission/flight profiles will be permitted?

112. Question: Is the task of integrating commercial space vehicles into the NAS achieved through the establishment of a new class of airspace that would support departure and entry of CSVs "to and from an En-route structure"?

91.144 Temporary restriction on flight operations during abnormally high barometric pressure conditions. NA

91.145 Management of aircraft operations in the vicinity of aerial demonstrations and major sporting events.

113. Question: What additional considerations must be given to commercial space vehicle operations over or in the vicinity of aerial demonstrations in major sporting events?

114. Question: What restrictions must be placed on general and commercial aircraft operating in an area of CSV operations?

91.146 Passenger-carrying flights for the benefit of a charitable, nonprofit, or community event.

115. Question: Will CSVs be permitted to operate under this provision?

91.147 Passenger carrying flights for compensation or hire. NA.

(Part 91.147 should be addressed under other CSV operational parameters, but not as part of integration into the NAS.)

91.148-91.149 [Reserved] NA

91.151 Fuel requirements for flight in VFR conditions.

116. Question: If CSVs are authorized to perform VFR flight, what fuel requirements will be placed upon CSVs or ferry aircraft?

91.153 VFR flight plan: Information required.

117. Question: What specific information will be needed in order to file a VFR flight plan for CSVs and/or aircraft involved in CSV operations?

118. Question: What are the communication protocols and requirements, involved in the filing of a VFR flight plan for CSVs?

91.155 Basic VFR weather minimums.

119. Question: Are there special requirements regarding weather minimums for VFR flight by CSVs?

120. Question: Does minimum cloud clearances, as defined in subsection 91.155, adequately addresses the dynamic nature of commercial spaceflight operations?

91.157 Special VFR weather minimums.

121. Question: Will CSVs and/or vehicles participating in CSV operations be permitted to operate under subsection 91.157, "Special VFR weather minimums"?

91.159 VFR cruising altitude or flight level.

122. Question: If VFR operations will be permitted, will VFR cruising altitudes need to be redefined?

91.161 Special awareness training required for pilots flying under visual flight rules within a 60-nautical mile radius of the Washington, DC VOR/DME. NA

91.162-91.165 [Reserved] NA

91.167 Fuel requirements for flight in IFR conditions.

123. Question: What are the fuel requirements for CSVs and/or aircraft involved in CSV operations conducted under subsection 91.167?
124. Question: If a CSV is involved in the carriage of mission essential hazardous material, chemicals, fuels, etc. will the fuel requirements need to be adjusted?
125. Question: What will be the fuel requirements for aircraft and vehicles involved in CSV operations that execute contingency profiles (e.g. aborted missions that require the ferry aircraft to RTB with a CSV attached)?
126. Question: What are the weather criteria for IFR fuel minima in CSVs?

91.169 IFR flight plan: Information required.

127. Question: What information is required for an IFR flight plan for CSVs and/or vehicles involved in CSV operations performing IFR flight under subsection 91.169?
128. Question: What are the weather minimums, approach criteria, and filing restrictions for CSV contingency plans?
129. Question: In filing for an alternate, what additional considerations must be given for CSVs and/or vehicles involved in CSV operation?
130. Question: What are the permitted instrument approaches for aircraft or vehicles involved in CSVs?

91.171 VOR equipment check for IFR operations.

131. Question: Will VOR equipment be required in CSVs and/or aircraft involved in CSV operations?

91.173 ATC clearance and flight plan required.

132. Question: What conceptual model will be needed for CSVs to file an IFR flight plan and receive an appropriate ATC clearance?

91.175 Takeoff and landing under IFR.

(Subsection 91.175 (a) requires the use of a standard instrument approach procedure prescribed in part 97; while (b) defines the authorized DA/DH or MDA.)

133. Question: What additional constraints, limitations, or guidance should be placed upon the use of certain standard instrument approach procedures by CSVs?

(Subsection 91.175 (c) describes operation below DA/DH or MDA.)

134. Question: What constitutes "a normal rate of descent using normal maneuvers" for CSV operations?
135. Question: Will the touchdown zone of the runway of intended landing need to be redefined for certain CSV operations?
136. Question: What changes to the instrument approach procedure, runway lighting, visual slope indicators, and/or runway markings need to be made for CSV operations?
137. Question: Under Section (e) of this Part, what missed approach procedures or go-around guidelines will be required for CSV operations?
138. Question: Under Section (f) of this Part, what civil airport takeoff minimums as prescribed in this section are appropriate for CSV operations?
139. Question: Under Section (f) of this Part, what will the requirement for CSVs be to operated in accordance with the ATC assigned or published obstacle departure procedures?
140. Question: Under Section (h) of this Part, what additional considerations need to be made to RVR and ground visibility requirements for vehicles and aircraft involved in CSV operations?
141. Question: Under Section (i) of this Part, what are the appropriate use of unpublished routes and radar assistance provided by ATC?
142. Question: Will ATC expect, direct, or permit a vehicle involved in CSV operations to use unpublished routes and radar assistance?
143. Question: What additional training, equipment and procedures will be required for the ATC controllers and facilities handling CSVs in the airspace?
144. Question: Will CSVs and/or aircraft involved in CSV operations be permitted to use enhanced flight vision systems (EFVS)?

91.177 Minimum altitudes for IFR operations. NA

91.179 IFR cruising altitude or flight level.

145. Question: Will ATC be permitted to issue "the VFR conditions on top" clearance to CSVs?
146. Question: What will be the upper prescribed flight levels with which CSVs must comply in regards to flight levels and magnetic course conventions?
147. Question: Will CSVs and/or aircraft involved in commercial space vehicle operations be permitted to "participate" in reduced vertical airspace minimum (RVSM) airspace?
148. Question: Given the fact that CSVs must travel through RVSM airspace, will participation in altitude assignments and spacing be required by ATC as if the vehicle were a traditional aircraft?

91.181 Course to be flown.

(Subsection 91.181 defines courses to be flown; specifically, operations are allowed to be conducted along the centerline of an ATS route, and along any direct course between navigational aids and fixes, and the maneuvering of the aircraft in regard to other air traffic - particularly under VFR conditions.)

149. Question: If specific areas are closed due to commercial space vehicle operations, or areas remain open allowing for concomitant operations of traditional aircraft, what changes to communication, notification, training, navigation, and surveillance need to be made by ATC?

91.183 IFR communications. NA

91.185 IFR operations: Two-way radio communications failure.

150. Question: What will be required of CSV operations in the event of two way radio failure?
151. Question: What procedures will be necessary in the event of two-way radio failure involving CSVs that have begun a deorbit and subsequent descent towards the national airspace system?

91.187 Operation under IFR in controlled airspace: Malfunction reports. NA

91.189 Category II and III operations: General operating rules.

152. Question: Under what conditions will CSV flights be permitted to conduct category II or category III operations?
153. Question: What changes to infrastructure, equipment, mission conditions, and procedures must be made in order to support category II and category III operations by CSVs?

91.191 Category II and Category III manual. (See 91.189 above.)

91.193 Certificate of authorization for certain Category II operations. NA

Subpart C—Equipment, Instrument, and Certificate Requirements

91.20 1 [Reserved] NA

91.203 Civil aircraft: Certifications required. NA

91.205 Powered civil aircraft with standard category U.S. airworthiness certificates: Instrument and equipment requirements.

154. Question: What additional equipment will be required for vehicles and/or aircraft involved in CSV operations?

91.207 Emergency locator transmitters. NA

91.209 Aircraft lights. NA

91.211 Supplemental oxygen.

(Subsection 91.211 prescribes supplemental oxygen requirements at various flight levels, with the last flight level described as flight above FL410. Commercial operations for space vehicles conducted in the national airspace system will routinely occur between FL410 and the upper limit of the present national airspace system, FL600.)

155. Question: What will be the supplemental oxygen requirements for passengers and crew of CSVs?

91.213 Inoperative instruments and equipment.

156. Question: What will be the minimum equipment list for commercial space vehicles and/or aircraft evolved commercial space vehicle operations?
157. Question: Will the minimum equipment list change based upon different CSV flight and mission profiles?
158. Question: Who will be responsible for determining if flight is continued with regards to issues related to an inoperative instrument or piece of equipment?
159. Question: What type of safety management system will operators be required to have operational when making the decisions regarding continued flight with inoperative instruments or equipment?

91.215 ATC transponder and altitude reporting equipment and use.

160. Question: Will the highly dynamic flight profiles, that are peculiar to CSV operations, be appropriate for the "performance and environmental requirements of any class of TSO-C74b (Mode A) or any class of TSO-C74c (Mode A with altitude reporting capability)…, or the appropriate class of TSO-C112 (Mode S").
161. Question: What is the current speed at which interrogation information is gathered and assessed by ATC regarding CSVs?
162. Question: Does the current speed for CSVs support all airspace management requirements?
163. Question: What current data on CSVs is exchanged in ATCRBS interrogation?
164. Question: Is the current equipment for interrogation appropriate for routine formation flight and/or the ferry of CSVs?
165. Question: At what point in the ascent or descent profile of CSVs should altitude reporting equipment be placed in the "on" position?

91.217 Data correspondence between automatically reported pressure altitude data and the pilot's altitude reference.

166. Question: For routine flight at altitudes above FL600, what additional considerations must be given to automatic reported pressure altitude equipment and reporting?

91.219 Altitude alerting system or device: Turbojet-powered civil airplanes. NA

91.221 Traffic alert and collision avoidance system (TCAS) equipment and use.

(Subsection 91.221 prescribes equipment requirements for a traffic alert and collision avoidance system (TCAS)).

167. Question: What equipment and procedures need to be developed for TCAS use with CSVs and/or participating aircraft?

91.223 Terrain awareness and warning system (TAWS).

168. Question: Since current TAWS alerting algorithms may be inappropriate for the dynamic flight and mission profiles of CSVs and/or aircraft involved in their operations, what requirements will be placed upon the use of TAWS by CSVs and/or aircraft involved in these operations?

91.225 Automatic Dependent Surveillance-Broadcast (ADS–B) Out equipment and use.

91.227 Automatic Dependent Surveillance-Broadcast (ADS–B) Out equipment performance requirements.

169. Question: Based upon the reporting rate of ADS-B equipment, what equipment and procedure changes need to be considered to support dynamic trajectory monitoring, prediction, and management functions of CSVs?
170. Question: If the CSV reporting rate is increased, how will that affect ATC controller performance of ATC task?

91.228-91.299 [Reserved] NA

Subpart D—Special Flight Operations

91.301 [Reserved] NA

91.303 Aerobatic flight. NA

91.305 Flight test areas. NA

91.307 Parachutes and parachuting. NA

91.309 Towing: Gliders and unpowered ultra-light vehicles. NA

91.311 Towing: Other than under Sub Part 91.309.

171. Question: What are the procedures and/or equipment requirements necessary to support the "tow" of commercial space vehicles in the national airspace system?
172. Question: How will air traffic control be managed in tow operations conducted in class A airspace?

173. Question: What altitude assignments will be appropriate for towed CSVs?

174. Question: What are the spacing requirements for towed CSVs?

175. Question: Will CSV towing operations be conducted under regulations and procedures similar to MARSA operations?

91.313 Restricted category civil aircraft: Operating limitations.

91.315 Limited category civil aircraft: Operating limitations.

91.317 Provisionally certificated civil aircraft: Operating limitations.

91.319 Aircraft having experimental certificates: Operating limitations.

(Subsections 91.313 through 91.319 prescribed operating limitations regarding restricted, limited, provisionally certificated, and experimental aircraft. Subsection 91.313 (e) prescribes restrictions upon restricted category civil aircraft; specifically it states:

Except when operating in accordance with the terms and conditions of a certificate of waiver or special operating limitations issued by the Administrator, no person may operate a restricted category civil aircraft within the United States—

(1) Over a densely populated area;

(2) In a congested airway; or

(3) Near a busy airport where passenger transport operations are conducted.)

176. Question: What restrictions will be placed on CSVs operating under one or more of these conditions?

91.321 Carriage of candidates in elections. NA

91.323 Increased maximum certificated weights for certain airplanes operated in Alaska. NA

91.325 Primary category aircraft: Operating limitations. NA

91.327 Aircraft having a special airworthiness certificate in the light-sport category: Operating limitations. NA

91.328-91.399 [Reserved] NA

Subpart E—Maintenance, Preventive Maintenance, and Alterations

Subpart E discusses maintenance, prevented maintenance, and alterations; as such does not directly related to the topic of discussion of integration of commercial space vehicles into the national airspace system. Therefore, Subpart E is not applicable to the scope of our inquiry.

Subpart F, G, H and K

Subpart F, G, H, and K discuss operating rules for large and turbine powered multiengine airplanes operating under Part 91 rules including the use of aircraft fractional ownership operations. As with Part 135, Part 121 prescribes rules governing operator responsibilities and the requirements for operations of aircraft under these Parts. The questions that have already been addressed, mainly in subparts A, B, and C, more directly impact the integration of CSVs into the NAS. Therefore, subpart F, G, H and K do not directly affect this inquiry.

However, within the subparts there is a discussion that pertains to MNPS and RVSM. This discussion may have direct applicability to the question of integration of CSVs into the NAS. Therefore, these topics will be examined in subpart 91 appendices C and G.

Subpart I—Operating Noise Limits and Appendix B to Part 91—Authorizations To Exceed Mach 1 (§91.817)

(Subpart I and appendix B pertain to commercial space vehicle operations to the extent that their operations will exceed Mach 1 and therefore require rulemaking that pertains to operational noise limits. Subpart 36 and Annex 16 of ICAO will also apply. The integration of CSVs into the NAS seeks to make CSV flights routine while supporting the safe, secure, and efficient use of all stakeholders within and affected by the NAS.)

177. Question: What rules and procedures must be developed to support these goals in light of the high-speed flight requirements for CSVs?
178. Question: What lateral and vertical parameters will define areas of permitted operations in excess of Mach 1?
179. Question: What specific ATC procedures and airspace infrastructure must be in place to support CSV operations?
180. Question: At what point can the CSV be permitted to exceed Mach 1?
181. Question: At what point will CSVs be expected to slow to below Mach 1?
182. Question: What is the method of filing a flight plan that defines the intended point of acceleration to Mach 1 or deceleration from Mach 1?
183. Question: What spacing will be required between CSVs and other participating aircraft?
184. Question: Will CSVs perform routine operational flight by using published procedures in current FLIP?
185. Question: Will CSVs be using common and uncommon routing that currently support aircraft on the North Atlantic Track System?
186. Question: What are the environmental considerations that must be addressed in the integration efforts of CSVs exceeding Mach 1 into the NAS?

Subpart J—Waivers

NA

Subpart L—Continued Airworthiness and Safety Improvements

NA

Subpart M—Special Federal Aviation Regulations

91.1603 Special Federal Aviation Regulation No. 112—Prohibition Against Certain Flights Within the Tripoli (HLLL) Flight Information Region (FIR). NA

Appendix A to Part 91—Category II Operations: Manual, Instruments, Equipment, and Maintenance

NA

Appendix B to Part 91—Authorizations To Exceed Mach 1 (91.817)

NA

(See subpart 91 I)

Appendix C to Part 91—Operations in the North Atlantic (NAT) Minimum Navigation Performance Specifications (MNPS) Airspace

187. Question: Will CSVs or allied participating aircraft be allowed to enter into MNPS airspace?
188. Question: If CSVs are allowed in the MNPS, what minimum equipment will be required for CSVs and/or allied participating aircraft?
189. Question: What procedures for filing, clearances, and waivers for CSVs and/or allied participating aircraft will be required within the MNPS?

Appendix D to Part 91—Airports/Locations: Special Operating Restrictions

The following airports require special considerations under this Part:

Atlanta, GA (The William B. Hartsfield Atlanta International Airport)

Baltimore, MD (Baltimore Washington International Airport)

Boston, MA (General Edward Lawrence Logan International Airport)

Chantilly, VA (Washington Dulles International Airport)

Charlotte, NC (Charlotte/Douglas International Airport)

Chicago, IL Chicago-O'Hare International Airport)

Cleveland, OH (Cleveland-Hopkins International Airport)

Covington, KY (Cincinnati Northern Kentucky International Airport)

Dallas, TX (Dallas/Fort Worth Regional Airport)

Denver, CO (Denver International Airport)

Detroit, MI (Metropolitan Wayne County Airport)

Honolulu, HI (Honolulu International Airport)

Houston, TX (George Bush Intercontinental Airport/Houston)

Kansas City, KS (Mid-Continent International Airport)

Las Vegas, NV (McCarran International Airport)

Los Angeles, CA (Los Angeles International Airport)

Memphis, TN (Memphis International Airport)

Miami, FL (Miami International Airport)

Minneapolis, MN (Minneapolis-St. Paul International Airport)

Newark, NJ (Newark International Airport)

New Orleans, LA (New Orleans International Airport-Moisant Field)

New York, NY (John F. Kennedy International Airport)

New York, NY (LaGuardia Airport)

Orlando, FL (Orlando International Airport)

Philadelphia, PA (Philadelphia International Airport)

Phoenix, AZ (Phoenix Sky Harbor International Airport)

Pittsburgh, PA (Greater Pittsburgh International Airport)

St. Louis, MO (Lambert-St. Louis International Airport)

Salt Lake City, UT (Salt Lake City International Airport)

San Diego, CA (San Diego International Airport)

San Francisco, CA (San Francisco International Airport)

Seattle, WA (Seattle-Tacoma International Airport)

Tampa, FL (Tampa International Airport)

Washington, DC (Ronald Reagan Washington National Airport and Andrews Air Force Base, MD)

190. Question: What considerations will be necessary for CSV operations in or around these areas?

Appendix E to Part 91—Airplane Flight Recorder Specifications

NA

Appendix G to Part 91—Operations in Reduced Vertical Separation Minimum (RVSM) Airspace

191. Question: Will commercial space vehicles and/or participating aircraft be permitted to operate within RVSM airspace?
192. Question: If commercial space vehicles and/or participating aircraft will be permitted to operate within RVSM, what policies, procedures, and equipment will be required?
193. Question: When will the operator a CSV be required to notify air traffic control authorities of intent to traverse RVSM airspace?
194. Question: What equipment design (e.g. TCAS) must be available for vertical separation between CSVs and participating aircraft in the RVSM?
195. Question: Will hazardous payloads or catastrophic probabilities of vehicle failure on particular missions affect the ability of CSVs and/or sporting aircraft to use the RVSM airspace?
196. Question: If a CSV is permitted to overfly the RVSM airspace to include airspace used within the North Atlantic Track System, what steps towards risk mitigation are necessary to protect participating aircraft in the event of a catastrophic failure of the vehicle?

FAA Order 7110.65T

(NAS Integration Analysis of 7110.65 for CSV Operations)

Chapter 3 Airport Traffic Control− Terminal

Section 7. Taxi and Ground Movement Procedures

3−7−1. GROUND TRAFFIC MOVEMENT

Issue by radio or directional light signals specific instructions which approve or disapprove the movement of aircraft, vehicles, equipment, of personnel on the movement area except where permitted in an LOA.

a. Do not issue *conditional* instructions that are dependent upon the movement of an arrival aircraft on or approaching the runway or a departure aircraft established on a takeoff roll. Do not say, "Line up and wait behind landing traffic," or "Taxi/proceed across Runway Three−Six behind departing/landing Citation." The above requirements do not preclude issuing instructions to follow an aircraft observed to be operating on the movement area in accordance with an ATC clearance/instruction and in such a manner that the instructions to follow are not ambiguous.

b. Do not issue unconditional instructions when authorizing movement on a runway/taxiway for the purpose of airfield checks or other airport operations. Instructions must ensure positive control with specific instructions to proceed on a runway or movement area, and as necessary, hold short instructions.

NOTE−

The following are examples of unconditional instructions and are not approved for use: "THE FIELD IS YOURS,"

"CLEARED ON ALL SURFACES," "THE AIRPORT IS YOURS," and "PROCEED ON ALL RUNWAYS AND TAXIWAYS."

c. Do not use the word "cleared" in conjunction with authorization for aircraft to taxi or equipment/ vehicle/personnel operations. Use the prefix "taxi," "proceed," or "hold," as appropriate, for aircraft instructions and "proceed" or "hold" for equipment/ vehicles/personnel.

d. Intersection departures may be initiated by a controller or a controller may authorize an intersection departure if a pilot requests. Issue the measured distance from the intersection to the runway end rounded "down" to the nearest 50 feet to any pilot who requests and to all military aircraft, unless use of the intersection is covered in appropriate directives.

NOTE−

1. *Exceptions are authorized where specific military aircraft routinely make intersection takeoffs and procedures are defined in appropriate directives. The authority exercising operational control of such aircraft ensures that all pilots are thoroughly familiar with these procedures, including the usable runway length from the applicable* *intersection.*

2. *Some airports publish "declared distances" for a particular runway. These are published in the Airport Facility Directory (A/FD) or the Aeronautical Information Publication (AIP) and there is no requirement that facility personnel be aware of them. These distances are a means of satisfying airport design criteria and are intended to be*

used by pilots and/or operators for preflight performance planning only. There are no special markings, signing, or lighting associated with declared distances and they do not

limit the actual runway available for use by an aircraft. Therefore, they cannot be used for any air traffic control purpose. If pilots inquire about the existence of declared

distances, refer them to the A/FD or AIP.

3−7−2. TAXI AND GROUND MOVEMENT OPERATIONS

Issue the route for the aircraft/vehicle to follow on the movement area in concise and easy to understand terms. The taxi clearance must include the specific route to follow. When a taxi clearance to a runway is issued to an aircraft, confirm the aircraft has the correct runway assignment.

NOTE−

1. *A pilot's read back of taxi instructions with the runway assignment can be considered confirmation of runway assignment.*

2. *Movement of aircraft or vehicles on non-movement areas is the responsibility of the pilot, the aircraft operator, or the airport management.*

a. When authorizing an aircraft/vehicle to proceed on the movement area or to any point other than assigned takeoff runway, specify the route/taxi instructions. If it is the intent to hold the aircraft/vehicle short of any given point along the taxi route, issue the route and then state the holding instructions.

b. When authorizing an aircraft to taxi to an assigned takeoff runway, state the departure runway followed by the specific taxi route. Issue hold short restrictions when an aircraft will be required to hold short of a runway or other points along the taxi route.

197. Question: Will ATC controllers be trained to handle CSV ground operations in conjunction with other aircraft movements?

c. Aircraft/vehicles must receive a clearance for each runway their route crosses. An aircraft/vehicle must have crossed a previous runway before another runway crossing clearance may be issued.

d. When an aircraft/vehicle is instructed to "follow" traffic and requires a runway crossing, issue a runway crossing clearance in addition to the follow instructions and/or hold short instructions, as applicable.

e. At those airports where the taxi distance between runway centerlines is less than 1,000 feet, multiple runway crossings may be issued with a single clearance. The air traffic manager must submit a request to the appropriate Terminal Services Director of Operations for approval before authorizing multiple runway crossings.

f. Request a read back of runway hold short instructions when it is not received from the pilot/vehicle operator.

2. *"Cleveland Tower, American Sixty Three is ready for departure."*

"American Sixty Three, hold short of Runway Two Three

Left, traffic one mile final."

"American Sixty Three, Roger."

"American Sixty Three, read back hold instructions."

3. *"OPS Three proceed via taxiway Charlie hold short of Runway Two Seven." or*

"OPS Three proceed via Charlie hold short of Runway Two Seven."

"OPS Three, Roger."

"OPS Three, read back hold instructions."

NOTE−

Read back hold instructions phraseology may be initiated for any point on a movement area when the controller believes the read back is necessary.

g. Issue progressive taxi/ground movement instructions when:

1. A pilot/operator requests.

2. The specialist deems it necessary due to traffic or field conditions, e.g., construction or closed taxiways.

3. Necessary during reduced visibility, especially when the taxi route is not visible from the tower.

NOTE−

Progressive instructions may include step−by−step directions and/or directional turns.

h. Issue instructions to expedite a taxiing aircraft or a moving vehicle.

3−7−3. GROUND OPERATIONS WAKE TURBULENCE APPLICATION

Avoid clearances which require:

a. Heavy jet aircraft to use greater than normal taxiing power.

198. Question: Should clearances that involve CSVs using greater than normal power be avoided?

b. Small aircraft or helicopters to taxi in close proximity to taxiing or hover-taxi helicopters.

199. Question: Will a similar procedure caution small aircraft or helicopters from taxiing in close proximity to CSVs along with hover-taxi helicopters?

3−7−4. RUNWAY PROXIMITY *NA*

Hold a taxiing aircraft or vehicle clear of the runway as follows:

a. Instruct aircraft or vehicle to hold short of a specific runway.

b. Instruct aircraft or vehicle to hold at a specified point.

c. Issue traffic information as necessary.

3−7−5. PRECISION APPROACH CRITICAL AREA *NA*

a. ILS critical area dimensions are described in FAAO 6750.16, Siting Criteria for Instrument Landing Systems. Aircraft and vehicle access to the ILS/MLS critical area must be controlled to ensure the integrity of ILS/MLS course signals whenever conditions are less than reported ceiling 800 feet or visibility less than 2 miles. Do not authorize vehicles/aircraft to operate in or over the critical area, except as specified in subpara a1, whenever an arriving aircraft is inside the ILS outer marker (OM) or the fix used in lieu of the OM unless the arriving aircraft has reported the runway in sight or is circling to land on another runway.

PHRASEOLOGY−

HOLD SHORT OF (runway) ILS/MLS CRITICAL AREA.

1. LOCALIZER CRITICAL AREA NA

(a) Do not authorize vehicle or aircraft operations in or over the area when an arriving aircraft is inside the ILS OM or the fix used in lieu of the OM when conditions are less than reported ceiling 800 feet or visibility less than 2 miles, except:

(1) A preceding arriving aircraft on the same or another runway that passes over or through the area while landing or exiting the runway.

(2) A preceding departing aircraft or missed approach on the same or another runway that passes through or over the area.

(b) In addition to subpara a1(a), do not authorize vehicles or aircraft operations in or over the area when an arriving aircraft is inside the middle marker when conditions are less than reported ceiling 200 feet or RVR 2,000 feet.

2. GLIDESLOPE CRITICAL AREA. Do not authorize vehicles or aircraft operations in or over the area when an arriving aircraft is inside the ILS OM or the fix used in lieu of the OM unless the arriving aircraft has reported the runway in sight or is circling to land on another runway when conditions are less than reported ceiling 800 feet or visibility less than 2 miles.

b. Air carriers commonly conduct "coupled" or "autoland" operations to satisfy maintenance, training, or reliability program requirements. Promptly issue an advisory if the critical area will not be protected when an arriving aircraft advises that a "coupled," "CATIII," "autoland," or similar type approach will be conducted and the weather is reported ceiling of 800 feet or more, and the visibility is 2 miles or more.

PHRASEOLOGY−

ILS/MLS CRITICAL AREA NOT PROTECTED.

c. The Department of Defense (DOD) is authorized to define criteria for protection of precision approach critical areas at military controlled airports. This protection is provided to all aircraft operating at that military controlled airport. Waiver authority for DOD precision approach critical area criteria rests with the appropriate military authority.

NOTE−

Signs and markings are installed by the airport operator to define the ILS/MLS critical area. No point along the longitudinal axis of the aircraft is permitted past the hold line for holding purposes. The operator is responsible to properly position the aircraft, vehicle, or equipment at the appropriate hold line/sign or designated point. The requirements in para 3−1−12, Visually Scanning Runways, remain valid as appropriate.

3−7−6. PRECISION OBSTACLE FREE ZONE (POFZ) AND FINAL APPROACH OBSTACLE CLEARANCE SURFACES (OCS) NA

a. Ensure the POFZ is clear of traffic (aircraft or vehicles) when an aircraft on a vertically−guided final approach is within 2 miles of the runway threshold and the reported ceiling is below 300 feet or visibility is less than 3/4 SM to protect aircraft executing a missed approach.

NOTE−

Only horizontal surfaces (e.g., the wings) can penetrate the POFZ, but not the vertical surfaces (e.g., fuselage or tail). Three hundred feet (300) is used because ATC does not measure ceilings in fifty (50) foot increments.

b. Ensure the final approach OCS (e.g., ILS /LPV W, X, and Y surfaces) are clear of aircraft/vehicles when an aircraft on the vertically−guided approach is within 2 miles of the runway threshold and the reported ceiling is below 800 feet or visibility is less than 2 SM to protect aircraft executing a missed approach.

NOTE−

1. *The POFZ and the close−in portion of the final approach obstacle clearance surfaces protect aircraft executing a missed approach. Their dimensions are described in FAAO 8260.3b, Volume III, Chapter 3, para 3.4, United States Standards for Terminal Instrument Procedures.*

2. *Vehicles that are less than 10 feet in height, necessary for the maintenance of the airport and/or navigation facilities operating outside the movement area, are exempt.*

c. If it is not possible to clear the POFZ or OCS prior to an aircraft reaching a point 2 miles from the runway threshold and the weather is less than described in subparas a or b above, issue traffic to the landing aircraft.

Section 8. Spacing and Sequencing

3−8−1. SEQUENCE/SPACING
APPLICATION

Establish the sequence of arriving and departing aircraft by requiring them to adjust flight or ground operation, as necessary, to achieve proper spacing.

NOTE−

1. *The "Cleared for the Option" procedure will permit an instructor pilot/flight examiner/pilot the option to make a touch-and-go, low approach, missed approach, stop and- go, or full stop landing. This procedure will only be used at those locations with an operational control tower and will be subject to ATC approval.*

2. *For proper helicopter spacing, speed adjustments may be more practical than course changes.*

3. *Read back of hold short instructions apply when hold instructions are issued to a pilot in lieu of a takeoff clearance*

.3−8−2. TOUCH-AND-GO OR STOP-AND-GO OR LOW APPROACH NA

Consider an aircraft cleared for touch-and-go, stop-and-go, or low approach as an arriving aircraft until it touches down (for touch-and-go), or makes a complete stop (for stop-and-go), or crosses the landing threshold (for low approach), and thereafter as a departing aircraft.

3−8−3. SIMULTANEOUS SAME DIRECTION OPERATION NA
Authorize simultaneous, same direction operations on parallel runways, on parallel landing strips, or on a runway and a parallel landing strip only when the following conditions are met:

a. Operations are conducted in VFR conditions unless visual separation is applied.

b. Two-way radio communication is maintained with the aircraft involved and pertinent traffic information is issued.

c. The distance between the runways or landing strips is in accordance with the minima in TBL 3−8−1 (use the greater minimum if two categories are involved). ***TBL 3−8−1***

Same Direction Distance Minima

Aircraft category	Minimum distance (feet) between parallel Runway centerlines	Edges of adjacent strips or runway and strip
Lightweight, single−engine, propeller driven	300	200
Twin−engine, propeller driven	500	400
All others	700	600

Question: Will CSVs be included in the "All others" category for the Same Direction Distance Minima in Table 3-8-1?

3−8−4. SIMULTANEOUS OPPOSITE DIRECTION OPERATION

Authorize simultaneous opposite direction operations on parallel runways, on parallel landing strips, or on a runway and a parallel landing strip only when the following conditions are met:

a. Operations are conducted in VFR conditions.

b. Two-way radio communication is maintained with the aircraft involved and pertinent traffic information is issued.

PHRASEOLOGY−

TRAFFIC (description) ARRIVING/DEPARTING/LOW

APPROACH, OPPOSITE DIRECTION ON PARALLEL

RUNWAY/LANDING STRIP.

c. The distance between the runways or landing strips is in accordance with the minima in ***TBL 3−8−2, TBL 3−8−2***

Opposite Direction Distance Minima

Type of Operation	Minimum distance (feet) between parallel Runway centerlines	Edges of adjacent strips or runway and strip

Between sunrise and		
Sunset	1,400	1,400
Between sunset and		
Sunrise	2,800	Not authorized

Section 9. Departure Procedures and Separation

3-9-1. DEPARTURE INFORMATION

Provide current departure information, as appropriate, to departing aircraft.

a. Departure information contained in the ATIS broadcast may be omitted if the pilot states the appropriate ATIS code.

200. Question: Will standard information still apply to CSV or will certain information be required that is not usually included in the ATIS?
201. Question: Will the normal ATIS broadcast be expanded to included specialized information for departing CSVs?
202. Question: What kind of weather, runway and atmospheric restrictions will be required for each type of CSV?
203. Question: Will solar wind patterns, sunspots and ionosphere winds need to be reported on ATIS?
204. Question: What CSV entity is required to know the ATIS information? (The pilot, operator?)
205. Question: Will CSVs have a newly defined priority or will they be subject to the current *"First come, first served"* system?

b. Issue departure information by including the following: N/A

c. Time, when requested. N/A

d. Issue the official ceiling and visibility, when available, to a departing aircraft before takeoff as follows: N/A

e. Issue the route for the aircraft/vehicle to follow on the movement area in concise and easy to understand terms. The taxi clearance must include the specific route to follow. N/A

f. *USAF NOT APPLICABLE.* An advisory to "check density altitude" when appropriate.

206. Question: Will CSVs be an exception as well? "CSV NOT APPLICABLE"

g. Issue braking action for the runway in use as received from pilots or the airport management when Braking Action Advisories are in effect. N/A

3-9-2. DEPARTURE DELAY INFORMATION

USA/USAF/USN NOT APPLICABLE

When gate-hold procedures are in effect, issue the following departure delay information as appropriate:

207. Question: Will CSVs be subject to "Gate-Hold" procedures?

a. Advise departing aircraft the time at which the pilot can expect to receive engine startup advisory.

208. Question: If "Gate-Hold" is in effect, will CSVs be given a priority over other participating aircraft?

b. Advise departing aircraft when to start engines and/or to advise when ready to taxi.

209. Question: If some CSVs (VTVL or VTHL) do not have taxi capability, what will be the "Ramp-Hold" procedure?
210. Question: What specific phraseology will be approved for CSV taxi operations?

c. If the pilot requests to hold in a delay absorbing area, the request shall be approved if space and traffic conditions permit. N/A

d. Advise all aircraft on GC/FD frequency upon termination of gate hold procedures. N/A

3-9-3. DEPARTURE CONTROL INSTRUCTIONS

Inform departing IFR, SVFR, VFR aircraft receiving radar service, and TRSA VFR aircraft of the following:

a. Before takeoff.

1. Issue the appropriate departure control frequency and beacon code. The departure control frequency may be omitted if a SID has been or will be assigned and the departure control frequency is published on the SID.

PHRASEOLOGY-DEPARTURE FREQUENCY (frequency), SQUAWK (code).

211. Question: Will CSVs have SID and STAR capabilities?
212. Question: Will CSV be equipped with transponders (required if issued SQUAWK codes)?

2. Inform all departing IFR military turboprop/turbojet aircraft (except transport and cargo types) to change to departure control frequency. If the local controller has departure frequency override, transmit urgent instructions on this frequency. If the override capability does not exist, transmit urgent instructions on the emergency frequency. **NA**

3. *USAF.* USAF control towers are authorized to inform all departing IFR military transport/cargo type aircraft operating in formation flight to change to departure control frequency before takeoff.

213. Question: Will CSVs be handled in the same manner as USAF aircraft departures?

b. After takeoff.

1. When the aircraft is about $^1/_2$ mile beyond the runway end, instruct civil aircraft, and military transport, and cargo types to contact departure control, provided further communication with you is not required.

214. Question: Will CSVs be required to contact departure control?

Question: Will another control entity be responsible for departure clearances and procedures?

215. Question: If departure control is responsible for CSVs, which LOAs will need to be updated?

2. Do not request departing military turboprop/turbojet aircraft (except transport and cargo types) to make radio frequency or radar beacon changes before the aircraft reaches 2,500 feet above the surface.

