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14 CFR Parts 401, 417, and 420
Licensing and Safety Requirements for Operation of a Launch Site; Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 401, 417, and 420

[Docket No. FAA–1999–5833; Amendment No. 401–2, 417–1 and 420–1]

RIN 2120–AG15

Licensing and Safety Requirements for Operation of a Launch Site

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule; request for comments on handling of solid propellants and cooperation with the National Transportation Safety Board.

SUMMARY: The Department of Transportation's (DOT or the Department) Federal Aviation Administration (FAA) amends its commercial space transportation licensing regulations to add licensing and safety requirements for the operation of a launch site. To date, commercial launches have occurred principally at federal launch ranges under safety procedures developed by federal launch range operators. To enable the development and use of launch sites that are not operated by a federal launch range, rules are needed to establish specific licensing and safety requirements for operating a launch site, whether that site is located on or off of a federal launch range. These rules will provide licensed launch site operators with licensing and safety requirements to protect the public from the risks associated with activities at a launch site.

DATES: *Effective Date:* December 18, 2000. An application pending at the time of the effective date must conform to any new requirements of this rulemaking as of the effective date. All license terms and conditions, and all safety requirements of this rulemaking also apply as of the effective date.

Comment Date: Comments on handling of solid propellants and cooperation with the National Transportation Safety Board must be submitted on or before December 18, 2000.

ADDRESSES: Address your comments to the Docket Management System, U.S. Department of Transportation, Room Plaza 401, 400 Seventh Street, SW., Washington, DC 20590–0001. You must identify the docket number FAA–1999–5833 at the beginning of your comments, and you should submit two copies of your comments. If you wish to receive confirmation that FAA received your comments, include a self-addressed, stamped postcard.

You may also submit comments through the Internet to http://dms.dot.gov. You may review the public docket containing comments to these regulations in person in the Dockets Office between 9:00 a.m. and 5:00 p.m., Monday through Friday, except Federal holidays. The Dockets Office is on the plaza level of the NASSIF Building at the Department of Transportation at the above address. Also, you may review public dockets on the Internet at http://dms.dot.gov.

FOR FURTHER INFORMATION CONTACT: J. Randall Repcheck, Licensing and Safety Division (AST–200), Commercial Space Transportation, Federal Aviation Administration, 800 Independence Avenue, Washington, DC 20591; telephone (202) 267–8602; or Laura Montgomery, Office of the Chief Counsel (AGC–250), FAA, 800 Independence Avenue, Washington, DC 20591; telephone (202) 267–3150.

SUPPLEMENTARY INFORMATION:

Comments Invited

In the NPRM, the FAA proposed explosive siting requirements for facilities on a launch site that would handle solid and liquid propellants and other explosives. The FAA did not propose rules for solid explosives other than ''division 1.3,'' as described below.

As noted in the NPRM, the FAA is adopting the United Nations Organization (UNO) classification system for the transport of dangerous goods. The hazard classification system consists of nine classes for dangerous goods, of which explosives are included as UNO ''Class 1, Explosives.'' Class 1 explosives are further subdivided into six ''divisions'' based on the character and predominance of the associated hazards and on the potential for causing casualties or property damage. Two explosive divisions that are likely to be present on a launch site are division 1 and division 3, referred to as division 1.1 and 1.3, respectively. Division 1.1 consists of explosives that have a mass explosion hazard, and division 1.3 consists of explosives that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.

In the NPRM, the FAA proposed criteria only for division 1.3 because the FAA believed that the only solid explosives for commercial launches that would likely affect separation distances on a launch site were division 1.3 propellants. The FAA noted that although launch vehicles frequently have components incorporating division 1.1 explosives, such as those used to initiate flight termination systems, the quantity is small. The FAA also noted that division 1.1 explosives would not likely be present in sufficient quantities to affect the application of Q–D criteria. The only division 1.1 solid rocket motors existing today are from old military missiles, which are not likely to be used at a commercial launch site.

One government commenter, the 45th Space Wing Range Safety Engineering Support (45SW/SESE), pointed out that this was not a correct assumption, and the FAA agrees. As noted by the 45SW/SESE, experience with explosive siting at Cape Canaveral Air Force Station shows that division 1.1 explosives are often significant enough to influence explosive site plans.

Accordingly, section 420.65, Handling of Solid Propellants, now includes requirements for division 1.1 explosives. Because this change is being adopted without prior notice and public comment, interested persons are also invited to submit written comments on section 420.65.

The FAA also includes a new requirement in this rulemaking explicitly requiring a launch site operator licensee to cooperate with the National Transportation Safety Board in section 420.59 for launch accidents as well as for launch site accidents. The FAA will implement this change without prior notice and comment and therefore invites interested persons to submit written comments on section 420.59. Pending the evaluation of the public comments, the FAA has decided to proceed with due diligence to implement its requirements.

The FAA will consider and respond to comments on the new provisions. The FAA will consider all comments received, and will publish in the **Federal Register** a summary of the disposition of those comments and, if appropriate, changes to the rule that may result from consideration of those comments.

Comments must include the regulatory docket or amendment number and must be submitted in triplicate to the address above. The FAA will review all comments received and will file all comments in the public docket. The docket is available for public inspection before and after the comment closing date.

Commenters who want the FAA to acknowledge receipt of their comments submitted in response to this final rule must include a preaddressed, stamped postcard with those comments on which the following statement is made: ''Comments to Docket No. FAA–1999–5833.'' The postcard will be date-stamped by the FAA and mailed to the commenter.

Availability of Final Rules

You can get an electronic copy using the Internet by taking the following steps:

(1) Go to the search function of the Department of Transportation's electronic Docket Management System (DMS) Web page (http://dms.dot.gov/search).

(2) On the search page type in the last four digits of the Docket number shown at the beginning of this rulemaking document. Click on ''search.''

(3) On the next page, which contains the Docket summary information for the Docket you selected, click on the final rule.

You can also get an electronic copy using the Internet through FAA's web page at http://www.faa.gov/avr/arm/nprm/nprm.htm or the **Federal Register's** web page at http://www.access.gpo.gov/su_docs/aces/aces140.html.

You can also get a copy by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680. Make sure to identify the amendment number or docket number of this final rule.

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires the FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. Therefore, any small entity that has a question regarding this document may contact its local FAA official, or the person listed under **FOR FURTHER INFORMATION CONTACT.** You can find out more about SBREFA on the Internet at our site, http://www.gov/avr/arm/sbrefa.htm. For more information on SBREFA, e-mail us *9–AWA–SBREFA@faa.gov.*

Outline of Final Rule

I. Background

The Commercial Space Launch Act of 1984, as codified at 49 U.S.C. Subtitle IX—Commercial Space Transportation, ch. 701—Commercial Space Launch Activities, 49 U.S.C. 70101–70121 (the Act), authorizes the Secretary of Transportation to license a launch or the operation of a launch site carried out by a U.S. citizen or within the United States. 49 U.S.C. 70104, 70105. The Act directs the Secretary to exercise this responsibility consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. 49 U.S.C. 70105. On August 4, 1994, a National Space Transportation Policy reaffirmed the government's commitment to the commercial space transportation industry and the critical role of the Department of Transportation (DOT) in encouraging and facilitating private sector launch activities. A National Space Policy released on September 19, 1996, notes and reaffirms that DOT is responsible as the lead agency for regulatory guidance pertaining to commercial space transportation activities.

A. The FAA's Commercial Space Transportation Licensing Role

On November 15, 1995, the Secretary of Transportation delegated commercial space licensing authority to the Federal Aviation Administration. The FAA licenses commercial launches and the operation of launch sites pursuant to the Act and implementing regulations at 14 CFR Ch. III. The first commercial launch licensing regulations were issued in April 1988, 53 FR 11004, when no commercial launches had yet taken place. Accordingly, DOT established a flexible licensing process intended to be responsive to an emerging industry while ensuring public safety. The Department noted that it would ''continue to evaluate and, when necessary, reshape its program in response to growth, innovation, and diversity in this critically important industry.'' 53 FR 11006.

Under the 1988 regulations, DOT implemented a case-by-case approach to evaluating launch and launch site operator license applications. At the time, it was envisioned that most commercial launches would take place from federal launch ranges, which imposed extensive ground and flight safety requirements on launch operators, pending the development of commercial launch sites. The federal launch ranges provided commercial launch operators with facilities and launch support, including flight safety services.

Since 1988, DOT and now the FAA have taken steps designed to simplify further the licensing process for launch operators. The regulatory and licensing emphasis during the past decade has been on launch operators. The emergence of a commercial launch site sector has only become a reality during the past few years.

B. Growth and Current Status of Launch Site Industry

The United States government has, since the 1950s, built, operated, and maintained a space launch infrastructure for launching satellites into space. Much of the demand for and use of these launch sites has traditionally come from U.S. military and civil government agencies. Beginning in the early 1980s, a number of the government-operated launch sites began providing support for commercial launch activities as well, with the National Aeronautics and Space Administration (NASA) acting as the primary intermediary for providing launch services to satellite operators. Following the Challenger accident, a White House decision in August 1986 allowed launch customers to solicit bids directly from the launch vehicle builders who would, in turn, lease launch facilities from NASA or the United States Air Force (USAF). This decision, coupled with the 1984 U.S. Commercial Space Launch Act and its 1988 amendments, did much to foster commercial launch business, which continues to grow to this day.

The number of commercial space launches has steadily grown over the years since the first licensed commercial launch in 1989. From March 29, 1989 to July 28, 2000, 130 licensed launches have taken place. Launch vehicles have included traditional orbital launch vehicles such as the Atlas, Titan and Delta, as well as suborbital vehicles such as the Starfire. New vehicles using traditional launch techniques include Lockheed Martin Corporation's (Lockheed Martin) Atlas III and Athena, EER's Conestoga, Orbital Sciences Corporation's (Orbital) Taurus, and The Boeing Company's (Boeing) Delta III. Unique vehicles such as Orbital's Pegasus and the Zenit 3–SL of Sea Launch Limited Partnership (Sea Launch), launched from a modified oil rig located in the Pacific Ocean, are included in this count. New launch vehicles are proposed every year. On the horizon are Lockheed Martin's Atlas V and Boeing's Delta IV. A number of companies are proposing partially and fully reusable launch vehicles. In addition, some companies are participating in partnership with NASA to develop X–33 and X–34 launch vehicles incorporating reusable and single-stage-to-orbit technology, a partnership which could result in vehicles for commercial use.

The launch site industry, the focus of this final rule, has also made progress. Commercial launch site operations are coming on line with the stated goal of providing flexible and cost-effective facilities both for existing launch vehicles and for new vehicles. When the commercial launch industry began, commercial launch companies based their launch operations chiefly at federal launch ranges operated by the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA). Federal launch ranges that have supported licensed launches include the Eastern Range, located at Cape Canaveral Air Force Base in Florida (CCAFB), and the Western Range located at Vandenberg Air Force Base (VAFB), in California, both operated by the U.S. Air Force; Wallops Flight Facility in Virginia, operated by NASA; White Sands Missile Range (WSMR) in New Mexico, operated by the U.S. Army; and the Kauai Test Facility in Hawaii, operated by the U.S. Navy. Federal launch ranges provide the advantage of existing launch infrastructure and range safety services. Launch companies are able to obtain a number of services from a federal launch range, including radar, tracking and telemetry, flight termination and other launch services.

Today, most commercial launches still take place from federal launch ranges; however, this pattern may change as other launch sites become more prevalent. On September 19, 1996, the FAA granted the first license to operate a launch site to Spaceport Systems International to operate California Spaceport. That launch site is located within VAFB. Three other launch site operators have received licenses. Spaceport Florida Authority (SFA) received an FAA license to operate Launch Complex 46 at CCAS as a launch site. Virginia Commercial Space Flight Authority (VCSFA) received a license to operate Virginia Spaceflight Center (VSC) within NASA's Wallops Flight Facility. Most recently, Alaska Aerospace Development Corporation (AADC) received a license to operate Kodiak Launch Complex (KLC) as a launch site on Kodiak Island, Alaska. It is evident from this list that federal launch ranges still play a role in the licensed operation of a number of launch sites. California Spaceport, Spaceport Florida and VSC are located on federal launch range property. Two launches each have taken place from California Spaceport, KLC, and SFA.

Other commercial launch sites are being considered in other states. The New Mexico Office of Space Commercialization proposes to operate Southwest Regional Spaceport adjacent to the White Sands Missile Range as a site for reusable launch vehicles. The State of Montana is proposing to fly reusable launch vehicles from a site near Great Falls, Montana and Malmstrom Air Force Base. The state of Nevada is supporting the development of a launch site at the Nevada Test Site, Nye County, Nevada. The State of New Mexico proposes to construct and operate the Southwest Regional Spaceport (SRS) located in south central New Mexico for use by private companies conducting commercial space activities and operations. The State of Texas has enabled the development of a commercial Spaceport for reusable launch vehicles. Lastly, in Utah, the Wah Wah Valley Interlocal Cooperation Entity, proposes to construct and operate a commercial launch site utilizing approximately 70,000 acres of Utah State Trust lands located 30 miles southwest of Milford, Utah.

Whether launching from a federal launch range, a launch site located on a federal launch range, or a non-federal launch site, a launch operator is responsible for ground and flight safety under its FAA license. At a federal launch range a launch operator must comply with the rules and procedures of the federal launch range. The safety rules, procedures and practice, in concert with the safety functions of the federal launch ranges, have been assessed by the FAA, and found to satisfy the majority of the FAA's safety concerns. In contrast, when launching from a non-federal launch site, a launch operator's responsibility for ground and flight safety takes on added importance. In the absence of federal launch range oversight, it will be incumbent upon each launch operator to demonstrate the adequacy of its ground and flight safety to the FAA.

C. Current Practices

Because of the time and investment involved in bringing a commercial launch facility into being, several entities that have been planning to establish these facilities asked the DOT for guidance concerning the information that might be requested as part of an application for a license to operate a launch site. In response to these requests, DOT's then Office of Commercial Space Transportation (Office) published ''Site Operators License, Guidelines for Applicants,'' on August 8, 1995, as guidance for potential launch site operators. The guidelines described the information that DOT, and then the FAA, expected from an applicant for a license to operate a commercial launch site. This information included launch site location information, a hazard analysis, and a launch site safety operations document that governed how the facility would be operated to ensure public safety and the safety of property. The Office intended that the guidelines would assist an applicant with the parts of the application that are critical to assessing the suitability of the launch site location, the applicant's organization, and the facility for providing safe operations.

The Office issued the guidelines as an interim measure for potential developers of launch sites pending this rulemaking, and the guidelines describe the information that the FAA requests of an applicant as part of its application for a license to operate a launch site. The pace of development of the launch site industry has resulted in the FAA describing the process and requirements for applications for launch site operator licenses under the guidelines. As noted above, the FAA issued its first license to operate a launch site to Spaceport Systems International for the operation of California Spaceport. The FAA issued this license under its general authority under 49 U.S.C. 70104 and 70105 and 14 CFR Ch. III to license the operation of a launch site. Because the operation of California Spaceport as a launch site occurs at a federal launch range, the U.S. Air Force plays a significant role in California Spaceport's safety process. In fact, the FAA was able to review the Spaceport Systems International application expeditiously because the applicant certified its intention to observe the safety requirements currently applied by the Western Range and contained in ''Eastern and Western Range 127–1, Range Safety Requirements (EWR 127–1),'' (Mar. 1995).[1] The FAA determined that applicant compliance with EWR 127–1, together with Air Force approval of other important elements of the operation of a launch site protected public health and safety and the safety of property. In general, the FAA deems the compliance by a licensed launch site

[1] EWR 127–1 is updated on an ongoing basis. The latest version of these requirements may be found at http://www.pafb.af.mil/450SW/.

operator with these requirements in combination with other safety practices imposed by a federal launch range as acceptable for purposes of protecting the public and property from hazards associated with launch site activities at a licensed launch site operator's facilities. In 1997, the FAA entered into a Memorandum of Agreement with Department of Defense and National Aeronautics and Space Administration regarding safety oversight of licensed launch site operators located on federal launch ranges.