216. Question: Will a similar rule be put into effect for CSVs?

3-9-4. LINE UP AND WAIT (LUAW)

a. The intent of LUAW is to position aircraft for an imminent departure. Authorize an aircraft to line up and wait, except as restricted in subpara g, when takeoff clearances cannot be issued because of traffic. Issue traffic information to any aircraft so authorized. Traffic information may be omitted when the traffic is another aircraft which has landed on or is taking off the runway and is clearly visible to the holding aircraft. Do not use conditional phrases such as "behind landing traffic" or "after the departing aircraft."

217. Question: Will CSVs participate in LUAW operations?

b. First state the runway number followed by the lineup and wait clearance.

218. Question: If CSVs are participating in LUAW, what exact terminology will be developed for handling CSVs?

c. Procedures.

219. Question: Will the following procedures regarding LUAW apply to CSV or will exceptions be put in place?

1. At facilities without a safety logic system or facilities with the safety logic system in the limited configuration:

(a) Do not issue a landing clearance to an aircraft requesting a full-stop, touch-and-go, stop-and-go, option, or unrestricted low approach on the same runway with an aircraft that is holding in position or taxiing to line up and wait until the aircraft in position starts takeoff roll.

(b) Do not authorize an aircraft to LUAW if an aircraft has been cleared to land, touch-and-go, stop-and–go, option, or unrestricted low approach on the same runway.

3-9-5. ANTICIPATING SEPARATION

Takeoff clearance needs not be withheld until prescribed separation exists if there is a reasonable assurance it will exist when the aircraft starts takeoff roll.

220. Question: Can controllers "anticipate separation" with CSVs during normal traffic operations?

3-9-6. SAME RUNWAY SEPARATION

Separate a departing aircraft from a preceding departing or arriving aircraft using the same runway by ensuring that it does not begin takeoff roll until:

221. Question: Will the following rules apply to control of CSVs during departures?

a. The other aircraft has departed and crossed the runway end or turned to avert any conflict. (See FIG 3-9-1.) If you can determine distances by reference to suitable landmarks, the other aircraft needs only be airborne if the following minimum distance exists between aircraft: (See FIG 3-9-2.)

1. When only Category I aircraft are involved- *3,000 feet.*

2. When a Category I aircraft is preceded by a Category II aircraft- *3,000 feet.*

3. When either the succeeding or both are Category II aircraft- *4,500 feet.*

4. When either is a Category III aircraft- *6,000 feet.*

5. When the succeeding aircraft is a helicopter, visual separation may be applied in lieu of using distance minima.

CATEGORY I- small aircraft weighing 12,500 lbs. or less, with a single propeller driven engine, and all helicopters.

CATEGORY II- small aircraft weighing 12,500 lbs. or less, with propeller driven twin-engines.

CATEGORY III- all other aircraft.

222. Question: Will CSVs fall under the "CATEGORY III – all other aircraft" group or will their characteristics be distinct enough to warrant a different classification?
223. Question: What aerodynamic/operating parameters of CSVs will define separation requirements?
224. Question: If a different class or category of aircraft is formed, will it be based on weight, engine type, or speed?
225. Question: What CSV wake turbulence characteristics will be taken into consideration?
226. Question: Will different CSV launch profiles be taken into consideration (VTVL, VTHL, HTHL)?
227. Question: What will be the nose to tail separation requirements for CSVs?
228. Question: What runway temperatures will change the departures of CSVs?
229. Question: What blast and debris patterns will be expected in a CSV departure?
230. Question: What aerodynamic (wind tunnel?) experiments must be conducted to ensure safety of departing CSVs from the airfield?

b. A preceding landing aircraft is clear of the runway.

c. Do not issue clearances which imply or indicate approval of rolling takeoffs by heavy jet aircraft except as provided in para 3-1-14, Ground Operations When Volcanic Ash is Present. N/A

d. Do not issue clearances to a small aircraft to line up and wait on the same runway behind a departing heavy jet aircraft to apply the necessary intervals. N/A

REFERENCE-
AC 90-23, Aircraft Wake Turbulence.

e. The minima in para 5-5-4, Minima, may be applied in lieu of the 2 minute requirement in subpara f. When para 5-5-4, Minima, are applied, ensure that the appropriate radar separation exists at or prior to the time an aircraft becomes airborne when taking off behind a heavy jet/B757.

231. Question: Will a similar exception be included for CSVs?

NOTE-
The pilot may request additional separation; i.e., 2 minutes vs. 4 miles, but should make this request before taxiing on the runway.

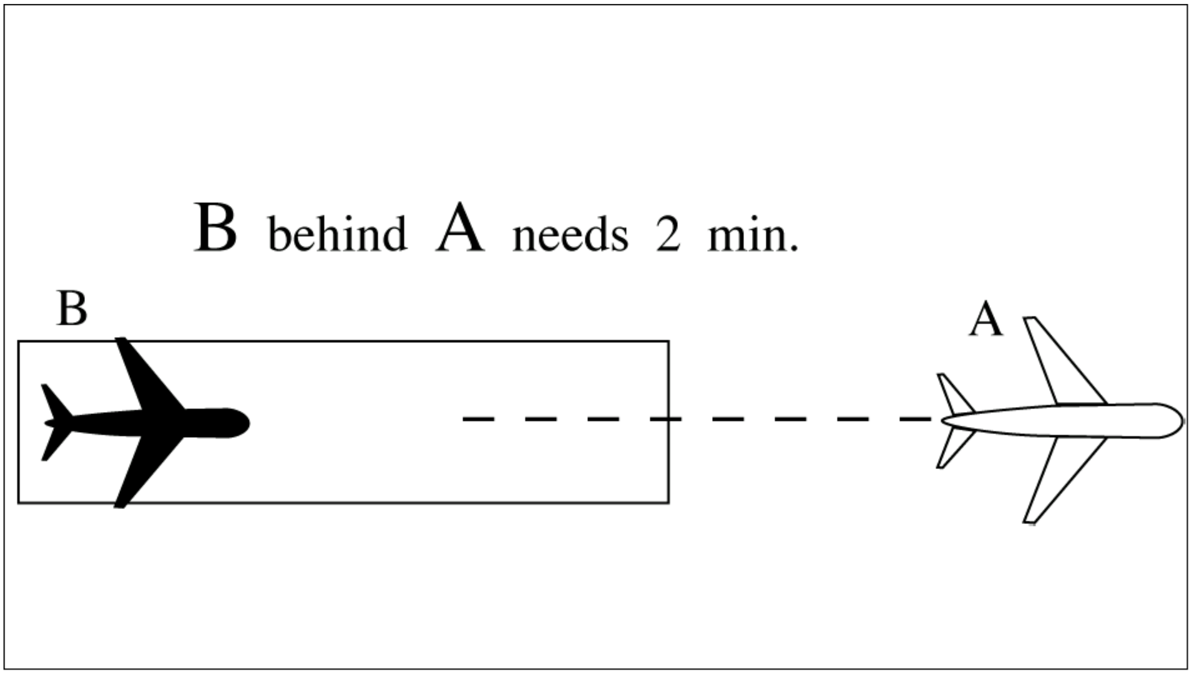
f. Separate IFR/VFR aircraft taking off behind a heavy jet/B757 departure by 2 minutes, when departing:

232. Question: What will be the exception requirements for CSVs?

NOTE-
Takeoff clearance to the following aircraft should not be issued until 2 minutes after the heavy jet/B757 begins takeoff roll.

1. The same runway. (See FIG 3-9-4.)

FIG 3-9-4
2 Minute Separation



2. A parallel runway separated by less than 2,500 feet.

g. Separate an aircraft from a heavy jet/B757 when operating on a runway with a displaced landing threshold if projected flight paths will cross- *2 minutes when:*

Question: What will the exceptions be for CSVs when operating on runways with displaced thresholds?**1. A departure follows a heavy jet/B757 arrival.**

3-9-7. WAKE TURBULENCE SEPARATION FOR INTERSECTION DEPARTURES

a. Apply the following wake turbulence criteria for intersection departures:

1. Separate a small aircraft taking off from an intersection on the same runway (same or opposite direction takeoff) behind a preceding departing large aircraft by ensuring that the small aircraft does not start takeoff roll until at least 3 minutes after the large aircraft has taken off.

2. Separate any aircraft taking off from an intersection on the same runway (same or opposite direction takeoff), parallel runways separated by less than 2,500 feet, and parallel runways separated by less than 2,500 feet with runway thresholds offset by 500 feet or more, by ensuring that the aircraft does not start takeoff roll until at least 3 minutes after a heavy aircraft/B757 has taken off.

NOTE-
Parallel runways separated by less than 2,500 feet with runway thresholds offset by less than 500 feet shall apply para 3-9-6, Same Runway Separation, subpara f.

3. Separate a small aircraft weighing 12,500 lbs. or less taking off from an intersection on the same runway (same or opposite direction takeoff) behind a preceding small aircraft weighing more than 12,500 lbs. by ensuring the following small aircraft does not start takeoff roll until at least 3 minutes after the preceding aircraft has taken off.

4. Inform an aircraft when it is necessary to hold in order to provide the required 3-minute interval.

Questions: Will an analysis of similar separation requirements be developed for CSVs?

233. Question: What aerodynamic/operating parameters of CSVs will define separation requirements?

PHRASEOLOGY-
HOLD FOR WAKE TURBULENCE.

NOTE-
Aircraft conducting touch-and-go and stop-and-go operations are considered to be departing from an intersection.

b. The 3-minute interval is not required when:

1. A pilot has initiated a request to deviate from that interval unless the preceding departing aircraft is a heavy aircraft/B757.

NOTE-
A request for takeoff does not initiate a waiver request; the request for takeoff must be accomplished by a request to deviate from the 3-minute interval.

234. Question: Will CSVs be allowed to request a deviation from the takeoff norms outlined under this paragraph?

2. USA NOT APPLICABLE. The intersection is 500 feet or less from the departure point of the preceding aircraft and both aircraft are taking off in the same direction. NA

3. Successive touch-and-go and stop-and-go operations are conducted with a small aircraft following another small aircraft weighing more than 12,500 lbs. or a large aircraft in the pattern, or a small aircraft weighing more than 12,500 lbs. or a large aircraft departing the same runway, provided the pilot of the small aircraft is maintaining visual separation/spacing behind the preceding large aircraft. Issue a wake turbulence cautionary advisory and the position of the large aircraft.NA

EXAMPLE-
"Caution wake turbulence, DC-9 on base leg."

4. Successive touch-and-go and stop-and-go operations are conducted with any aircraft following a heavy aircraft/B757 in the pattern, or heavy aircraft/B757 departing the same runway, provided the pilot of the aircraft is maintaining visual separation/spacing behind the preceding heavy aircraft/B757. Issue a wake turbulence cautionary advisory and the position of the heavy aircraft/B757. NA

EXAMPLE-
"Caution wake turbulence, heavy Lockheed C5A departing runway two three."

5. If action is initiated to reduce the separation between successive touch-and-go or stop-and-go operations, apply 3 minutes separation.

c. When applying the provision of subpara b:

1. Issue a wake turbulence advisory before clearing the aircraft for takeoff.

2. Do not clear the intersection departure for an immediate takeoff.

3. Issue a clearance to permit the trailing aircraft to deviate from course enough to avoid the flight path of the preceding large departure when applying subpara b1 or b2.

4. Separation requirements in accordance with para 3-9-6, Same Runway Separation, must also apply.

REFERENCE-
FAAO JO 7110.65, Para 3-9-6, Same Runway Separation.

3-9-8. INTERSECTING RUNWAY SEPARATION

a. Issue traffic information to each aircraft operating on intersecting runways.

b. Separate departing aircraft from an aircraft using an intersecting runway, or nonintersecting runways when the flight paths intersect, by ensuring that the departure does not begin takeoff roll until one of the following exists: NA

3-9-9. TAKEOFF CLEARANCE

When issuing a clearance for takeoff, first state the runway number followed by the takeoff clearance. NA

3-9-10. CANCELLATION OF TAKEOFF CLEARANCE

Cancel a previously issued clearance for takeoff and inform the pilot of the reason if circumstances require. Once an aircraft has started takeoff roll, cancel the takeoff clearance only for the purpose of safety.

235. Question: What will be the notification procedure of a cancellation of takeoff clearance?

NOTE-
In no case should a takeoff clearance be canceled after an aircraft has started its takeoff roll solely for the purpose of meeting traffic management requirements/EDCT.

PHRASEOLOGY-
CANCEL TAKEOFF CLEARANCE (reason).

Section 10. Arrival Procedures and Separation

3-10-1. LANDING INFORMATION

Provide current landing information, as appropriate, to arriving aircraft. Landing information contained in the ATIS broadcast may be omitted if the pilot states the appropriate ATIS code. Runway, wind, and altimeter may be omitted if a pilot uses the phrase "have numbers." Issue landing information by including the following:

236. Question: Will these requirements still apply to CSVs, or will additional technical information be required that is not usually included in the ATIS?
237. Question: Will the ATIS be expanded to included pertinent information for arriving CSVs?
238. Question: Will landing clearances of CSVs continue to be governed by the wide variety of runway separation rules, meteorology conditions and vehicle performance capabilities used for conventional aircraft?
239. Question: Can CSVs be sequenced in a standard arrival pattern?
240. Question: Can CSVs be maneuvered to alternate runways or landing pads if conflicts occur?

(a). Specific traffic pattern information (may be omitted if the aircraft is to circle the airport to the left). N/A

(b). Runway in use. N/A

(c). Surface wind. N/A

(d). Altimeter setting. N/A

(e). Any supplementary information.

241. Question: What supplementary information will spacecraft require for landing clearance?

(f). Clearance to land.

242. Question: Will ATCT have the authority to grant or withhold landing clearance of a CSV?

3-10-2. FORWARDING APPROACH INFORMATION BY NONAPPROACH CONTROL FACILITIES

(a). Forward the following, as appropriate, to the control facility having IFR jurisdiction in your area. You may eliminate those items that, because of local conditions or situations, are fully covered in a letter of agreement or a facility directive.

243. Question: Which Letters of Agreement (LOA) will need to be updated to include appropriate spacecraft STCs?

3-10-3. SAME RUNWAY SEPARATION

(a). Separate an arriving aircraft from another aircraft using the same runway by ensuring that the arriving aircraft does not cross the landing threshold until one of the following conditions exists or unless authorized in para 3-10-10, Altitude Restricted Low Approach.

1. The other aircraft has landed and is clear of the runway. (See FIG 3-10-1.) Between sunrise and sunset, if you can determine distances by reference to suitable landmarks and the other aircraft has landed, it need not be clear of the runway if the following minimum distance from the landing threshold exists:

When a Category I aircraft is landing behind a Category I or II- *3,000 feet*. (See FIG 3-10-2.)

When a Category II aircraft is landing behind a Category I or II- *4,500 feet*. (See FIG 3-10-3.)

244. Question: What are the aerodynamic/operating parameters of CSVs that will define separation requirements?
245. Question: If a different CATEGORY is formed, will it be based on weight, engine type, speed or some other characteristic?
246. Question: What wake turbulence characteristics will be taken into consideration?
247. Question: Which launch profiles will be taken into consideration for control of CSVs (VTVL, VTHL, HTHL)?

248. Question: What will be the nose to tail separation requirements between the other CATEGLORIES of aircraft and CSVs?
249. Question: What runway temperatures, or some other temperatures, be taken into account by ATC when launching/recovering a CSV?
250. Question: What blast and debris patterns will be taken into account for launching and separation of CSVs?
251. Question: What wind tunnel experiments must be conducted to ensure safety of launch/recovery of CSVs on the airfield?

2. The other aircraft has departed and crossed the runway end. (See FIG 3-10-4). If you can determine distances by reference to suitable landmarks and the other aircraft is airborne, it need not have crossed the runway end if the following minimum distance from the landing threshold exists:

(a) Category I aircraft landing behind Category I or II- *3,000 feet.*

(b) Category II aircraft landing behind Category I or II- *4,500 feet.*

(c) When either is a category III aircraft- *6,000 feet.* (See FIG 3-10-5.)

252. Question: Will this concept of "Anticipated Separation" apply to CSVs as well?
253. Question: If Anticipated Separation is approved, what visual and operational parameters of CSVs must be considered?

3. When the succeeding aircraft is a helicopter, visual separation may be applied *in lieu of using distance minima.* *N/A*

3-10-4. INTERSECTING RUNWAY SEPARATION

Issue traffic information to each aircraft operating on intersecting runways.

(a). Separate an arriving aircraft using one runway from another aircraft using an intersecting runway or a nonintersecting runway when the flight paths intersect by ensuring that the arriving aircraft does not cross the landing threshold or flight path of the other aircraft until one of the following conditions exists:

Questions: Will a similar procedures be included for CSVs?

254. Question: What aerodynamic/operating parameters of CSVs will define separation requirements?

3-10-5. LANDING CLEARANCE

(a). When issuing a clearance to land, first state the runway number followed by the landing clearance. If the landing runway is changed, controllers must preface the landing clearance with "Change to runway."

255. Question: If the spacecraft has VTVL characteristics, what command will be used instead of "runway"?

(b). Procedures. **N/A**

(c). Inform the closest aircraft that is requesting a full-stop, touch-and-go, stop-and-go, option, or unrestricted low approaches when there is traffic authorized to line up and wait on the same runway. **N/A**

(d). USA/USN/USAF. Issue runway identifier along with surface wind when clearing an aircraft to land, touch and go, stop and go, low approach, or the option. **N/A**

3-10-6. ANTICIPATING SEPARATION

(a). Landing clearance to succeeding aircraft in a landing sequence need not be withheld if you observe the positions of the aircraft and determine that prescribed runway separation will exist when the aircraft crosses the landing threshold. Issue traffic information to the succeeding aircraft if a preceding arrival has not been previously reported and when traffic will be departing prior to their arrival.

256. Question: Can controllers "anticipate separation" with spacecraft or will they be exempt when dealing with those vehicles?

(b). Anticipating separation must not be applied when conducting LUAW operations, except as authorized in paragraph 3-10-5b2. Issue applicable traffic information when using this provision.

3-10-7. LANDING CLEARANCE WITHOUT VISUAL OBSERVATION

When an arriving aircraft reports at a position where he/she should be seen but has not been visually observed, advise the aircraft as a part of the landing clearance that it is not in sight and restate the landing runway. **N/A**

3-10-8. WITHHOLDING LANDING CLEARANCE

Do not withhold a landing clearance indefinitely even though it appears a violation of Title 14 of the Code of Federal Regulations has been committed. The apparent violation might be the result of an emergency situation. In any event, assist the pilot to the extent possible. **N/A**

3-10-9. RUNWAY EXITING

(a). Instruct aircraft where to turn-off the runway after landing, when appropriate, and advise the aircraft to hold short of a runway or taxiway if required for traffic. **N/A**

(b). Taxi instructions shall be provided to the aircraft by the local controller when:

Compliance with ATC instructions will be required before the aircraft can change to ground control, or

The aircraft will be required to enter an active runway in order to taxi clear of the landing runway.

c. Ground control and local control shall protect a taxiway/runway/ramp intersection if an aircraft is required to enter that intersection to clear the landing runway. **N/A**

(d). Request a read back of runway hold short instructions when not received from the pilot. N/A

3-10-10. ALTITUDE RESTRICTED LOW APPROACH

A low approach with an altitude restriction of not less than 500 feet above the airport may be authorized except over an aircraft in takeoff position or a departure aircraft. Do not clear aircraft for restricted altitude low approaches over personnel unless airport authorities have advised these personnel that the approaches will be conducted. Advise the approaching aircraft of the location of applicable ground traffic, personnel, or equipment.

257. Question: Will other aircraft be allowed to overfly CSVs and CSV facilities and personnel?
258. Question: If other aircraft are allowed to overfly CSV activity, what altitude restrictions will apply?

3-10-11. CLOSED TRAFFIC

Approve/disapprove pilot requests to remain in closed traffic for successive operations subject to local traffic conditions.

259. Question: If CSVs are allowed to perform special maneuvers in the ATCT, what will be the exact wording of the approval/disapproval be for the CSVs?

3-10-12. OVERHEAD MANEUVER

Issue the following to arriving aircraft that will conduct an overhead maneuver:

(a). Pattern altitude and direction of traffic. Omit either or both if standard or when you know the pilot is familiar with a nonstandard procedure. N/A

(b). Request for report on initial approach. N/A

(c). "Break" information and request for pilot report. Specify the point of "break" only if nonstandard. Request the pilot to report "break" if required for traffic or other reasons. N/A

(d). Overhead maneuver patterns are developed at airports where aircraft have an operational need to conduct the maneuver. An aircraft conducting an overhead maneuver is on VFR and the IFR flight plan is cancelled when the aircraft reaches the "initial point" on the initial approach portion of the maneuver. The existence of a standard overhead maneuver pattern does not eliminate the possible requirement for an aircraft to conform to conventional rectangular patterns if an overhead maneuver cannot be approved.

260. Question: What special procedures and/or overhead patterns should be developed for CSVs operating from established airports?

(e). Timely and positive controller action is required to prevent a conflict when an overhead pattern could extend into the path of a departing or a missed approach aircraft. Local procedures and/or coordination requirements should be set forth in an appropriate letter of agreement, facility directive, base flying manual etc., when the frequency of occurrence warrants. N/A

3-10-13. SIMULATED FLAMEOUT (SFO) APPROACHES/EMERGENCY LANDING PATTERN (ELP) OPERATIONS/PRACTICE PRECAUTIONARY APPROACHES

(a). Authorize military aircraft to make SFO/ELP/practice precautionary approaches if the following conditions are met:

(b).Traffic information regarding aircraft in radio communication with or visible to tower controllers which are operating within or adjacent to the flameout maneuvering area is provided to the SFO/ELP aircraft and other concerned aircraft. N/A

(c). The high-key altitude or practice precautionary approach maneuvering altitudes of the aircraft concerned are obtained prior to approving the approach. (See FIG 3-10-14 and FIG 3-10-16.) NA

Chapter 4. IFR

Section 1. NAVAID Use Limitations

4−1−1. ALTITUDE AND DISTANCE LIMITATIONS

When specifying a route other than an established airway or route, do not exceed the limitations in the table on any portion of the route which lies within controlled airspace.

261. Question: Will all CSVs be able to operate within the limitations of the table? If not, what NAVAIDS will be available for their use?

4−1−2. EXCEPTIONS

Altitude and distance limitations need not be applied when any of the following conditions are met:

(a). Routing is initiated by ATC or requested by the pilot and the following is provided:

1. Radar monitoring. NA

2. As necessary, course guidance unless the aircraft is /E, /F, /G, or /R equipped. NA

(b). Operational necessity requires and approval has been obtained from the Frequency Management and Flight Inspection Offices to exceed them. NA

(c). Requested routing is via an MTR.

262. Question: Will CSVs be authorized to use MTRs for training or testing?

4−1−3. CROSSING ALTITUDE

Use an altitude consistent with the limitations of the aid when clearing an aircraft to cross or hold at a fix.

263. Question: Will the CSVs have the capability of performing complex ATC instructions such as compliance with a crossing altitude requirement?

4−1−4. VFR-ON-TOP

Use a route not meeting service volume limitations only if an aircraft requests to operate "VFR-on-top" on this route. N/A

4−1−5. FIX USE

Request aircraft position reports only over fixes shown on charts used for the altitude being flown, except as follows:

264. Question: Will CSVs be required to report positions over fixes?

(a). Unless the pilot requests otherwise, use only those fixes shown on high altitude en route charts, high altitude instrument approach procedures charts, and SID charts when clearing military turbojet single-piloted aircraft.

265. Question: Will CSVs have similar, single entity, limitations imposed for ATC?

(b). Except for military single-piloted turbojet aircraft, unpublished fixes may be used if the name of the NAVAID and, if appropriate, the radial/course/ azimuth and frequency/channel are given to the pilot.

266. Question: Will this instruction apply to CSV operations as well as military aircraft?

An unpublished fix is defined as one approved and planned for publication which is not yet depicted on the charts or one which is used in accord with the following:

(c). Fixes contained in the route description of MTRs are considered filed fixes. NA

(d). TACAN-only aircraft (type suffix M, N, or P) possess TACAN with DME, but no VOR or LF navigation system capability. Assign fixes based on TACAN or VORTAC facilities only.

267. Question: Will CSVs have these NAVAIDS aboard, or will they have some system not listed here?

268. Question: Regardless of the NAVAID systems aboard the CSV, what will be the basis for assigning fixes?

(e). DME fixes shall not be established within the no-course signal zone of the NAVAID from which inbound holding course information would be derived. NA

Section 2. Clearances

4−2−1. CLEARANCE ITEMS

Issue the following clearance items, as appropriate, in the order listed below:

Aircraft identification.

269. Question: How will CSVs be identified?
270. Question: Will registration numbers, i.e. "N" numbers be issued?

Clearance limit.

271. Question: Will the CSVs have to obtain and comply with standard clearance limits?

Standard Instrument Departure (SID).

272. Question: Will special SIDs be developed for CSV use?

Route of flight including PDR/PDAR/PAR when applied.

273. Question: What route of flight will be required of CSVs?
274. Question: What special terminal procedures, besides those that are listed above, will be required for the CSVs?

Altitude data in the order flown.

275. Question: Will the CSV entire flight profile from launch to touchdown be required to be listed?

Mach number, if applicable.

276. Question: Will the CSV speed, in MACH, be required under this provision?

***USAF.* When issuing a clearance to an airborne aircraft containing an altitude assignment, do not include more than one of the following in the same transmission:**

1. Frequency change.

2. Transponder change.

3. Heading.

4. Altimeter setting.

5. Traffic information containing an altitude.

h. Holding instructions.

i. Any special information.

j. Frequency and beacon code information.

4−2−2. CLEARANCE PREFIX *N/A*

a. Prefix a clearance, information, or a request for information which will be relayed to an aircraft through a non−ATC facility by stating "A−T−C clears," "A−T−C advises," or "A−T−C requests. NA

b. Flight service stations shall prefix a clearance with the appropriate phrase: "ATC clears," "ATC advises," etc. NA

4−2−3. DELIVERY INSTRUCTIONS

Issue specific clearance delivery instructions, if appropriate. N/A

4−2−4. CLEARANCE RELAY

Relay clearances verbatim. N/A

4−2−5. ROUTE OR ALTITUDE AMENDMENTS *N/A*

a. Amend route of flight in a previously issued clearance by one of the following:

1. State which portion of the route is being amended and then state the amendment.

2. State the amendment to the route and then state that the rest of the route is unchanged.

3. Issue a clearance "direct" to a point on the previously issued route.

4. Issue the entire route by stating the amendment.

5. When route or altitude in a previously issued clearance is amended, restate all applicable altitude restrictions.

b. Issue an amended clearance if a speed restriction is declined because it cannot be complied with concurrently with a previously issued altitude restriction.

c. Air traffic control specialists should avoid route and/or altitude changes for aircraft participating in the North American Route Program (NRP) and that are displaying "NRP" in the remarks section of their flight plan. Specialists at facilities actively participating in the High Altitude Redesign (HAR) program should avoid route and/or altitude changes for aircraft participating in full HAR and high altitude Point−to−point (PTP), and that are displaying "HAR," or "PTP" in the remarks section of their flight plan.

4−2−6. THROUGH CLEARANCES

You may clear an aircraft through intermediate stops. N/A

4−2−7. ALTRV CLEARANCE

Use the phrase "via approved altitude reservation flight plan," if the aircraft will operate in an approved ALTRV. N/A

4−2−8. IFR−VFR AND VFR−IFR FLIGHTS

a. Clear an aircraft planning IFR operations for the initial part of flight and VFR for the latter part to the fix at which the IFR part ends.

277. Question: Will CSVs file IFR flight plans for airspace operations and declare VFR for space operations?

b. Treat an aircraft planning VFR for the initial part of flight and IFR for the latter part as a VFR departure. Issue a clearance to this aircraft when it requests IFR clearance approaching the fix where it proposes to start IFR operations. The phraseology CLEARED TO (destination) AIRPORT AS FILED may be used with abbreviated departure clearance procedures.

278. Question: Are these procedures and phraseology adequate for CSV operation in the NAS if they are to exit the atmosphere to space?

c. When an aircraft changes from VFR to IFR, the controller shall assign a beacon code to Mode-C equipped aircraft that will allow MSAW alarms.

279. Question: Will CSVs use ATCRBS or some other system such as ADS-B to keep ATC informed of their position and performance?

d. When a VFR aircraft, operating below the minimum altitude for IFR operations, requests an IFR clearance and you are aware that the pilot is unable to climb in VFR conditions to the minimum IFR altitude: NA

1. Before issuing a clearance, ask if the pilot is able to maintain terrain and obstruction clearance during a climb to the minimum IFR altitude. NA

2. If the pilot is able to maintain terrain and obstruction separation, issue the appropriate clearance as prescribed in para 4−2−1, Clearance Items, and para 4−5−6, Minimum En Route Altitudes. NA

3. If unable to maintain terrain and obstruction separation, instruct the pilot to maintain VFR and to state intentions. NA

4. If appropriate, apply the provisions of para 10−2−7, VFR Aircraft In Weather Difficulty, or para 10−2−9, Radar Assistance Techniques, as necessary. NA

4−2−9. CLEARANCE ITEMS

The following guidelines shall be utilized to facilitate the processing of airfile aircraft:

a. Ensure the aircraft is within your area of jurisdiction unless otherwise coordinated.

280. Question: Will CSVs have the option of filing flight plans while airborne?

281. Question: What FAA entity (ARTCC, ATCT or Flight Service Stations) will have jurisdiction if CSVs file?

b. Obtain necessary information needed to provide IFR service.

282. Question: What information will be required of CSVs for service by ATC?

c. Issue clearance to destination, short range clearance, or an instruction to the pilot to contact a FSS or AFSS if the flight plan cannot be processed. NA

4−2−10. CANCELLATION OF IFR FLIGHT PLAN

a. If necessary, before instructing an IFR aircraft arriving at an airport not served by an air traffic control tower or flight service station to change to the common traffic advisory frequency, provide the pilot with instructions on how to cancel his/her IFR flight plan.

283. Question: What information, if any, must be given to CSVs landing at airports not served by an ATCT?

1. Airports with an air/ground communications station:

2. Airports without an air/ground communications station:

b. Respond to a pilot's cancellation of his/her IFR flight plan as follows: NA

Section 3. Departure Procedures

4−3−1. DEPARTURE TERMINOLOGY

Avoid using the term "takeoff" except to actually clear an aircraft for takeoff or to cancel a takeoff clearance. Use such terms as "depart," "departure," or "fly" in clearances when necessary.

284. Question: Should there be special terminology used by ATC to affect a CSV launch?

4−3−2. DEPARTURE CLEARANCES

Include the following items in IFR departure clearances:

285. Question: Will the following requirements apply to CSVs as well as normal traffic?

a. Always include the airport of departure when issuing a departure clearance for relay to an aircraft by an FSS, dispatcher, etc.

b. Clearance Limit.

c. Departure Procedures.

1. Specify direction of takeoff/turn or initial heading/azimuth to be flown after takeoff as follows:

286. Question: For a CSV that is brought to altitude on a carrier, will two clearances be required?

287. Question: If two clearances are required, what is the departure point for the clearance for the CSV carried CSV?

288. Question: If the carrier returns to the same spaceport after the CSV detaches, what type of clearance will be required?

289. Question: Will a new type of clearance be developed for CSVs launched form "Mother" ships?

290. Question: What type of clearance will be required for each of the CSVs if one is released for return to the departure point clearance?

(a) Locations with Airport Traffic Control Service− Specify these items as necessary.

(b) Locations without Airport Traffic Control Service, but within a Class E surface area− specify these items if necessary. Obtain/solicit the pilot's concurrence concerning these items before issuing them in a clearance.

(c) At all other airports− Do not specify direction of takeoff/turn after takeoff. If necessary to specify an initial heading/azimuth to be flown after takeoff, issue the initial heading/azimuth so as to apply only within controlled airspace.

2. Where only textually described obstacle departure procedures (ODP) have been published for a location and pilot compliance is necessary to insure separation, include the procedure as part of the ATC clearance. N/A

3. Compatibility with a procedure issued may be verified by asking the pilot if items obtained/solicited will allow him/her to comply with local traffic pattern, terrain, or obstruction avoidance. N/A

4. SIDs:

(Preferential Departure Route (PDR) is a specific departure route from an airport or terminal area to an en route point where there is no further need for flow control. It may be included in an Instrument Departure Procedure (DP) or a Preferred IFR Route.)

(a) Assign a SID (including transition if necessary). Assign a PDR or the route filed by the pilot, only when a SID is not established for the departure route to be flown, or the pilot has indicated that he/she does not wish to use a SID.

291. Question: Will SIDs be developed for CSVs?

292. Question: Will SIDs that are appropriate for CSVs be designated differently?

293. Question: Can a PDR be used by CSVs?

(b) If it is necessary to assign a crossing altitude which differs from the SID altitude, repeat the changed altitude to the pilot for emphasis. N/A

(c) Specify altitudes when they are not included in the SID. N/A

(d) Route of flight. N/A

(e). Altitude. N/A

4−3−3. ABBREVIATED DEPARTURE CLEARANCE
Issue an abbreviated departure clearance if its use reduces verbiage and the following conditions are met:

1. The route of flight filed with ATC has not been changed by the pilot, company, operations officer, input operator, or in the stored flight plan program prior to departure.

294. Question: What positions of authority will be allowed to change the route of flight filed for CSVs?

2. All ATC facilities concerned have sufficient route of flight information to exercise their control responsibilities.

NOTE− The route of flight information to be provided may be covered in letters of agreement.

295. Question: Which Letters of Agreement will be updated to include CSV information?

3. When the flight will depart IFR, destination airport information is relayed between the facilities concerned prior to departure. NA

4. The assigned altitude, according to the provisions in para 4−3−2, Departure Clearances, subpara e, is stated in the clearance. N/A

(a). If it is necessary to modify a filed route of flight in order to achieve computer acceptance due, for example, to incorrect fix or airway identification, the contraction "FRC," meaning "Full Route Clearance Necessary," or "FRC/(fix)," will be added to the remarks. "FRC" or "FRC/ (fix)" must always be the first item of intra-center remarks. N/A

(b). Specify the destination airport in the clearance.

296. Question: What will be the designation (i.e., Registration name/number) if the destination is a spaceport (not an airport)?

297. Question: What will be the designation (i.e. Registration name/number) if the destination is in space, or a Space Station?

(c). When no changes are required in the filed route, state the phrase: "Cleared to (destination) airport, (SID and SID transition, as appropriate); then, as filed." N/A

(d). When a filed route will require revision, the controller responsible for initiating the clearance to the aircraft shall either: N/A

1. Issue a FRC/FRC until a fix; NA **or**

2. If it reduces verbiage, state the phrase: "Cleared to (destination) airport, (SID and SID transition, as appropriate), then as filed, except . . .." Specify the necessary revision, then the assigned altitude; and if required, add any additional instructions or information. If a SID is not assigned, state: "Cleared to (destination) airport as filed, except . . ...." Specify the necessary revision, the assigned altitude; and if required, add any additional instructions or information. NA

(e). In a nonradar environment specify one, two, or more fixes, as necessary, to identify the initial route of flight. N/A

(g). Do not apply these procedures when a pilot requests a detailed clearance or to military operations conducted within ALTRV, stereo routes, operations above FL 600, and other military operations requiring special handling. N/A

4−3−4. DEPARTURE RESTRICTIONS, CLEARANCE VOID TIMES, HOLD FOR RELEASE, AND RELEASE TIMES

Assign departure restrictions, clearance void times, hold for release, or release times when necessary to separate departures from other traffic or to restrict or regulate the departure flow.

a. Clearance Void Times. N/A

b. Hold For Release (HFR). N/A

c. Release Times. N/A

d. When expect departure clearance times (EDCT) are assigned through traffic management programs, the departure terminal must, to the extent possible, plan ground movement of aircraft destined to the affected airport(s) so that flights are sequenced to depart no earlier than 5 minutes before, and no later than 5 minutes after the EDCT. Do not release aircraft on their assigned EDCT if a ground stop (GS) applicable to that aircraft is in effect, unless approval has been received from the originator of the GS.

298. Question: How will the current traffic management programs be updated to include CSV characteristics?

4−3−5. GROUND STOP

Do not release an aircraft if a ground stop (GS) applicable to that aircraft is in effect, without the approval of the originator of the GS. N/A

4−3−6. DELAY SEQUENCING

When aircraft elect to take delay on the ground before departure, issue departure clearances to them in the order in which the requests for clearance were originally made if practicable. N/A

4−3−7. FORWARD DEPARTURE DELAY INFORMATION

Inform approach control facilities and/or towers of anticipated departure delays. N/A

4−3−8. COORDINATION WITH RECEIVING FACILITY

a. Coordinate with the receiving facility before the departure of an aircraft if the departure point is less than 15 minutes flying time from the transferring facility's boundary unless an automatic transfer of data between automated systems will occur, in which case, the flying time requirement may be reduced to 5 minutes or replaced with a mileage from the boundary parameter when mutually agreeable to both facilities.

b. The actual departure time or a subsequent strip posting time shall be forwarded to the receiving facility unless assumed departure times are agreed upon and that time is within 3 minutes of the actual departure time.

299. Question: How will the time limits be adjusted for CSV characteristics?

4−3−9. VFR RELEASE OF IFR DEPARTURE

When an aircraft which has filed an IFR flight plan requests a VFR departure through a terminal facility, FSS, or air/ground communications station:

a. After obtaining, if necessary, approval from the facility/sector responsible for issuing the IFR clearance, you may authorize an IFR flight planned aircraft to depart VFR. Inform the pilot of the proper frequency and, if appropriate, where or when to contact the facility responsible for issuing the clearance.

300. Question: Will CSVs be allowed to participate in the VFR release option?

b. If the facility/sector responsible for issuing the clearance is unable to issue a clearance, inform the pilot, and suggest that the delay be taken on the ground. If the pilot insists upon taking off VFR and obtaining an IFR clearance in the air, inform the facility/sector holding the flight plan of the pilot's intentions and, if possible, the VFR departure time.

4−3−10. FORWARDING DEPARTURE TIMES

TERMINAL

Unless alternate procedures are prescribed in a letter of agreement or automatic departure messages are being transmitted between automated facilities, forward departure times to the facility from which you received the clearance and also to the terminal departure controller when

Section 4. Route Assignment

4−4−1. ROUTE USE

Clear aircraft via routes consistent with the altitude stratum in which the operation is to be conducted by one or more of the following:

NOTE−

Except for certain NAVAIDs/routes used by scheduled air carriers or authorized for specific uses in the control of IFR aircraft, Air Traffic Service (ATS) routes, and NAVAIDs established for use at specified altitudes are shown on U.S. government charts or DOD FLIP charts.

301. Question: Will ATS routes for CSVs be shown on US government charts or DOD FLIP charts or will they be omitted like the routes used by specialized aviation vehicles?

a. Designated ATS routes. N/A

b. Radials, courses, azimuths, or direct to or from NAVAIDs. N/A

c. DME arcs of VORTAC, MLS, or TACAN aids. N/A

d. Radials, courses, azimuths, and headings of departure or arrival routes. N/A

e. SIDs/STARs/FMSPs.

302. Question: Will SIDs and STARs be available for CSVs?

303. Question: Will CSVs have specific TERPS, other than STARs and SIDs, developed for their use?

f. Vectors. N/A

g. Fixes defined in terms of degree-distance from NAVAIDs for special military operations. N/A

h. Courses, azimuths, bearings, quadrants, or radials within a radius of a NAVAID. N/A

i. Fixes/waypoints defined in terms of: N/A

1. Published name; or

2. Degree-distance from NAVAIDs; or

3. Latitude/longitude coordinates, state the latitude and longitude in degrees and minutes including the direction from the axis such as North or West; or

4. Offset from published or established ATS route at a specified distance and direction for random (impromptu) RNAV Routes.

j. RNAV aircraft transitioning to/from High Altitude Redesign (HAR) or Point−to−point (PTP) operations via pitch/catch points. N/A

4−4−2. ROUTE STRUCTURE TRANSITIONS

To effect transition within or between route structure, clear an aircraft by one or more of the following methods, based on VOR, VORTAC, TACAN, or MLS NAVAIDs (unless use of other NAVAIDs are essential to aircraft operation or ATC efficiency):

304. Question: What procedures will be available for the CSV that consider its maneuverable capabilities?

a. Vector aircraft to or from radials, courses, or azimuths of the ATS route assigned. N/A

b. Assign a SID/STAR/FMSP. N/A

c. Clear departing or arriving aircraft to climb or descend via radials, courses, or azimuths of the ATS route assigned. N/A

d. Clear departing or arriving aircraft directly to or between the NAVAIDs forming the ATS route assigned. N/A

e. Clear aircraft to climb or descend via the ATS route on which flight will be conducted. N/A

f. Clear aircraft to climb or descend on specified radials, courses, or azimuths of NAVAIDs. N/A

g. Provide radar monitor when transition to or from a designated or established RNAV route is made along random RNAV routes. NA

EN ROUTE EXCEPTION. Radar monitoring is not required for aircraft equipped with IFR−certified GPS systems operating on point−to−point RNAV routes within Anchorage Air Route Traffic Control Center controlled airspace (excluding oceanic airspace) where ATC surveillance coverage is not available.

305. Question: Will CSVs be monitored and have systems aboard that are compatible with ATC monitoring?

h. Clear RNAV aircraft transitioning to or between designated or established RNAV routes direct to a named waypoint on the new route. N/A

4−4−3. DEGREE-DISTANCE ROUTE DEFINITION FOR MILITARY OPERATIONS

EN ROUTE

a. Do not accept a military flight plan whose route or route segments do not coincide with designated airways or jet routes or with a direct course between NAVAIDs unless it is authorized in subpara b and meets the following degree-distance route definition and procedural requirements:

306. Question: Will certain CSV operations be qualified for similar exceptions?

1. The route or route segments shall be defined in the flight plan by degree-distance fixes composed of:

(a) A location identifier;

(b) Azimuth in degrees magnetic; and

(c) Distance in miles from the NAVAID used.

307. Question: What NAVAIDS will be available for CSVs in similar cases?

2. The NAVAIDs selected to define the degree-distance fixes shall be those authorized for use at the altitude being flown and at a distance within the published service volume area.

3. The distance between the fixes used to define the route shall not exceed:

(a) Below FL 180− 80 miles;

(b) FL 180 and above− 260 miles; and (c) For celestial navigation routes, all altitudes− 260 miles.

308. Question: What are the appropriate distances and altitudes for a CSV operating in this environment?

4. Degree-distance fixes used to define a route shall be considered compulsory reporting points except that an aircraft may be authorized by ATC to omit reports when traffic conditions permit. NA

5. Military aircraft using degree-distance route definition procedures shall conduct operations in accordance with the following: NA

(a) Unless prior coordination has been effected with the appropriate air traffic control facility, flight plan the departure and the arrival phases to conform with the routine flow of traffic when operating within 75 miles of the departure and the arrival airport. Use defined routes or airways or direct courses between NAVAIDs or as otherwise required to conform to the normal flow of traffic.

309. Question: Will CSVs be able to file a flight plan that conforms to the airport traffic area restrictions for other aircraft?

(b) Flight plans must be filed at least 2 hours before the estimated time of departure.

310. Question: What is an appropriate time limit for filing a CSV flight plan?

b. The following special military operations are authorized to define routes, or portions of routes, by degree-distance fixes:

311. Question: Will CSVs be able to use degree-distance fixes?

1. Airborne radar navigation, radar bomb scoring (RBS), and airborne missile programming conducted by the USAF, USN, and RAF. NA

2. Celestial navigation conducted by the USAF, USN, and RAF. NA

3. Target aircraft operating in conjunction with air defense interceptors, and air defense interceptors while en route to and from assigned airspace. NA

4. Missions conducted above FL 450.

312. Question: Will CSV operations fall under this paragraph for control purposes?

5. USN fighter and attack aircraft operating in positive control airspace. NA

6. USN/USMC aircraft, TACAN equipped, operating within the Honolulu FIR/Hawaiian airways area. NA

7. USAF/USN/USMC aircraft flight planned to operate on MTRs.

313. Question: Will CSVs be authorized to operate on MTRs?

8. USAF Air Mobility Command (AMC) aircraft operating on approved station-keeping equipment (SKE) routes in accordance with the conditions and limitations listed in FAA Exemption No. 4371 to 14 CFR Section 91.177(a)(2) and 14 CFR Section 91.179(b)(1). NA

4−4−4. ALTERNATIVE ROUTES

When any part of an airway or route is unusable because of NAVAID status, clear aircraft other than /E, /F, /G, or /R, via one of the following alternative routes:

314. Question: If a normal NAVAID is unavailable, what is the approved procedure for defining a route for a CSV?

a. A route depicted on current U.S. Government charts/publications. Use the word "substitute" immediately preceding the alternative route in issuing the clearance. NA

b. A route defined by specifying NAVAID radials, courses, or azimuths. NA

c. A route defined as direct to or between NAVAIDs. NA

d. Vectors.

315. Question: Will CSVs be capable of receiving, and respond to, vector instructions?

4−4−5. CLASS G AIRSPACE

Include routes through Class G airspace only when requested by the pilot. N/A

4−4−6. DIRECT CLEARANCES

a. Do not issue a routing clearance that will take an aircraft off of its flight plan route if the destination airport is included in a ground delay program (GDP), ground stop (GS), or Playbook route, when known, unless operational necessity dictates. N/A

b. *EN ROUTE*. Do not issue revised routing clearances that will take an aircraft off its flight plan route past the last fix in your facility's airspace, unless requested by the pilot or operational necessity dictates. N/A

Section 5. Altitude Assignment and Verification

4−5−1. VERTICAL SEPARATION MINIMA
Separate instrument flight rules (IFR) aircraft using the following minima between altitudes:

316. Question: Will any of these separation minima need to be changed for certain CSVs?

a. Up to and including FL 410− 1,000 feet.

b. Apply 2,000 feet at or above FL 290 between non−RVSM aircraft and all other aircraft at or above FL 290.

c. Above FL 410− 2,000 feet, except:

1. In oceanic airspace, above FL 450 between a supersonic and any other aircraft− 4,000 feet.

2. Above FL 600 between military aircraft− 5,000 feet.

317. Question: Should FAA create another class of airspace above FL 600 specifically designed for CSVs?

4−5−2. FLIGHT DIRECTION
Clear aircraft at altitudes according to the TBL 4−5−1. N/A

4−5−3. EXCEPTIONS
When traffic, meteorological conditions, or aircraft operational limitations prevent assignment of altitudes prescribed in para 4−5−2, Flight Direction, assign any cardinal altitude or flight level below FL 410 or any odd cardinal flight level at or above FL 410 without regard to direction of flight as follows:

a. For traffic conditions, take this action only if one of the following conditions exists:

1. Aircraft remain within a facility's area and prior approval is obtained from other affected positions or sectors or the operations are covered in a Facility Directive.

2. Aircraft will proceed beyond the facility's area and specific operations and procedures permitting random altitude assignment are covered in a letter of agreement between the appropriate facilities.

NOTE−

Those en route facilities using host software that provides capability for passing interim altitude shall include the specific operations and procedures for use of this procedure in a letter of agreement between the appropriate facilities.

318. Question: What software update will be necessary for CSV operations under these provisions?

319. Question: What provisions in a new Letter of Agreement will be required for updating procedures for CSV operations?

b. Military aircraft are operating on random routes and prior approval is obtained from the facility concerned. N/A

c. For meteorological conditions, take this action only if you obtain prior approval from other affected positions or sectors within your facility and, if necessary, from the adjacent facility concerned. N/A

d. For aircraft operational limitations, take this action only if the pilot informs you the available appropriate altitude exceeds the operational limitations of his/her aircraft and only after you obtain prior approval from other affected positions or sectors within your facility and, if necessary, from the adjacent facility concerned. N/A

e. For mission requirements, take this action only when the aircraft is operating on an MTR.

320. Question: Will Space Transition Routes (STC) be designed and implemented for CSVs?

321. Question: Can this action be taken if the CSV is operation on an STC, just like an aircraft on an MTR?

4−5−4. LOWEST USABLE FLIGHT LEVEL

If a change in atmospheric pressure affects a usable flight level in your area of jurisdiction, use TBL 4−5−2 to determine the lowest usable flight level to clear aircraft at or above 18,000 feet MSL. N/A

4−5−5. ADJUSTED MINIMUM FLIGHT LEVEL

When the prescribed minimum altitude for IFR operations is at or above 18,000 feet MSL and the atmospheric pressure is less than 29.92”, add the appropriate adjustment factor from TBL 4−5−3 to the flight level equivalent of the minimum altitude in feet to determine the adjusted minimum flight level. N/A

4−5−6. MINIMUM EN ROUTE ALTITUDES

Except as provided in subparas a and b below, assign altitudes at or above the MEA for the route segment being flown. When a lower MEA for subsequent segments of the route is applicable, issue the lower MEA only after the aircraft is over or past the Fix/NAVAID beyond which the lower MEA applies unless a crossing restriction at or above the higher MEA is issued. N/A

4−5−7. ALTITUDE INFORMATION

Issue altitude instructions as follows:

a. Altitude to maintain or cruise. When issuing cruise in conjunction with an airport clearance limit and an unpublished route will be used, issue an appropriate crossing altitude to ensure terrain

clearance until the aircraft reaches a fix, point, or route where the altitude information is available to the pilot. When issuing a cruise clearance to an airport which does not have a published instrument approach, a cruise clearance without a crossing restriction may be issued. **N/A**

b. Instructions to climb or descend including restrictions, as required. Specify a time restriction reference the UTC clock reading with a time check. If you are relaying through an authorized communications provider, such as ARINC, FSS, etc., advise the radio operator to issue the current time to the aircraft when the clearance is relayed. The requirement to issue a time check shall be disregarded if the clearance is issued via Controller Pilot Data Link Communications (CPDLC).

322. Question: Will CSVs be equipped with, and capable of using, CPDLC?

d. Specified altitude for crossing a specified fix or waypoint; or, specified altitude for crossing a distance (in miles) and direction from a specified fix or waypoint.

323. Question: Will CSVs have the aerodynamic capability to comply with such ATC directions?

d. A specified altitude over a specified fix for that portion of a descent clearance where descent at pilot's discretion is permissible. At any other time it is practicable, authorize climb/descent at pilot's discretion. **N/A**

e. When a portion of a climb/descent may be authorized at the pilot's discretion, specify the altitude the aircraft must climb/descend to followed by the altitude to maintain at the pilot's discretion.

324. Question: What procedures are available if the CSV is unable to climb/descend?

f. When the "pilot's discretion" portion of a climb/descent clearance is being canceled by assigning a new altitude, inform the pilot that the new altitude is an "amended altitude." **N/A**

g. Altitude assignments involving more than one altitude. **N/A**

h. Instructions to vertically navigate on a STAR/RNAV STAR/FMSP with published restrictions. **N/A**

i. When a pilot is unable to accept a clearance, issue revised instructions to ensure positive control and standard separation. **N/A**

4−5−8. ANTICIPATED ALTITUDE CHANGES

If practicable, inform an aircraft when to expect climb or descent clearance or to request altitude change from another facility. **N/A**

4−5−9. ALTITUDE CONFIRMATION− NONRADAR

a. Request a pilot to confirm assigned altitude on initial contact and when position reports are received unless: **N/A**

1. The pilot states the assigned altitude, or

2. You assign a new altitude to a climbing or descending aircraft, or

3. ***TERMINAL.*** **The aircraft was transferred to you from another sector/position within your facility (intrafacility).**

b. ***USA.*** **Reconfirm all pilot altitude read backs. N/A**

Chapter 5

Section 2. Beacon Systems

5−2−1. ASSIGNMENT CRITERIA
a. General.

1. Mode 3/A is designated as the common military/civil mode for air traffic control use.

2. Make radar beacon code assignments to only Mode 3/A transponder-equipped aircraft.

325. Question: Will all or most CSVs be Mode 3/A transponder-equipped?

b. Unless otherwise specified in a directive or a letter of agreement, make code assignments to departing, en route, and arrival aircraft in accordance with the procedures specified in this section for the radar beacon code environment in which you are providing ATC service. Give first preference to the use of discrete beacon codes.

5−2−2. DISCRETE ENVIRONMENT
a. Issue discrete beacon codes assigned by the computer. Computer-assigned codes may be modified as required. N/A

b. Make handoffs to other positions/sectors on the computer-assigned code. N/A

c. Coastal facilities accepting "over" traffic that will subsequently be handed-off to an oceanic ARTCC shall reassign a new discrete beacon code to an aircraft when it first enters the receiving facility's airspace. The code reassignment shall be accomplished by inputting an appropriate message into the computer and issued to the pilot while operating in the first sector/position in the receiving facility's airspace.

326. Question: Will CSVs need to receive new discrete beacon codes if they are to be handed-off to an oceanic ARTCC?
327. Question: Will CSVs be handled through regular ARTCC sectors?
328. Question: If the CSV is going too fast to be handled like an aircraft, how will the procedures be changed? (Could the changes for the military SR77 be examined and used as a template?)

5−2−3. NONDISCRETE ENVIRONMENT
N/A

5−2−4. MIXED ENVIRONMENT
N/A

5−2−5. RADAR BEACON CODE CHANGES
N/A

5−2−6. FUNCTION CODE ASSIGNMENTS

Unless otherwise specified by a directive or a letter of agreement, make nondiscrete code assignments from the following categories:

329. Question: Of these choices, which category encompasses CSVs?

330. Question: Will new Code assignments be added to comply with CSV operations?

a. Assign codes to departing IFR aircraft as follows:

1. Code 2000 to an aircraft which will climb to FL 240 or above or to an aircraft which will climb to FL 180 or above where the base of Class A airspace and the base of the operating sector are at FL 180, and for inter-facility handoff the receiving sector is also stratified at FL 180. The en route code shall not be assigned until the aircraft is established in the high altitude sector.

2. Code 1100 to an aircraft which will remain below FL 240 or below FL 180 as above.

3. For handoffs from terminal facilities when so specified in a letter of agreement as follows:

(a) Within NBCAP airspace− **Code 0100 to Code 0400** inclusive or any other code authorized by the appropriate service area office.

(b) Outside NBCAP airspace− **Code 1000** or one of the codes from **0100 to 0700** inclusive or any other code authorized by the appropriate service area office.

b. Assign codes to en route IFR aircraft as follows:

1. Aircraft operating below FL 240 or when control is transferred to a controller whose area includes the stratum involved.

(a) Code 1000 may be assigned to aircraft changing altitudes.

(b) Code 1100 to an aircraft operating at an assigned altitude below FL 240. Should an additional code be operationally desirable, **Code 1300** shall be assigned.

2. Aircraft operating at or above FL 240 or when control is transferred to a controller whose area includes the stratum involved.

(a) Code 2300 may be assigned to aircraft changing altitudes.

(b) Code 2100 to an aircraft operating at an assigned altitude from FL 240 to FL 330 inclusive.

Should an additional code be operationally desirable, **Code 2200** shall be assigned.

(c) Code 2400 to an aircraft operating at an assigned altitude from FL 350 to FL 600 inclusive.

Should an additional code be operationally desirable, **Code 2500** shall be assigned.

3. Code 4000 when aircraft are operating on a flight plan specifying frequent or rapid changes in assigned altitude in more than one stratum or other conditions of flight not compatible with a stratified code assignment.

c. Assign the following codes to arriving IFR aircraft, except military turbojet aircraft as specified in para 4−7−4, Radio Frequency and Radar Beacon Changes for Military Aircraft:

1. Code 2300 may be assigned for descents while above FL 240.

2. Code 1500 may be assigned for descents into and while within the strata below FL 240, or with prior coordination the specific code utilized by the destination controller, or the code currently assigned when descent clearance is issued.

3. The applicable en route code for the holding altitude if holding is necessary before entering the terminal area and the appropriate code in subparas 1or 2.

5−2−7. EMERGENCY CODE ASSIGNMENT

Assign codes to emergency aircraft as follows:

331. Question: Is there any reason Code 7700 cannot be used by CSVs to declare an emergency?
332. Question: What code will CSVs be required to squawk if an emergency needs to declared?

a. Code 7700 when the pilot declares an emergency and the aircraft is not radar identified.

b. After radio and radar contact have been established, you may request other than single piloted helicopters and single-piloted turbojet aircraft to change from **Code 7700** to another code appropriate for your radar beacon code environment.

c. The following shall be accomplished on a Mode C equipped VFR aircraft which is in emergency but no longer requires the assignment of **Code 7700**:

1. *TERMINAL.* Assign a beacon code that will permit terminal minimum safe altitude warning (MSAW) alarm processing.

2. *EN ROUTE.* An appropriate keyboard entry shall be made to ensure en route MSAW (EMSAW) alarm processing.

5−2−8. RADIO FAILURE

When you observe a **Code 7600** display, apply the procedures in para 10−4−4, Communications Failure.

NOTE−*Should a transponder-equipped aircraft experience a loss of two-way radio communications capability, the pilot can be expected to adjust his/her transponder to* ***Code 7600****.*

333. Question: Is there any reason Code 7600 cannot be used by CSVs to declare a radio failure?

5−2−9. VFR CODE ASSIGNMENTS

N/A

5−2−10. BEACON CODE FOR PRESSURE SUIT FLIGHTS AND FLIGHTS ABOVE FL 600

a. Mode 3/A, **Code 4400**, and discrete **Codes 4440 through 4465** are reserved for use by R−71, F−12, U−2, B−57, pressure suit flights, and aircraft operations above FL 600.

334. Question: Will any Code 4400 series be set aside for CSVs?

b. Ensure that aircraft remain on **Code 4400** or one of the special use discrete codes in the **4400** subset if filed as part of the flight plan. Except when unforeseen events, such as weather deviations, equipment failure, etc., cause more than one aircraft with same Mode 3/A discrete beacon codes to be in the same or adjacent ARTCC's airspace at the same time, a controller may request the pilot to make a code change, squawk standby, or to stop squawk as appropriate.

5−2−11. AIR DEFENSE EXERCISE BEACON CODE ASSIGNMENT
N/A

5−2−15. INOPERATIVE OR MALFUNCTIONING INTERROGATOR
Inform aircraft concerned when the ground interrogator appears to be inoperative or malfunctioning. N/A

5−2−16. FAILED TRANSPONDER IN CLASS A AIRSPACE
Disapprove a request or withdraw previously issued approval to operate in Class A airspace with a failed transponder solely on the basis of traffic conditions or other operational factors. N/A

5−2−17. VALIDATION OF MODE C READOUT
Ensure that Mode C altitude readouts are valid after accepting an inter-facility handoff, initial track start, track start from coast/suspend tabular list, missing, or unreasonable Mode C readouts. For TPX−42 and equivalent systems ensure that altitude readout is valid immediately after identification. (TCDD−/BANS−equipped tower cabs are not required to validate Mode C readouts after receiving inter-facility handoffs from TRACONs according to the procedures in para 5−4−3, Methods, subpara a4.) N/A

5−2−18. ALTITUDE CONFIRMATION−MODE C
Request a pilot to confirm assigned altitude on initial contact N/A

5−2−19. ALTITUDE CONFIRMATION−NON−MODE C
N/A

5−2−20. AUTOMATIC ALTITUDE REPORTING
Inform an aircraft when you want it to turn on/off the automatic altitude reporting feature of its transponder. N/A

5−2−21. INFLIGHT DEVIATIONS FROM TRANSPONDER/MODE C REQUIREMENTS BETWEEN 10,000 FEET AND 18,000 FEET
Apply the following procedures to requests to deviate from the Mode C transponder requirement by aircraft operating in the airspace of the 48 contiguous states and the District of Columbia at and above 10,000 feet MSL and below 18,000 feet MSL, excluding the airspace at and below 2,500 feet AGL. N/A

5−2−22. BEACON TERMINATION
Inform an aircraft when you want it to turn off its transponder. N/A

5−2−23. ALTITUDE FILTERS
TERMINAL

Set altitude filters to display Mode C altitude readouts to encompass all altitudes within the controller's jurisdiction. Set the upper limits no lower than 1,000 feet above the highest altitude for which the controller is responsible. In those stratified positions, set the lower limit to 1,000 feet or more below the lowest altitude for which the controller is responsible. When the position's area of responsibility includes down to an airport field elevation, the facility will normally set the lower altitude filter limit to encompass the field elevation so that provisions of para 2−1−6, Safety Alert, and para 5−2−17, Validation of Mode C Readout, subpara a2 may be applied. Air traffic managers may authorize temporary suspension of this requirement when target clutter is excessive. N/A

Section 5. Radar Separation

5−5−1. APPLICATION

a. Radar separation shall be applied to all RNAV aircraft operating on a random (impromptu) route at or below FL 450 and to all published Q routes in the conterminous United States.

335. Question: What will be the RADAR separation requirements for a CSV performing flight under these conditions?

EN ROUTE EXCEPTION. Aircraft equipped with IFR−certified GPS systems operating on point−to−point RNAV routes within the Anchorage Air Route Traffic Control Center (ARTCC) controlled airspace (excluding oceanic airspace) where ATC surveillance coverage is not available, may be provided non radar separation, in lieu of radar separation, when an operational advantage will be gained.

336. Question: Will the CSVs launched from the Alaskan space facilities require a new set of ARTCC rules for flight in oceanic airspace?
337. Question: Is it possible to apply conventional (non radar) criteria to CSV operations?

b. Radar separation may be applied between:

1. Radar identified aircraft. N/A

2. An aircraft taking off and another radar identified aircraft when the aircraft taking off will be radar-identified within 1 mile of the runway end. N/A

3. A radar-identified aircraft and one not radar-identified when either is cleared to climb/descend through the altitude of the other provided: N/A

(a) The performance of the radar system is adequate and, as a minimum, primary radar targets or ASR−9/Full Digital Radar Primary Symbol targets are being displayed on the display being used within the airspace within which radar separation is being applied; and

(b) Flight data on the aircraft not radar identified indicate it is a type which can be expected to give adequate primary/ASR−9/Full Digital Radar Primary Symbol return in the area where separation is applied; and

(c) The airspace within which radar separation is applied is not less than the following number of miles from the edge of the radar display:

(1) When less than 40 miles from the antenna− ***6 miles;***

(2) When 40 miles or more from the antenna− *10 miles*;

(3) Narrowband radar operations− *10 miles;* and

(d) Radar separation is maintained between the radar-identified aircraft and all observed primary, ASR−9/Full Digital Radar Primary Symbol, and secondary radar targets until non radar separation is established from the aircraft not radar identified; and

(e) When the aircraft involved are on the same relative heading, the radar-identified aircraft is vectored a sufficient distance from the route of the aircraft not radar identified to assure the targets are not superimposed prior to issuing the clearance to climb/descend.

5−5−2. TARGET SEPARATION

a. Apply radar separation:

- Between the centers of primary radar targets; however, do not allow a primary target to touch another primary target or a beacon control slash.
- Between the ends of beacon control slashes.
- Between the end of a beacon control slash and the center of a primary target.
- All−digital displays. Between the centers of digitized targets. Do not allow digitized targets to touch.

338. Question: How will CSV targets be differentiated from other, conventional, targets?

339. Question: What will CSV targets have as a separation requirement?

5−5−3. TARGET RESOLUTION

a. A process to ensure that correlated radar targets or digitized targets do not touch. N/A

b. Mandatory traffic advisories and safety alerts shall be issued when this procedure is used. N/A

c. Target resolution shall be applied as follows: N/A

- **Between the edges of two primary targets or the edges of primary digitized targets.**
- **Between the end of the beacon control slash and the edge of a primary target or primary digitized target.**
- **Between the ends of two beacon control slashes.**

5−5−4. MINIMA

Separate aircraft by the following minima:

a. *TERMINAL*. Single Sensor ASR or Digital Terminal Automation System (DTAS):

1. **When less than 40 miles from the antenna− *3 miles*.**
2. **When 40 miles or more from the antenna− *5 miles*.**
3. **For single sensor ASR−9 with Mode S, when less than 60 miles from the antenna− *3 miles*.**

NOTE−Wake turbulence procedures specify increased separation minima required for certain classes of aircraft because of the possible effects of wake turbulence.

340. Question: According to the above NOTE, some minima are increased. Will CSV minima be increased as well?

b. Stage A/DARC, MEARTS Mosaic Mode, Terminal Mosaic/Multi−Sensor Mode: N/A

1. Below FL 600− ***5 miles.***

2. At or above FL 600− ***10 miles.***

3. For areas meeting all of the following conditions:

(a) Radar site adaptation is set to single sensor.

(b) Significant operational advantages can be obtained.

(c) Within 40 miles of the antenna.

(d) Below FL 180.

(e) Facility directives specifically define the area where the separation can be applied. Facility directives may specify 3 miles.

4. When transitioning from terminal to en route control, 3 miles increasing to 5 miles or greater, provided:

(a) The aircraft are on diverging routes/courses, and/or

(b) The leading aircraft is and will remain faster than the following aircraft; and

(c) Separation constantly increasing and the first center controller will establish 5 NM or other appropriate form of separation prior to the aircraft departing the first center sector; and

(d) The procedure is covered by a letter of agreement between the facilities involved and limited to specified routes and/or sectors/positions.

c. MEARTS Mosaic Mode: N/A

1. When less than 40 miles from the antenna− ***3 miles.***

2. When 40 miles or more from the antenna− ***5 miles.***

d. STARS Multi−Sensor Mode N/A

e. Separate aircraft operating directly behind, or directly behind and less than 1,000 feet below, or following an aircraft conducting an instrument approach by:

341. Question: What will be a CSVs' new designation if their characteristics are not similar enough to be considered "Large" or "Heavy"?

342. Question: If a new designation is developed, what will be the mileage requirement between them?

1. Heavy behind heavy− *4 miles.*

2. Large/heavy behind B757− *4 miles*.

3. Small behind B757− *5 miles.*

4. Small/large behind heavy − *5 miles.*

f. *TERMINAL.* In addition to subpara e, separate an aircraft landing behind another aircraft on the same runway, or one making a touch-and-go, stop-and-go, or low approach by ensuring the following minima will exist at the time the preceding aircraft is over the landing threshold:

1. Small behind large− *4 miles*.

2. Small behind B757− *5 miles.*

3. Small behind heavy− *6 miles.*

343. Question: What are the criteria for “small” behind a VTVL CSV?
344. Question: What are the criteria for small behind a VTHL or HTHL CSV?

g. *TERMINAL*. 2.5 nautical miles (NM) separation is authorized between aircraft established on the final approach course within 10 NM of the landing runway when operating in single sensor slant range mode and aircraft remains within 40 miles of the antenna and:

1. The leading aircraft's weight class is the same or less than the trailing aircraft;

2. Heavy aircraft and the Boeing 757 are permitted to participate in the separation reduction as the trailing aircraft only;

3. An average runway occupancy time of 50 seconds or less is documented;

345. Question: What will be the average runway occupancy time of each of the CSV types?

4. CTRDs are operational and used for quick glance references;

5. Turnoff points are visible from the control tower.

5−5−5. VERTICAL APPLICATION
Aircraft not laterally separated, may be vertically separated by one of the following methods:

a. Assign altitudes to aircraft, provided valid Mode C altitude information is monitored and the applicable separation minima is maintained at all times.

346. Question: Will CSVs be equipped with Mode C equipment for the purpose of vehicle separation in the NAS?

b. Assign an altitude to an aircraft after the aircraft previously at that altitude has been issued a climb/descent clearance and is observed (valid Mode C), or reports leaving the altitude.

5−5−6. EXCEPTIONS

a. Do not use Mode C to effect vertical separation with an aircraft on a cruise clearance, contact approach, or as specified in para 5−15−4, System Requirements, subpara e3.

347. Question: Will CSVs also be an "exception" in 5-5-6?

b. Assign an altitude to an aircraft only after the aircraft previously at that altitude is observed at or passing through another altitude separated from the first by the appropriate minima when:

1. Severe turbulence is reported.

2. Aircraft are conducting military aerial refueling.

348. Question: If CSVs are participating in a block of airspace such as that assigned for MARSA, will ATC use the same separation procedures noted here?

3. The aircraft previously at that altitude has been issued a climb/descent at pilot's discretion.

5−5−7. PASSING OR DIVERGING

a. *TERMINAL.* In accordance with the following criteria, all other approved separation may be discontinued and passing or diverging separation applied when: N/A

1. Aircraft are on opposite/reciprocal courses and you have observed that they have passed each other; or aircraft are on same or crossing courses/assigned radar vectors and one aircraft has crossed the projected course of the other, and the angular difference between their courses/assigned radar vectors is at least 15 degrees.

2. The tracks are monitored to ensure that the primary targets, beacon control slashes, or full digital terminal system primary and/or beacon target symbols will not touch.

b. *EN ROUTE.* Vertical separation between aircraft may be discontinued when they are on opposite courses as defined in para 1−2−2, Course Definitions; and N/A

1. You are in communications with both aircraft involved; and

2. You tell the pilot of one aircraft about the other aircraft, including position, direction, type; and

3. One pilot reports having seen the other aircraft and that the aircraft have passed each other; and

4. You have observed that the radar targets have passed each other; and

5. You have advised the pilots if either aircraft is classified as a heavy jet/B757 aircraft.

6. Although vertical separation may be discontinued, the requirements of para 5−5−4, Minima, subparas e and f must be applied when operating behind a heavy jet/B757.