On June 25, 1999, the FAA released a notice of proposed rulemaking, *Licensing and Safety Requirements for Operation of a Launch Site,* 64 FR 34316 (Jun. 25, 1999). This will be referred to throughout this document as the Launch Site NPRM.

Comparison of the Guidelines and the Final Rule

The existing guidelines will no longer be in effect as of the effective date of this final rule. A comparison of some of the similarities and differences may therefore prove of assistance. The one aspect of the licensing process that will not change is that the FAA will issue a license to operate a launch site only if the operation of the launch site will not jeopardize the public health and safety, the safety of property, or national security or foreign policy interests of the United States. The guidelines were flexible and were intended to identify the major elements of an application and lead the applicant through the application process with the FAA. The final rule codifies the requirements that must be met before a license will be issued.

The guidelines and the final rule share some common elements, namely, the need for the applicant to supply information to support the FAA's environmental determination under the National Environmental Policy Act (NEPA) and the FAA's policy review that addresses national security and foreign policy issues. These requirements are discussed in detail below, in the description of the final regulations. Under the final regulations, the information requirements for these reviews remain for the most part unchanged from the guidelines.

A review of the suitability of the proposed location of the launch site is an important component of both the guidelines and the final regulations. Although both approaches call for a site location review, the reviews differ in breadth and specificity. The guidelines request an applicant to provide information regarding geographic characteristics, flight paths and impact areas and the meteorological environment. To describe a launch site's geographic characteristics, an applicant is requested to provide information regarding the launch site location, size, and shape, its topographic and geological characteristics, its proximity to populated areas, and any local commercial and recreational activities that may be affected by launches such as air traffic, shipping, hunting, and offshore fishing. An applicant also provides planned possible flight paths and general impact areas designated for launch. If planned flight corridors overfly land, the guidelines request that an applicant provide flight safety analyses for generic sets of launch vehicles and describe, where applicable, any arrangements made to clear the land of people prior to launch vehicle flight. With respect to the meteorological environment, the guidelines request an applicant to provide data regarding temperature, surface and upper wind direction and velocity, temperature inversions, and extreme conditions that may affect the safety of launch site operations. Under the guidelines, an application includes the frequency (average number of days for each month) of extremes in wind or temperature inversion that could have an impact on launch.

In contrast to the guidelines, the final rules require an applicant to use specified methods to demonstrate the suitability of the launch site location for launching at least one type of launch vehicle, including orbital, guided sub-orbital, or unguided sub-orbital expendable launch vehicles, and reusable launch vehicles. Each proposed launch point on the launch site must be evaluated for each type of launch vehicle that the applicant wishes to have launched from the launch point. An applicant is provided with a choice of methods to develop a flight corridor for a representative launch of an orbital or guided sub-orbital expendable launch vehicle, or to develop a set of impact dispersion areas for a representative launch of an unguided sub-orbital expendable launch vehicle. If a flight corridor or set of impact dispersion areas exists that does not encompass populated areas, no additional analysis is required. Otherwise, an applicant is required to conduct a risk analysis to demonstrate that the risk to the public from a representative launch does not exceed a casualty expectation (E_c) of 30×10^{-6}. The FAA will review the applicant's analyses to ensure the applicant's process was correct, and will approve the launch site location if the E_c risk criteria were met.

Under either the guidelines or the final regulations, little or no launch site location review is needed if the applicant proposes to locate a launch site at a federal launch range. The fundamental purpose of the FAA's proposed launch site location review—to determine whether a launch may potentially take place safely from the proposed launch site— has been amply demonstrated at each of the ranges. Exceptions may occur if a prospective launch site operator plans to use a launch site at a federal launch range for launches markedly different from past federal launch range launches, or if an applicant proposes a new launch point from which no launch has taken place.

The guidelines and final regulations differ markedly in their approach to ground and flight safety. For ground safety under the guidelines, applicants perform a hazard analysis and develop a comprehensive ground safety plan and a safety organization. Explosive safety is part of the analysis and safety plan. In contrast, the final regulations require the submission of an explosive site plan, but impose fewer operational ground safety responsibilities on a launch site operator. For flight safety, under the guidelines and final rules, a launch site operator license contains minimal flight safety responsibilities. The FAA assigns almost all responsibility for flight safety and significant ground safety responsibility to a licensed launch operator. Extensive ground and flight safety requirements will accompany a launch license. This does not mean a launch site operator cannot offer flight safety services or equipment to its customers. However, the adequacy of such services and equipment typically will be assessed in the FAA's review of a launch license application.

II. Summary of the Regulations and Discussion of Comments

With this rulemaking, the FAA creates in 14 CFR Chapter III a new part 420 to contain the requirements for obtaining and possessing a license to operate a launch site. If a prospective launch site operator proposes to offer its launch site to others, that person must obtain a license to operate a launch site.

Part 420 does not apply in two notable situations. A launch operator operating a private site for its own launches does not need a license to operate a launch site because its launch license would cover the safety issues associated with the launch site. A person wishing to operate a site to support amateur rocket activities, as defined in 14 CFR 401.5, also does not need a license to operate a launch site because the launches taking place from the site are exempt from AST's regulations.

By means of operational, explosive safety, and site location requirements, the FAA's regulations will address public safety issues associated with launches that take place from a launch site whose operation the FAA has licensed. Additionally, the FAA will address environmental issues, and will have international obligations and national security interests reviewed by the appropriate agencies, in the course of a license review. Environmental review may precede or take place concurrently with the licensing process.

The grant of a license to operate a launch site does not guarantee that a launch license will be granted for any particular launch proposed for the site. All launches will be subject to separate FAA review and licensing.

AST received comments from 11 members of the public and one government organization. The one government commenter was the 45th Space Wing Range Safety Engineering Support (45SW/SESE). The public commenters were:

—ACTA, Inc. [2]
—New Mexico Office for Space Commercialization
—Kistler Aerospace Corporation
—Lockheed Martin Corporation
—National Fire Protection Association
—Don A. Nelson
—Nelson Engineering Co.
—Oklahoma Aeronautics and Space Commission
—Christopher Shove, Ph.D.
—Space Access, LLC
—Texas Aerospace Commission

A. Overview

The FAA's approach to licensing the operation of a launch site focuses on five areas of concern critical to ensuring that operation of a launch site will not jeopardize public health and safety, the safety of property, U.S. national security or foreign policy interests or international obligations of U.S. interests. These reviews encompass the environment, policy considerations, the siting of explosives and other explosive safety measures, the safety of a launch site location, and operational responsibilities.

Part 420 is divided into four subparts. Subpart A includes the scope and applicability of the part, and definitions applicable to the part. Subpart B includes the criteria and information requirements for obtaining a license. Subpart C lists the terms and conditions of a license to operate a launch site. Subpart D lists the other responsibilities of a licensee.

Part 420 separates the requirements to obtain a license from the responsibilities of a licensee. Much of the information required by subpart B pertains to how the applicant will meet its responsibilities in accordance with subpart D.

Under the regulations, an applicant is required to provide the FAA with information sufficient to conduct environmental and policy reviews and determinations. An applicant is also required to submit an explosive site plan that shows the location of all explosive hazard facilities and distances between them, and the distances to public areas.

The regulations provide an applicant options for proving to the FAA that a launch could be conducted from the site without jeopardizing public health and safety. The requirement for a launch site location approval would not normally apply to an applicant who proposes to operate an existing launch point at a federal launch range, unless the applicant plans to use a launch point different than used previously by the federal launch range, or to use an existing launch point for a different type or larger launch vehicle than used in the past. The fact that launches have taken place safely from any particular launch point at a federal launch range may provide the same demonstration that is accomplished by the FAA's launch site location review: namely, a showing that launch may occur safely from the site.

The FAA is imposing specific operational ground safety responsibilities on a licensed launch site operator, and requires that a license applicant demonstrate how those requirements will be met. A launch site operator licensee's responsibilities include: preventing unauthorized public access to the site; properly preparing the public and customers to visit the site; informing customers of limitations on use of the site; scheduling and coordinating hazardous activities conducted by customers; maintaining agreements with the U.S. Coast Guard and with the FAA regional office having jurisdiction over the airspace through which launches will take place and among other measures, the issuance of a Notice to Mariners and Notice to Airmen, respectively, prior to a launch from the launch site; and notifying adjacent property owners and local jurisdictions of the pending flight of a launch vehicle. Part 420 also contains launch site operator responsibilities with regard to record keeping, license transfer, compliance monitoring, accident investigation and explosives. Other federal government agencies have jurisdiction over a number of ground safety issues, and the FAA does not intend to duplicate their efforts.[3]

Discussion of Comments Regarding Overview

A few commentors provided comments that focussed on the FAA's regulatory approach.