5−5−8. ADDITIONAL SEPARATION FOR FORMATION FLIGHTS

Because of the distance allowed between formation aircraft and lead aircraft, additional separation is necessary to ensure the periphery of the formation is adequately separated from other aircraft, adjacent airspace, or obstructions. Provide supplemental separation for formation flights as follows: N/A

5−5−9. SEPARATION FROM OBSTRUCTIONS

a. Except in En Route Stage A/DARC or Stage A/EDARC, separate aircraft from obstructions depicted on the radar display by the following minima: N/A

1. When less than 40 miles from the antenna− ***3 miles.***

2. When 40 miles or more from the antenna− ***5 miles.***

b. Except in En Route Stage A/DARC or Stage A/EDARC, vertical separation of aircraft above an obstruction depicted on the radar display may be discontinued after the aircraft has passed it. N/A

c. En Route Stage A/DARC or Stage A/EDARC, apply the radar separation minima specified in para 5−5−4, Minima, subpara b1. N/A

5−5−10. ADJACENT AIRSPACE

a. If coordination between the controllers concerned has not been effected, separate radar-controlled aircraft from the boundary of adjacent airspace in which radar separation is also being used by the following minima: N/A

1. **When less than 40 miles from the antenna−** ***1 1/2 miles.***
2. **When 40 miles or more from the antenna−** ***2 1/2 miles.***

3. En route Stage A/DARC or Stage A/EDARC:

(a) Below Flight Level 600− ***2 1/2 miles*****.**

(b) Flight Level 600 and above− ***5 miles*****.**

b. Separate radar-controlled aircraft from the boundary of airspace in which non radar separation is being used by the following minima: N/A

1. When less than 40 miles from the antenna− ***3 miles*****.**

2. When 40 miles or more from the antenna− ***5 miles*****.**

3. En route Stage A/DARC or Stage A/EDARC:

(a) Below Flight Level 600− ***5 miles.***

(b) Flight Level 600 and above− ***10 miles.***

5−5−11. EDGE OF SCOPE

Separate a radar-controlled aircraft climbing or descending through the altitude of an aircraft that has been tracked to the edge of the scope/display by the following minima until nonradar separation has been established: N/A

a. When less than 40 miles from the antenna− ***3 miles*** **from edge of scope.**

b. When 40 miles or more from the antenna− ***5 miles*** **from edge of scope.**

c. En route Stage A/DARC or Stage A/EDARC:

1. Below Flight Level 600− ***5 miles*****.**

2. Flight Level 600 and above− ***10 miles*****.**

5−5−12. BEACON TARGET DISPLACEMENT

When using a radar target display with a previously specified beacon target displacement to separate a beacon target from a primary target, adjacent airspace, obstructions, or terrain, add a 1 mile correction factor to the applicable minima. The maximum allowable beacon target displacement which may be specified by the facility air traffic manager is 1/2 mile. N/A

5−5−13. GPA 102/103 CORRECTION FACTOR

When using a radar display whose primary radar video is processed by the GPA 102/103 modification to a joint-use radar system, apply the following correction factors to the applicable minima: N/A

a. If less than 40 miles from the antenna− add ***1 mile.***

b. If 40 miles or more but not over 200 miles from the antenna− add ***3 miles.***

Section 7. Speed Adjustment

5−7−1. APPLICATION

Keep speed adjustments to the minimum necessary to achieve or maintain required or desired spacing. Avoid adjustments requiring alternate decreases and increases. Permit pilots to resume normal speed when previously specified adjustments are no longer needed.

a. Consider the following when applying speed control:

1. Determine the interval required and the point at which the interval is to be accomplished.

2. Implement speed adjustment based on the following principles.

(a) Priority of speed adjustment instructions is determined by the relative speed and position of the aircraft involved and the spacing requirement.

(b) Speed adjustments are not achieved instantaneously. Aircraft configuration, altitudes, and speed determine the time and distance required to accomplish the adjustment.

349. Question: Since some CSVs will be difficult to control because of speed, how will they be controlled under this procedure?

3. Use the following techniques in speed control situations:

(a) Compensate for compression when assigning air speed adjustment in an in-trail situation by using one of the following techniques:

(1) Reduce the trailing aircraft first.

(2) Increase the leading aircraft first.

(b) Assign a specific airspeed if required to maintain spacing.

(c) Allow increased time and distance to achieve speed adjustments in the following situations:

(1) Higher altitudes.

(2) Greater speed.

(3) Clean configurations.

(d) Ensure that aircraft are allowed to operate in a clean configuration as long as circumstances permit.

(e) Keep the number of speed adjustments per aircraft to the minimum required to achieve and maintain spacing.

b. Do not assign speed adjustment to aircraft:

350. Question: How will ATC controllers know what speeds of CSVs will be permissible in order to control speed for separation purposes?
351. Question: Should controllers be prohibited from using speed adjustments for CSVs?

1. At or above FL 390 without pilot consent.

2. Executing a published high altitude instrument approach procedure.

3. In a holding pattern.

4. Inside the final approach fix on final or a point 5 miles from the runway, whichever is closer to the runway.

c. At the time approach clearance is issued, previously issued speed adjustments shall be restated if required. **N/A**

d. Approach clearances cancel any previously assigned speed adjustment. Pilots are expected to make their own speed adjustments to complete the approach unless the adjustments are restated.
N/A

e. Express speed adjustments in terms of knots based on indicated airspeed (IAS) in 10−knot increments. At or above FL 240, speeds may be expressed in terms of Mach numbers in 0.01 increments for turbojet aircraft with Mach meters (i.e., Mach 0.69, 0.70, 0.71, etc.). **N/A**

5−7−2. METHODS

a. Instruct aircraft to:

1. Maintain present/specific speed.

2. Maintain specified speed or greater/less.

3. Maintain the highest/lowest practical speed.

4. Increase or reduce to a specified speed or by a specified number of knots.

b. To obtain pilot concurrence for a speed adjustment at or above FL 390, as required by para 5−7−1, Application, use the following phraseology **N/A**

c. Simultaneous speed reduction and descent can be extremely difficult, particularly for turbojet aircraft. Specifying which action is to be accomplished first removes any doubt the pilot may have as to controller intent or priority. Specify which action is expected first when combining speed reduction with a descent clearance. **N/A**

1. **Speed reductions prior to descent.**
2. **Speed reduction following descent.**

d. Specify combined speed/altitude fix crossing restrictions. **N/A**

5−7−3. MINIMA

When assigning airspeeds, use the following recommended minima:

a. To aircraft operating between FL 280 and 10,000 feet, a speed not less than 250 knots or the equivalent Mach number.

352. Question: Will CSVs receive operational waivers to these minima?

NOTE−

1. ***On a standard day the Mach numbers equivalent to250 knots CAS (subject to minor variations) are:***

FL 240−0.6

FL 250−0.61

FL 260−0.62

FL 270−0.64

FL 280−0.65

FL 290−0.66.

2. ***If a pilot is unable to comply with the speed assignment, the pilot will advise.***

b. When an operational advantage will be realized, speeds lower than the recommended minima may be applied. N/A

c. To arrival aircraft operating below 10,000 feet: N/A

1. Turbojet aircraft. A speed not less than 210 knots; except when the aircraft is within 20 flying miles of the runway threshold of the airport of intended landing, a speed not less than 170 knots.

2. Reciprocating engine and turboprop aircraft. A speed not less than 200 knots; except when the aircraft is within 20 flying miles of the runway threshold of the airport of intended landing, a speed not less than 150 knots.

d. Departures:

1. Turbojet aircraft. A speed not less than 230 knots.

2. Reciprocating engine and turboprop aircraft. A speed not less than 150 knots.

353. Question: Will a third designation for CSVs be developed and included?

e. Helicopters. A speed not less than 60 knots. N/A

5−7−4. TERMINATION
Advise aircraft when speed adjustment is no longer needed. N/A

Section 10. Radar Approaches− Terminal

5−10−1. APPLICATION

a. Provide radar approaches in accordance with standard or special instrument approach procedures.

354. Question: What type of approaches will be developed for CSVs?

b. A radar approach may be given to any aircraft upon request and may be offered to aircraft in distress regardless of weather conditions or to expedite traffic.

355. Question: Will ATC controllers be adequately trained to offer CSVs radar assistance upon request?

5−10−2. APPROACH INFORMATION
N/A

5−10−3. NO-GYRO APPROACH
N/A

5−10−4. LOST COMMUNICATIONS
N/A

5−10−5. RADAR CONTACT LOST

If radar contact is lost during an approach and the aircraft has not started final approach, clear the aircraft to an appropriate NAVAID/fix for an instrument approach.

356. Question: If radar contact is lost with a CSV, what specific acts must ATC controllers take?

5−10−6. LANDING CHECK

USA/USN. Advise the pilot to perform landing check while the aircraft is on downwind leg and in time to complete it before turning base leg. If an incomplete pattern is used, issue this before handoff to the final controller for a PAR approach, or before starting descent on final approach for surveillance approach. **N/A**

5−10−7. POSITION INFORMATION

Inform the aircraft of its position at least once before starting final approach.

357. Question: Will ATC be responsible for informing a CSV of its position before beginning an approach?

5−10−8. FINAL CONTROLLER CHANGEOVER

When instructing the aircraft to change frequency for final approach guidance, include the name of the facility. N/A

5−10−9. COMMUNICATIONS CHECK

On initial contact with the final controller, ask the aircraft for a communication check. N/A

5−10−10. TRANSMISSION ACKNOWLEDGMENT

After contact has been established with the final controller and while on the final approach course, instruct the aircraft not to acknowledge further transmissions. N/A

5−10−11. MISSED APPROACH

Before an aircraft starts final descent for a full stop landing and weather reports indicate that any portion of the final approach will be conducted in IFR conditions, issue a specific missed approach procedure approved for the radar approach being conducted.

358. Question: What specific missed approach instructions and procedures must ATC enact for CSVs?

5−10−12. LOW APPROACH AND TOUCH AND GO

Before an aircraft which plans to execute a low approach or touch-and-go begins final descent, issue appropriate departure instructions to be followed upon completion of the approach. Climb-out instructions must include a specific heading and altitude except when the aircraft will maintain VFR and contact the tower. **N/A**

5−10−13. TOWER CLEARANCE

a. When an aircraft is on final approach to an airport served by a tower, obtain a clearance to land, touch-and-go, or make low approach. Issue the clearance and the surface wind to the aircraft.

359. Question: For a CSV to land, will it require other information besides the clearance and surface winds?

b. If the clearance is not obtained or is canceled, inform the aircraft and issue alternative instructions.

5−10−14. FINAL APPROACH ABNORMALITIES

Instruct the aircraft if runway environment not in sight, execute a missed approach if previously given; or climb to or maintain a specified altitude and fly a specified course whenever the completion of a safe approach is questionable because one or more of the following conditions exists. The conditions in subparas a, b, and c do not apply after the aircraft passes decision height on a PAR approach.

360. Question: What action is required if the CSV is not capable of a missed approach?

a. Safety limits are exceeded or radical target deviations are observed.

b. Position or identification of the aircraft is in doubt.

c. Radar contact is lost or a malfunctioning radar is suspected.

d. Airport conditions or traffic preclude approach completion.

5−10−15. MILITARY SINGLE FREQUENCY APPROACHES

a. Utilize single frequency approach procedures as contained in a letter of agreement.

361. Question: Will CSVs have single frequency approach procedures in letters of agreements?

b. Do not require a frequency change from aircraft on a single frequency approach after the approach has begun unless:

1. Landing or low approach has been completed.

2. The aircraft is in visual flight rules (VFR) conditions during daylight hours.

3. The pilot requests the frequency change.

4. An emergency situation exists.

5. The aircraft is cleared for a visual approach.

6. The pilot cancels instrument flight rules (IFR).

c. Accomplish the following steps to complete communications transfer on single frequency approaches after completion of a handoff:

1. Transferring controller: Position transmitter selectors to preclude further transmissions on the special use frequencies.

2. Receiving controller: Position transmitter and receiver selectors to enable communications on the special use frequencies.

3. Do not require or expect the flight to check on frequency unless an actual frequency change is transmitted to the pilot.

Section 15. Automated Radar Terminal Systems (ARTS) − Terminal

5−15−1. APPLICATION

ARTS/STARS may be used for identifying aircraft assigned a discrete beacon code, maintaining identity of targets, and performing handoffs of these targets between controllers.

362. Question: Can ARTS be applied to CSVs?

5−15−2. RESPONSIBILITY

This equipment does not relieve the controller of the responsibility to ensure proper identification, maintenance of identity, handoff of the correct target associated with the alphanumeric data, and separation of aircraft. N/A

5−15−3. FUNCTIONAL USE

In addition to other uses specified herein, terminal automation may be used for the following functions:

a. Tracking.

b. Tagging.

c. Handoff.

d. Altitude information.

e. Coordination.

f. Ground speed.

g. Identification.

363. Question: Will all of these functions be available and compatible with CSVs?
364. Question: Will the use of ARTS make CSV operations safer or more prone to error?
365. Question: Will any other uses be available in regards to CSVs?

5−15−4. SYSTEM REQUIREMENTS

Use terminal automation systems as follows:

a. Inform all appropriate positions before terminating or reinstating use of the terminal automation system at a control position. When terminating the use of terminal automation systems, all pertinent flight data of that position shall be transferred or terminated. N/A

b. Inform other interfaced facilities of scheduled and unscheduled shutdowns. N/A

c. Initiate a track/tag on all aircraft to the maximum extent possible. As a minimum, aircraft identification should be entered, and automated handoff functions should be used. N/A

d. Assigned altitude, if displayed, shall be kept current at all times. Climb and descent arrows, where available, shall be used to indicate other than level flight. N/A

e. The automatic altitude readout of an aircraft under another controller's jurisdiction may be used for vertical separation purposes without verbal coordination provided: N/A

1. Operation is conducted using single site radar coverage.

2. Prearranged coordination procedures are contained in a facility directive in accordance with para 5−4−10, Prearranged Coordination, and FAAO 7210.3, para 3−7−7, Prearranged Coordination.

3. Do not use Mode C to effect vertical separation within a Mosaic radar configuration.

5−15−5. INFORMATION DISPLAYED

a. Two-letter ICAO designators or three-letter designators, as appropriate, shall be used unless program limitations dictate the use of a single letter alpha prefix. N/A

b. Use of the inhibit/select functions to remove displayed information no longer required shall be in accordance with local directives, which should ensure maximum required use of the equipment. N/A

c. Information displayed shall be in accordance with national orders and specified in local directives.

366. Question: What will the national orders dictate in regards to CSVs?
367. Question: Who will develop these and when?
368. Question: What will the local directives dictate in regards to CSVs?
369. Question: Who will develop these and when?

5−15−6. CA/MCI

a. When a CA or MCI alert is displayed, evaluate the reason for the alert without delay and take appropriate action. N/A

b. If another controller is involved in the alert, initiate coordination to ensure an effective course of action. Coordination is not required when immediate action is dictated. N/A

c. Suppressing/Inhibiting CA/MCI alert. N/A

1. The suppress function may be used to suppress the display of a specific CA/MCI alert.

2. The inhibit function shall only be used to inhibit the display of CA for aircraft routinely engaged in operations where standard separation criteria do not apply.

3. Computer entry of a message suppressing a CA/MCI alert constitutes acknowledgment for the alert and signifies that appropriate action has or will be taken.

4. CA/MCI alert may not be suppressed or inhibited at or for another control position without being coordinated.

5−15−7. INHIBITING MINIMUM SAFE ALTITUDE WARNING (MSAW)

a. Inhibit MSAW processing of VFR aircraft and aircraft that cancel instrument flight rules (IFR) flight plans unless the pilot specifically requests otherwise. N/A

b. A low altitude alert may be suppressed from the control position. Computer entry of the suppress message constitutes an acknowledgment for the alert and indicates that appropriate action has or will be taken. N/A

5−15−8. TRACK SUSPEND FUNCTION

Use the track suspend function only when data block overlap in holding patterns or in proximity of the final approach create an unworkable situation. If necessary to suspend tracks, those which are not displaying automatic altitude readouts shall be suspended. If the condition still exists, those displaying automatic altitude readouts may then be suspended. N/A

AIM

Chapter 3. Airspace

Section 1. General

General 3-1-1.

a. There are two categories of airspace or airspace areas:

1. Regulatory (Class A, B, C, D and E airspace areas, restricted and prohibited areas); and

2. Nonregulatory (military operations areas (MOAs), warning areas, alert areas, and controlled firing areas).

370. Question: Will another category of airspace need to be developed to account for the integration of CSV's?

NOTE-
Additional information on special use airspace (prohibited areas, restricted areas, warning areas, MOAs, alert areas and controlled firing areas) may be found in Chapter 3, Airspace, Section 4, Special Use Airspace, paragraphs 3-4-1 through 3-4-7.

b. Within these two categories, there are four types:

1. Controlled,

2. Uncontrolled,

3. Special use, and

4. Other airspace.

371. Question: If airspace for CSV's is developed, will it fall into the "other airspace" category, or will it be substantial enough to require its own category?

c. The categories and types of airspace are dictated by:

1. The complexity or density of aircraft movements,

2. The nature of the operations conducted within the airspace,

3. The level of safety required, and

4. The national and public interest.

N/A

d. It is important that pilots be familiar with the operational requirements for each of the various types or classes of airspace. Subsequent sections will cover each class in sufficient detail to facilitate understanding. N/A

General Dimensions of Airspace

3-1-2. Segments
Refer to Code of Federal Regulations (CFRs) for specific dimensions, exceptions, geographical areas covered, exclusions, specific transponder or equipment requirements, and flight operations.N/A

Hierarchy of Overlapping Airspace

3-1-3. Designations
a. When overlapping airspace designations apply to the same airspace, the operating rules associated with the more restrictive airspace designation apply. N/A

b. For the purpose of clarification:

1. Class A airspace is more restrictive than Class B, Class C, Class D, Class E, or Class G airspace;

2. Class B airspace is more restrictive than Class C, Class D, Class E, or Class G airspace;

3. Class C airspace is more restrictive than Class D, Class E, or Class G airspace;

4. Class D airspace is more restrictive than Class E or Class G airspace; and

5. Class E is more restrictive than Class G airspace.

372. Question: In the event of airspace being developed for CSV's where will it fall within the hierarchy level?

3-1-4 Basic VFR Weather Minimums .
a. No person may operate an aircraft under basic VFR when the flight visibility is less, or at a distance from clouds that is less, than that prescribed for the corresponding altitude and class of airspace. N/A

NOTE-
Student pilots must comply with 14 CFR Section 61.89(a) (6) and (7).

b. Except as provided in 14 CFR Section 91.157, Special VFR Weather Minimums, no person may operate an aircraft beneath the ceiling under VFR within the lateral boundaries of controlled airspace designated to the surface for an airport when the ceiling is less than 1,000 feet. (See 14 CFR Section91.155(c).) N/A

TBL 3-1-1
Basic VFR Weather Minimums

Airspace	Flight Visibility	Distance from Clouds
Class A	Not Applicable	Not Applicable
Class B	3 statute miles	Clear of Clouds
Class C	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
Class D	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
Class E Less than 10,000 feet MSL	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
At or above 10,000 feet MSL	5 statute miles	1,000 feet below 1,000 feet above 1 statute mile horizontal
Class G 1,200 feet or less above the surface (regardless of MSL altitude).		
Day, except as provided in section 91.155(b)	1 statute mile	Clear of clouds
Night, except as provided in section 91.155(b)	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
More than 1,200 feet above the surface but less than 10,000 feet MSL.		
Day	1 statute mile	500 feet below 1,000 feet above 2,000 feet horizontal

Night	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
More than 1,200 feet above the surface and at or above 10,000 feet MSL.	5 statute miles	1,000 feet below 1,000 feet above 1 statute mile horizontal

373. Question: In the event that new airspace is developed to accommodate CSVs what will the VFR weather minimums be?

374. Question: Will these weather minimums be applicable to CSVs or will they need to abide by other weather minimum requirements?

VFR Cruising Altitudes and Flight Levels 3-1-5.

TBL 3-1-2
VFR Cruising Altitudes and Flight Levels

If your magnetic course (ground track) is:	**And you are more than 3,000 feet above the surface but below 18,000 feet MSL, fly:**	**And you are above 18,000 feet MSL to FL 290, fly:**
0° to 179°	Odd thousands MSL, plus 500 feet (3,500; 5,500; 7,500, etc.)	Odd Flight Levels plus 500 feet (FL 195; FL 215; FL 235, etc.)
180° to 359°	Even thousands MSL, plus 500 feet (4,500; 6,500; 8,500, etc.)	Even Flight Levels plus 500 feet (FL 185; FL 205; FL 225, etc.)

375. Question: Will CSVs use the same procedures or will they need to establish a system separate from other traffic?

Section 2. Controlled Airspace
General

3-2-1.

Controlled Airspace**.** a. A generic term that covers the different classification of airspace (Class A, Class B, Class C, Class D, and Class E airspace) and defined dimensions within which air traffic control service is provided to IFR flights and to VFR flights in accordance with the airspace classification. (See FIG 3-2-1.) N/A

IFR Requirements**.** b. IFR operations in any class of controlled airspace requires that a pilot must file an IFR flight plan and receive an appropriate ATC clearance. N/A

IFR Separation. c. Standard IFR separation is provided to all aircraft operating under IFR in controlled airspace.

376. Question: Will the IFR separation requirements for CSV's have to be different than current aircraft?

VFR Requirements**.** d. It is the responsibility of the pilot to ensure that ATC clearance or radio communication requirements are met prior to entry into Class B, Class C, or Class D airspace. The pilot retains this responsibility when receiving ATC radar advisories. (See 14 CFR Part 91.)

377. Question: Will CSV's operate like an IFR flight where clearance through airspace is given ahead of time rather than requiring radio communications?

Traffic Advisories**.** e. Traffic advisories will be provided to all aircraft as the controller's work situation permits.

378. Question: Will controllers be able to warn CSV's and other traffic fast enough to avoid a mid-air collision?

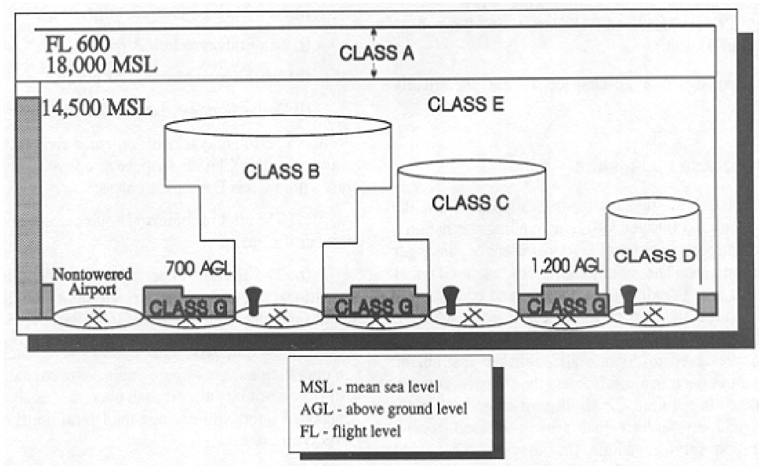
Safety Alerts**.** f. Safety Alerts are mandatory services and are provided to ALL aircraft. There are two types of Safety Alerts: N/A

Terrain/Obstruction Alert. 1. A Terrain/Obstruction Alert is issued when, in the controller's judgment, an aircraft's altitude places it in unsafe proximity to terrain and/or obstructions; and N/A

Aircraft Conflict/Mode C Intruder Alert. 2. An Aircraft Conflict/Mode C Intruder Alert is issued if the controller observes another aircraft which places it in an unsafe proximity. When feasible, the controller will offer the pilot an alternative course of action.

379. Question: Will the Mode C intruder alert give enough of a warning to the fast moving CSV's?

FIG 3-2-1
Airspace Classes



Ultralight Vehicles. g. No person may operate an ultralight vehicle within Class A, Class B, Class C, or Class D airspace or within the lateral boundaries of the surface area of Class E airspace designated for an airport unless that person has prior authorization from the ATC facility having jurisdiction over that airspace. (See 14 CFR Part 103.) N/A

Unmanned Free Balloons. h. Unless otherwise authorized by ATC, no person may operate an unmanned free balloon below 2,000 feet above the surface within the lateral boundaries of Class B, Class C, Class D, or Class E airspace designated for an airport. (See 14 CFR Part 101.) N/A

Parachute Jumps. i. No person may make a parachute jump, and no pilot-in-command may allow a parachute jump to be made from that aircraft, in or into Class A, Class B, Class C, or Class D airspace without, or in violation of, the terms of an ATC authorization issued by the ATC facility having jurisdiction over the airspace. (See 14 CFR Part 105.) N/A

3-2-2 Class A Airspace .

Definition. a. Generally, that airspace from 18,000 feet MSL up to and including FL 600, including the airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States and Alaska; and designated international airspace beyond 12 nautical miles of the coast of the 48 contiguous States and Alaska within areas of domestic radio navigational signal or ATC radar coverage, and within which domestic procedures are applied.

380. Question: Will there have to be new airspace developed beyond FL600 to accommodate CSV traffic?

Operating Rules and Pilot/Equipment b. Requirements. Unless otherwise authorized, all persons must operate their aircraft under IFR. (See 14 CFR Section 71.33 and 14 CFR Section 91.167 through 14 CFR Section 91.193.) N/A

Charts. c. Class A airspace is not specifically charted. N/A

3-2-3. Class B Airspace

Definition. a. Generally, that airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of IFR operations or passenger enplanements. The configuration of each Class B airspace area is individually tailored and consists of a surface area and two or more layers (some Class B airspace areas resemble upside-down wedding cakes), and is designed to contain all published instrument procedures once an aircraft enters the airspace. An ATC clearance is required for all aircraft to operate in the area, and all aircraft that are so cleared receive separation services within the airspace. The cloud clearance requirement for VFR operations is "clear of clouds."

381. Question: Will CSVs be allowed to operate in Class B airspace?
382. Question: Will CSVs be able to navigate safely in congested airspace such as Class B?
383. Question: Will some Class B airspace have to be expanded to accommodate CSV instrument procedures?

Operating Rules and Pilot/Equipment b. Requirements for VFR Operations. Regardless of weather conditions, an ATC clearance is required prior to operating within Class B airspace. Pilots should not request a clearance to operate within Class B airspace unless the requirements of 14 CFR Section 91.215 and 14 CFR Section 91.131 are met. Included among these requirements are: N/A

1. Unless otherwise authorized by ATC, aircraft must be equipped with an operable two-way radio capable of communicating with ATC on appropriate frequencies for that Class B airspace. N/A

2. No person may take off or land a civil aircraft at the following primary airports within Class B airspace unless the pilot-in-command holds at least a private pilot certificate:

(a)Andrews Air Force Base, MD

(b)Atlanta Hartsfield Airport, GA

(c)Boston Logan Airport, MA

(d)Chicago O'Hare Intl. Airport, IL

(e)Dallas/Fort Worth Intl. Airport, TX

(f)Los Angeles Intl. Airport, CA

(g)Miami Intl. Airport, FL

(h)Newark Intl. Airport, NJ

(i)New York Kennedy Airport, NY

(j)New York La Guardia Airport, NY

(k)Ronald Reagan Washington National Airport, DC

(l)San Francisco Intl. Airport, CA

384. Question: Will the operation of CSVs need to be restricted within these airspaces as well?

3. No person may take off or land a civil aircraft at an airport within Class B airspace or operate a civil aircraft within Class B airspace unless: N/A

(a)The pilot-in-command holds at least a private pilot certificate; or N/A

(b)The aircraft is operated by a student pilot or recreational pilot who seeks private pilot certification and has met the requirements of 14 CFR Section 61.95. N/A

4. Unless otherwise authorized by ATC, each person operating a large turbine engine-powered airplane to or from a primary airport must operate at or above the designated floors while within the lateral limits of Class B airspace. N/A

5. Unless otherwise authorized by ATC, each aircraft must be equipped as follows:

(a)For IFR operations, an operable VOR or TACAN receiver; and

(b)For all operations, a two-way radio capable of communications with ATC on appropriate frequencies for that area; and

(c)Unless otherwise authorized by ATC, an operable radar beacon transponder with automatic altitude reporting equipment.

NOTE-
ATC may, upon notification, immediately authorize a deviation from the altitude reporting equipment requirement; however, a request for a deviation from the 4096 transponder equipment requirement must be submitted to the controlling ATC facility at least one hour before the proposed operation.

385. Question: If CSVs are allowed to operate within Class B airspace will all of the equipment listed above be required for CSVs? Will deviations from the use of a 4096 transponder be permitted for CSVs?

REFERENCE-
AIM, Transponder Operation, Paragraph 4-1-20.

Mode C Veil**.** 6.The airspace within 30 nautical miles of an airport listed in Appendix D, Section 1 of 14 CFR Part 91 (generally primary airports within Class B airspace areas), from the surface upward to 10,000 feet MSL. Unless otherwise authorized by ATC, aircraft operating within this airspace must be equipped with automatic pressure altitude reporting equipment having Mode C capability.

386. Question: Will CSVs be able to operate within the mode C Veil?

However, an aircraft that was not originally certificated with an engine-driven electrical system or which has not subsequently been certified with a system installed may conduct operations within a Mode C veil provided the aircraft remains outside Class A, B or C airspace; and below the altitude of the ceiling of a Class B or Class C airspace area designated for an airport or 10,000 feet MSL, whichever is lower. N/A

Charts. c.Class B airspace is charted on Sectional Charts, IFR En Route Low Altitude, and Terminal Area Charts. N/A

Flight Procedures. d.

Flights. 1. Aircraft within Class B airspace are required to operate in accordance with current IFR procedures. A clearance for a visual approach to a primary airport is not authorization for turbine-powered airplanes to operate below the designated floors of the Class B airspace. N/A

VFR Flights. 2.

(a)Arriving aircraft must obtain an ATC clearance prior to entering Class B airspace and must contact ATC on the appropriate frequency, and in relation to geographical fixes shown on local charts. Although a pilot may be operating beneath the floor of the Class B airspace on initial contact, communications with ATC should be established in relation to the points indicated for spacing and sequencing purposes. N/A

(b)Departing aircraft require a clearance to depart Class B airspace and should advise the clearance delivery position of their intended altitude and route of flight. ATC will normally advise VFR aircraft when leaving the geographical limits of the Class B airspace. Radar service is not automatically terminated with this advisory unless specifically stated by the controller. N/A

(c)Aircraft not landing or departing the primary airport may obtain an ATC clearance to transit the Class B airspace when traffic conditions permit and provided the requirements of 14 CFR Section 91.131 are met. Such VFR aircraft are encouraged, to the extent possible, to operate at altitudes above or below the Class B airspace or transit through established VFR corridors. Pilots operating in VFR corridors are urged to use frequency 122.750 MHz for the exchange of aircraft position information.

387. Question: Will CSVs be able to operate within VFR corridors to transition through Class B airspace?

ATC Clearances and Separation. e. An ATC clearance is required to enter and operate within Class B airspace. VFR pilots are provided sequencing and separation from other aircraft while operating within Class B airspace.

388. Question: Will ATC be able to provide sequencing and separation for CSV traffic within Class B airspace?

REFERENCE-
AIM, Terminal Radar Services for VFR Aircraft, Paragraph 4-1-18.

NOTE-
1.*Separation and sequencing of VFR aircraft will be suspended in the event of a radar outage as this service is dependent on radar. The pilot will be advised that the service is not available and issued wind, runway information and the time or place to contact the tower.* N/A

2. *Separation of VFR aircraft will be suspended during CENRAP operations. Traffic advisories and sequencing to the primary airport will be provided on a workload permitting basis. The pilot will be advised when center radar presentation (CENRAP) is in use.* N/A

1. VFR aircraft are separated from all VFR/IFR aircraft which weigh 19,000 pounds or less by a minimum of:

(a)Target resolution, or

(b) 500 feet vertical separation, or

(c)Visual separation.

2. VFR aircraft are separated from all VFR/IFR aircraft which weigh more than 19,000 and turbojets by no less than:

(a) 1 $^{1}/_{2}$ miles lateral separation, or

(b) 500 feet vertical separation, or

(c)Visual separation.

389. Question: How will CSVs be separated from other traffic and what separation requirements will be necessary?

390. Question: Will CSVs be able to use visual separation procedures?

3. This program is not to be interpreted as relieving pilots of their responsibilities to see and avoid other traffic operating in basic VFR weather conditions, to adjust their operations and flight path as necessary to preclude serious wake encounters, to maintain appropriate terrain and obstruction clearance or to remain in weather conditions equal to or better than the minimums required by 14 CFR Section 91.155. Approach control should be advised and a revised clearance or instruction obtained when compliance with an assigned route, heading and/or altitude is likely to compromise pilot responsibility with respect to terrain and obstruction clearance, vortex exposure, and weather minimums.

391. Question: If CSVs are operating at high airspeeds, will they be able to see and avoid other traffic?

4. ATC may assign altitudes to VFR aircraft that do not conform to 14 CFR Section 91.159. "RESUME APPROPRIATE VFR ALTITUDES" will be broadcast when the altitude assignment is no longer needed for separation or when leaving Class B airspace. Pilots must return to an altitude that conforms to 14 CFR Section 91.159.

392. Question: Will CSVs be able to use these VFR altitudes as well or will they need to operate within other cruising altitudes?

Proximity operations**.** f. VFR aircraft operating in proximity to Class B airspace are cautioned against operating too closely to the boundaries, especially where the floor of the Class B airspace is 3,000 feet or less above the surface or where VFR cruise altitudes are at or near the floor of higher levels. Observance of this precaution will reduce the potential for encountering an aircraft operating at the altitudes of Class

B floors. Additionally, VFR aircraft are encouraged to utilize the VFR Planning Chart as a tool for planning flight in proximity to Class B airspace. Charted VFR Flyway Planning Charts are published on the back of the existing VFR Terminal Area Charts. N/A

3-2-4. Class C Airspace

Definition**.** a. Generally, that airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower, are serviced by a radar approach control, and that have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C airspace area is individually tailored, the airspace usually consists of a 5 NM radius core surface area that extends from the surface up to 4,000 feet above the airport elevation, and a 10 NM radius shelf area that extends no lower than 1,200 feet up to 4,000 feet above the airport elevation. N/A

Charts. b. Class C airspace is charted on Sectional Charts, IFR En Route Low Altitude, and Terminal Area Charts where appropriate. N/A

Operating Rules and Pilot/Equipment c. Requirements:

Pilot Certification. 1. No specific certification required. N/A

Equipment. 2.

(a)Two-way radio; and N/A

(b)Unless otherwise authorized by ATC, an operable radar beacon transponder with automatic altitude reporting equipment.

393. Question: Will a beacon transponder with automatic altitude reporting equipment (Mode C) also be a requirement for CSVs to operate within Class C airspace?

NOTE-
See paragraph 4-1-20, Transponder Operation, subparagraph f2(c) for Mode C transponder requirements for operating above Class C airspace. N/A

Arrival or Through Flight Entry Requirements**.** 3. Two-way radio communication must be established with the ATC facility providing ATC services prior to entry and thereafter maintain those communications while in Class C airspace. Pilots of arriving aircraft should contact the Class C airspace ATC facility on the publicized frequency and give their position, altitude, radar beacon code, destination, and request Class C service. Radio contact should be initiated far enough from the Class C airspace boundary to preclude entering Class C airspace before two-way radio communications are established. N/A

NOTE-
1.*If the controller responds to a radio call with, "(aircraft callsign) standby," radio communications have been established and the pilot can enter the Class C airspace.*

394. Question: Will “aircraft calling standby” procedures apply to CSVs or will they need prior permission to enter Class C airspace?

2. *If workload or traffic conditions prevent immediate provision of Class C services, the controller will inform the pilot to remain outside the Class C airspace until conditions permit the services to be provided.* N/A

3. *It is important to understand that if the controller responds to the initial radio call without using the aircraft identification, radio communications have not been established and the pilot may not enter the Class C airspace.* N/A

4. *Though not requiring regulatory action, Class C airspace areas have a procedural Outer Area. Normally this area is 20 NM from the primary Class C airspace airport. Its vertical limit extends from the lower limits of radio/radar coverage up to the ceiling of the approach control's delegated airspace, excluding the Class C airspace itself, and other airspace as appropriate. (This outer area is not charted.)*

395. Question: Will the operation of CSVs within this Outer Area of Class C airspace require regulatory actions?

396. Question: Could the operation of CSVs within this outer area propose separation problems?

5. *Pilots approaching an airport with Class C service should be aware that if they descend below the base altitude of the 5 to 10 mile shelf during an instrument or visual approach, they may encounter nontransponder, VFR aircraft.* N/A

EXAMPLE-

1. *[Aircraft callsign] “remain outside the Class Charlie airspace and standby.”* N/A

2. *“Aircraft calling Dulles approach control, standby.”* N/A

Departures from: 4.