Space Access believed that instead of focussing on the launch site location, the rule should put primary interest on the activity occurring on a site, including preparation for a launch, launch, and any activity or process conducted on or near the site that might endanger the public health and safety. *Space Access* at 1. The FAA agrees, but believes that a launch site location analysis is necessary in order to determine whether a launch could safely take place from the location selected. As noted in the NPRM, the FAA does not plan to license the operation of a launch site from which even a hypothetical launch could not take place and has devised the location review to avoid such an eventuality. The other requirements in part 420, in conjunction with the ground and flight safety requirements of a launch license, should address the activity occurring on a site.

Space Access also notes that the rule must achieve minimum safety standards but not require excessive agency

[2] ACTA, Inc. divided its comments into those from ACTA itself and those from ACTA staff.

[3] The U.S. Occupational Safety and Health Administration (OSHA) and the U.S. Environmental Protection Agency (EPA) play a role in regulating ground activities at a launch site. OSHA regulations cover worker safety issues, and may, as a by-product, help protect public safety as well. One provision of particular note is 29 CFR 1910.119, process safety management of highly hazardous chemicals (PSM). The requirements of the PSM standard are intended to eliminate or mitigate the consequences of releases of highly hazardous chemicals that may be toxic, reactive, flammable, or explosive. Management controls are emphasized to address the risks associated with handling or working near hazardous chemicals. These requirements may apply to some launch site and launch operators. EPA regulations are designed to protect the public health and safety from releases of chemicals. One regulation of note is 40 CFR part 68, Accidental release prevention provisions. It applies to an owner or operator of a stationary source that has more than a threshold quantity of a regulated substance in a process, and requires the owner or operator to develop and implement a risk management program to prevent accidents and limit the severity of any accidents that occur. The EPA rule further requires sources to conduct an offsite consequence analysis to define the potential impacts of worst-case releases and other release scenarios. For any process whose worst-case release would reach the public, the source must develop and implement a prevention program and an emergency response program. Both the EPA and OSHA prevention rules require regulated entities to conduct formal analyses of the risks involved in the use and storage of covered substances and consider all possible ways in which existing systems could fail and result in accidental releases.

oversight or business duplication of effort. *Space Access* at 2. The desire to avoid duplication of effort was also expressed by Kistler Aerospace Corporation and Christopher Shove, Ph.D., a Senior Consultant for Space Data Systems, Inc. Although Kistler commends the FAA for striving to keep the regulatory environment free from redundant requirements levied by multiple agencies, *Kistler Aerospace Corporation* at 2; *Christopher Shove* at 1. Kistler also states that this goal should be expanded to include launch site operators operating out of localities that already address similar concerns through local rules or ordinances.

The FAA agrees that it should not impose requirements that duplicate other federal regulations. That is why there are relatively few operational responsibilities of a launch site licensee in part 420. For example, OSHA and the EPA have many regulations that apply to launch site operators, which the FAA does not duplicate. If an applicant is required to fulfill other safety requirements because of state or local regulations, or rules of property owners, the FAA will work with the applicant to avoid duplication of paper work. However, applicants must meet FAA and other federal standards.

The New Mexico Office for Space Commercialization (NMOSC) thought that the proposed regulations should not relate only to launch operations. NMOSC suggested that the proposed regulations be expanded to include recovery operations. *New Mexico Office for Space Commercialization* at 1. The FAA agrees that recovery operations are important. However, recovery operations are covered in another rulemaking. *Commercial Space Transportation Reusable Launch Vehicle and Reentry Licensing,* 65 FR 56617 (Sept. 19, 2000).

Because the FAA stated in the NPRM that when launching from a non-federal launch site, a launch operator's responsibility for ground and flight safety takes on added importance, NMOSC suggested that the FAA is willing to accept a double standard on safety. NMOSC believes that New Mexico will be treated differently from Florida and California because their launch sites are federal, and New Mexico's is not. *NMOSC* at 2. This is not true. The FAA did not mean to imply that a launch operator has more responsibility for flight safety from a commercial launch site than from a federal launch site. In both cases, the launch operator is responsible for the safety of its flight. The FAA was only pointing out that a launch operator at a non-federal launch site will not be able to depend on an established flight safety infrastructure that currently exists at federal launch ranges.

Lockheed Martin Corporation (LMC) recommended, in the interest of standardization and interoperability, that a launch site operator be required to establish and maintain at its facility a range safety/tracking system that functions at an industry-wide standard and demonstrate that it meets the standard. *LMC* at 4. A launch operator should be required to demonstrate to the FAA that its launch vehicle interfaces with this standardized range safety/tracking system. The FAA agrees on the importance of range safety and tracking for most launch operations. Because launch safety is the responsibility of the launch operator, because interoperability and standardization are business issues about which a launch site operator may wish to make its own decisions, the FAA notes with interest but declines to pursue this suggestion. Although the federal launch ranges offer a standardized form of range safety and tracking, the FAA is reluctant to enshrine particular standards through regulation, especially when the ranges themselves are re-visiting how to provide tracking, transmission and other launch safety services. Nothing precludes a launch site operator from providing such services as well; a launch operator will continue, of course, to remain responsible under its launch license for the safety of the flight of its vehicle, regardless of with whom it contracts for supporting services.

B. Environmental

Licensing the operation of a launch site is a major federal action for purposes of the National Environmental Policy Act, 42 U.S.C. 4321 et seq. As a result, the FAA is required to assess the environmental impacts of constructing and operating a proposed launch site to determine whether these activities will significantly affect the quality of the environment. Because the FAA is responsible under NEPA regulations for preparing an environmental assessment or environmental impact statement (EIS), part 420 requires a license applicant to provide the FAA with sufficient information to conduct an analysis in accordance with the requirements of the Council on Environmental Quality (CEQ) Regulations Implementing the Procedural Provisions of NEPA, 40 CFR parts 1500–1508, and the FAA's Procedures for Considering Environmental Impacts, FAA Order 1050.1D. An applicant will typically engage a contractor with specialized experience in the NEPA process to conduct the study underpinning the FAA's environmental analysis.

The FAA encourages an applicant to begin the environmental review, including the gathering of pertinent information to perform the assessment, early in the planning process, but after the applicant has defined its proposed action and considered feasible alternatives. The FAA will determine whether a finding of no significant impact (FONSI) may be issued after an environmental assessment, or whether an environmental impact statement followed by a record of decision is necessary. An applicant may be subject to restrictions on activities at a proposed launch site. An applicant may acquire property for future use as a launch site; however, absent a FONSI, the FAA must prepare an environmental review that includes consideration of reasonable alternatives to the site. According to the CEQ regulations as interpreted by the courts, an applicant may not use the purchase of a site or construction at the site to limit the array of reasonable alternatives. As a result, an applicant must complete the environmental process before construction or improvement of the site. The FAA will not issue a license if the FAA has not concluded an environmental review in accordance with all applicable regulations and guidelines.

Discussion of Comments Regarding the Environmental Review

Nelson Engineering Co. stated that the X–33 EIS process included overflight and safety issues. Nelson Engineering felt that including overflight and safety issues for licensed activities was a duplication of effort since these safety issues are covered in the license process as well. It noted that the public has the right to know and comment on overflight and safety issues, but it would be best to handle it separate from the EIS process. *Nelson Engineering* at 2. The FAA agrees. Safety issues are better addressed in the licensing process where safety standards exist. When the question of safety comes up during the FAA's environmental review process, the FAA notes in the environmental documentation that safety issues are addressed in the licensing process.