(a)A primary or satellite airport with an operating control tower. Two-way radio communications must be established and maintained with the control tower, and thereafter as instructed by ATC while operating in Class C airspace. N/A

(b)A satellite airport without an operating control tower. Two-way radio communications must be established as soon as practicable after departing with the ATC facility having jurisdiction over the Class C airspace. N/A

Aircraft Speed. 5. Unless otherwise authorized or required by ATC, no person may operate an aircraft at or below 2,500 feet above the surface within 4 nautical miles of the primary airport of a Class C airspace area at an indicated airspeed of more than 200 knots (230 mph). N/A

Air Traffic Services**.** d.When two-way radio communications and radar contact are established, all participating VFR aircraft are: N/A

1. Sequenced to the primary airport. N/A

2. Provided Class C services within the Class C airspace and the outer area. N/A

3. Provided basic radar services beyond the outer area on a workload permitting basis. This can be terminated by the controller if workload dictates. N/A

Aircraft Separation. e. Separation is provided within the Class C airspace and the outer area after two-way radio communications and radar contact are established. VFR aircraft are separated from IFR aircraft within the Class C airspace by any of the following:

1. Visual separation.

2.500 feet vertical; except when operating beneath a heavy jet.

3. Target resolution.

397. Question: What separation requirements will be applicable for CSVs?
398. Question: What wake turbulence procedures will apply to CSVs?

NOTE-
1.*Separation and sequencing of VFR aircraft will be suspended in the event of a radar outage as this service is dependent on radar. The pilot will be advised that the service is not available and issued wind, runway information and the time or place to contact the tower.* N/A

2. *Separation of VFR aircraft will be suspended during CENRAP operations. Traffic advisories and sequencing to the primary airport will be provided on a workload permitting basis. The pilot will be advised when CENRAP is in use.* N/A

3. *Pilot participation is voluntary within the outer area and can be discontinued, within the outer area, at the pilot's request. Class C services will be provided in the outer area unless the pilot requests termination of the service.*

399. Question: Will this radar service be optional for CSVs as well?

4. *Some facilities provide Class C services only during published hours. At other times, terminal IFR radar service will be provided. It is important to note that the communications and transponder requirements are dependent of the class of airspace established outside of the published hours.* N/A

Secondary Airports f.

1. In some locations Class C airspace may overlie the Class D surface area of a secondary airport. In order to allow that control tower to provide service to aircraft, portions of the overlapping Class C airspace may be procedurally excluded when the secondary airport tower is in operation. Aircraft operating in these procedurally excluded areas will only be provided airport traffic control services when in communication with the secondary airport tower. N/A

2. Aircraft proceeding inbound to a satellite airport will be terminated at a sufficient distance to allow time to change to the appropriate tower or advisory frequency. Class C services to these aircraft will be discontinued when the aircraft is instructed to contact the tower or change to advisory frequency. N/A

3. Aircraft departing secondary controlled airports will not receive Class C services until they have been radar identified and two-way communications have been established with the Class C airspace facility. N/A

4. This program is not to be interpreted as relieving pilots of their responsibilities to see and avoid other traffic operating in basic VFR weather conditions, to adjust their operations and flight path as necessary to preclude serious wake encounters, to maintain appropriate terrain and obstruction clearance or to remain in weather conditions equal to or better than the minimums required by 14 CFR Section 91.155. Approach control should be advised and a revised clearance or instruction obtained when compliance with an assigned route, heading and/or altitude is likely to compromise pilot responsibility with respect to terrain and obstruction clearance, vortex exposure, and weather minimums.

400. Question: Will CSVs have the ability to change their flight path mid-flight?
401. Question: In the event of a CSV deviations how will a clear route of flight be ensured?

Class C Airspace Areas by State g.

These states currently have designated Class C airspace areas that are depicted on sectional charts. Pilots should consult current sectional charts and NOTAMs for the latest information on services available.

Pilots should be aware that some Class C airspace underlies or is adjacent to Class B airspace. N/A

(See TBL 3-2-1.)

TBL 3-2-1
Class C Airspace Areas by State

State/City	Airport
ALABAMA	
Birmingham	Birmingham-Shuttlesworth International
Huntsville	International-Carl T Jones Fld
Mobile	Regional
ALASKA	
Anchorage	Ted Stevens International
ARIZONA	
Davis-Monthan	AFB
Tucson	International
ARKANSAS	
Fayetteville (Springdale)	Northwest Arkansas Regional
Little Rock	Adams Field

CALIFORNIA	
Beale	AFB
Burbank	Bob Hope
Fresno	Yosemite International
Monterey	Peninsula
Oakland	Metropolitan Oakland International
Ontario	International
Riverside	March AFB
Sacramento	International
San Jose	Norman Y. Mineta International
Santa Ana	John Wayne/Orange County
Santa Barbara	Municipal
COLORADO	
Colorado Springs	Municipal
CONNECTICUT	
Windsor Locks	Bradley International
FLORIDA	
Daytona Beach	International
Fort Lauderdale	Hollywood International
Fort Myers	SW Florida Regional
Jacksonville	International
Orlando	Sanford International
Palm Beach	International
Pensacola	NAS
Pensacola	Regional
Sarasota	Bradenton International
Tallahassee	Regional
Whiting	NAS
GEORGIA	
Columbus	Metropolitan

Savannah	Hilton Head International
HAWAII	
Kahului	Kahului
IDAHO	
Boise	Air Terminal
ILLINOIS	
Champaign	Urbana U of Illinois-Willard
Chicago	Midway International
Moline	Quad City International
Peoria	Greater Peoria Regional
Springfield	Abraham Lincoln Capital
INDIANA	
Evansville	Regional
Fort Wayne	International
Indianapolis	International
South Bend	Regional
IOWA	
Cedar Rapids	The Eastern Iowa
Des Moines	International
KANSAS	
Wichita	Mid-Continent
KENTUCKY	
Lexington	Blue Grass
Louisville	International-Standiford Field
LOUISIANA	
Baton Rouge	Metropolitan, Ryan Field
Lafayette	Regional
Shreveport	Barksdale AFB
Shreveport	Regional

MAINE	
Bangor	International
Portland	International Jetport
MICHIGAN	
Flint	Bishop International
Grand Rapids	Gerald R. Ford International
Lansing	Capital City
MISSISSIPPI	
Columbus	AFB
Jackson	Jackson-Evers International
MISSOURI	
Springfield	Springfield-Branson National
MONTANA	
Billings	Logan International
NEBRASKA	
Lincoln	Lincoln
Omaha	Eppley Airfield
Offutt	AFB
NEVADA	
Reno	Reno/Tahoe International
NEW HAMPSHIRE	
Manchester	Manchester
NEW JERSEY	
Atlantic City	International
NEW MEXICO	
Albuquerque	International Sunport
NEW YORK	
Albany	International
Buffalo	Niagara International

Islip	Long Island MacArthur
Rochester	Greater Rochester International
Syracuse	Hancock International
NORTH CAROLINA	
Asheville	Regional
Fayetteville	Regional/Grannis Field
Greensboro	Piedmont Triad International
Pope	AFB
Raleigh	Raleigh-Durham International
OHIO	
Akron	Akron-Canton Regional
Columbus	Port Columbus International
Dayton	James M. Cox International
Toledo	Express
OKLAHOMA	
Oklahoma City	Will Rogers World
Tinker	AFB
Tulsa	International
OREGON	
Portland	International
PENNSYLVANIA	
Allentown	Lehigh Valley International
PUERTO RICO	
San Juan	Luis Munoz Marin International
RHODE ISLAND	
Providence	Theodore Francis Green State
SOUTH CAROLINA	
Charleston	AFB/International
Columbia	Metropolitan
Greer	Greenville-Spartanburg

	International
Myrtle Beach	Myrtle Beach International
Shaw	AFB
TENNESSEE	
Chattanooga	Lovell Field
Knoxville	McGhee Tyson
Nashville	International
TEXAS	
Abilene	Regional
Amarillo	Rick Husband International
Austin	Austin-Bergstrom International
Corpus Christi	International
Dyess	AFB
El Paso	International
Harlingen	Valley International
Laughlin	AFB
Lubbock	Preston Smith International
Midland	International
San Antonio	International
VERMONT	
Burlington	International
VIRGIN ISLANDS	
St. Thomas	Charlotte Amalie Cyril E. King
VIRGINIA	
Richmond	International
Norfolk	International
Roanoke	Regional/Woodrum Field
WASHINGTON	
Point Roberts	Vancouver International
Spokane	Fairchild AFB

Spokane	International
Whidbey Island	NAS, Ault Field
WEST VIRGINIA	
Charleston	Yeager
WISCONSIN	
Green Bay	Austin Straubel International
Madison	Dane County Regional-Traux Field
Milwaukee	General Mitchell International

N/A

Section 3. Class G Airspace

3-3-1. General

Class G airspace (uncontrolled) is that portion of airspace that has not been designated as Class A, Class B, Class C, Class D, or Class E airspace. N/A

3-3-2. VFR Requirements

Rules governing VFR flight have been adopted to assist the pilot in meeting the responsibility to see and avoid other aircraft. Minimum flight visibility and distance from clouds required for VFR flight are contained in 14 CFR Section 91.155.

(See TBL 3-1-1.)

402. Question: Will these VFR flight requirements be adequate for CSVs to be able to see and avoid? Will see and avoid operations be sufficient for all CSVs?

3-3-3. IFR Requirements

a. Title 14 CFR specifies the pilot and aircraft equipment requirements for IFR flight. Pilots are reminded that in addition to altitude or flight level requirements, 14 CFR Section 91.177 includes a requirement to remain at least 1,000 feet (2,000 feet in designated mountainous terrain) above the highest obstacle within a horizontal distance of 4 nautical miles from the course to be flown.

403. Question: Will all of the equipment specified within 14 CFR and Section 91.177 be required for CSVs and their pilots?

b. IFR Altitudes.

(See TBL 3-3-1.)

TBL 3-3-1

IFR Altitudes

Class G Airspace

If your magnetic course (ground track) is:	And you are below 18,000 feet MSL, fly:
0° to 179°	Odd thousands MSL, (3,000; 5,000; 7,000, etc.)
180° to 359°	Even thousands MSL, (2,000; 4,000; 6,000, etc.)

404. Question: If CSVs are operating under IFR conditions should these altitudes be used or will other altitudes need to be developed specifically for CSVs?

Section 4. Special Use Airspace

3-4-1. General

a. Special use airspace consists of that airspace wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both. Except for controlled firing areas, special use airspace areas are depicted on aeronautical charts.

405. Question: Will CSVs require the development of a Special Use Airspace entity?
406. Question: If a new Special Use Airspace is created, will current procedures for seizing specific airspace segments be voided?

b. Prohibited and restricted areas are regulatory special use airspace and are established in 14 CFR Part 73 through the rulemaking process.

407. Question: If a new type of airspace is developed, will it be designated as a "Prohibited" area or a "Restricted" area?
408. Question: Can current, high speed, military climb corridors designed for US Air Defense be used for CSV launches?

c. Warning areas, military operations areas (MOAs), alert areas, and controlled firing areas (CFAs) are non-regulatory special use airspace.

409. Question: Since CSV trajectories and velocities are expected to be high, will special climb corridors be developed for their use?
410. Question: If special climb corridors or warning areas are classified as non-regulatory, how will CSV flight paths be cleared through them?

d. Special use airspace descriptions (except CFAs) are contained in FAA Order JO 7400.8, Special Use Airspace. N/A

e. Special use airspace (except CFAs) are charted on IFR or visual charts and include the hours of operation, altitudes, and the controlling agency.

411. Question: Will any new special use airspace designed for CSVs be charted using the same system currently employed for MOAs and similar airspace systems?

412. Question: Will publication of the active dates, times and altitudes on charts and NOTAMS be adequate?

3-4-2. Prohibited Areas

Prohibited areas contain airspace of defined dimensions identified by an area on the surface of the earth within which the flight of aircraft is prohibited. Such areas are established for security or other reasons associated with the national welfare. These areas are published in the Federal Register and are depicted on aeronautical charts.

413. Question: In order to continue providing security to the protected areas, will prohibited areas need to be expanded to account for the use of CSVs?

414. Question: Will establishing a prohibited area for CSVs hamper the integration of CSV operations into the normal NAS system?

3-4-3. Restricted Areas

a. Restricted areas contain airspace identified by an area on the surface of the earth within which the flight of aircraft, while not wholly prohibited, is subject to restrictions. Activities within these areas must be confined because of their nature or limitations imposed upon aircraft operations that are not a part of those activities or both. Restricted areas denote the existence of unusual, often invisible, hazards to aircraft such as artillery firing, aerial gunnery, or guided missiles. Penetration of restricted areas without authorization from the using or controlling agency may be extremely hazardous to the aircraft and its occupants. Restricted areas are published in the Federal Register and constitute 14 CFR Part 73.

415. Question: Will normally restricted areas such as VOR intersections, Class B airspace etc. within the existing airspace needs to be restricted specifically for CSVs?

416. Question: Will the current restricted areas provide adequate separation from the special activities being conducted by CSV traffic?

417. Question: Will the same restrictions that apply to atmospheric aircraft also apply to CSVs?

b. ATC facilities apply the following procedures when aircraft are operating on an IFR clearance (including those cleared by ATC to maintain VFR-on-top) via a route which lies within joint-use restricted airspace.

418. Question: What will the procedure be for CSVs operating on an IFR clearance within joint-use restricted airspace?

419. Question: Will CSV operations require different routes and procedures for safety of flight?

1. If the restricted area is not active and has been released to the controlling agency (FAA), the ATC facility will allow the aircraft to operate in the restricted airspace without issuing specific clearance for it to do so. N/A

2. If the restricted area is active and has not been released to the controlling agency (FAA), the ATC facility will issue a clearance which will ensure the aircraft avoids the restricted airspace unless it is on an approved altitude reservation mission or has obtained its own permission to operate in the airspace and so informs the controlling facility.

420. Question: What will be the maneuverability capability of CSVs to avoid specific airspace at the direction of ATC?

NOTE-
The above apply only to joint-use restricted airspace and not to prohibited and nonjoint-use airspace. For the latter categories, the ATC facility will issue a clearance so the aircraft will avoid the restricted airspace unless it is on an approved altitude reservation mission or has obtained its own permission to operate in the airspace and so informs the controlling facility.

c. Restricted airspace is depicted on the en route chart appropriate for use at the altitude or flight level being flown. For joint-use restricted areas, the name of the controlling agency is shown on these charts. For all prohibited areas and nonjoint-use restricted areas, unless otherwise requested by the using agency, the phrase "NO A/G" is shown.

3-4-4. Warning Areas
A warning area is airspace of defined dimensions, extending from three nautical miles outward from the coast of the U.S., which contains activity that may be hazardous to nonparticipating aircraft. The purpose of such warning areas is to warn nonparticipating pilots of the potential danger. A warning area may be located over domestic or international waters or both.

421. Question: Will CSVs engender a specific type of warning for all aircraft operating in or over warning areas?

422. Question: How will a CSV be guaranteed a clear flight path within a warning area?

3-4-5. Military Operations Areas
a. MOAs consist of airspace of defined vertical and lateral limits established for the purpose of separating certain military training activities from IFR traffic. Whenever a MOA is being used, nonparticipating IFR traffic may be cleared through a MOA if IFR separation can be provided by ATC. Otherwise, ATC will reroute or restrict nonparticipating IFR traffic.

423. Question: What IFR separation requirements will apply to CSVs?

424. Question: Will it be necessary to develop separate IFR procedures and routes for CSVs operating in a MOA?

425. Question: Will ATC need to develop special areas, similar to MOAs, for the exclusive use of CSVs?

b. Examples of activities conducted in MOAs include, but are not limited to: air combat tactics, air intercepts, aerobatics, formation training, and low-altitude tactics. Military pilots flying in an active MOA are exempted from the provisions of 14 CFR Section 91.303(c) and (d) which prohibits aerobatic flight within Class D and Class E surface areas, and within Federal airways. Additionally, the Department of Defense has been issued an authorization to operate aircraft at indicated airspeeds in excess of 250 knots below 10,000 feet MSL within active MOAs.

426. Question: Will FAA develop areas with similar characteristics and breadth of operations for CSVs?

c. Pilots operating under VFR should exercise extreme caution while flying within a MOA when military activity is being conducted. The activity status (active/inactive) of MOAs may change frequently. Therefore, pilots should contact any FSS within 100 miles of the area to obtain accurate real-time information concerning the MOA hours of operation. Prior to entering an active MOA, pilots should contact the controlling agency for traffic advisories.

427. Question: Due to the high velocities and limited maneuverability at which CSVs are expected operate, should CSVs avoid active MOAs completely?

428. Question: Should CSVs be restricted from flying in active MOAs?

d. MOAs are depicted on sectional, VFR Terminal Area, and En-route Low Altitude charts.

3-4-6. Alert Areas

Alert areas are depicted on aeronautical charts to inform nonparticipating pilots of areas that may contain a high volume of pilot training or an unusual type of aerial activity. Pilots should be particularly alert when flying in these areas. All activity within an alert area must be conducted in accordance with CFRs, without waiver, and pilots of participating aircraft as well as pilots transiting the area must be equally responsible for collision avoidance.

429. Question: Will the operation of CSVs be allowed in alert areas?

3-4-7. Controlled Firing Areas (CFA)

CFAs contain activities which, if not conducted in a controlled environment, could be hazardous to nonparticipating aircraft. The distinguishing feature of the CFA, as compared to other special use airspace, is that its activities are suspended immediately when spotter aircraft, radar, or ground lookout positions indicate an aircraft might be

approaching the area. There is no need to chart CFAs since they do not cause a nonparticipating aircraft to change its flight path.

430. Question: Will the current methods used for spotting aircraft be able to spot CSVs and halt operations fast enough to allow safe passage through the CFA?
431. Question: Will it be necessary for CFAs to be plotted so that CSVs can avoid hazards when the area is in operation?
432. Question: When active, will CFA cause CSVs to change their flight path?
433. Question: Should CFA be depicted on charts to ensure that CSV don't inadvertently enter a CFA that is active?

Section 5. Other Airspace Areas

3-5-1. Airport Advisory/Information Services

a. There are three advisory type services available at selected airports.

1. Local Airport Advisory (LAA) service is operated within 10 statute miles of an airport where a control tower is not operating but where a FSS is located on the airport. At such locations, the FSS provides a complete local airport advisory service to arriving and departing aircraft. During periods of fast changing weather the FSS will automatically provide Final Guard as part of the service from the time the aircraft reports "on-final" or "taking-the-active-runway" until the aircraft reports "on-the-ground" or "airborne." N/A

NOTE-

Current policy, when requesting remote ATC services, requires that a pilot monitor the automated weather broadcast at the landing airport prior to requesting ATC services. The FSS automatically provides Final Guard, when appropriate, during LAA/Remote Airport Advisory (RAA) operations. Final Guard is a value added wind/altimeter monitoring service, which provides an automatic wind and altimeter check during active weather situations when the pilot reports on-final or taking the active runway. During the landing or take-off operation when the winds or altimeter are actively changing the FSS will blind broadcast significant changes when the specialist believes the change might affect the operation. Pilots should acknowledge the first wind/altimeter check but due to cockpit activity no acknowledgement is expected for the blind broadcasts. It is prudent for a pilot to report on-the-ground or airborne to end the service. N/A

2. RAA service is operated within 10 statute miles of specified high activity GA airports where a control tower is not operating. Airports offering this service are listed in the A/FD and the published service hours may be changed by NOTAM D. Final Guard is automatically provided with RAA. N/A

3. Remote Airport Information Service (RAIS) is provided in support of short term special events like small to medium fly-ins. The service is advertised by NOTAM D only. The FSS will not have access to a continuous readout of the current winds and altimeter; therefore, RAIS does not include weather and/or Final Guard service. However, known traffic, special event instructions, and all other services are provided. N/A

NOTE-
The airport authority and/or manager should request RAIS support on official letterhead directly with the manager of the FSS that will provide the service at least 60 days in advance. Approval authority rests with the FSS manager and is based on workload and resource availability. N/A

REFERENCE-
AIM, Traffic Advisory Practices at Airports Without Operating Control Towers, Paragraph 4-1-9.

b. It is not mandatory that pilots participate in the Airport Advisory programs. Participation enhances safety for everyone operating around busy GA airports; therefore, everyone is encouraged to participate and provide feedback that will help improve the program. N/A

3-5-2. Military Training Routes

a. National security depends largely on the deterrent effect of our airborne military forces. To be proficient, the military services must train in a wide range of airborne tactics. One phase of this training involves "low level" combat tactics. The required maneuvers and high speeds are such that they may occasionally make the see-and-avoid aspect of VFR flight more difficult without increased vigilance in areas containing such operations. In an effort to ensure the greatest practical level of safety for all flight operations, the Military Training Route (MTR) program was conceived.

434. Question: Will VFR flight see-and- avoid operations be more difficult for CSVs as well?

b. The MTR program is a joint venture by the FAA and the Department of Defense (DOD). MTRs are mutually developed for use by the military for the purpose of conducting low-altitude, high-speed training. The routes above 1,500 feet AGL are developed to be flown, to the maximum extent possible, under IFR. The routes at 1,500 feet AGL and below are generally developed to be flown under VFR.

435. Question: Will CSVs need to develop similar routes to navigate safely around other aircraft?

436. Question: Could these routes be opened up for CSVs use?

c. Generally, MTRs are established below 10,000 feet MSL for operations at speeds in excess of 250 knots. However, route segments may be defined at higher altitudes for purposes of route continuity. For example, route segments may be defined for descent, climb out, and mountainous terrain. There are IFR and VFR routes as follows:

437. Question: If CSVs were allowed to use these routes or similar technology, could the same procedures be used to develop more, higher altitude routes, optimal decent routes and to accommodate vertical takeoffs?

1. IFR Military Training Routes-(IR). Operations on these routes are conducted in accordance with IFR regardless of weather conditions. N/A

2. VFR Military Training Routes-(VR). Operations on these routes are conducted in accordance with VFR except flight visibility must be 5 miles or more; and flights must not be conducted below a ceiling of less than 3,000 feet AGL. N/A

d. Military training routes will be identified and charted as follows: N/A

1. Route identification.

(a) MTRs with no segment above 1,500 feet AGL must be identified by four number characters; e.g., IR1206, VR1207. N/A

(b) MTRs that include one or more segments above 1,500 feet AGL must be identified by three number characters; e.g., IR206, VR207. N/A

(c) Alternate IR/VR routes or route segments are identified by using the basic/principal route designation followed by a letter suffix, e.g., IR008A, VR1007B, etc. N/A

2. Route charting.

(a) IFR Low Altitude En Route Chart. This chart will depict all IR routes and all VR routes that accommodate operations above 1,500 feet AGL. N/A

(b) VFR Sectional Charts. These charts will depict military training activities such as IR, VR, MOA, Restricted Area, Warning Area, and Alert Area information.

438. Question: Will CSV routes need to be published in a similar manner?

(c) Area Planning (AP/1B) Chart (DOD Flight Information Publication-FLIP). This chart is published by the DOD primarily for military users and contains detailed information on both IR and VR routes. N/A

REFERENCE-
AIM, National Geospatial-Intelligence Agency (NGA) Products, Paragraph 9-1-5, Subparagraph a.

e. The FLIP contains charts and narrative descriptions of these routes. This publication is available to the general public by single copy or annual subscription from: N/A

Aeronautical Navigation Products (AeroNav)
Logistics Group
Federal Aviation Administration

10201 Good Luck Road
Glenn Dale, MD 20769-9700
Toll free phone: 1-800-638-8972
Commercial: 301-436-8301

N/A

This DOD FLIP is available for pilot briefings at FSS and many airports.

f. Nonparticipating aircraft are not prohibited from flying within an MTR; however, extreme vigilance should be exercised when conducting flight through or near these routes. Pilots should contact FSSs within 100 NM of a particular MTR to obtain current information or route usage in their vicinity. Information available includes times of scheduled activity, altitudes in use on each route segment, and actual route width. Route width varies for each MTR and can extend several miles on either side of the charted MTR centerline. Route width information for IR and VR MTRs is also available in the FLIP AP/1B along with additional MTR (slow routes/air refueling routes) information. When requesting MTR information, pilots should give the FSS their position, route of flight, and destination in order to reduce frequency congestion and permit the FSS specialist to identify the MTR which could be a factor.

439. Question: Will the information available for MTRs be adequate for CSVs; what additional information might be necessary for CSV pilots?
440. Question: Will CSVs be allowed to operate along MTRs in the same manner as aircraft, or will special procedures need to be developed for CSVs?

3-5-3. Temporary Flight Restrictions

a. General. This paragraph describes the types of conditions under which the FAA may impose temporary flight restrictions. It also explains which FAA elements have been delegated authority to issue a temporary flight restrictions NOTAM and lists the types of responsible agencies/offices from which the FAA will accept requests to establish temporary flight restrictions. The 14 CFR is explicit as to what operations are prohibited, restricted, or allowed in a temporary flight restrictions area. Pilots are responsible to comply with 14 CFR Sections 91.137, 91.138, 91.141 and 91.143 when conducting flight in an area where a temporary flight restrictions area is in effect, and should check appropriate NOTAMs during flight planning.

441. Question: What additional restrictions will apply to CSV operations within a TFR?
442. Question: Will CSVs be allowed to operate within a TFR?

b. The purpose for establishing a temporary flight restrictions area is to:

1. Protect persons and property in the air or on the surface from an existing or imminent hazard associated with an incident on the surface when the presence of low flying aircraft would magnify, alter, spread, or compound that hazard (14 CFR Section 91.137(a)(1)); N/A

2. Provide a safe environment for the operation of disaster relief aircraft (14 CFR Section 91.137(a)(2)); or **3.** Prevent an unsafe congestion of sightseeing aircraft above an incident or event which may generate a high degree of public interest (14 CFR Section 91.137(a)(3)). N/A

4. Protect declared national disasters for humanitarian reasons in the State of Hawaii (14 CFR Section 91.138). N/A

5. Protect the President, Vice President, or other public figures (14 CFR Section 91.141). N/A

6. Provide a safe environment for space agency operations (14 CFR Section 91.143).

443. Question: Will CSVs and operators be able to seize airspace if they are operating for hire?

c. Except for hijacking situations, when the provisions of 14 CFR Section 91.137(a)(1) or (a)(2) are necessary, a temporary flight restrictions area will only be established by or through the area manager at the Air Route Traffic Control Center (ARTCC) having jurisdiction over the area concerned. A temporary flight restrictions NOTAM involving the conditions of 14 CFR Section 91.137(a)(3) will be issued at the direction of the service area office director having oversight of the airspace concerned. When hijacking situations are involved, a temporary flight restrictions area will be implemented through the TSA Aviation Command Center. The appropriate FAA air traffic element, upon receipt of such a request, will establish a temporary flight restrictions area under 14 CFR Section 91.137(a)(1). N/A

d. The FAA accepts recommendations for the establishment of a temporary flight restrictions area under 14 CFR Section 91.137(a)(1) from military major command headquarters, regional directors of the Office of Emergency Planning, Civil Defense State Directors, State Governors, or other similar authority. For the situations involving 14 CFR Section 91.137(a)(2), the FAA accepts recommendations from military commanders serving as regional, sub regional, or Search and Rescue (SAR) coordinators; by military commanders directing or coordinating air operations associated with disaster relief; or by civil authorities directing or coordinating organized relief air operations (includes representatives of the Office of Emergency Planning, U.S. Forest Service, and State aeronautical agencies). Appropriate authorities for a temporary flight restrictions establishment under 14 CFR Section 91.137(a)(3) are any of those listed above or by State, county, or city government entities. N/A

e. The type of restrictions issued will be kept to a minimum by the FAA consistent with achievement of the necessary objective. Situations which warrant the extreme restrictions of 14 CFR Section 91.137(a)(1) include, but are not limited to: toxic gas leaks or spills, flammable agents, or fumes which if fanned by rotor or propeller wash could endanger persons or property on the surface, or if entered by an aircraft could endanger persons or property in the air; imminent volcano eruptions which could endanger airborne aircraft and occupants; nuclear accident or incident; and hijackings. Situations which warrant the restrictions associated with 14 CFR Section 91.137(a)(2) include: forest fires which are being fought by releasing fire retardants from aircraft; and aircraft relief activities following a disaster (earthquake, tidal wave, flood, etc.). 14 CFR Section 91.137(a)(3) restrictions are established for events and incidents that would attract an unsafe congestion of sightseeing aircraft. N/A

f. The amount of airspace needed to protect persons and property or provide a safe environment for rescue/relief aircraft operations is normally limited to within 2,000 feet above the surface and within a 3-nautical-mile radius. Incidents occurring within Class B, Class C, or Class D airspace will normally be handled through existing procedures and should not require the issuance of a temporary flight restrictions NOTAM. Temporary flight restrictions affecting airspace outside of the U.S. and its territories and possessions are issued with verbiage excluding that airspace outside of the 12-mile coastal limits. N/A

g. The FSS nearest the incident site is normally the "coordination facility." When FAA communications assistance is required, the designated FSS will function as the primary communications facility for coordination between emergency control authorities and affected aircraft. The ARTCC may act as liaison for the emergency control authorities if adequate communications cannot be established between the designated FSS and the relief organization. For example, the coordination facility may relay authorizations from the on-scene emergency response official in cases where news media aircraft operations are approved at the altitudes used by relief aircraft. N/A

h. ATC may authorize operations in a temporary flight restrictions area under its own authority only when flight restrictions are established under 14 CFR Section 91.137(a)(2) and (a)(3). The appropriate ARTCC/airport traffic control tower manager will, however, ensure that such authorized flights do not hamper activities or interfere with the event for which restrictions were implemented. However, ATC will not authorize local IFR flights into the temporary flight restrictions area. N/A

i. To preclude misunderstanding, the implementing NOTAM will contain specific and formatted information. The facility establishing a temporary flight restrictions area will format a NOTAM beginning with the phrase "FLIGHT RESTRICTIONS" followed by: the location of the temporary flight restrictions area; the effective period; the area defined in statute miles; the altitudes affected; the FAA coordination facility and commercial telephone number; the reason for the temporary flight restrictions; the agency directing any relief activities and its commercial telephone number; and other information considered appropriate by the issuing authority.

444. Question: Will CSV operators be able to submit NOTAMS?

EXAMPLE-

1. *14 CFR Section 91.137(a)(1):*
The following NOTAM prohibits all aircraft operations except those specified in the NOTAM. Flight restrictions Matthews, Virginia, effective immediately until 9610211200. Pursuant to 14 CFR Section 91.137(a)(1) temporary flight restrictions are in effect. Rescue operations in progress. Only relief aircraft operations under the direction of the Department of Defense are authorized in the airspace at and below 5,000 feet MSL within a 2-nautical-mile radius of Laser AFB, Matthews, Virginia. Commander, Laser AFB, in charge (897) 946-5543 (122.4). Steenson FSS (792) 555-6141 (123.1) is the FAA coordination facility. N/A

2. *14 CFR Section 91.137(a)(2):*
The following NOTAM permits flight operations in accordance with 14 CFR Section 91.137(a)(2). The on-site emergency response official to authorize media aircraft operations below the altitudes used by the relief aircraft. Flight restrictions 25 miles east of Bransome, Idaho, effective immediately until 9601202359 UTC. Pursuant to 14 CFR Section 91.137(a)(2) temporary flight restrictions are in effect within a 4-nautical-mile radius of the intersection of county roads 564 and 315 at and below 3,500 feet MSL to provide a safe environment for firefighting aircraft operations. Davis County sheriff's department (792) 555-8122 (122.9) is in charge of on-scene emergency response activities. Glivings FSS (792) 555-1618 (122.2) is the FAA coordination facility. N/A

3. *14 CFR Section 91.137(a)(3):*
The following NOTAM prohibits sightseeing aircraft operations.
Flight restrictions Brown, Tennessee, due to Olympic activity. Effective 9606181100 UTC until 9607190200 UTC. Pursuant to 14 CFR Section 91.137(a)(3) temporary flight restrictions are in effect within a 3-nautical-mile radius of N355783/W835242 and Volunteer VORTAC 019 degree radial 3.7 DME fix at and below 2,500 feet MSL. Norton FSS (423) 555-6742 (126.6) is the FAA coordination facility. N/A

4. *14 CFR Section 91.138:*
The following NOTAM prohibits all aircraft except those operating under the authorization of the official in charge of associated emergency or disaster relief response activities, aircraft carrying law enforcement officials, aircraft carrying personnel involved in an emergency or legitimate scientific purposes, carrying properly accredited news media, and aircraft operating in accordance with an ATC clearance or instruction.
Flight restrictions Kapalua, Hawaii, effective 9605101200 UTC until 9605151500UTC.