NMOSC commented on the FAA's statement that an applicant may acquire property for future use as a launch site. NMOSC states that according to the CEQ regulations as interpreted by the courts, an applicant may not use the purchase of a site or construction at the site to limit the array of reasonable alternatives. *NMOSC* at 2. The FAA partially agrees with NMOSC in that purchasing a site with the intent to build a launch facility, without looking at other possible locations, limits the launch site selection and evaluation of alternatives and is contrary to the requirements of the National Environmental Protection Act (NEPA). NEPA requires an applicant to show that it looked at several feasible sites based on certain criteria and that it chose one of those sites as the preferred or selected alternative. However, an applicant can in fact purchase property for future use as a launch site if the applicant can show that it looked at several sites and picked a particular site based on certain parameters. It must also document the evaluation of those alternative sites.

C. Policy

The FAA conducts a policy review of an application for a license to operate a launch site to determine whether operation of the proposed launch site would jeopardize national security, foreign policy interests, or international obligations of the United States. The FAA conducts the policy review in coordination with other federal agencies that have responsibility for national and international interests. The Department of Defense is consulted to determine whether a license application presents any issues affecting national security. The Department of State reviews an application for issues affecting foreign policy or international obligations. Other agencies, such as NASA, are consulted as appropriate. By this rulemaking, the regulations require an applicant to supply information relevant to the FAA's policy approval, including, for example, identification of foreign ownership of the applicant. The FAA will obtain other information required for a policy review from information submitted by an applicant in other parts of the application. During a policy review, the FAA will consult with an applicant regarding any questions or issues before making a final determination. An applicant would have the opportunity to address any questions before completion of the review.

No comments regarding policy review were received and no changes have been made to part 420 from the Launch Site NPRM.

D. Explosive Site Plan Review

The final rules establish criteria and procedures for the siting of facilities at a launch site where solid propellants, liquid propellants, and other explosives are located to prepare launch vehicles and payloads for flight. These criteria and procedures are commonly referred to as quantity-distance (Q–D) requirements because they provide minimum separation distances between explosive hazard facilities, surrounding facilities and locations where the public may be present on the basis of the type and quantity of explosive material located within the area. Minimum prescribed separation distances are necessary to protect the public from explosive hazards on a launch site so that the effects of an explosion do not reach the public.

An applicant must provide the FAA with an explosive site plan that demonstrates compliance with the Q–D requirements. Because the FAA must approve this plan, applicants are cautioned not to begin construction of facilities requiring an explosive site plan until obtaining FAA approval. Note also that the Q–D requirements do not address any toxic hazards. Toxic hazards may be mitigated through procedural means, and the FAA addresses toxic hazards in a separate rulemaking on licensing and safety requirements for launch. If a toxic hazard is a controlling factor in siting, a prudent launch site operator will address the issue when preparing its site plan.

The quantity-distance criteria are a critical mitigation measure required in a launch site operator application to provide the public protection from ground operations at a launch site. The final rules have other mitigation measures, including launch site operator responsibilities that address accident prevention measures, and procedural requirements to protect other launch site customers and visitors on the launch site. Any other procedural requirements necessary to protect the public from explosive hazards will be the responsibility of a launch operator under a launch license.[4]

The FAA has made certain changes in response to comments to part 420, from what was proposed in the Launch Site NPRM regarding the explosive site plan requirements. A brief summary of these changes is discussed below and is discussed in further detail in the Part analysis.

- The NPRM did not require an applicant proposing to locate a launch site at a federal launch range to submit an explosive site plan. In the final rule, the applicant must submit an explosive site plan to the federal launch range operator.

[4] A launch license encompasses ground activities involved in the preparation of a launch vehicle for flight at a launch site in the United States. This may include the storage and handling of explosives involved with the handling and assembly of launch vehicles at a launch site.

- Q–D requirements for hazard class 1.1 were added, including a provision for public traffic route distance.
- The assumption that solid and liquid stages on a launch vehicle would not explode simultaneously has been removed from the Q–D requirements for locating solid and liquid propellants together.
- The explosive site plan requirements were moved from subpart B, Application Requirements, to subpart D, Licensee Responsibility. Although an applicant must complete an explosive site plan to obtain a license, this section was moved because the explosive site plan is a document with which a licensee must comply and keep up to date at all times.
- A provision was added to clarify that explosive siting issues outside the scope of the part 420 requirements will be evaluated by the FAA on an individual basis consistent with industry safety standards.

A discussion of launch site explosive hazards, the reason the FAA is adopting explosive siting criteria, current Q–D standards, the FAA's use of NASA and DOD Q–D standards, other approaches to explosive safety, and the application of ATF, DOD or NASA standards are covered in the Launch Site NPRM. 64 FR at 34320—34322. Solid explosive divisions, future changes in liquid propellant requirements, and solid and liquid bi-propellants at launch pads are discussed below.

Solid Explosive Divisions

The Launch Site NPRM proposed requirements for division 1.3 solid explosives. As noted in the Launch Site NPRM, the FAA is adopting the United Nations Organization (UNO) classification system, a system that governs transport of dangerous goods. The Department of Transportation's Research and Special Programs Administration assigns dangerous goods to the appropriate class in accordance with 49 CFR part 173. The hazard classification system consists of nine classes for dangerous goods, of which ammunition and explosives are included as the UNO ''Class 1, Explosives.'' Class 1 explosives are further subdivided into ''divisions'' based on the character and predominance of the associated hazards and on the potential for causing casualties or property damage. As defined in 49 CFR 173.50:

- *Division 1.1*—consists of explosives that have a mass explosion hazard. A mass explosion is one which affects almost the entire load instantaneously.

• *Division 1.2*—consists of explosives that have a projection hazard but not a mass explosion hazard.
• *Division 1.3*—consists of explosives that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.
• *Division 1.4*—consists of explosives that present a minor explosion hazard.
• *Division 1.5*—consists of very insensitive explosives.
• *Division 1.6*—consists of extremely insensitive articles which do not have a mass explosion hazard.

The FAA originally proposed criteria only for division 1.3 because it believed that the only solid explosives for commercial launches that would likely affect separation distances on a launch site were division 1.3 propellants. The FAA noted that although launch vehicles frequently have components incorporating division 1.1 explosives, such as those used to initiate flight termination systems, the quantity is small. The FAA also noted that division 1.1 explosives will not likely be present in sufficient quantities to affect the application of Q–D criteria. The only division 1.1 solid rocket motors existing today are from old military missiles, which are not likely to be used at a commercial launch site.

In response to comments from the 45th Space Wing pointing out the errors underlying this assumption, part 420 now includes quantity-distance requirements for explosive division 1.1 explosives. Compared with explosive division 1.3 explosives, the distances are greater due to their more hazardous nature.

Future Change in Liquid Propellant Requirements

The DOD Explosive Safety Board (DDESB) initiated a DOD Explosive Safety Standard for Energetic Liquids Program, and established an interagency advisory board called the Liquid Propellants Working Group (LPWG). The FAA is a member of this group. A number of possible inconsistencies and irregularities have been identified in the current approach to siting liquid propellants. These include Q–D criteria for most liquid propellants, possible inconsistencies in hazard group and compatibility group definitions, and possible inaccurate characterization of blast overpressure hazards of liquid propellant explosions. The purpose of the LPWG is to address issues of explosive equivalence, compatibility mixing, and quantity-distance criteria, and to develop recommended revisions to DOD STD 6055.9, which addresses liquid propellants and other liquid energetic materials.

The DDESB work is almost completed, and the recommendations of the LPWG should be incorporated in the DOD standard in the near future. Because the DDESB is possibly the best-equipped group in the country to address these issues, the FAA will carefully consider its recommendations. The basic approach outlined in the final rule should not change. However, the DDESB is likely to specify new hazard and compatibility groups, distance values, and equivalency values, and the public may anticipate their eventual consideration and possible adoption by the FAA.

Solid and Liquid Bi-Propellants at Launch Pads

In the Launch Site NPRM, the FAA proposed a special requirement at launch pads for launch vehicles that use liquid bi-propellant and solid propellant components. The required separation distance would be the greater of the distance determined by the explosive equivalent of the liquid propellant alone or the solid propellant alone. An applicant would not have to add the separation distances of both. This proposal rested on the conclusion that, generally, no credible scenario existed that could produce a simultaneous explosion reaction of both liquid propellant tanks and solid propellant motors. This requirement has changed because the assumption may not always be correct.

Under the final rule, an applicant must conduct an analysis of the maximum credible event (MCE), or the worst case explosion that is expected to occur. If analysis shows that an explosion caused by the liquid propellants will not cause a simultaneous explosion of the solid propellants, and an explosion due to the solid propellants will not cause a simultaneous explosion of the liquid propellants, the distance between the explosive hazard facility and all other explosive hazard facilities and public areas should be based on the MCE.

Discussion of Comments

The 45th Space Wing Range, Safety Engineering Support division (45SW/SESE), provided a number of comments on the FAA's proposed explosive safety requirements. First, the 45SW/SESE suggests including alternative approaches to Q–D standards such as risk-based thresholds and limits. *45th Space Wing Range, Safety Engineering Support division* at 1. The FAA agrees that alternative approaches to Q–D may be appropriate. However, the FAA will not formally adopt such an approach at this time for the following reasons.

On December 9, 1999, the DDESB approved, for limited use at DOD facilities, the use of risk-based explosives safety siting of explosives facilities for calendar years 2000 through 2002. Specifically, on a case-by-case basis, a risk-based explosives safety analysis that supports an explosives facility siting may be submitted to the DDESB Secretariat for review and approval.[5] A risk based analysis is used when a waiver or exemption would be required to approve a facility. The FAA will monitor the experience of the DDESB during those three years, and may take regulatory action at that time.

In the meantime, an applicant unable to meet the Q–D requirements might attempt a risk-based approach if able to provide a clear and convincing demonstration that the proposed method provides an equivalent level of safety to that required by Q–D. Such a demonstration would have to include an explosives safety analysis that analyzes hazards associated with handling explosive materials on the launch site. The applicant should examine the relationship between an explosive hazard facility and an exposed facility to determine what effect one has on the other in the event of an accidental explosion. As discussed in the NPRM, net explosives weight is used to calculate Q–D separations by means of the formula: $D=KW^{1/3}$, where D is the required distance (in feet), K is the protection factor depending on the degree of risk assumed or permitted, and $W^{1/3}$ is the cube root of the net explosives weight (NEW) in pounds. This formula is also used for assessing risk. Dividing the distance by the cube root of the NEW will give the actual K factor of protection. A K factor equates to an overpressure, as shown in table 1. Knowing the expected overpressure can help in understanding the facility or equipment damage and the personnel injuries expected to be sustained by a particular blast overpressure. Hazardous fragments must also be considered when preparing a risk assessment.

For more information on blast pressure, blast effects, and fragment hazards, see Air Force Manual

[5] Memorandum from USAF Colonel Daniel T. Tompkins to the Army, Navy, Air Force, and Marine Corps board members (Dec. 9, 1999).

(AFMAN) 91–201, Explosives Safety Standards, sections 4.48 and 4.49 (Mar. 7, 2000).

TABLE 1.—K-FACTOR TO PSI RELATIONSHIP [6]

K-factor	PSI	K-factor	PSI
1.0	1000	20	3.0
1.2	763	21	2.8
1.4	597	22	2.6
1.6	475	23	2.4
1.8	384	24	2.3
2.0	315	25	2.2
2.5	200	26	2.1
3.0	135	27	2.0
3.5	95	28	1.9
4.0	70	29	1.8
4.5	53	30	1.7
5.0	42	31	1.63
6.0	28	32	1.56
7.0	20	33	1.5
8.0	15	34	1.4
9.0	12	35	1.4
10	9.6	36	1.3
11	8.0	37	1.3
12	6.8	38	1.25
13	5.9	39	1.2
14	5.2	40	1.2
15	4.7	45	1.0
16	4.2	50	0.9
17	3.8	60	0.7
18	3.5	70	0.6
19	3.2	80	0.5

45SW/SESE asks whether there is an assumption that all DOD explosive site plan approval is current for launch sites on a federal range? What if formal DDESB approval is not on record? *45SW/SESE* at 1. The FAA does assume that all DOD explosive site plan approval is current for launch sites on a federal range and that formal DDESB approval is on record. The FAA's launch site safety assessments of the national launch ranges show that the DOD ranges enforce their standards. However, if the FAA discovers through its safety inspection program that a licensee is operating out of compliance with the DDESB approved explosive site plan, it will consider this a violation of the license and may take appropriate enforcement action.

With respect to the FAA's statement that a launch site operator is responsible for preventing unauthorized public access to the site, the 45SW/SESE commented that this should include surrounding areas designated as posing an environmental or explosives hazard. *45SW/SESE* at 2. The FAA agrees in principle. With respect to environmental hazards, surrounding areas posing an environmental hazard will be addressed in the environmental review process.

[6] Table 4.2 in AFMAN 91–201 (Mar. 7, 2000).

With respect to explosives, to comply with these rules adopted today, areas posing an explosive hazard during ground activities must, by regulatory requirement, be contained within the launch site. A launch site operator is responsible for preventing unauthorized access to the site. It is also responsible for ensuring that hazardous areas within the site are clear and that other users of the site are not placed at risk during hazardous operations. In the NPRM, the FAA stated that minimum prescribed separation distances are necessary to protect the public from explosive hazards on a launch site so that the effects of an explosion do not reach the public. 45SW/SESE notes that some other reasons for separation distances include to prevent unnecessary injuries or casualty to workers related to the explosive operation; to protect property; to avoid propagation from one explosive location to another; and remote explosives testing. *45SW/SESE* at 2. The FAA agrees, but wishes to stress that these requirements are intended to protect public safety because public safety is the FAA's mandate. Property belonging to members of the public also achieves some measure of protection in accordance with these requirements. Also, propagation from one explosive location to another is covered through part 420's intraline distance requirements.

In the NPRM, the FAA states that it must approve the explosive site plan that an applicant provides to the FAA. The 45SW/SESE asks whether explosive site plans already approved by the DDESB will be granted FAA approval. *45SW/SESE* at 3. The answer is yes. A new requirement from the NPRM is that the FAA now requires applicants for launch sites located on a federal launch range to provide the FAA with a copy of an explosive site plan. However, the FAA will not approve it. The FAA will use the explosive site plan for compliance monitoring purposes only.

The 45SW/SESE notes that ''launch site'' in some contexts implies ''launch complex,'' which excludes other launch processing facilities or areas at the launch range. *45SW/SESE* at 3. The FAA does not wish to imply that a launch site is merely a launch complex on a launch site. To clarify, a launch site includes the entire land area operated by a launch site operator, including all launch complexes and facilities within.[7]

In the NPRM, the FAA stated that the proposed requirements do not account for the use of barricades and other protective measures to mitigate the effect of an explosion on exposed areas.

[7] The Act and the regulations define launch site as the location on Earth from which a launch takes place (as defined in a license the Secretary issues or transfers under this chapter) and necessary facilities. 49 USC 70102(6); 14 CFR 401.5.

An applicant proposing to use such measures in order to deviate from the proposed siting rules may, during the application process, provide a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by Q–D. 45SW/SESE states that this use of a waiver is inconsistent with the way the Air Force uses them. A waiver is used to document a condition or requirement that is not achieved, not one where the condition or requirement is being met. *45SW/SESE* at 4. The FAA did not mean ''waiver'' in the way the Air Force uses it. If a launch site operator plans to use barricades or other protective measures to mitigate the effect of an explosion on exposed area, the applicant would have to submit a clear and convincing demonstration of an equivalent level of safety.

In the NPRM, the FAA stated that proposed subpart B would establish criteria and procedures for the siting of facilities at a launch site where solid and liquid propellants are located to prepare launch vehicles and payloads for flight. 45SW/SESE notes that propellants are not enough. The requirements should include other explosives as well including linear shaped charges, safe and arm devices, initiators, and igniters. *45SW/SESE* at 2, 4. The FAA agrees, and has modified the explosive siting requirements to include those explosives, which are division 1.1 explosives.