Pursuant to 14 CFR Section 91.138 temporary flight restrictions are in effect within a 3-nautical-mile radius of N205778/W1564038 and Maui/OGG/VORTAC 275 degree radial at 14.1 nautical miles. John Doe 808-757-4469 or 122.4 is in charge of the operation. Honolulu/HNL 808-757-4470 (123.6) FSS is the FAA coordination facility. N/A

5. *14 CFR Section 91.141:*
The following NOTAM prohibits all aircraft.
Flight restrictions Stillwater, Oklahoma, June 21, 1996. Pursuant to 14 CFR Section 91.141 aircraft flight operations are prohibited within a 3-nautical-mile radius, below 2000 feet AGL of N360962/W970515 and the Stillwater/SWO/VOR/DME 176 degree radial 3.8-nautical-mile fix from 1400 local time to 1700 local time June 21, 1996, unless otherwise authorized by ATC. N/A

6. *14 CFR Section 91.143:*
The following NOTAM prohibits any aircraft of U.S. registry, or pilot any aircraft under the authority of an airman certificate issued by the FAA.
Kennedy space center space operations area effective immediately until 9610152100 UTC. Pursuant to 14 CFR Section 91.143, flight operations conducted by FAA certificated pilots or conducted in aircraft of U.S. registry are prohibited at any altitude from surface to unlimited, within the following area 30-nautical-mile radius of the Melbourne/MLB/VORTAC 010 degree radial 21-nautical-mile fix. St. Petersburg, Florida/PIE/FSS 813-545-1645 (122.2) is the FAA coordination facility and should be contacted for the current status of any airspace associated with the space shuttle operations. This airspace encompasses R2933, R2932, R2931, R2934, R2935, W497A and W158A. Additional warning and restricted areas will be active in conjunction with the operations. Pilots must consult all NOTAMs regarding this operation. N/A

3-5-4. Parachute Jump Aircraft Operations

a. Procedures relating to parachute jump areas are contained in 14 CFR Part 105. Tabulations of parachute jump areas in the U.S. are contained in the A/FD. N/A

b. Pilots of aircraft engaged in parachute jump operations are reminded that all reported altitudes must be with reference to mean sea level, or flight level, as appropriate, to enable ATC to provide meaningful traffic information. N/A

c. Parachute operations in the vicinity of an airport without an operating control tower - there is no substitute for alertness while in the vicinity of an airport. It is essential that pilots conducting parachute operations be alert, look for other traffic, and exchange traffic information as recommended in paragraph 4-1-9, Traffic Advisory Practices at Airports Without Operating Control Towers. In addition, pilots should avoid releasing parachutes while in an airport traffic pattern when there are other aircraft in that pattern. Pilots should make appropriate broadcasts on the designated Common Traffic Advisory Frequency (CTAF), and monitor that CTAF until all parachute activity has terminated or the aircraft has left the area. Prior to commencing a jump operation, the pilot should broadcast the aircraft's altitude and position in relation to the airport, the approximate relative time when the jump will commence and terminate, and listen to the position reports of other aircraft in the area. N/A

3-5-5. Published VFR Routes

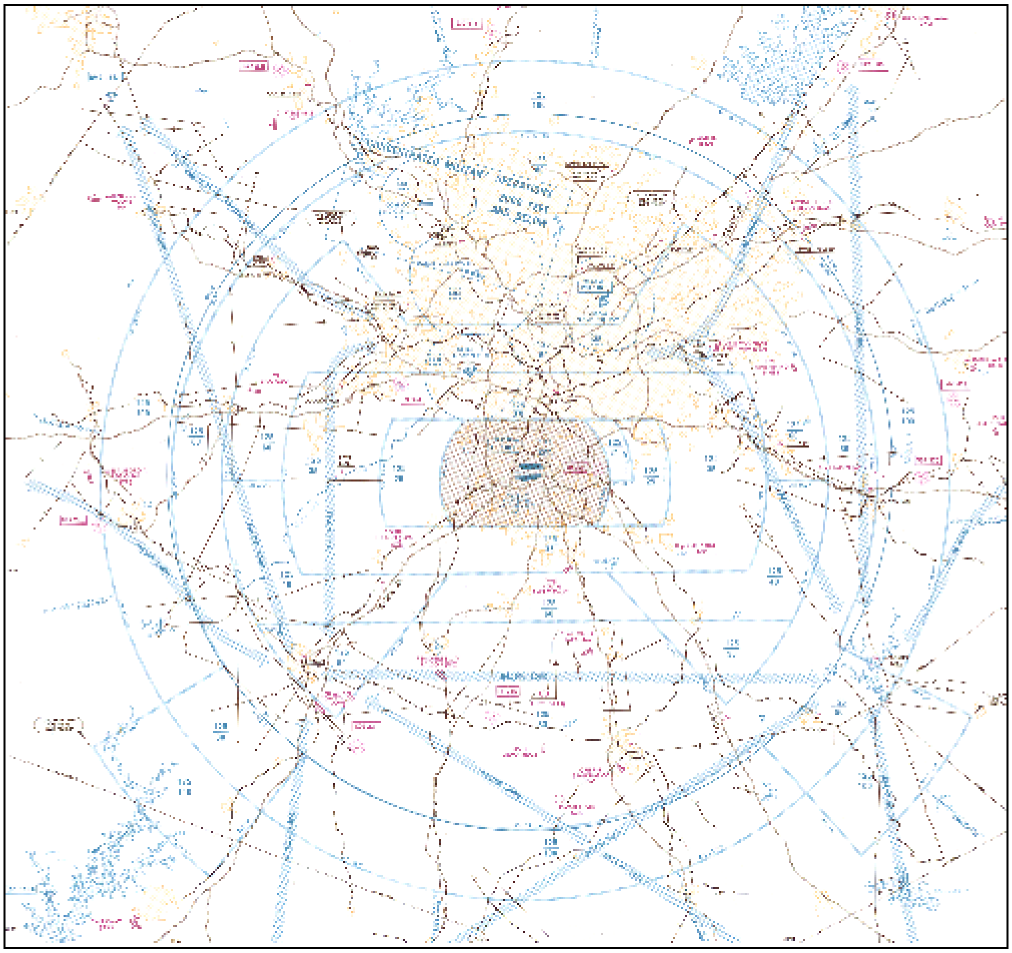
Published VFR routes for transitioning around, under and through complex airspace such as Class B airspace were developed through a number of FAA and industry initiatives. All of the following terms, i.e., "VFR Flyway" "VFR Corridor" and "Class B Airspace VFR Transition Route" have been used when referring to the same or different types of routes or airspace. The following paragraphs identify and clarify the functionality of each type of route, and specify where and when an ATC clearance is required. N/A

a. VFR Flyways.

1. VFR Flyways and their associated Flyway Planning Charts were developed from the recommendations of a National Airspace Review Task Group. A VFR Flyway is defined as a general flight path not defined as a specific course, for use by pilots in planning flights into, out of, through or near complex terminal airspace to avoid Class B airspace. An ATC clearance is NOT required to fly these routes.

445. Question: Will CSVs be authorized to use VFR flyways?

FIG 3-5-1
VFR Flyway Planning Chart



2. VFR Flyways are depicted on the reverse side of some of the VFR Terminal Area Charts (TAC), commonly referred to as Class B airspace charts. (See FIG 3-5-1.) Eventually all TACs will include a VFR Flyway Planning Chart. These charts identify VFR flyways designed to help VFR pilots avoid major controlled traffic flows. They may further depict multiple VFR routings throughout the area which may be used as an alternative to flight within Class B airspace. The ground references provide a guide for improved visual navigation. These routes are not intended to discourage requests for VFR operations within Class B airspace but are designed solely to assist pilots in planning for flights under and around busy Class B airspace without actually entering Class B airspace. N/A

3. It is very important to remember that these suggested routes are not sterile of other traffic. The entire Class B airspace, and the airspace underneath it, may be heavily congested with many different types of aircraft. Pilot adherence to VFR rules must be exercised at all times. Further, when operating beneath Class B airspace, communications must be established and maintained between your aircraft and any control tower while transiting the Class B, Class C, and Class D surface areas of those airports under Class B airspace. N/A

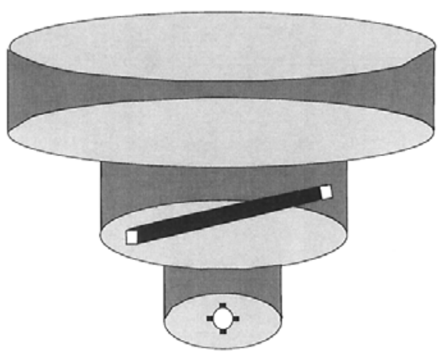
b. VFR Corridors.

1. The design of a few of the first Class B airspace areas provided a corridor for the passage of uncontrolled traffic. A VFR corridor is defined as airspace through Class B airspace, with defined vertical and lateral boundaries, in which aircraft may operate without an ATC clearance or communication with air traffic control.

446. Question: Will CSVs be able to use VFR corridors?

2. These corridors are, in effect, a "hole" through Class B airspace. (See FIG 3-5-2.) A classic example would be the corridor through the Los Angeles Class B airspace, which has been subsequently changed to Special Flight Rules airspace (SFR). A corridor is surrounded on all sides by Class B airspace and does not extend down to the surface like a VFR Flyway. Because of their finite lateral and vertical limits, and the volume of VFR traffic using a corridor, extreme caution and vigilance must be exercised. N/A

FIG 3-5-2
Class B Airspace



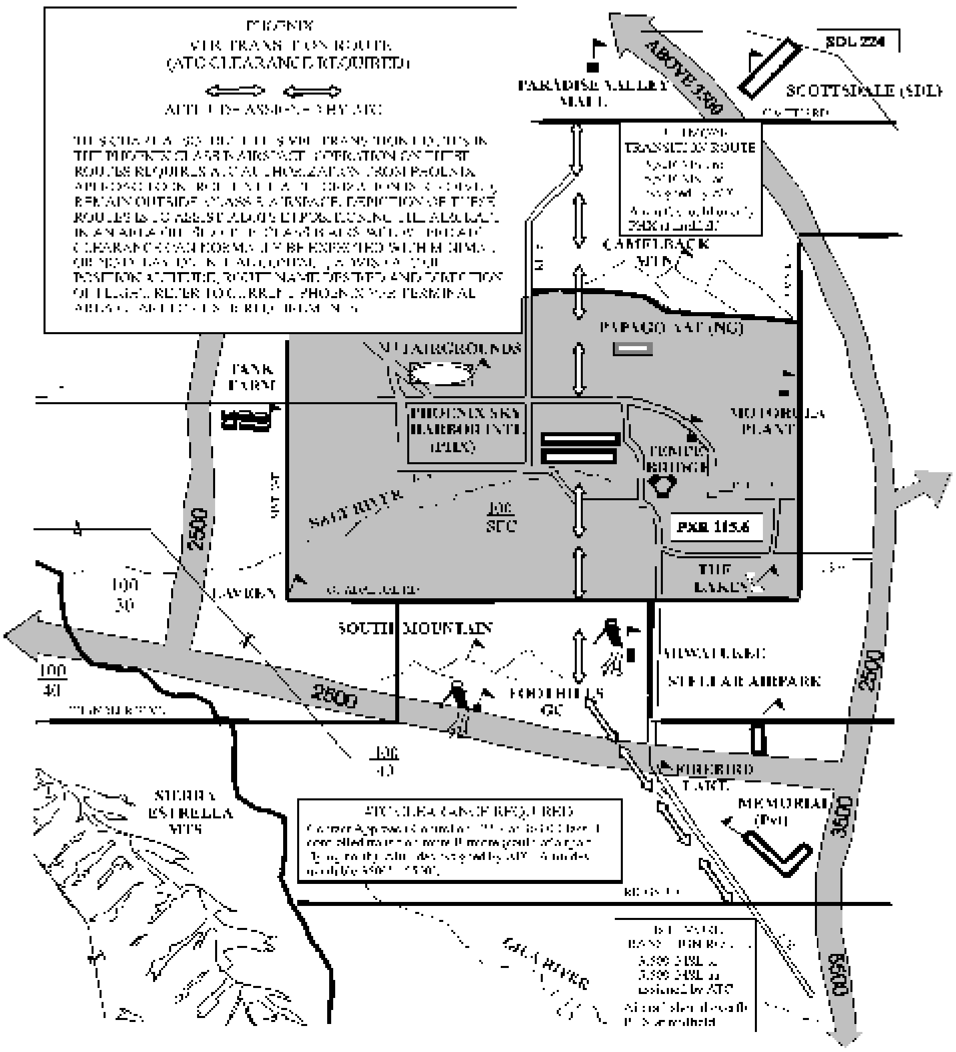
3. Because of the heavy traffic volume and the procedures necessary to efficiently manage the flow of traffic, it has not been possible to incorporate VFR corridors in the development or modifications of Class B airspace in recent years. N/A

c. Class B Airspace VFR Transition Routes.

1. To accommodate VFR traffic through certain Class B airspace, such as Seattle, Phoenix and Los Angeles, Class B Airspace VFR Transition Routes were developed. A Class B Airspace VFR Transition Route is defined as a specific flight course depicted on a TAC for transiting a specific Class B airspace. These routes include specific ATC-assigned altitudes, and pilots must obtain an ATC clearance prior to entering Class B airspace on the route. N/A

2. These routes, as depicted in FIG 3-5-3, are designed to show the pilot where to position the aircraft outside of, or clear of, the Class B airspace where an ATC clearance can normally be expected with minimal or no delay. Until ATC authorization is received, pilots must remain clear of Class B airspace. On initial contact, pilots should advise ATC of their position, altitude, route name desired, and direction of flight. After a clearance is received, pilots must fly the route as depicted and, most importantly, adhere to ATC instructions. N/A

FIG 3-5-3
VFR Transition Route



N/A

3-5-6. Terminal Radar Service Area (TRSA)

a. Background. TRSAs were originally established as part of the Terminal Radar Program at selected airports. TRSAs were never controlled airspace from a regulatory standpoint because the establishment of TRSAs was never subject to the rulemaking process; consequently, TRSAs are not contained in 14 CFR Part 71 nor are there any TRSA operating rules in 14 CFR Part 91. Part of the Airport Radar Service Area (ARSA) program was to eventually replace all TRSAs. However, the ARSA requirements became relatively stringent and it was subsequently decided that TRSAs would have to meet ARSA criteria before they would be converted. TRSAs do not fit into any of the U.S. airspace classes; therefore, they will continue to be non-Part 71 airspace areas where participating pilots can receive additional radar services which have been redefined as TRSA Service.

447. Question: How will CSVs be handled within a TRSA?

b. TRSAs. The primary airport(s) within the TRSA become(s) Class D airspace. The remaining portion of the TRSA overlies other controlled airspace which is normally Class E airspace beginning at 700 or 1,200 feet and established to transition to/from the en route/terminal environment. N/A

c. Participation. Pilots operating under VFR are encouraged to contact the radar approach control and avail themselves of the TRSA Services. However, participation is voluntary on the part of the pilot. See Chapter 4, Air Traffic Control, for details and procedures. N/A

d. Charts. TRSAs are depicted on VFR sectional and terminal area charts with a solid black line and altitudes for each segment. The Class D portion is charted with a blue segmented line. N/A

3-5-7. National Security Areas

National Security Areas consist of airspace of defined vertical and lateral dimensions established at locations where there is a requirement for increased security and safety of ground facilities. Pilots are requested to voluntarily avoid flying through the depicted NSA. When it is necessary to provide a greater level of security and safety, flight in NSAs may be temporarily prohibited by regulation under the provisions of 14 CFR Section 99.7. Regulatory prohibitions will be issued by System Operations, System Operations Airspace and AIM Office, Airspace and Rules, and disseminated via NOTAM. Inquiries about NSAs should be directed to Airspace and Rules.

448. Question: Will CSVs be able to operate through NSAs if operating a scheduled route?

Chapter 5. Air Traffic Procedures

Section 1. Preflight

5-1-10. IFR Operations to High Altitude Destinations

a. Pilots planning IFR flights to airports located in mountainous terrain are cautioned to consider the necessity for an alternate airport even when the forecast weather conditions would technically relieve them from the requirement to file one.

449. Question: What are the criteria to be considered when choosing an alternate for CSVs?

b. The FAA has identified three possible situations where the failure to plan for an alternate airport when flying IFR to such a destination airport could result in a critical situation if the weather is less than forecast and sufficient fuel is not available to proceed to a suitable airport. N/A

1. An IFR flight to an airport where the Minimum Descent Altitudes (MDAs) or landing visibility minimums for *all instrument approaches* are higher than the forecast weather minimums specified in 14 CFR Section 91.167(b). For example, there are 3 high altitude airports in the U.S. with approved instrument approach procedures where all of the MDAs are greater than 2,000 feet and/or the landing visibility minimums are greater than 3 miles (Bishop, California; South Lake Tahoe, California; and Aspen-Pitkin Co./Sardy Field, Colorado). In the case of these airports, it is possible for a pilot to elect, on the basis of forecasts, not to carry sufficient fuel to get to an alternate when the ceiling and/or visibility is actually lower than that necessary to complete the approach. N/A

2. A small number of other airports in mountainous terrain have MDAs which are slightly (100 to 300 feet) below 2,000 feet AGL. In situations where there is an option as to whether to plan for an alternate, pilots should bear in mind that just a slight worsening of the weather conditions from those forecast could place the airport below the published IFR landing minimums.

450. Question: Will CSVs operate under the same weather minimum requirements as other aircraft or will a new set of rules need to be developed?
451. Question: Since some CSVs are gliders upon reentry, are CSVs guaranteed the opportunity to land and at their destination?
452. Question: What weather minimums will be required for CSVs to operate?

3. An IFR flight to an airport which requires special equipment; i.e., DME, glide slope, etc., in order to make the available approaches to the lowest minimums. Pilots should be aware that all other minimums on the approach charts may require weather conditions better than those specified in 14 CFR Section 91.167(b). An inflight equipment malfunction could result in the inability to comply with the published approach procedures or, again, in the position of having the airport below the published IFR landing minimums for all remaining instrument approach alternatives.

453. Question: What instruments will CSVs be required to carry on board?
454. Question: Will CSVs be able to use normal approach systems?

455. Question: What will be the alternate requirements for CSVs?

456. Question: In the event of specific equipment failures on CSVs, how will the CSVs be guided to landing?

Conclusion

A careful analysis of the existing regulations reveals that actual minute to minute control of commercial space vehicles in the airspace will require answers which have yet to be researched. This research effort has attempted to identify specific areas requiring immediate attention by the research community and the Federal Aviation Administration in order to make coherent control of commercial space vehicles in the national airspace system possible. The questions in section 4 of this report are a guide to the fields of research that the authors feel is needed before commercial space vehicles can be safely integrated into the daily operations of the national airspace system.

The appendices at the end of this report look at high-level control and management theories of how commercial space vehicle operations should be handled. That background information is extremely important and serves as a framework for future structures which will be needed to integrate commercial space vehicles into normal commercial aviation operations around the globe. However, the actual physical control of the space vehicles in relationship to other vehicles in the airspace has not been addressed by these studies. With this work, however, we hope to highlight those areas which will assist the FAA in developing specific procedures for the ATC system to safely integrate commercial space vehicles into the national airspace system. This report is intended to be used as a guide to the research that will be needed to answer the questions required for control of the vehicles using the current ATC system as it progresses into NEXTGEN.

Appendices

ADDENDUM 1: OPERATIONAL DESCRIPTION

Concept of Operations for CST in the NAS, Addendum 1 FAA AST Space Systems Development Division Revision 0 i June 15, 2005
Concept of Operations for CST in the NAS, Addendum 1 FAA AST Space Systems Development Division
Revision 0 i June 15, 2005

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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Patricia Grace Smith
Associate Administrator for
Commercial Space Transportation
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

TABLE OF CONTENTS

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.

Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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.

Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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 (Table not Included)

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

Revision 0 3 June 15, 2005
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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.*

Revision 0 5 June 15, 2005
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1 *Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division*
Revision 0 6 June 15, 2005

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 system2 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.(Not Included)
Cape Canaveral Spaceport Kennedy Space Center Cape Canaveral AFS
Vandenberg AFB
Wallops Flight Facility
Edwards AFB
White Sands Missile Range

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."

•Florida Space Authority Spaceport
California Spaceportirginia Space Flight Center Kodiak Launch Complex Mojave Civilian Test Flight Center
Southwest Regional Spaceport
Montana Spaceport
Texas Spaceport
(3 proposed sites)
Nevada Test Site Utah Spaceport
Oklahoma Spaceport
South Dakota Spaceport
(location TBD)
Spaceport Alabama
Wisconsin Spaceport
Spaceport Washington

LEGEND
Federal Spaceport

Proposed Non-Federal Spaceport
•♦♦♦♦•∗••Non-Federal Spaceport
Spaceport
• Center
• Center•

Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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 VEHICLES3

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.

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,(Not Included) these elements are in the areas of mission planning, launch operations, and reentry operations.

Table 2-1: Common Space Mission Elements. (Table not included)
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 to the NAS
 Upper Stage Separation
 Conventional Retu
 Vertical Ascent Through t
 Atmospheric Reentry
 Steep Descent Through the NAS
 Non-Conventional Retu

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.

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 phed 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 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 require 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.

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, (Not Included) 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.

Revision 0 9 June 15, 2005
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division
Figure 2-2: General Launch and Reentry Elements. *Orbital Altitude (>450k Feet)*

TSTO**Piloted Aircraft1stStage**SSTO
ELV
TSTO
Autonomous Aircraft
1st Stage
Common

Vertical
Ascent
1st Stage Return **1st Stage Return**
RESERVED AIRSPACE
Upper Limit of NAS Traffic Environment
LAUNCH ELEMENTS
TSTO
Piloted Aircraft
1st Stage
SSTO *Orbital Altitude (>450k Feet)*
Conventional Return
Winged, Powered, Piloted
Vehicle
Gliding Return
Piloted or
Autonomous
Autonomous Pilotage
Winged & Powered
Vehicle
Common
Ballistic
Descent
RESERVED AIRSPACE
Upper Limit of NAS Traffic Environment
Ballistic Return
De-Orbit
Suborbital
Reentry
REENTRY ELEMENTS

CONCEPT OF OPERATIONS FOR COMMERCIAL SPACE TRANSPORTATION IN THE NAS

ADDENDUM 1: OPERATIONAL DESCRIPTION

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.

Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1

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.

Revision 0 12 June 15, 2005
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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 cannot 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. STRATEGICMISSION 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.

Revision 0 13 June 15, 2005
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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.

Revision 0 14 June 15, 2005
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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 pre-departure 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.

Revision 0 16 June 15, 2005
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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.

Revision 0 17 June 15, 2005
Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1 *Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division*
Revision 0 18 June 15, 2005

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.

Space and Air Traffic Management System (SATMS) Concept of Operations for CST in the NAS, Addendum 1
Routine Access to Space Through Integrated Space and Aviation Operations in the NAS FAA AST Space Systems Development Division

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.

ADDENDUM 2: Separation Distances for Rocket Launch Operations

Separation Distances for Rocket Launch Operations

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An experimental permit issued by the Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST) authorizes reusable suborbital rockets to fly within a predefined operating area. Specifically, an operating area must contain a suborbital rocket's instantaneous impact point at all times. This paper will present a method for determining a buffer zone surrounding an operating area to mitigate the risks to nonparticipating aircraft from the hazards involving rocket operations. Determining the size of the buffer zone is a multi-step process. First, a principal operating area is established. Next, the risk to aircraft flying at the edge of the operating area is determined. Finally, the buffer zone size is established based on the additional distance beyond the edge of the operating area required to reduce the aircraft risk to acceptable levels. This paper will familiarize the reader with these proposed processes and the methodologies that support them.

Nomenclature

kft = thousands of feet
n. mi. = nautical miles
Pf = Probability of failure
PI = Probability of impact
IIP = Instantaneous impact point

I. Introduction

Growth of the commercial reusable suborbital launch industry has increased the demand for experimental permits issued by the Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST). The experimental permit (permit) is an avenue for commercial space companies to receive authorization to flight test their technology in a rapid prototyping environment. Commercial space companies are eligible to apply for a permit for a reusable suborbital launch vehicle (RLV) by meeting one of three criteria. One criterion is that the company is performing research and development to test new design concepts, new equipment, or new operating techniques. Another criterion is that the company is showing compliance with requirements for obtaining a license. Lastly, a company may apply for a permit to train the crew of the RLV before obtaining a license.

In order to encourage and develop the commercial space transportation industry, Congressional guidance associated with the Commercial Space Launch Amendments Act of 2004 directed the FAA to develop a permit authorization process as a streamlined version of the license authorization process1. One of the key differences between permit and license applications resulting from this streamlining is that the FAA/AST does not require permit applicants to perform an expected casualty analysis to quantify the risks to the public. Instead, the permit applicant must identify and qualitatively characterize the risks of each of the potential hazards associated with its proposed operation and apply mitigation measures that lower high risks to public health and safety and the safety of property to acceptable levels. For a permitted flight transitioning through the National Airspace System (NAS) on its way to or from space, a potential hazard exists through which the RLV may explode or breakup causing falling debris to impact nearby aircraft. A permit applicant can mitigate the risk to these nonparticipating aircraft by entering into an agreement with the FAA Air Traffic Control to preemptively close the airspace through and below which the RLV operates. However, there is a potential for the falling debris to spread beyond the bounds of this operating area and this mitigation measure on its own would not prevent nonparticipating aircraft from flying at the edge of the operating area.

The FAA/AST estimates the risk to the public on board aircraft flying at the edge of a proposed operating area. The FAA/AST reduces the risk to public on board nonparticipating aircraft to acceptable levels by imposing an additional separation distance for aircraft beyond the edge of the operating area. The designation of the additional area associated with this distance is the aircraft buffer zone. The extent of the aircraft buffer zone applied to the edge of the operating area is determined by first assessing the probability of an aircraft located at the edge of the operating area being impacted by debris capable of causing catastrophic damage. Next the computation is repeated at increasing radial distances from the edge of the operating area until the resulting probability is reduced to an acceptable level. Therefore, the size of the aircraft buffer zone directly relates to the threshold value for acceptable risk to the public.

By reducing the probability of impact of a debris fragment capable of causing catastrophic damage with a nonparticipating aircraft, an aircraft buffer zone protects the public on board aircraft during experimental permit operations. The extent of an aircraft buffer zone arises from the potential for debris to spread as it falls through the atmosphere following a vehicle failure and the vulnerability of aircraft to small pieces of debris. Given the speed at which aircraft travel, and the associated energy at impact with a piece of falling debris, aircraft are susceptible to catastrophic damage from impacts with smaller debris pieces that would generally not cause harm to a person on the ground; this is explained in detail in reference 2. This paper expands on the existing process of developing an aircraft hazard area as explained in reference 2 and will familiarize the reader with the proposed FAA processes and methodologies of determining the size of the aircraft buffer zone and aircraft hazard area.

II. Definitions

A. Operating Area and Safety Clear Zone

In the context of an experimental permit, an operating area is a volume of space that extends up from the surface of the Earth to the maximum planned altitude for permitted launch operations. 14 CFR §437.573 requires a permit applicant to propose an operating area of sufficient size to contain its proposed operations and then to prove that the RLV's vacuum instantaneous impact point (IIP) will not go beyond the edge of the operating area during both nominal and off-nominal flight conditions. Established within the boundaries of the operating area is a safety clear zone. The safety clear zone is the area that typically surrounds the launch and landing areas that is sized to contain the hazards associated with all pre- and post-flight activities per §437.53. In order to assure safety, a permittee must restrict public access to this area during hazardous operations. During flight, the launch operator rescinds the safety clear zone leaving a void that the operating area then envelops. The operating area may not contain nor be adjacent to densely populated areas or significant automobile, railway, and waterborne vessel traffic. Once the permittee establishes the operating area and safety clear zone size the permittee must obtain a written agreement with the responsible Air Traffic Control authority having jurisdiction over the airspace through which a permitted launch or reentry is to take place. Among other things, agreements between air traffic control and the permittee reflect the amount of restricted airspace required to maintain acceptable levels of risk to nonparticipating aircraft.

B. Aircraft Buffer Zone and Aircraft Hazard Area

The aircraft buffer zone is the volume of space surrounding the operating area as shown in figure 1. The aircraft buffer zone, operating area, and safety clear zone combine to make up the aircraft hazard area. The aircraft buffer zone acts as the boundary between the aircraft and the edge of the operating area. The experimental permit allows the RLV to fly anywhere within the operating area. A failure of the RLV near the edge of the operating area increases the probability of debris exiting the operating area and impacting an aircraft flying parallel to its edge. Additional area is established between the operating area edge and neighboring aircraft because as will be shown below, an in-flight accident can disperse debris relatively great distances and a small piece of debris can cause a catastrophic aircraft accident.

Keeping nonparticipating aircraft out of the aircraft Aircraft Hazard Area, Aircraft Buffer Zone, Operating Area, Safety Clear Zone, Figure 1. (Not Included)
Drawing of an example Aircraft Hazard Area, Aircraft Buffer Zone, Operating Area, and Safety Clear Zone for an experimental permit.

Hazard area prevents exposure of aircraft to unacceptable risk levels. Air Traffic Control maintains a clear flight hazard area by issuing a temporary flight restriction (TFR) for the launch or reentry window.

III. Procedure and Methodology Development

Determining the size of the aircraft buffer zone is a multi-step process and for that reason defining the key assumptions is an essential first step. There are five main underlying assumptions that contribute to the determination of the size of the aircraft buffer zone. The first assumption is that the vehicle utilizes a flight safety system capable of containing the IIP of the vehicle within the operating area regardless of the failure scenario. The effectiveness of a flight safety system is determined separately from the buffer zone analysis during a permit application evaluation and therefore it will not be discussed here, but will instead be assumed to be a sufficiently reliable method for containing the vehicle’s IIP. The second assumption is a probability of failure of one for the mission (i.e. the vehicle is assumed to fail). The third assumption is that, unless restricted from doing so, nonparticipating aircraft will be flying parallel to the edge of the operating area during the permitted flight. The fourth assumption is that a vehicle failure is no less likely to occur at the operating area boundary than anywhere else in the operating area. The last assumption is that the risk to non-participating aircraft must be no greater than one in ten million (1.0E-7).

A. Probability of Failure

The assignment of probability of vehicle failure during flight is one of the determining criteria in sizing the aircraft buffer zone. A lack of flight history and operational experience of a vehicle generally leads the FAA to size the aircraft buffer zone minimum extent based on a maximum credible event. To accomplish this, the FAA assumes a probability of failure (Pf) equal to 1.0 at each point in time in the proposed trajectory of the vehicle, effectively assuming a failure at each trajectory time step. An examination of the collection of resulting failure scenarios then leads to the identification of the worst-case failure scenario, which is then designated the maximum redible event.

Whereas intuition may suggest that other, less severe events may be more likely to occur, sufficient flight test data with which to rank the likelihood of occurrence of events relative to each other does not currently exist for most permitted vehicles. Consequently, sizing these aircraft hazard areas based on hazardous events other than the maximum credible event could provide inadequate protection to aircraft. Once sufficient experience has been gained and data has been collected, the FAA will consider more probabilistic or risk-based approaches to sizing these areas. But until that time, the FAA will continue to determine their minimum dimensions based on a maximum credible event.

B. Nonparticipating Aircraft

Permit applicants are required to obtain an agreement with the local Air Traffic Control (ATC) to coordinate use of the airspace through which the permitted flight will take place. In the absence of available, existing special use airspace, ATC uses a TFR to keep nonparticipating aircraft out of the potentially hazarded airspace during permitted flight operations. As there is no restriction on the permitted operation that would prevent the vehicle from operating anywhere within its proposed operating area, the closed volume of airspace must be at a minimum no smaller than the operating area. With no other restrictions in place, aircraft would tend to fly at the edge of the operating area during hazardous operations to increase efficiency and minimize impacts to the system's capacity.

Since hazards exist through which an in-flight failure of the vehicle within the operating area can spread debris beyond the bounds of the operating area, an aircraft buffer zone moves aircraft further from the operating area boundary thereby lowering the risk to aircraft. With the closed volume of airspace in place, it is prudent to next analyze the probability of debris impacting aircraft at the edge of the operating area, as well as the aircraft's vulnerability to debris impacts.

This project employed a probabilistic risk analysis for modeling the risk to aircraft from debris impacts. The probabilistic risk analysis approach is summarized below.

"In probabilistic risk analysis we employ a probability density distribution of debris. The full set of debris is separated into fragment groups, each of which is represented by a single debris cloud. Then the probability of impact Pi1, from a single fragment of the ith fragment group, is the probability density of the debris cloud integrated over the volume swept out by the aircraft." For the detailed equations used in the probabilistic risk analysis approach please refer to reference 11.

Aircraft location, size, and speed are key factors in the determination of the probability of impact (PI) of debris on aircraft. The analysis of aircraft susceptibility also depends on several other factors, including aircraft direction when debris impacts, location on the aircraft of the impact, and the composition of the impacting fragment, and the velocity imparted on the fragment as a result of the failure2. FAA/AST contracted ACTA, Inc. of Torrance, CA to research the process of creating an aircraft hazard area. The resulting report2 uses the Range Commanders' Council American Institute of Aeronautics and Astronautics (RCC) standard 321-074 threshold limit of debris heavier than one gram impacting an aircraft being able to cause a catastrophic accident. Recent advances in aircraft vulnerability modeling for commercial transport aircraft were not included in this analysis2. Currently the FAA/AST abides by the "one gram" standard; a future reevaluation of the standard will determine the level of conservatism necessary for aircraft protection.12, 13

C. Flight Operations and Threshold Risk Limit

The basis for the fourth assumption stems from the experimental permit regulation allowing an RLV to fly anywhere within the operating area as long as the IIP is contained. If the vehicle can operate at any location then the probability of failure is independent of failure location within the operating area. The most conservative failure scenario to be considered is one that occurs at the edge of the operating area (which has the possibility to be the "expected" flight plan for a given launch, because the permit does not require submission of individual mission plans).

Limiting the risk to nonparticipating aircraft to no more than one in ten million is a standard threshold risk limit from the RCC 321-074. A license requires an applicant to meet the same risk probability or to provide an equivalent level of safety to methods in use at the Federal ranges. The FAA has chosen to use the same level of risk in an experimental permit.

D. Vehicle Breakup

With the previous five assumptions in place, the determination of the aircraft buffer zone size depends on when and where the failure occurs, the worst-case debris generation due to explosive potential or aerodynamic breakup at time of failure, and what type of aircraft could be at the operating area edge. Deciding when and where the maximum credible event can occur requires a trajectory analysis. Applicants are not required to submit a specific trajectory analysis in the permit application. However, the operating area size, a limited set of vehicle characteristics, and the planned maximum altitude are required in the application. Modeling of the trajectory requires the maximum altitude, engine performance data, propellant loads, and vehicle gross liftoff weight. Using a trajectory analysis program5, the state vectors describing a proposed flight path can be approximated. The input of the state vectors into the flight safety analysis program describes the initial conditions at each state time at which the program will model the effects of a vehicle failure. The aircraft buffer zone size varies directly with the nature of the maximum credible event. Earlier in flight the vehicle has more propellant capable of producing a larger explosion, but has not entered the NAS where aircraft are affected by an in-flight failure. Later in flight the vehicle has less propellant, but is above the NAS where aircraft will be affected by an in-flight failure, the debris is exposed to the effects of winds for a longer period of time, and the atmospheric density is less capable of limiting the distance that the debris may be propelled by an explosion.

The next component of the aircraft buffer zone size is the debris cloud expected to be generated based on maximum explosive potential and aerodynamic breakup properties of the vehicle. The maximum explosive potential is dependent on the amount of propellant in the vehicle, which changes throughout the flight. The likelihood of an aerodynamic breakup depends on the flight dynamics of the vehicle at the time of failure. An explosive or aerodynamic failure will cause two different aircraft buffer zone sizes, the larger of which is chosen for conservatism when a potential for the occurrence of both failure modes exists. As the example model will show later, the explosive failure causes larger aircraft buffer zones at higher altitudes. The reason explosive failures are more detrimental to aircraft than aerodynamic breakups is two-fold. Explosive failures have more energy to impart on the vehicle fragments than an aerodynamic vehicle breakup, thus spreading the hazardous debris pieces farther.

Explosive failures also create a larger number of small debris pieces. Similar to large debris pieces, small pieces of debris impacting aircraft can also cause catastrophic accidents. Due to differences in vehicle configurations, propellant types, failure modes, and modeling limitations, a considerable amount of uncertainty exists in the estimated magnitude of the imparted velocity on each fragment.   ACTA uses a proprietary modeling technique to predict vehicle break up characteristics10. Data from these models, applied to the available configurations of two expendable launch vehicles, were used to construct the fragment model and respective imparted velocities discussed later in the example.
Figure 1. Tiered Aircraft Buffer Zone Areas. (Not Included)
Figure 2. Tiered Aircraft Hazard areas (Not Included)

E. Aircraft Types

The last element in sizing the aircraft buffer zone is the type of aircraft flying at the operating area edge. The classification and altitude of the aircraft are dependent on the maximum planned altitude of the RLV. For example, a planned maximum altitude of 500 ft. requires analysis of only general aviation aircraft because en route commercial aircraft fly at higher altitudes. RLV flights penetrating both the general aviation aircraft and commercial aircraft airspace may have aircraft buffer zone sizes that vary with altitude. Figure 2 (Not Included) shows two aircraft hazard areas for two different types of aircraft flying at different altitudes. The bottom tier is the aircraft buffer zone for smaller, slower general aviation aircraft whereas the top tier is for commercial aircraft. For each aircraft buffer zone evaluation the most conservative (largest) aircraft and flight altitude are chosen. Choosing the aircraft type to use for the analysis can depend on a local air traffic analysis. If a proposed operating area does not encroach on commercial air traffic routes, only general aviation aircraft will be used to calculate the probability of impacting an aircraft. However, for all proposed operating areas the most conservative aircraft that can potentially penetrate the operating area's airspace will be used for the analysis.