In the NPRM, the FAA stated that division 1.1 explosives would not likely be present in sufficient quantities to affect the application of Q–D criteria. 45SW/SESE points out that this is incorrect, and the FAA agrees. The linear shaped charge, which is an explosive division 1.1 explosive, is the driver of distance requirements because in most cases a solid rocket booster is zero percent trinitrotoluene (TNT) equivalency. *45SW/SESE* at 5. ACTA adds that DOD 6055.9 states that the inhabited building distance for division 1.1 solid propellants ranging from 1–35,000 lb is 1250 ft. Proposed table E–1 only requires 800 ft. for quantities up to 1,000,000 lb. This is true even when quantities of 1.1 explosives are present. *ACTA* at 5. The FAA agrees that its assumption that division 1.1 explosives would not likely be present in sufficient quantities to affect the application of Q–D criteria was incorrect. The FAA has added division 1.1 explosives to this final rule.

In the NPRM, the FAA also stated that because division 1.3 solid propellants are all compatible, the proposed regulations do not incorporate compatibility groups for solid propellants. 45SW/SESE asks how compatibility would be determined if there was a need to store other explosives with the solids? *45SW/SESE* at 5. Ensuring that explosives in an explosives hazard facility are compatible is a procedural requirement of a launch operator. Ground safety will be covered in a separate proposed rulemaking on licensing and safety requirements for launch.

In the NPRM, the FAA proposed a special requirement at launch pads for launch vehicles that use liquid bi-propellant and solid propellant components. The required separation distance would be the greater of the distance determined by the explosive equivalent of the liquid propellant alone or the solid propellant alone. An applicant did not have to add the separation distances of both. The NPRM assumed that generally, no credible scenario existed that could produce a simultaneous explosion reaction of both liquid propellant tanks and solid propellant motors. 45SW/SESE states that the general assumption that a simultaneous explosion reaction of both liquid propellant tanks and solid propellant motors is unlikely is not a prudent approach. 45SW/SESE recommends analyses be performed on a case-by-case basis to determine a credible scenario. A number of current Q–D site plans considered TNT equivalencies from both the solids and liquids. *45SW/SESE* at 5, 6; *but see Lockheed Martin* at 3 (agreeing with the NPRM proposal as permitting greater flexibility in operations and launch vehicle design).

The FAA agrees with 45SW/SESE, and adopts the suggestion to require that an applicant address an explosion of both solid and liquid propellants at the same time. Air Force standard AFMAN 91–201, section 3.8 states that the combined bulk explosive weight of explosive items is not necessarily the weight used for Q–D calculations. Q–D is based on the maximum credible event (MCE), namely, the worst case explosion, that is expected to occur. Section 3.8.3 further states the basic rule when combining mass-detonating (e.g., the explosive equivalent of liquid propellants) and nonmass-detonating explosives (e.g., an explosive division 1.3 solid rocket motor). Consider the distance for the combined explosives weight of 1.1 and 1.3 first as 1.1. Then consider the distance for the combined explosives weight of 1.1 and 1.3 as 1.3. The required distance is the greater of the two. However, section 3.8 further states that exceptions are granted when analyses or test results demonstrate that the explosive division 1.1 (for liquid propellants) will not cause detonation of the explosive division 1.3 explosives.

This approach has now been incorporated into the final rule, in section 420.69. Note that the FAA still considers a simultaneous explosion reaction of both liquid propellant tanks and solid propellant motors to be unlikely. The FAA requires that this improbability be demonstrated. Otherwise, a launch site operator will have to use the combined explosive weight of the solids and liquids to determine required distances.

In the NPRM, the FAA proposed to adopt a provision of DOD STD 6055.9 that exempts the need for a lightning protection system when a local lightning warning system is used to terminate operations before the incidence of an electrical storm, if all personnel can and will be provided with protection equivalent to a public traffic route distance. The 45SW/SESE notes that this exception is not prudent in Florida where lightning strikes can occur without warning, except possibly an unmanned small licensed location where the value of the facility and its content are assumable risks. *45SW/SESE* at 6.

The FAA agrees that if lightning strikes can occur without warning, then it would be prudent to have a lightning protection system. The final rule would require a lightning protection system in that situation. A licensee must ensure the withdrawal of the public to a public area distance prior to an electrical storm. If this is not possible, then a lightning protection system is required. Note also that the objective is not to protect the licensee's property or that of its contractors, subcontractors, or customers, but members of the public and their property.

In the NPRM, the FAA defined intraline distance as the minimum distance permitted between any two explosive hazard facilities in the ownership, possession or control of one launch site customer. The FAA notes that unlike distances to protect the public, intraline distance will not protect workers with the same level or protection as the public. If intraline distances are not maintained between two explosive hazard facilities, then the larger area encompassing both quantities must be used for Q–D purposes when determining prescribed distances to the public. The 45SW/SESE questions how that could be acceptable when worker safety is diminished, and personnel protection must be established to be consistent with OSHA. *45SW/SESE* at 7. Worker safety comes under the jurisdiction of OSHA, and, as noted in the NPRM, the FAA does not plan to duplicate the requirements of other regulatory agencies.

45SW/SESE also notes that inhabited building distance, which the FAA proposed as public area distance, has an assumed 20% facility damage and some injury. 45SW/SESE states that this may be a reasonable risk on a DOD installation, and asks whether 20% facility damage and injury is acceptable to the general public? *45SW/SESE* at 8; *see also* ACTA at 3 (noting that the Q–D criterion for public buildings allows a glass fragment serious injury probability of up to 30%). This would not be acceptable if Q–D requirements were the only measures taken to protect the public. The protection offered by Q–D along with the procedural requirements covered in a proposed rulemaking governing licensing and safety requirements for launch will be adequate to protect the public to an acceptable level. These other safety controls are the responsibility of a launch operator and will be covered in a separate proposed rulemaking on licensing and safety requirements for launch.

ACTA staff notes that the FAA uses DOD and NASA standards as the basis for explosive safety requirements. ACTA asked that since OSHA, EPA, and ATF have the responsibility for safety during production and assembly of hazardous materials, why shouldn't this apply to launch site operations as well. *ACTA* at 8.

OSHA and EPA regulations do apply on launch sites, but neither agency has Q–D requirements. ATF does have Q–D requirements, but, as noted in the NPRM, they only cover the storage of explosives at a launch site. ATF regulations do not cover the handling of explosives, which includes the majority of hazardous activities at launch sites. DOD and NASA standards are currently used at every major launch site in the United States, and the FAA requirements reflect the current practice. Note also that the distances used in this final rule for the ''use'' of explosives are consistent with ATF regulations on the ''storage'' of explosives, and that the FAA is not duplicating the ATF storage requirements. An ACTA staff member stated that the NPRM provides excruciating details on how to handle explosives but does not consider public risks associated with either toxicity or blast overpressure focussing. These are major factors in siting decisions. *ACTA at 7.* The FAA agrees that these are important issues, but are not critical for the layout of a launch site. These issues are covered in the proposed rulemaking governing licensing and safety requirements for launch.

Space Access, LLC, (Space Access) also commented on the explosive siting requirements. In the NPRM, the FAA stated that the DDESB is likely to specify new hazard and compatibility groups, distance values, and equivalency values, and the public may anticipate their eventual consideration and possible adoption by the FAA. Space Access recommends the FAA accelerate this work and provide these values as soon as possible. These proposed changes could have a major financial impact to both the site operators and launch vehicle operators in terms of launch acquisition, usage, safety separation distances for storage and public access and procedures for use in all phases of operations leading up to the launch. Space Access was concerned that launch operators will never achieve aircraft-like operations if they are continually evacuating sites and areas to meet outdated policies and suggested that no flexibility to meet safety criteria by means other than total separation distance. *Space Access* at 2. The FAA would like to stress that the work is being conducted by the DDESB, and is not in the control of the FAA. It is, however, near completion and the FAA will consider it once it is completed and adopted by the DDESB.

Space Access also states that there seems to be a lack of discussion of the distances required by the Department of Transportation (DOT). Space Access wants a single standard for propellants. DOT uses numbers in tens of feet for public safety distances. Other standards also exist in the National Fire Protection Agency (NFPA) publications and in local fire codes. *Space Access* at 2, 3. The FAA agrees that other liquid Q–D standards are much different than those proposed by the FAA, but the FAA selected standards representing current procedures for the launch industry. That is why the new liquid Q–D standards that the DDESB will likely adopt are important since they are based on a review of all relevant government and industry standards in this area, including those of DOT. There will not likely be a single standard for propellants, as Space Access would like, but the standards applicable to launch sites will be more consistent with other commercial and government standards.