F. Sizing the Aircraft Buffer Zone

Upon completion of the assumption definitions and initial analyses, the data are input into the flight safety analysis tool6. The model of the RLV trajectory is the baseline trajectory for the flight safety analysis tool. The fragment model from either the explosive or aerodynamic break up failure is input into the flight safety analysis tool. The last input in the flight safety analysis tool is the type, speed, and altitude of the chosen aircraft. With these inputs, the flight safety analysis tool displays separate probability of impact contours for each aircraft type as shown in figure 3. (Not Included) The contour labeled one in ten million (1.0E-7) represents the boundary at which aircraft of the type analyzed can fly with an acceptable level of risk. Centered on the launch pad is the probability of impact contours. Shifting the center of these contours to the edge of the operating area represents the aircraft buffer zone required for a failure at the edge of the operating area. The aircraft buffer zone radius is determined by choosing the largest 1.0E -7 probability of impact contour from the all the aircraft failure scenarios, measuring its radius, and adding the operating area radius to this value.

IV. Implementation

Upon completing the development of the procedure, a test case was used to examine the application of the process for determining aircraft buffer zones for experimental permits. The hypothetical suborbital RLV used for the test case is vertically launched and has a gross lift-off weight of 100,000 lb. and a maximum planned altitude of 350,000 ft. The nominal flight profile for the RLV is broken up into three segments. From launch the RLV accelerates full throttle until main engine cut-off time occurs at which time it then coasts to the apogee. Once the RLV reaches apogee, it begins the descent stage returning to Earth and landing on a pad adjacent to the launch pad.

The operating area is set to a circle with a radius of 5 nautical miles, centered on the launch pad. With a nominal apogee of 350,000 ft. the RLV flies through and over the NAS requiring analysis of both general aviation aircraft and commercial aircraft for the aircraft buffer zone size. The next step in the procedure is to define possible trajectories for the RLV using a trajectory analysis tool5. Eight separate nominal trajectories are modeled. Each trajectory originates from the same launch point, using the 100,000 lb. gross liftoff weight, and flies along the same vertical profile at maximum thrust. However, different burnout times are employed to produce incrementally increasing apogee altitudes, ranging from 25,000 ft. to 350,000 ft. The state vectors output from the tool are input into a flight safety analysis tool6 thus defining the initial conditions from which this tool will model the effects of the failure. The flight safety analysis tool propagates each of the debris fragments associated with the vehicle failure to their impact with the surface, accounting for any velocity imparted on them as a result of the failure, the size and shape of the fragment, and the effects of winds and other atmospheric variations.

Creating a fragment catalogue is the next step in the procedure. Several fragment catalogues were considered before selecting the final version. The first few versions contain a small number of large pieces, corresponding mainly to the vehicle components. The later versions represent a more realistic model of the expected fragments based on preexisting fragment databases from similarly designed expendable launch vehicles. For the baseline RLV test case, the chosen vehicle fragment catalogue consists of 1,116 fragments. These fragments are created by dividing the components of the vehicle, such as the engines, propellant tanks, skin, and fins, into smaller pieces. Each component was broken up into fragments of relatively equal size. The vehicle components expected to fracture into the largest number of fragments are the propellant tanks, avionics, wiring, plumbing, and airframe. Imparted velocity quantities are assigned to each fragment upon completion of the debris catalogue. The chosen imparted velocities are established with the aid of previous analyses from similarly designed expendable launch vehicles.

For simplicity, the same fragment catalogue as the explosive case study, sans the imparted velocity, is used in the modeling of the aerodynamic breakup of the RLV. This generally produces conservative results since the explosive catalogue contains a larger number of small pieces than would be expected from an aerodynamic breakup and these smaller pieces tend to drift greater distances than larger pieces as a result of winds. Wind is the primary factor in buffer zone size for aerodynamic breakups.

Examining the aircraft density and what types of aircraft are most common in the region of the RLV flight path is the next step in the procedure. The test case identifies an inland region of the United State where a variety of commercial and general aviation aircraft are flown. This region is assumed to be sufficiently far away from major airports to support the assumption that all commercial aircraft in the vicinity are flying at cruising altitudes. Based on the conservatism provided from its larger size, the Boeing 747 was selected to represent these commercial aircraft. The Cessna 172 was used to represent the general aviation aircraft operating in this region at lower altitudes, based on its wide use and the availability of data describing its dimensions. The frontal and top areas of the Boeing 747 are 1613 ft2 and 10812 ft2 respectively. The altitude and average cruising speed of the Boeing 747 is 37,500 ft. and 831 ft./s respectively. The frontal and top areas of the Cessna 172 are 52 ft2 and 281 ft2 respectively. The altitude and average cruising speed of the Cessna 172 is 2,500 ft. and 165 ft./s. As stated above, an impact of debris weighing one gram or more counts as an impact to the aircraft that can cause a catastrophic accident.

The flight safety analysis tool requires the RLV trajectory, fragment catalogue, and aircraft data to generate the impact probability contours for nonparticipating aircraft. To accomplish this, the tool established a grid of user defined resolution that covers the estimated area at risk. The tool places an aircraft of one of the two types described above at each node on the grid at its corresponding altitude. At each state vector time in the RLV trajectory, the tool computes the probability of impact at each grid node. Nodes with probabilities of impact of similar order of magnitude are then collected into contours. The tool then examines the resulting collection of contours, one set for each state vector time, to identify the largest set. This set represents the worst credible event associated with that aircraft type. The process is then repeated for the other aircraft type. An atmospheric model associated with the month of October and the geographical region containing the launch pad was used for the test case. The database used for the atmospheric model is the Global Gridded Upper Atmosphere Statistics (GGUAS7) which models atmospheric conditions from data obtained over a 15 year time span from all over the world. The GGUAS database contains average wind, wind variation, average air temperature, and average air density for each month. The effect on the aircraft buffer zone size for launching during various months was also examined.

V. Results

The RLV modeled in this example has several aircraft hazard areas related to the altitude of the failure, failure mode, and the type of aircraft in the failure region. The two failure modes analyzed for this test case are the explosive and aerodynamic breakups of the RLV. The results shown in figures 4 and 5 (Not Included) are for the month of October. Figures 6 and 7 (Not Included) represent change in size for the aircraft hazard areas depending on the average atmospheric conditions of the month the launch occurs. The nonparticipating aircraft considered in this analysis are the Cessna 172 and Boeing 747 flying at altitudes of 2,500 ft. and 37,500 ft. respectively.

Figure 4 (Not Included) shows the Boeing 747 and Cessna 172 aircraft hazard area radius for an operating area radius of 5 n.mi. These aircraft hazard areas are from the explosive breakup failure mode of the test case RLV. For the trajectories flown to lower apogee altitudes (below 50,000 ft.), the aircraft hazard areas for the Cessna 172 and the Boeing 747 are nearly equal. For higher altitude flights of the RLV (above 50,000 ft.), the aircraft hazard area is larger for the Boeing 747. This difference is due to the size and flight altitude differences of the two aircraft2. The atmospheric density is lower at higher altitudes, leading to additional dispersion of debris from the explosion altitude. The added dispersion in debris increases the extent of the aircraft hazard area and lowers the overall density of the debris. Near the edge of the hazard area (45-60 miles out), the debris density has reduced to the point that the likelihood of the smaller Cessna being impacted by debris is lower than the likelihood of the larger 747. These results also illustrate the potential to use the "tiered aircraft hazard area" approach discussed in the procedure and methodology development section. At altitudes above 200,000 ft., where the density of the atmosphere becomes too small to effectively slow the horizontal velocity of the fragments, the hazard area radius becomes nearly constant. Figure 5 (Not Included) displays the aircraft hazard areas for an aerodynamic breakup failure mode for the test case RLV. With only the effects of the wind to disperse the debris, the extent of the hazard area is nearly three times smaller than the explosive hazard area. Unlike the aircraft hazard areas for the explosive breakup failure mode, the aircraft hazard areas for the Cessna 172 and the Boeing 747 are nearly equal at all apogee altitudes.

This arises because there is no explosive velocity, so the remaining two most significant effects defining the buffer work in opposite directions for the two aircraft. The Cessna is smaller, but it is lower, so there is more debris spread before it reaches the Cessna altitude. The next series of results provides an additional representation of how the explosive breakup case is the dominant element in aircraft hazard area analysis. Figures 6 and 7 (Not Included) illustrate the effects of local atmospheric conditions on the size of the aircraft hazard area. Figure 6 displays the explosive breakup test case results for four months, whereas figure 7 displays the results for the aerodynamic breakup test case. In the explosive breakup test case, the aircraft hazard area for the Cessna 172 is largest in October, and for the Boeing 747, the month of June. The Boeing 747 aircraft hazard areas range in size from 59 to 62 n. mi., which includes the operating area radius of 5 n. mi. The Cessna 172 aircraft hazard areas range from 39 to 45 n. mi. for the same operating area radius. The Boeing has a larger hazard area because it is larger and moving faster and most debris spread occurs above the altitude where the aircraft are flying (due to the explosion velocity).

Figure 6. Explosive Breakup Aircraft Hazard Area Radius for the Months of March, June, October, and December. Figure 4. Explosive Breakup Aircraft Hazard Area Radius Figure 5. Aerodynamic Breakup Aircraft Hazard Area.

However, the risk to the Cessna is much more significantly affected by the wind conditions. This is because the wind effects are significant below 37,500 ft., and winds are typically stronger—especially in the jet stream—in October than June.

Figure 7 (Not Included) reveals the effect of atmospheric conditions on the aircraft hazard areas for both the Boeing 747 and Cessna 172 in the case of aerodynamic breakup. The Boeing 747's range of aircraft hazard areas is 15 to 19 n.mi., and the Cessna 172's range is 12 to 20 n. mi. For the aerodynamic breakup test case, the probability of impact contours indicate a minor difference in the two aircraft's hazard areas. Since aerodynamic breakup assumes no imparted velocity on debris, atmospheric conditions are the sole contributors to spreading the debris after the breakup.

With the above results, the aircraft buffer zone radius is chosen by selecting the largest radius from the above analysis. For the RLV's maximum altitude of 350,000 ft. the aircraft buffer zone radius is 57 n. mi. and thus the aircraft hazard area radius is 62 n. mi. The maximum aircraft buffer zone radius produced by the Cessna 172 is 45 n. mi. and is therefore smaller than the radius produced by the Boeing 747. In this test case the Boeing 747 aircraft hazard area radius must be used if the RLV plans to operate with a maximum planned altitude of 350,000 ft. These distances could be reduced if the RLV's maximum altitude was below 200,000 ft. For example, from Figure 4, the size of the aircraft hazard area is approximately 40 n.mi. if the maximum altitude of the example RLV is not above 150,000 ft.

VI. Future Work

The FAA/AST procedure for determining the size of an aircraft buffer zone for each experimental permit applicant is a continually improving process. An aircraft hazard area with a radius of 62 n. mi. would create a problem in most regions of the United States' air traffic routes. In order for aircraft to avoid a potential aircraft hazard area of 124 n. mi. diameter, the route would need to be altered far in advanced of the restricted airspace.

Consequently altering aircraft flight routes adds to the overall flight time and fuel usage. Another potential problem of closing an extensive amount of airspace is the interruption of operations for smaller municipal airports that may lie underneath the restricted airspace. Decreasing the size of the aircraft buffer zone size in order to decrease the aircraft hazard area is the major concern for high altitude inland RLV launches. This paper recommends for future work the following studies in order to decrease the aircraft buffer zone radius.

1. Continue examining the vulnerability of different class and aircraft type to debris.
2. Determine a failure probability reference and confidence bounds table for RLVs or an equivalent means of assigning probability of failures to new RLVs.
3. Identify operational approaches to implementing safety in the current air traffic system to support frequent rocket launches into the NAS.
4. Create fragment catalogues for various RLVs to use for future analyses.

Examining various types and classes of aircraft will help the FAA to learn more of the vulnerability to impacts from debris. Preliminary research has shown that larger aircraft, such as the Boeing 747, can withstand an impact from debris larger than 1 gram and not suffer a catastrophic accident8. Future research will show if aircraft buffer zones can be reduced by allowing the analysis to discard smaller pieces of debris or by reducing the amount of the total area of the aircraft used in the analysis that is considered to be vulnerable to debris. The aircraft buffer zones could be reduced in size if a smaller probability of failure is applied during the analysis.

Decreasing the Pf requires constructing a justification for a more reliable vehicle. Providing a rationale that the vehicle has a smaller probability of exploding or demonstrating that fuel is depleted are two possibilities to decrease the Pf. Decreasing the Pf by 10% would effectively allow the acceptable risk criterion to be set at one in a million probability of impact (1.0E-6)2 instead of the current one in ten million criterion, since Pf is a multiplicative factor in the computation of probability of impact. This would further reduce the aircraft buffer zone radius. In particular, investigate how to bind the probability of in-flight explosions (and likewise, examine closely applicant's methods to reduce the probability of such events).

Figure 7. (Not Included) Aerodynamic Breakup Aircraft Hazard Area Radius for the Months of March, June, October, and December.

The third recommendation for future work is improving the current air traffic system's ability to address the risks from rocket operations in a more operational manner9. The current program for managing air traffic together with rocket operations is already in place, but is not operational. The future work would include improving the operational response for rerouting aircraft around aircraft hazard areas.

Lastly it is recommended to create fragment catalogues for different RLVs in order to more accurately capture the potential fragment pieces from an explosion or aerodynamic breakup. At the time of this study similar RLV fragment catalogues were not available for comparison, and it would have been beneficial to the study to compare the created test case fragment list with preexisting RLV fragment databases.

VII. Conclusion

The commercial space transportation industry is another form of transportation that must coordinate with the commercial aircraft transportation sector. The space industry's need to share the National Airspace System (NAS) with aircraft triggered the origination of the aircraft buffer zone. Protection of non-participating aircraft is the responsibility of the FAA as RLVs fly through the NAS. Likewise, the determination of the buffer zone size is also a duty of the FAA. This paper explains and demonstrates the proposed procedure for determining the aircraft buffer zone size for experimental permit applications, as well as the results from testing this procedure on a RLV. The generic RLV used as the model to test the procedure produced an aircraft buffer zone radius of approximately 62 nautical miles from an explosive event. A viable solution to reduce the aircraft buffer zone area is necessary to be able to sustain demanding launch schedules of the future.

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ADDENDUM 3: Lessons Learned in Operational Space and Air Traffic Management

American Institute of Aeronautics and Astronautics
1
Lessons Learned in Operational Space and Air Traffic Management

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Since the STS-114 mission in August of 2005, the FAA has partnered with NASA to protect aircraft flying in the National Airspace System from the potential hazards associated with a catastrophic failure of a reentering Space Shuttle orbiter, similar to that which occurred during STS-107 in February of 2003. This work has produced a set of procedures and tools for use before and during the reentry to provide FAA air traffic managers and controllers with increased situational awareness. An initial approach was implemented for STS-114 based on the need to maximize the time for the FAA to react to an orbiter failure. This approach has evolved over time through the identification of lessons learned on subsequent flights and the subsequent development of additional requirements to address them. This includes the development of the Shuttle Hazard Area to Aircraft Calculator (SHAAC), a dedicated tool for use in both reentry planning and real-time modes. This paper describes some of those key lessons and the approaches taken to address them. Emphasis is placed on those lessons that resulted from specific air traffic management needs. Many of the lessons learned to date have been captured as requirements for a next-generation FAA tool that will provide similar capabilities during the planning and operational phases of the launches and reentries of future commercial space vehicles. Future commercial space operators and air traffic managers in other organizations may find these lessons useful in the development of future tools to support their space and air traffic safety needs.

Introduction

In the spring of 2005, the Federal Aviation Administration (FAA) began investigating the use of existing air traffic tools to establish Temporary Flight Restrictions (TFRs) for protecting aircraft from the potential hazards of a NASA Space Shuttle orbiter failure during the planned reentry of the "Return to Flight" (STS-114) mission. This work was initiated from a recommendation of the Columbia Accident Investigation Board (CAIB), which highlighted the potential risks to aircraft from the hazards of falling spacecraft debris using data from a study of the Space Shuttle Columbia (STS-107) accident1. Although a number of procedures for FAA support of Shuttle operations were in existence prior to this accident, these procedures did not take into account the potential hazards to aircraft of falling Shuttle debris during a planned reentry. In the process of this investigation, several approaches to airspace management were considered. Each approach relied on the same key capabilities in its formulation: the ability to accurately model a Shuttle reentry accident, the ability to identify the potentially affected airspace, and the ability to assess the potential impacts on the air traffic in the National Airspace System (NAS). This paper describes the new tools that were developed and the existing tools that were modified to provide FAA air traffic managers with these capabilities. The method by which these tools were used to identify the ultimate approach and the airspace management plan that has been in place since the STS-114 reentry are also discussed. Further, insight gained in the preparation for STS-114 and the operational experience gained in subsequent missions has yielded a number of lessons learned that have been applied to the FAA's support of subsequent Shuttle flights. Many of these lessons learned will apply to the operations of future commercial launch and reentry vehicles that will transit the NAS on their way to and from space.

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 Background

STS-114 posed several operational challenges to protecting aircraft from the potential debris hazard, many of which will be common to any commercial space vehicle operation. First, it may be difficult to ascertain when a hazardous condition exists. An unexpected loss of telemetry data and voice communications would most likely be NASA's first and perhaps only indication that there may be a problem, as was the case with Columbia. However, during a typical Shuttle reentry, the orbiter can periodically lose contact with Mission Control for several minutes at a time due to reentry plasma interference, antenna geometry, and other less predictable phenomena like telemetry and tracking system failures.

Future commercial space vehicles returning from orbit may incur losses of communication, navigation, and surveillance (CNS) data for the same reasons as the Shuttle. Although not as susceptible to reentry plasma effects due to their lower velocities, suborbital vehicles can also suffer from antenna pointing errors and tracking system failures. While periods of data loss can be predicted to some extent based on trajectory design and link analyses, this is not always the case, and air traffic management actions taken in response to false indications of an accident can be just as risky as those taken during actual accident scenarios. Traffic reroutes of any nature can create airspace and airport capacity and demand imbalances, increasing air traffic controller workload. Further, the false declaration of an accident could cause previously restricted airspace to be released prematurely, increasing the risk of a collision between the spacecraft and aircraft.

At the same time, the difficulty in determining an accident has taken place can limit the FAA's time to respond. Based on NASA estimates, debris from a Shuttle failure on reentry could begin impacting the Earth's surface in as little as three to four minutes after the failure occurs. Depending upon the altitude of the failure, debris capable of damaging or destroying an aircraft could continue to fall for the next 90 minutes. In addition, the Shuttle is capable of landing at multiple, geographically dispersed sites, each requiring over flight of multiple FAA Air Route Traffic Control Centers (ARTCCs) and hundreds of miles of the NAS.

Preparation time could also be limited, given that weather conditions at a landing site can delay the selection of a particular landing opportunity until as late as just one hour prior to the scheduled touchdown. Most commercial vehicles returning from orbit are anticipated to pose the same types of operational challenges. In addition to its timeliness, the presentation of information to air traffic controllers and managers must take into account existing standards and expectations. In order to minimize the amount of specialized training required, the processes and tools applied to airspace management of space operations must conform as closely as possible to those applied to more traditional airspace management issues.

Efforts to obtain conformance could also help in reducing errors, as commonality can provide the air traffic managers with a sense of familiarity with the response to a situation, regardless of its cause. Most air traffic managers in today's workforce lack significant experience in space mission operations. While this presents some issues, as described below, the careful design of the operational plan to manage airspace around space operations can effectively address these issues.

Operational Plan

In order to minimize the impact on normal operations in the NAS, it is necessary to limit the amount of protected airspace required for space vehicle operations. For the reentries of the Space Shuttle, the most effective way to reduce the NAS impact is to allow the airspace below the planned trajectory to remain open for regular operations. Once a de-orbit burn occurs, the orbiter begins to reenter the Earth's atmosphere, and will touch down at its landing site, normally at the Kennedy Space Center, within one hour. During that hour, air traffic proceeds as normal along usual routes, but with the awareness that a Shuttle reentry is taking place provided by advanced notification. The advanced notification provides air traffic managers with the opportunity to identify the extent the airspace that can potentially be affected in the event of vehicle breakup. The air traffic managers will in turn examine the traffic flow during this time period in order to prepare for the potential hazard of falling debris. Since the orbiter does not reenter the NAS (i.e., descend below 60,000 ft.) until it reaches the restricted airspace above its landing site within minutes of touchdown, a collision between an aircraft and the orbiter is not a matter of concern for reentry. Rather, air traffic managers and controllers monitor the progress of the reentry and prepare to respond to a debris generating event that could occur in the high altitude airspace, sending debris down into the NAS, below 60,000 feet.

Alternatively, the potentially affected airspace from a Shuttle reentry trajectory could be preemptively closed to all air traffic. This would close significant portions of the NAS and capacity demands would be strained. As the FAA prepared for the landing of STS-114 in 2005, it conducted a series of air traffic conflict analyses to determine the potential capacity constraints that closures of the airspace below and ahead of a reentering Shuttle orbiter could create. These analyses examined the impacts to instrument flight rule (IFR) traffic over the continental United States as well as the en-route oceanic traffic over the Pacific Ocean and Gulf of Mexico using recorded air traffic loads. A conflict was recorded for each aircraft within the closed airspace at the time it was closed, as well as each aircraft that was planned or scheduled to enter the closed airspace during the closed periods. Only primary conflicts were identified; aircraft not scheduled to fly through a corridor that would be delayed or rerouted as a result of other aircraft directly affected by an airspace closure were not counted. In these analyses, the airspace closures were modeled as static TFRs. TFRs are one of several tools available for air traffic managers to use to close airspace. For the case of a Shuttle reentry, beginning at some point prior to the landing, a corridor of airspace spanning in range from the Shuttle's current position to the landing site and in altitude from the Shuttle's current altitude to the surface could be closed until the notification arrived of a successful landing or an accident. An example 25-mile wide corridor, plotted over the boundaries of the NAS air traffic control sectors, is shown in Figure 1. The minimum amount of time that the airspace would need to remain closed would depend upon the amount of time required for the Shuttle to traverse the length of this corridor and any additional time prior to the Shuttle's arrival required to clear the corridor of ambient traffic.

To examine the sensitivity to duration of a closure, the number of conflicts was counted over 35, 45, and 60-minute intervals. Analyses were conducted for several landing opportunities at each of the three potential landing sites at different times of day and different days of the week. For each scenario, a corridor of closed airspace was established along the nominal trajectory. The width of a corridor, measured as the perpendicular distance from the centerline to either edge, was kept constant for each scenario, but was varied from scenario to scenario. The results of an example analysis, corresponding to an 11:00 AM local time landing at KSC are listed in Table 1. *(Table not included in this publication)*

The results of this analysis show that significant amount of traffic would be affected. Similar analyses conducted for Edwards Air Force Base and White Sands Space Harbor showed similar results. Airspace closures, particularly those of the size and duration depicted above, are potentially complex and costly activities, requiring a level of coordination between air traffic managers and airspace customers that can take days to plan and establish. In addition to incurring delays, rerouting of flights sometimes requires particular flights to carry additional fuel, or, for flights that are already fuel-optimized, such as trans-Pacific flights, to be diverted to an alternate airport. In this regard, airspace closures can have a cascading effect across the NAS. Accordingly, the FAA determined that the airspace below a reentering Shuttle should remain open for normal air traffic operations, provided that an operational plan was in place to notify airspace users in advance and provide air traffic controllers with the necessary information to appropriately address a potential accident.

To provide the airspace-using community with the awareness that an operation is taking place, the Air Traffic Control System Command Center (ATCSCC) issues Notices to Airmen (NOTAMs). These notices are created prior to all proposed landing operations once NASA provides the FAA with trajectory data describing each opportunity, which generally occurs 48 hours in advance of the first landing opportunity. The ATCSCC uses the trajectory data to specify a series of latitude/longitude coordinates that identify the airspace under Advisory. For reentries of the Shuttle, the NOTAM is called a "Space Shuttle Landing Operations Advisory". An example is shown in Figure 2 below. (Figure not included.)

These NOTAMs notify airspace users that the specific area 25 nautical miles to either side of the nominal reentry trajectory is potentially vulnerable to debris, but the airspace is not closed. These advisories provide users the opportunity to plan according to the available information, but they do not prevent the airspace from normal operations, which would create a major impact to the NAS. When several landing opportunities may be considered, all of the applicable NOTAMs are created 48 hours prior to the first opportunity. The ATCSCC transmits the applicable NOTAM upon the completion of de-orbit burn, which is consequently cancelled in the minutes following a successful touchdown. Space vehicle debris advisory NOTAMs are currently created manually, but their creation should be automated through the system along with future developments to enable accurate space vehicle tracking, debris hazard area calculations and emergency movement protocols. Maximizing the response time if a debris event occurs will allow controllers to clear the affected airspace and implement other necessary traffic management initiatives, such as increased separation of adjacent traffic and ground stops at underlying airports. Predictions of the locations and extent of the airspace that could be hazarded provide air traffic managers and controllers with opportunities to plan and practice their response. Real time calculations, providing the best estimate of the extent of a debris event, must provide results to managers and controllers within a matter of seconds, in order to clear the affected airspace prior to collision opportunities. Additional procedures include the ability to quickly and efficiently shift support between alternative landing sites that are situated across the continent.

Coordinating with the ARTCCs across the NAS requires immediate action, including the input and display of new trajectories and predicted debris Table 1. (Table not included.)

Example Shuttle NOTAM.

FDC 9/1945 (A0856/09) - ...SPACE SHUTTLE LANDING OPERATIONS ADVISORY...
EFFECTIVE 0911271848 UTC UNTIL 0911271923 UTC SPACE SHUTTLE
LANDING OPERATIONS 25 NM EITHER SIDE OF THE LINE BETWEEN
2743S/17214W 0411N/16214W 2925N/13455W 3440N/11828W 3457N/11745W
FROM SURFACE TO UNLIMITED. WIE UNTIL UFN. CREATED: 25 NOV 21:11 2009

American Institute of Aeronautics and Astronautics hazard areas, NOTAM activation, and time zone considerations.

It is standard practice to keep traffic managers from these centers on an open teleconference line during a Shuttle reentry for contingency planning. Direct communications with NASA's Mission Control Center are advantageous for air traffic coordination, for direct notification of contingency plans, landing waive-offs, and off nominal events. As the first indication of a debris-producing event could be the loss of communications with the orbiter, air traffic controllers should also be made aware of any potential loss of signal or degraded signal periods during the reentry. Knowing these communication losses in advance will prevent air traffic from assuming a vehicle breakup has occurred, and initiating traffic management initiatives. Additionally, the real time calculations change to take these losses into account, as described in the following section, since the location of a vehicle loss cannot be pinpointed during that blackout period. The resulting airspace closure would be larger, necessitating the movement of more aircraft, and additional work for the controller, which should be identified immediately.

The launches and reentries of future commercial space vehicles will incur similar, complicating issues as those described for Shuttle reentries. These vehicles may utilize multiple, geographically separated landing sites. They may also be subject to similarly tight weather and operational constraints. Preliminary estimates of the capacity impact for these vehicles are of similar magnitude to those of the Shuttle described above. Accordingly, large scaled preemptive airspace closures for future commercial space operations are similarly undesirable. While these space vehicles may present a safety risk within the NAS, it has been demonstrated with the Shuttle that normal operations can continue in the airspace, with the proper data sharing, communication and planning to enable educated decision making.

Shuttle Hazard Area to Aircraft Calculator

The need to accurately model a Shuttle reentry accident and the ability to identify the potentially affected airspace prompted the FAA to develop a dedicated tool to support Shuttle reentries. The Shuttle Hazard Area to Aircraft Calculator (SHAAC) tool works in both a planning mode and a real time mode to predict the extent of the airspace that could contain falling debris hazardous to aircraft in the event of a Shuttle breakup during reentry. The requirements for this tool were based on a similar tool developed by NASA's Johnson Space Center Shuttle Descent Analysis Group3. The NASA tool uses a simplified Shuttle debris catalog and input wind characteristics to predict the size and location of a "footprint" that would contain the debris of the Shuttle if it were to break apart along a given trajectory at a given time. SHAAC performs the same operation as the NASA tool, but it is tailored for airspace management use. Similar to the NASA tool, SHAAC outputs an aircraft hazard area, or debris footprint, for each Shuttle state vector it receives. This hazard area depicts the extent of the airspace that could contain falling debris hazardous to aircraft if the Shuttle were to break apart at the time, position, and velocity associated with the input state vector. The hazard area computation can be conducted repeatedly in a planning mode, producing a file of hazard areas based on an input file of state vectors, or in a "real time" mode, producing a single hazard area for a single state vector. The detailed methodology for these computations is described in reference 4.

In addition to a Shuttle trajectory file, SHAAC imports forecasted wind data from the National Oceanic and Atmospheric Administration (NOAA) via a downloaded file. The use of forecasted wind data provides an accurate assessment of the additional airspace that could be affected by falling debris entrained in the prevailing winds. As there is a degree of uncertainty in the wind forecast, which increases with increasing time from the actual landing time, SHAAC applies an uncertainty factor to the length and width of the computed hazard areas. The extent of this factor also accounts for the debris to potentially generate lift as it falls. SHAAC outputs a set of four latitude/longitude coordinate pairs for each hazard area. These coordinates form a box that surrounds the airspace containing the hazardous debris. Four coordinates represent the ideal number of coordinates needed to represent this airspace on an air traffic control display, as described in the following section. The FAA uses SHAAC's planning mode to develop a preliminary set of aircraft hazard areas that are distributed to the potentially affected air traffic facilities. This preliminary set consists of a series of fifteen hazard areas for each potential landing trajectory. The air traffic managers at the ARTCCs use the planning mode results to obtain a preliminary look at the extent of the potentially affected airspace and the times at which the airspace may be affected. This information allows them to anticipate the potential air traffic load and plan their staffing of the reentry. In real time mode, SHAAC outputs a best estimate of the single hazard area that describes the affected airspace.

American Institute of Aeronautics and Astronautics

For ease of use, SHAAC was designed to minimize the number of inputs required to produce the necessary outputs. This is essential in real time mode, where a solution must be computed as quickly as possible (15 seconds or less per requirement) in order to maximize the time to respond. At the same time, the inputs were simplified in order to adapt the tool for use by air traffic managers. As discussed in more detail below, typical air traffic managers, while highly skilled in airspace management, generally lack space mission operations expertise. In an effort to minimize the amount of training required to run the tool, including any insight into the mathematics and physics which underlie the computation, the number of inputs was kept at a minimum. Specifically, the debris characteristics of the Shuttle, specified in terms of ballistic coefficient, were removed from the list of potential inputs and provided as default values for the tool. Default values were also provided for the uncertainty parameters associated with the wind and lift characteristics of the debris. Figure 3 shows the user input for the planning mode. Since its initial application, SHAAC has received two major enhancements. These enhancements incorporated the capability to characterize the uncertainty in the predicted Shuttle nominal trajectories received from NASA and the means to model the flight of the Shuttle during periods in which it loses contact with Mission Control. Both of these enhancements are described below.

The actual Shuttle flight during a nominal reentry can vary from NASA's trajectory prediction by such an amount that the computed hazard area could misrepresent the airspace at risk. Figure 4 (Not Included) below shows an example from a previous mission. In this case, the difference between the planned trajectory and the actual trajectory was large enough to offset the Shuttle's actual position (shown as a red line) outside the predicted hazard areas (shown as colored boxes).

Figure 3. SHAAC User Interface. (Not Included)

American Institute of Aeronautics and Astronautics

The causes of these discrepancies vary. In some cases, NASA may change the runway being targeted as the orbiter approaches (switching the approach to the opposite end) based on prevailing weather. In other cases, the Shuttle's onboard guidance may make fine adjustments based on the conditions it encounters during the reentry. These adjustments can cause it to make energy management maneuvers earlier or later than predicted, as was the case in the divergence shown in Figure 4. Statistics based on predicted versus actual trajectories have been collected for many of the Shuttle flights since STS-114 and used to incorporate a guidance and performance trajectory uncertainty into the size of the hazard areas computed in the SHAAC planning mode, making them slightly larger. The extent of the uncertainty is based on the difference between the time at which the planned trajectory (provided by NASA 24 to 48 hours in advance) is constructed and the time of the actual reentry. SHAAC allows the user to apply trajectory uncertainty modeling or not (the default value applies uncertainty). Accordingly, any hazard areas computed using this capability will include more area (individual hazard areas will be both longer and wider) than those computed without it.

As mentioned above, during a nominal reentry the orbiter sometimes passes through brief periods in which both voice and telemetry communications with Mission Control are lost. The timing and duration of these loss-of-signal (LOS) periods are typically known in advance. An LOS is often experienced when the orbiter is in a turn and a wing rises up to the point where it blocks the line of sight of the antenna on the top of the orbiter with the Tracking and Data Relay Satellites. Should the orbiter suffer a breakup during one of these LOS periods, the lack of reestablished communications with the orbiter at the predicted acquisition of signal (AOS) time might be NASA's only indication. In that case, a hazard area computed based on the last received state vector values (corresponding to the time at which LOS occurred) may not adequately characterize the area at risk, as the orbiter may have been capable of continuing to fly for some amount of time beyond the LOS point before suffering a breakup. Therefore, in the real time mode, SHAAC computes a larger hazard area assuming that the orbiter could have continued flying in any direction for an input LOS duration, which could be based either on the time that the LOS condition was scheduled to end or the time at which NASA receives some other indication that a breakup has occurred. SHAAC computes the larger hazard area by modeling the lift acceleration that could act on the orbiter during the LOS period in all possible directions of flight. The requirements for both of these enhancements were identified through experience gained in supporting Shuttle landings since the return to flight mission. This underscores the importance of developing space operations expertise in the air traffic managers who became the users of this tool, a point which is elaborated on further in the following section. Figure 4. (Not Included) STS-117 Traffic Situational Display of Data Discrepancy.

American Institute of Aeronautics and Astronautics

Air Traffic Controller Considerations

Space traffic control is a term that is frequently misused to describe a type of air traffic control of space vehicles. One of the main elements of contention with this term involves the physics of space vehicle performance, which limits their maneuverability and the duration of their operations in the NAS.

Alternatively, airspace management around space operations is the optimal means of integrating space vehicles into the NAS. The challenges presented by space vehicles operating in the NAS require a delicate balance of air traffic management, which takes into account the current operational procedures while reducing preemptive and reactive approaches to handling air traffic conflicts. Seamlessly integrating regular space vehicle operations into the NAS will require new approaches to data sharing that will conform to air traffic controller and airspace user needs and expectations. One of the foremost concerns for data sharing between space operations and the current air traffic management systems is the presentation of data on an air traffic controller's display. Whether data is imported through automated systems or manually, it should be reduced to a concise data set required to indicate the location and extent of the affected airspace. As discussed, this is currently accomplished by creating conservatively sized rectangular debris hazard areas. Emergency protocols might require the verbal transmission and manual input of data, and therefore fewer coordinate pairs and simple shapes are required.

In planning mode, the debris hazard areas should overlap. A slight overlap eliminates gaps in the potentially affected airspace, allowing air traffic managers to use a subset of the rectangles to initially overestimate a hazarded area in the event of an accident, until refined calculations can produce a best estimate of the area. In the interest of preventing confusion on behalf of the air traffic controller, the trajectory information shared on the air traffic display should be sufficient to accurately characterize the trajectory without cluttering the screen. To maintain an accurate depiction of the operations, overlap of the hazard areas should be optimized, especially in the turning portions of the trajectories, and areas that completely contain smaller fields should be eliminated. Figure 5 shows a typically configured Traffic Situational Display (TSD) with hazard flow evaluation areas.

In the interest of minimizing the impact on the NAS, air traffic controllers may be working sectors with regular traffic while at the same time monitoring the air traffic flow in and around potential debris fields denoted for a reentry trajectory. In the case of nominal reentry operations, an air traffic controller may prefer the ability to hide the field display on their screen, until the vehicle actually overflies the airspace of interest. Enabling these types of options on the air traffic display will support more seamless airspace management around the space operations, and enhance an air traffic controller's ability to focus on the imminent traffic

Figure 5. (Not Included)

TSD Shuttle Reentry Debris Hazard Area Screenshot.

American Institute of Aeronautics and Astronautics

needs as necessary. Sharing additional data, such as the tracking of a vehicle's position in regard to the debris hazard areas, at a real time rate will also enhance air traffic manager and controller judgment and decision making in the event of off-nominal operations requiring air traffic rerouting. Having access to real time streaming data is also necessary to enhance traffic management awareness. The TSD is currently updated manually to reflect the Shuttle's current position relative to the predicted debris hazard areas via flowing information from NASA for Shuttle operations, and latitude and longitude points are relayed on a digital display with verbal confirmation. All commercial space vehicles will need to

provide this data at a minimum, and direct vehicle communication will allow for verbal updates on the vehicle health status, weather constraints, and event notification.
Tools such as SHAAC will eventually be integrated into the Traffic Flow Management System (TFMS), allowing for minimal controller specialization with respect to space vehicle operations. While these tools are in development and vehicle launches are not commonplace, a dedicated group of traffic managers and controllers will provide expertise on these operations. Immediate obstacles that will need to be overcome include gathering devoted staff with sufficient levels of awareness and experience with the tools, who can comfortably support these missions. Dedicated controllers could work at all hours of the day, covering different shifts according to mission needs. Mission pre-planning would be similar to flight planning for typical airline operations, except earlier in the schedule. The schedule for the mission, predicted trajectories and hazard area computation would be required in advance of the launch or reentry day. Depending upon the tools that may be integrated into the TFMS, data will need to be transferred, and potentially modified for numerous uses. As mentioned previously, the majority of air traffic managers and controllers lack significant experience in space mission operations. Tools and processes are tailored accordingly to accommodate their needs, as described above. However, a general knowledge of space mission operations is also useful to provide context and perspective. Such knowledge can better facilitate the airspace management operations by providing controllers and managers with a better understanding of the rationale behind a space vehicle operator's decisions and the constraints that can frame these decisions. These constraints are important as they can affect the timing of events. For example, weather constraints, expressed in terms of wind speeds and directions, precipitation amounts, and visibility, may prompt a space vehicle operator to choose one landing opportunity over another. In addition, for piloted vehicles, crew considerations may become a factor, as increasing fatigue from living and working in space for extended durations may prompt an operator to choose a daylight landing opportunity, which is generally less taxing, over a night landing opportunity.

Operational constraints may also affect the geographical area in which the operations take place. For example, vehicles in orbit pass over a particular landing site on the Earth's surface multiple times per day, providing a number of opportunities to de-orbit and land, depending upon the vehicle's cross range capability. However, some of these opportunities take place on what are called ascending orbits and others take place on descending orbits. Ascending orbits are those in which the vehicle crosses the equator from south to north as it approaches its landing site. Descending orbits move from north to south as they approach the site. For landings at U.S. sites, ascending orbits provide the advantage of minimizing the amount of land that is overflown during the reentry, as approaches from the south overfly the Pacific Ocean or Gulf of Mexico.

The ability of air traffic managers to approach the airspace management of space operations in light of the orbital dynamics and vehicle performance constraints of an operator could facilitate greater understanding and more efficient planning.

Implications for the Future

Ultimately, the long term goal for air traffic will be to treat airspace management around space operations in the same manner as any other typical operational problem. Airspace management currently overcomes issues such as severe dynamic weather, VIP movements, military exercises, and system capacity demands. To ensure the seamless integration of space vehicles into the NAS, high data rate processing, flight planning and real time data communication will be required. Due to the speeds of these vehicles, high rate surveillance and tracking data must be accepted and processed by the system and tools, while being filtered and displayed alongside standard aircraft traffic data. Flight planning for launch and reentry vehicles will be required in advance of missions, and much earlier than traditional aviation flight plans. These plans will allow air traffic controllers to manage the mission needs and impacts to the NAS, while adapting to the off nominal events through planning and prediction tools. Tool adaptation and flexible support for numerous vehicles will permit real time debris hazard area calculations for minimizing risk and enhancing the safety of the NAS. Likewise, the capability to instantaneously transmit NOTAM and warning information through digital data systems straight into the cockpit will improve response time and increase situational awareness in the airspace5. Data sharing in the cockpit will necessitate precise implementation procedures for airspace clearance and re-routing on behalf of air traffic managers. The procedures for responding to a vehicle failure should be user-friendly and produce solutions with minimal tool-specific training, to avoid unnecessary burden on pilots, dispatchers and controllers. Ensuring safe means for airspace adaptation and responsive maneuvers will facilitate space vehicle integration into the world's safest aviation system.

Conclusion

As the current air traffic control systems merge into the FAA's Next Generation Air Transportation (NextGen) system, airspace management around space operations will be as commonplace as traditional air traffic control. As demonstrated with the support of the Space Shuttle reentries, the ability to maintain regular operations in the NAS without interruption during space vehicle events is a reality. Space operations will not be special events that require case-by-case management procedures, but rather, exercises of the truly flexible and reliable capabilities of the NextGen system. The development of dependable tools and procedures, controller training and vehicle equipage will be critical to the overall growth and success of the air traffic system. Through continued data sharing, lessons learned and industry effort, the FAA can develop the requirements necessary to build adaptable systems and respond to commercial space transportation needs.

The FAA will continue to successfully manage the NAS and provide the world's safest and most reliable aviation system for both aircraft and spacecraft users.

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ADDENDUM 4:Abstracts of Background Research Documents

Abstract: "The evolution of aviation over the past 100 years has been phenomenal, but much of the air traffic management vision took place over 50 years ago. As we enter the next century of flight, we see a vision for aeronautics that is even more spectacular than the changes we experienced during the first century: aircraft that can change shape, heal themselves, and fly (maneuver) like a bird as well as personal air vehicles allowing people to fly "door-to-door". Such remarkable advances in vehicle technology will completely change the air traffic management problem. Highways in the sky are already congested, and the significant addition of air vehicles with the envisioned operating characteristics will create a very complex airspace volume. Although there is surely enough air space to use, air traffic will require significant management to maintain safety, security, order, and efficiency that will provide enough flexibility to allow people and goods to be moved at will. We now have the opportunity to utilize technology to fix the airspace management system of today providing adequate capacity to meet demand during the early part of this century. Moreover, we have the opportunity to set the stage for the aerospace management system of the future that will keep safety, security, capacity, and efficiency paramount and allow the growth of aviation to continue unimpeded. Now is the time for the United States to set the course for the future of aeronautics and continue to maintain world leadership in aeronautics. The sky is no longer the limit." {{34 Cistone,Jim 2004}}

Abstract: "Continued dramatic growth in air traffic will press our National Airspace System (NAS) to the scalability limits of the radar-based traffic control procedures on which the current NAS was founded five decades ago. The technologies of the information revolution that are fueling robust national economic growth and vigorous air traffic growth are also the means for transforming the technical infrastructure underpinning our present air transportation system. In a transformed system, network enabled operations will embody trajectory-based traffic control procedures to greatly boost system capacity, efficiency, and security. The NAS of the future will be fundamentally more agile and more responsive to stakeholder needs. Transformation of the NAS will emerge through a growing integration among the airspace management, strategic management, traffic management, and separation management functions of the air traffic management (ATM) system. Network communications are the foundation for this; complemented with standards and an over-arching functional architecture for system-wide information management (SWIM), they will enable widespread information sharing across the NAS, including aircraft. The scalability limits of the current air transportation system are products of geographically defined long-distance point-to-point communications lines, data processing centers, and control facilities. Modern technology offers opportunities to overcome these legacy limitations and fundamentally transform air traffic operations by enabling a shift in focus from domain-specific programs and platforms to a system of systems that benefits the entire enterprise that is, a shift from viewing aircraft, sectors, and terminals as independent actors to viewing them as indigenous parts of the NAS as a whole. The ATM functions evolve into network enabled operations, and the transformed NAS is able to be dynamic and agile because it is integrated and widely coherent. Managing air traffic requires the skills of many people and the capabilities of many automated functions. The people and automation require information from disparate sources to perform their tasks, and often, in turn, they provide information for others. SWIM implements a common infrastructure and set of processes for sharing and managing data within the NAS. Once data are published on SWIM, they are available for any authorized user to discover and use. SWIM will significantly reduce the costs of developing new applications and sharing data within the NAS. Its common approach to information security should significantly reduce the cost of implementing information security and responding to emerging information security requirements. SWIM is a key enabler for many future capabilities envisioned by the FAA, including facility backup, continuity of operations, platform convergence, 4D trajectories, multiagency information sharing, and improved response to weather disruptions. Communications networks and SWIM are the infrastructure foundation for NAS-wide integration of ATM functions and, hence, for network-enabled ATM operations the core of NAS transformation. These operations comprise trajectory-based traffic management; true dynamic airspace configuration; integrated procedures across the en route, oceanic, terminal, and flow management domains; and coordinated multi-agency responses to airspace security incidents. They will transform ATC performance by doubling or tripling controller productivity and system capacity and by making the system highly robust to disruptions." {{31 Meserole,Chip 2007}}

Abstract: "As the global campaign against terrorism continues, the contributions of unmanned aircraft systems (UAS) have reached unprecedented levels. Some claim that these assets are essential to the armed forces ability to conduct modern warfare. Due to these systems capabilities, combatant commanders are requesting ever-greater numbers of unmanned vehicles. However, the employment of more UAS in the theater of operations comes at a price: there are tremendous challenges associated with unmanned aircraft (UA) sharing airspace with manned assets. There have been at least two recent collisions between unmanned and rotary-wing aircraft at lower altitudes in Iraq, as well as numerous near misses with fixed-wing aircraft at higher altitudes. Existing airspace management problems will be further compounded by introduction of additional assets into congested airspace. The effective integration of unmanned aircraft into the battle space will only occur with concurrent changes in doctrine, organization, training, and materiel. The synergy created by a blended force of manned and unmanned assets will be of great benefit to the Joint Force Commander (JFC)." {{30 Petrock,Christopher T. 2007}}

Abstract: "Recently there has been a lot of interest in the Air Traffic Management community towards modeling and analysis of the National Airspace System. The main focus of the current research initiatives is Air Traffic Flow Management with emphasis on the issue of congestion problems that are currently affecting the NAS, due to the growth in air traffic. The premise for this research is that some of the congestion problems can be addressed by better airspace management without any capacity enhancement. As a further step towards solving congestion problems in the National Airspace System, in this paper, we devise a two-level control system, which will prevent the density of aircraft from becoming too large in any control volume of the airspace, while seeking to maximize the throughput at airports in the region by controlling the flow of aircraft in and out of the control volumes and the aircraft take-off rates at airports. The outer-level control module of this two-level control system will take a large-scale view of the air traffic and generate an Eulerian model of the NAS by aggregating aircraft into interconnected control volumes. Using this Eulerian model of the airspace, control strategies like Model Predictive Control are applied to find the optimal inflow and outflow commands for each control volume so that efficient flows are achieved in the NAS. Each control volume will have its separate inner-level control module. The inner-level control module will take in the optimal inflow and outflow commands generated by the outer control module as reference inputs and it will use hybrid aircraft models to search for optimal trajectories to be flown by each aircraft so that the flows commanded by the outer control module are achieved. This is a trajectory based optimization approach, hence we call the inner module - the Lagrangian module. The two-level control system will be tested in a dynamic airspace simulation." {{32 Saraf,Aditya P. 2006}}

Abstract: "The FAA is about to enter a critical phase in its transition to satellite-based airspace management, with the debut of a system that will for the first time allow controllers to separate traffic at major airports using satellite surveillance. The nationwide deployment of Automatic Dependent Surveillance-Broadcast has already begun, but these initial sites have been limited to broadcasting information to aircraft. Now, contractor ITT Corp. is installing the first 'critical-service' ADS-B system at Louisville, Ky., which will bring GPS-derived data to controllers' displays. While ADS-B has been employed for air traffic control before, the FAA will break new ground by using it to provide standard 3-mi. aircraft separation in terminal airspace, says Vincent Capezzuto, the agency's program head." {{29 Schofield,Adrian 2009}}--

Abstract: "This paper describes past and present air-traffic-management research at NASA Ames Research Center. The descriptions emerge from the perspective of a technical manager who supervised the majority of this research for the last four years. Past research contributions built a foundation for calculating accurate flight trajectories to enable efficient airspace management in time. That foundation led to two predominant research activities that continue to this day - one in automatically separating aircraft and the other in optimizing traffic flows. Today's national airspace uses many of the applications resulting from research at Ames. These applications include the nationwide deployment of the Traffic Management Advisor, new procedures enabling continuous descent arrivals, cooperation with industry to permit more direct flights to downstream waypoints, a surface management system in use by two cargo carriers, and software to evaluate how well flights conform to national traffic management initiatives. The paper concludes with suggestions for prioritized research in the upcoming years. These priorities include: enabling more first-look operational evaluations, improving conflict detection and resolution for climbing or descending aircraft, and focusing additional attention on the underpinning safety critical items such as a reliable datalink." {{28 Schroeder,JA 2009}}

Abstract: "A capacity-enhancing, gate-to-gate air traffic management (ATM) operational concept for the U.S. National Airspace System in 2020 is presented. The concept defines five core services for ATM: airspace, flow, traffic, separation, and information management. Flow, traffic, and separation management are the services that directly influence air traffic movement, whereas airspace management determines the physical resources available to accommodate traffic demand. Information management is a new service that provides the collection, storage, and dissemination of air traffic information throughout the system. The planning and control authority of flow, traffic, and separation management is determined using a partitioning of planning time horizons to each service. A method for assessing the benefits of these and other operational concepts is also outlined." {{33 Sipe,Alvin L. 2005}}

Abstract: "Air traffic growth and air carrier economic pressures have motivated efforts to increase the flexibility of the air traffic management process and change the relationship between the air traffic control service provider and the system user. One of the most visible of these efforts is the U.S. government/industry 'free flight' initiative, in which the service provider concentrates on safety and cross-airline fairness, and the user on their business objectives and operating preferences, including selecting their own path and speed in real-time. In the terminal arrival phase of flight, severe restrictions and rigid control are currently placed on system users, typically without regard for individual user operational preferences. Airborne delays applied to arriving aircraft into capacity constrained airports are imposed on a first-come, first-serve basis, and thus do not allow the system user to plan for or prioritize late arrivals, or to economically optimize their arrival sequence. A central tenant of the free-flight operating paradigm is collaboration between service providers and users in reaching air traffic management decisions. Such collaboration would be particularly beneficial to an airline's 'hub' operation, where off-schedule arrival aircraft are a consistent problem, as they cause serious air-port ramp difficulties, rippling airline scheduling effects, and result in large economic inefficiencies. Greater collaboration can also lead to increased airport capacity and decrease the severity of over-capacity rush periods. In the NASA Collaborative Arrival Planning (CAP) project, both independent exchange of real-time data between the service provider and system user and collaborative decision support tools are addressed. Data exchange of real-time arrival scheduling, airspace management, and air carrier fleet data between the FAA service provider and an air carrier is being conducted and evaluated. Collaborative arrival decision support tools to allow intra-airline arrival preferences are being developed and simulated. The CAP project is part of and leveraged from the NASA/FAA Center TRACON Automation System (CTAS), a fielded set of decision support tools that provide computer generated advisories for both enroute and terminal area controllers to manage and control arrival traffic more efficiently. In this paper, the NASA Collaborative Arrival Planning project is outlined and recent results detailed, including the real-time use of CTAS arrival scheduling data by a major air carrier and simulations of tactical and strategic user preference decision support tools." {{35 Zelenka,Richard E. 2002}}

Abstract: "To understand the level of organization of air traffic and ensure the trade-off between ground and onboard decision systems in future airspace system, this paper firstly reviews two traffic complexity measurement models. Then, it introduces a new model based on the alliance effect. The model is used for the sector asset management problem and re-route strategies are discussed against two typical congestion scenarios. The approach is more suitable for the flexible use of the airspace concept compared with those based on aircraft counts. A new feasible pathway is presented for dynamic airspace management and multi-sector coordinated traffic flow management." {{27 Zhang,Chen 2010}}

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ADDENDUM 5: Tailored Arrivals and ADB-S

Tailored Arrivals

Abstract: "Allowing aircraft to descend uninterrupted at low engine power, continuous descent operations promise to maximize fuel efficiency while minimizing environmental impact Tailored arrivals is a concept for enabling continuous descents under constrained airspace conditions by integrating advanced air and ground automation through digital datalink. Operational trials were completed in January 2007 involving transpacific flights into San Francisco during early morning hours. Leveraging newly deployed Federal Aviation Administration automation in the oceanic environment, trajectory-based clearances were transmitted by datalink to Boeing 777 aircraft equipped with future air navigation system avionics. NASA's prototype ground-based automation for high-density arrival management tailored trajectory clearances to accommodate artificially imposed metering constraints. Upon sharing wind and descent-speed-intent data, ground-based and airborne automation were found to predict meter-fix arrival times to within a mean accuracy of 3 s over a 25 min prediction horizon. Corresponding mean altitude and along-track prediction errors of ground-based automation were -500 ft. and -1.3 n mile, respectively, in comparison with surveillance truth. A benefits analysis suggests Boeing 777 fuel savings of between 200 and 3000 lb. per flight (depending highly upon baseline traffic conditions) together with a corresponding reduction in CO(2) emissions of between 700 and 10,000 lb. per flight." {{20 Coppenbarger,Richard A. 2009}}

Abstract: "The Tailored Arrival concept for providing the most beneficial flight path available for arrivals in light of all known aircraft specific characteristics, air traffic, airspace, meteorological, obstacle clearance and environmental constraints, has moved into another phase at the San Francisco International airport. The procedure tested during the initial trials completed in January 2007 has been improved to progress towards allowing any FANS-1/A equipped oceanic flight to request a tailored arrival. This phase is aimed at incorporating ground and flight procedures capable of supporting the inter-facility and inter-sector coordination and clearance of dynamic Tailored Arrivals profiles. Full operations of the Tailored Arrival concept for arrival management are not practical until the core ground automation needed to create the conflict free dynamic routes (NASA's Enroute Descent Advisor) is completed. Current system capabilities do permit limited Tailored Arrival operations that provide tangible benefits for flight efficiency in today's environment. The benefits reported at SFO during limited Tailored Arrivals operations include, fuel efficiency, emissions reduction, and noise control. These results and discussion of overall project progress are presented." {{22 Elmer,Kevin R. 2008}}

Abstract: "Using a host of optimized operational procedures and ATC routings, Air New Zealand (ANZ) flight NZ8 – renamed ASPIRE 1 (Asia and South Pacific Initiative to Reduce Emissions) on this occasion – burned 4,600 liters less fuel than normal, a 4% savings, on a routing between Auckland and San Francisco. That translated into 12 tons less carbon dioxide emitted. ASPIRE is a joint initiative among US FAA, Airways New Zealand and Air services Australia. SFO is playing a leading role with tailored arrivals, a joint venture among Boeing, NASA, FAA and the airport. ANZ launched tailored arrivals into SFO in January and up to the end of May had saved 69,410 kg. of CO2 emissions. The flight underscored ANZ's environmental leadership role." {{21 Thomas, Geoffrey 2008}}

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Elmer, K. R., Mead, R., Bailey, L., Cornell, B., Follet, J., & Laneir, R. C. (2008). Operational implementation of tailored arrivals at SFO and expected environmental benefits. *8th AIAA Aviation Technology, Integration and Operations (ATIO) Conference,*

Thomas, G. (2008). Aspiring to one perfect flight. *Air Transport World, 45*(11), 24-24.

ADDENDUM 6: ADS-B Background Abstracts

Abstract: “The advent of Automatic Dependent Surveillance-Broadcast (***ADS-B***) has opened up a new realm of precise air-to-air surveillance in which flight crews, when properly supported by automation and procedures, will be able to accept new tasks and function at a level in keeping with far-term strategic goals in air traffic management. In pursuit of that goal, MITRE and NASA are participating in a Federal Aviation Administration (FAA)-sponsored group that is developing and testing an early airborne spacing application called Flight Deck-based Merging and Spacing (FDMS). Several human-in-the-loop and Monte Carlo simulations have validated the ability of an aircraft to ***space*** itself precisely relative to another aircraft during continuous descent arrivals (CDA). Results indicate that FDMS is viable and that expected benefits should be realized. A limited implementation of FDMS is currently certified and in use in revenue flights by UPS. This is the first fielding of an airborne spacing concept. (NASA), Hampton, VA.” {{24 Barmore,Bryan E. 2009}}

Abstract: “Current air traffic management systems suffer from poor radar coverage and a highly centralized architecture which can under heavy traffic loads overwhelm Air Traffic Control (ATC) centers. Such limitations can lead to inefficient use of the available airspace capacity and insecure scenarios such as low-visibility landings. Future air transportation systems with e-enabled aircraft and networked technologies, such as Automated Dependent Surveillance Broadcast (***ADS-B***), are cyber-physical systems that promise to help reduce traffic congestion and ATC inefficiencies by enabling exchange of precise surveillance data in shared airspace. This paper focuses on cyber security concerns with highly accurate surveillance of aircraft navigating in a future shared ***space***. A framework is proposed to protect traffic data for both ground and airborne surveillance of aircraft. The framework identifies major threats and vulnerabilities from cyber exploits, specifies security requirements and mitigation solutions. Major security challenges anticipated in supporting networked infrastructure are given along with some open problems. {{23 Sampigethaya,K. 2009}}

Abstract: “In recent years, the increasing demand on the national airspace system (NAS) has propelled further research on new technologies, communication systems, sensors and methods to handle the growing congestion around the terminal area. These include programs such as the Runway Incursion Prevention System (RIPS), Automatic Dependent Surveillance - Broadcast (***ADS-B***), the National Aeronautics and ***Space*** Administration's (NASA) Synthetic Vision Systems (SVS) and more recently, NASA's Integrated Intelligent Flight Deck (IIFD) project. One of the aspects of the IIFD is an External Hazard Monitor (EHM) function that interfaces with onboard terrain and obstacle databases, communications, and also with aircraft sensors. The EHM is envisioned to provide improved obstacle detection and hazard evaluation with added integrity and reliability. The work in this paper is performed in support of the EHM function and presents a modeling and simulation framework that models the aircraft sensors, synthesizes their measurements and analyzes their runway obstacle detection capability using both simulations and flight data playback. Various sensor parameters, measurement errors and physical properties of potential runway hazards/objects are evaluated in the simulations. Particular sensors that are considered for this work are: airborne laser scanner (ALS), 3D imaging camera, and forward-looking infrared camera (FLIR). The sensors are evaluated with regard to detection metrics such as probability of detection and time-to-alarm. Furthermore, results from the simulations using playback of actual flight test data in the vicinity of Braxton county airport (K48I), WV and Reno (RNO), NV are presented. {{25 Vadlamani,Ananth 2008}}

Abstract: "Suborbital ***space*** flight and ***space*** tourism are new potential markets that could significantly impact the National Airspace System (NAS). Numerous private companies are developing ***space*** flight capabilities to capture a piece of an emerging commercial ***space*** transportation market. These entrepreneurs share a common vision that sees commercial ***space*** flight as a profitable venture. Additionally, U.S. ***space*** exploration policy and national defense will impose significant additional demands on the NAS. Air traffic service providers must allow all users fair access to limited airspace, while ensuring that the highest levels of safety, security, and efficiency are maintained. The FAA's Next Generation Air Transportation System (NextGen) will need to accommodate spacecraft transitioning to and from ***space*** through the NAS. To accomplish this, ***space*** and air traffic operations will need to be seamlessly integrated under some common communications, navigation and surveillance (CNS) infrastructure. As part of NextGen, the FAA has been developing the Automatic Dependent Surveillance Broadcast (***ADS-B***) which utilizes the Global Positioning System (GPS) to track and separate aircraft. Another key component of NextGen, System- Wide Information Management/ Network Enabled Operations (SWIM/NEO), is an open architecture network that will provide NAS data to various customers, system tools and applications. NASA and DoD are currently developing a ***space***-based range (SBR) concept that also utilizes GPS, communications satellites and other CNS assets. The future SBR will have very similar utility for ***space*** operations as ***ADS-B*** and SWIM has for air traffic. Perhaps the FAA, NASA, and DoD should consider developing a common ***space***-based CNS infrastructure to support both aviation and ***space*** transportation operations. This paper suggests specific areas of research for developing a CNS infrastructure that can accommodate spacecraft and other new types of vehicles as an integrated part of NextGen. {{26 Vansuetendael,Richard 2008}}

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Vadlamani, A., Smearcheck, M., Bhattacharya, S., Zhu, Z., & de Haag, M. U. (2008). Runway obstacle detection using onboard sensors: Modeling and simulation analysis. *27th DASC: Digital Avionics Systems Conference Proceedings,*

Vansuetendael, R., Hayes, A., & Birr, R. (2008). A common communications, navigation & surveillance infrastructure for accommodating space vehicles in the next generation air transportation system. *AIAA Guidance, Navigation and Control Conference and Exhibit, AIAA Atmospheric Flight Mechanics Conference and Exhibit, AIAA Modeling and Simulation Technologies Conference and Exhibit, AIAA Paper 2008-6893*

NEAT, the **North European Aerospace Test** range, provides customers with a testing range for aerospace purposes, mainly for space systems (e.g. RLV re-entry tests) and UAVs. NEAT offers customers the possibility to fly their vehicles 350 km one way over a more than 25 000 square kilometer large area. Due to the low population in the area, vehicles that do not shed heavy unguided objects can be taken down in the area safely. In the summer of 2003 the Japanese space shuttle model HSFD was flown in the north part for aerodynamic tests in the transonic region. In May 2004 a German space shuttle model called Phoenix was flown in the south part of NEAT for tests of an automatic landing system. Other tests that have been discussed, but not yet carried out, are to use NEAT for re-entry tests of space vehicles and capsules, and for hypersonic flights. The huge restricted airspace that is available for aerospace tests makes NEAT an excellent resource for the aerospace community. The long-term objective for NEAT is to be a Center of Excellence in Europe for aerospace testing and training.

After almost 50 years of space flight, time has come to think about standards for navigation of space vehicles in outer space, „rules of the road". But since space navigation is not the first means of navigation, such rules exist already. Rather than re-inventing the wheel, this paper examines, in a comparative approach, air law principles for their suitability to traffic in Outer Space. While considering the absence of national airspace and the characteristics of orbital dynamics, the attempt is made to establish prototype standards for space traffic and navigation including the use of **Global Navigation Satellite Systems (GNSS)** for space vehicles.

Over the past several years there has been a steady increase in space launch operations and forecasters conservatively predict slight growth in future launch rates. New technologies, national security, and the development of new markets in the commercial space transportation industry could further accelerate this growth. Although the September 11, 2001 attacks have reduced the current level of operations, the FAA expects the long term growth in air travel to resume in the 2004 to 2013 timeframe.' These trends will require a safe and efficient integration of both air and space transportation vehicles operating in shared airspace. The Federal Aviation

Administration (FAA) and NASA are developing operational concepts that will seamlessly integrate air and space launch/reentry operations while ensuring that the highest levels of safety, security, and efficiency are maintained. The current procedure for ensuring aircraft are safely distanced from the spacecraft during a launch is to restrict all air traffic from flying in a very large region of **Special Use Airspace (SUA)** and/or **Altitude Reservations (ALTRV)** within the range? Figure 1 (Not Included) presents a debris hazard zone within a hypothetical SUA/ALTRV. During a launch, aircraft that would normally fly through this airspace simply take a longer, alternate route to their destination. This procedure accommodates today's launch rates and the air traffic around the launch site.

Title:	RLV Tests In The North Of Sweden
Authors:	Abrahamsson,Mattias; Norberg,Olle
Source:	2004, IAC Paper 04-V.2.06, European Space Agency, 810 Rue Mario Nikis, Paris, Cedex 15, F-75738, France

Title:	Rules Of The Road For Space Traffic
Authors:	Kaiser, Stefan
Source:	2003, IAC-03-IISL.4.09, International Astronautical Federation, 8-10 rue Mario-Nikis, Paris Cedex, 15, France, [mailto:iafwebcontact@iafastro.org], [URL:http://www.iafastro.com]

Title:	Evaluating a Complex Debris Dispersion Model Using Experimental Design Techniques
Authors:	VanSuetendae,Richard; Rekab,Kamel**Error! Hyperlink reference not valid.**
Source:	Journal of Aerospace Computing, 2004, 1, 2, 100-107, American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston, VA, 20191-4344, USA, [URL:http://www.aiaa.org], Information, and Communication

This presentation focuses on a cost effective **Virtual RF Test Bench Environment** utilizing a modular, scalable approach which minimizes cost and risk, of the outgrowth of architectures previously implemented in Virtual Aircraft Capability (VAC) and Joint Communication Simulator (JCS). This presentation includes a focus on a staged approach to development and implementation, the addition of waveforms added without significant impact to hardware, model air traffic communication traffic loads of realistic operational scenarios (flight plan), performance evaluation of throughput and delay of aeronautical sub networks under load, and support repeatable experimental trials.

Both the Military and Commercial segments of the aviation marketplace are looking to **Software Defined Radios** to solve the problem of rapidly changing technology and more efficient implementation of new waveforms. Airlines and avionics manufacturers are facing increased costs for new system development. This occurs because of the rapidly changing avionics waveform environment and the associated risk of development and qualification. This qualification process is time consuming and costly due to the high complexity of many of the new waveforms. Additionally, the cost of re-qualification of hardware and software for upgrades and modifications makes the fielding of new or upgraded systems less attractive. At the same time, the operational environment for communication systems is becoming increasingly complex with the rapid growth and expansion of military, civil, and commercial wireless technology. New Software based radio systems will be required to provide compatibility and inter-operability with existing waveforms, meet IEEE, EuroCAE and ARINC standards, Inter-operate with Military aircraft and meet new Software interface and architecture standards. As such SDR architectures are proposed as an agent for change in the commercial avionics arena. The driving requirements include an open architecture structure with independent software modules. This allows the architecture to become extensible. It is independent function by function with future growth added without impacting basic hardware, software or architecture. This design will also carry the ability of graceful degradation during failures through the use of redundant functionality and re-configurability. Finally, Life Cycle cost will drive the overall approach, manufacturing and deployment of the Software Defined Radio. This paper/presentation will describe how a representative SDR architecture with independent software modules and how this architecture certification may need to be approached to deploy a cost efficient design. Certification strategy is not limited to initial qualification of the system and functions but hinges on the ability of the system to accept future changes and upgrades and be re-certified without major schedule, cost or design impact to previously fielded systems.

JTRS architectural goals are quite consistent with the goals for future civil avionics developments. In particular, the goals stated in ARINC 660A, are consistent with the JTRS vision. The architectural approaches discussed for a civil avionics version of JTRS contain the key hardware and software elements required to implement an MMDA approach consistent with the goals of software programmability and upgradeability with minimal impact on the basic hardware and system. This proposed architecture has an open bus structure and uses SCA/CORBA to define software interfaces, content and performance. The JTRS architecture as applied to the civil aviation sector must be considered a functional architecture. The physical, installation and environmental requirements of the military sector would make this architecture much too expensive for direct application to the commercial world. The benefits of the new technology would not outweigh the cost, risk and scheduled implementation of the military world. Additionally, only five civil aviation applicable waveforms are being implemented in the JTRS program. JTRS may in the end, design and develop additional civil aviation-related waveforms, but in all likelihood commercial development will be required to meet a reasonable deployment schedule. MMDA will provide an unique blend of hardware and software, facilitating higher levels of performance coupled with ease of upgradeability. The upgradeability and re-certification of the system is key to its economic benefit to users. Upgrades in technology are generally thought to occur in cycles. RF technology rolls once every 7 - 15 years and digital technology is rolling in as little as 14 months. Digital technology upgrades usually include a significant increase in speed, throughput and memory. These performance improvements result in smaller hardware for avionics allowing more processing to be packaged in the available space. Although on a somewhat slower time scale, RF technology usually involves improved performance and miniaturization. Today, digital technology is creeping into areas traditionally considered RF. Signal processing capabilities of DSPs have enabled many functions that were traditionally accomplished in hardware (i.e., analog) to now be accomplished using software. Digital technology is now used in the Intermediate Frequency (IF) portions of designs to accomplish RF band pass filtering, demodulation and RF to digital conversion. Powerful processors coupled with re-programmable FPGAs have enabled designers to continually improve algorithms, processing techniques and filtering techniques. Even RF receivers are using more digital technology for front end filtering and signal capture. Future digital processing applications may include final RF with implantation of analog-to-digital conversions taking place at the antenna. RF amplifiers will, however, remain analog for the foreseeable future.

Accurate knowledge and understanding of data link traffic loads that will have an impact on the underlying communications infrastructure within the National Airspace System (NAS) is of paramount importance for planning, development and fielding of future airborne and ground-based communications systems. Attempting to better understand this impact, NASA Glenn Research Center (GRC), through its contractor Computer Networks & Software, Inc. (CNS, Inc.), has developed an emulation and test facility known as the Virtual Aircraft and Controller (VAC) to study data link interactions and the capacity of the NAS to support Controller Pilot Data Link Communications (CPDLC) traffic. The drawback of the current VAC test bed is that it does not allow the test personnel and researchers to present a real world RF environment to a complex airborne or ground system. Fortunately, the United States Air Force and Navy Avionics Test Commands, through its contractor ViaSat, Inc., have developed the Joint Communications Simulator (JCS) to provide communications band test and simulation capability for the RF spectrum through 18 GHz including Communications, Navigation, and Identification and Surveillance functions. In this paper, we are proposing the development of a new and robust test bed that will leverage on the existing NASA GRC's VAC and the Air Force and Navy Commands JCS systems capabilities and functionalities. The proposed NASA Glenn Research Center's Aeronautical Networks Research Simulator (ANRS) will combine current Air Traffic Control applications and physical RF stimulation into an integrated system capable of emulating data transmission behaviors including propagation delay, physical protocol delay, transmission failure and channel interference. The ANRS will provide a simulation/stimulation tool and test bed environment that allow the researcher to predict the performance of various aeronautical network protocol standards and their associated waveforms under varying density conditions. The system allows the user to define human-interactive and scripted aircraft and controller models of various standards, such as (but not limited to) Very High Frequency Digital Link (VDL) of various modes. (Author)

Title: Aeronautical network research simulator (ANRS)

Authors: Garcia,Manuel L.; Kocin,Michael; Musser,Gregory

Source: STAR, 2006, 44, 1, NASA, Suite 1M32, Washington, DC, 20546-0001, USA, [mailto:public-inquiries@hq.nasa.gov], [URL:http://www.nasa.gov]

Title: Qualification challenges for software defined radios

Authors: Kocin,Michael J.

Source: 2007, 45, 9, NASA, Suite 1M32, Washington, DC, 20546-0001, USA, [mailto:public-inquiries@hq.nasa.gov], [URL:http://www.nasa.gov]

Title: MMDA use of jtrs architecture

Authors: Kocin,Michael J.

Source: STAR, 2006, 44, 1, NASA, Suite 1M32, Washington, DC, 20546-0001, USA, [mailto:public-inquiries@hq.nasa.gov], [URL:http://www.nasa.gov]

Title: Proposed Development of NASA Glenn Research Center's Aeronautical Network Research Simulator

Authors: Nguyen,Thanh C.; Kerczewski,Robert J.; Wargo,Chris A.; Kocin,Michael J.; Garcia,Manuel L.

Source: 2004, NASA/CP-2004-213308