Space Access also notes that in addition to having realistic numbers for Q–D, there needs to be procedures and policies such that incentives are in place for actually designing and operating in a safe manner. For example, earthen berms can be used to reduce separation distances. This should be the same with adequate design and procedures. According to Space Access, there is no motivation for improving the design or procedures because all that matters is total quantity or TNT equivalency. Space Access strongly recommends the FAA adopt a methodology that trades design and procedures for distance. *Space Access* at 3.

The FAA agrees that separation distances can be reduced if certain features are built into a facility. The FAA has chosen not to include design standards in the final rule at this time because of their complexity. In recognition of the availability of such substitutes, the final rule now provides that for explosive siting issues not otherwise addressed by the requirements of §§ 420.65–420.69, a launch site operator must clearly and convincingly demonstrate a level of safety equivalent to that otherwise required by part 420. This means that the FAA may permit design features that provide an equivalent level of safety to substitute for separation distances.

Lockheed Martin Corporation also commented on the Q–D requirements. First, it believes the FAA should consider applying DOD Standard 6055.9 at non-federal launch sites instead of developing a new standard because 6055.9 represents a well-developed and mature regime with an impressive safety record; and because implementation of 6055.9 at non-federal launch sites would help ensure consistent regulation of explosives both at federal and non-federal launch ranges. *Lockheed Martin* at 3. The FAA agrees that 6055.9 represents a well-developed and mature regime with an impressive safety record. That is why the FAA's Q–D standards are modeled after this standard. The FAA believes, however, that codifying, instead of adopting by reference, the basic requirements of the standard in a regulation are beneficial for a number of reasons. First, codification permits the standard to be tailored to the needs of commercial launch sites. DOD standard 6055.9 is applicable to all military bases, worldwide. Second, the language within standards such as DOD regulation 6055.9 is not always stated in a regulatory manner. Often, discretion based on military need by the DDESB or other body is embedded in the standard. Third, changes to that standard by the DDESB could not automatically apply to applicants for a license. By adopting the basic requirements of that standard in the final rule, the FAA can monitor changes in the DDESB standard, consider the applicability and appropriateness of changes to commercial launch sites, and go through notice and comment rulemaking to adopt any change. Therefore, the FAA retains the approach of adopting pertinent requirements of that standard in the final rule rather than referencing the entire DOD standard 6055.9.

Lockheed Martin agrees with the FAA's approach to addressing hardening on a case-by-case basis, and suggests referring to National Fire Protection Association (NFPA) 70 and 496. *Lockheed Martin* at 3. NFPA 70, the National Electrical Code® (1999), includes safety requirements for all types of electrical installations. It is useful for work that involves electrical design, installation, identification, or inspection. NFPA 496, Standard for Purged and Pressurized Enclosure for Electrical Equipment, 1988, specifies requirements for design and operation of purged and pressurized electrical equipment enclosures to reduce or eliminate the hazardous location classification within the enclosures.

Those two standards are incorporated by reference in OSHA's Occupational Safety and Health Regulations at 29 CFR 1910.6. Because OSHA requires them, and because the FAA is seeking to avoid duplicating the requirements of other civilian regulatory agencies, the standards will not be incorporated into this final rule. In any event, the FAA will be willing to consider those standards in the event a launch site operator attempts to use them to demonstrate an equivalent level of safety.

E. Explosive Mishap Prevention Measures.

Application of the quantity-distance rules alone will not prevent mishaps from occurring on a launch site. The Q–D rules merely reduce the risk to the public to an acceptable level if a mishap occurs, and if the public is kept away from the mishap by a distance that is at least as great as the public area distance. Safe facility design and prudent procedural measures are critical to preventing a mishap from occurring in the first place. Because the public at a launch site cannot be protected by prudent site planning alone, the FAA today adopts launch site operator responsibilities to prevent mishaps involving propellants and other explosives.

Part 420 focuses on measures that are appropriate to be taken by a launch site operator. For the most part, the FAA considers it prudent to place the responsibility on a launch site operator for those measures that must be built into facilities. Requirements of a more operational nature will be covered in another FAA rulemaking.

Part 420 focuses on appropriate measures. These are particularly important for electro-explosive devices. Electric hazards include lightning, static electricity, electric supply systems, and electromagnetic radiation. The FAA is adopting launch site operator requirements for two of these electric hazards: lightning and electric supply systems. A full discussion of these can be found in the Launch Site NPRM. 64 FR at 34324–34325.

Other measures were considered but rejected because the FAA's proposed rulemaking on licensing and safety requirements for launch will cover other procedural measures to guard against inadvertent initiation of propellants from electricity. Moreover, launch and launch site operators should implement prudent design and construction measures to comply with local, state, and other federal law, such as OSHA requirements.

Discussion of Comments

In the NPRM, the FAA noted that the National Fire Protection Association (NFPA), Batterymarch Park, Quincy, Massachusetts, has published NFPA 780, Standard for the Installation of Lightning Protection Systems. The latest edition was published in 1997. NFPA 780 provides for the protection of people, buildings, special occupancies, heavy duty stacks, structures containing flammable liquids and gases, and other entities against lightning damage. The FAA asked for the public's views on the use and applicability of this code.

A number of commenters supported the FAA's adoption of NFPA 780. 45SW/SESE noted that the Air Force uses NFPA 780 as a core document to design lightning protection systems. *45SW/SESE* at 6. The NFPA stated that the FAA should adopt NFPA 780, which dates back to Benjamin Franklin's era. *NFPA* at 1, 2; *see also Lockheed Martin* at 3. The FAA agrees with the commentors regarding the importance of NFPA 780. However, the FAA will not incorporate NFPA 780 by reference because it does not always include mandatory language. Due to its importance and utility, the FAA will undoubtedly refer to it for appropriate guidance.

Although LMC believes NFPA 780 is an appropriate and useful standard for a lightning protection system, it states that a launch site operator should not be required to install and maintain an independent lightning protection system. A launch operator will likely have one as a way to attract customers. *Lockheed Martin* at 3. The FAA disagrees. The FAA has learned from experience that while most launch site operators might be expected to adhere to commonly held standards; this is not always the case. Without such requirements, an adequate level of safety or risk mitigation cannot be achieved. If most would do this anyway, then the impact is minimal. In any event, because it involves the construction of facilities, the FAA has made the installation of a lightning protection system a requirement for a launch site operator license to ensure its availability.

In addition to NFPA 780, the 45SW/SESE suggested that the FAA review DOD 6055.9, and applicable Air Force instructions to provide full regulatory requirements. The FAA has reviewed DOD 6055.9, Air Force Manual 91–201, and the National Aeronautics and Space Administration's (NASA) "Safety Standard for Explosives, Propellants, and Pyrotechnics," NSS 1740.12 (Aug.1993). The FAA believes that the requirements in the final rule cover the basic safety issues that need to be addressed for lightning protection systems. The FAA expects applicants to achieve the level of safety represented by the DOD and NASA standard.

Another explosive mishap prevention measure is the control of static electricity. The FAA did not propose any requirements in the NPRM regarding the control of static electricity because the FAA believed that the control of static electricity in launch operations is primarily procedural in nature, and is best covered by the FAA in another proposed rulemaking governing licensing and safety requirements for launch. The FAA asked for the public's view.

LMC agreed with the FAA and noted that new rules on control of static electricity should reflect current procedures used by the launch operators. *Lockheed Martin* at 4. The NFPA recommended NFPA 77, Recommended Practice on Static Electricity (1993), as a reference document. NFPA 77 provides a basic understanding of the phenomena of static electric discharges and how they can serve as ignition sources, and includes useful information on bonding and grounding.

F. Launch Site Location Review

The FAA intends a launch site location review to determine whether the location of a proposed launch site could support launches that would not jeopardize public health and safety, and the safety of property. To that end, the FAA will determine whether at least one hypothetical launch could take place safely from a launch point at the proposed site. The FAA will not license the operation of a launch site from which a launch could never safely take place. An applicant should, however, bear in mind that an FAA license to operate a launch site does not guarantee that a launch license would be issued for any particular launch proposed from that site. Accordingly, much of the decision making with respect to whether a particular site will be economically successful will rest, as it should, with a launch site operator, who will have to determine whether the site possesses sufficient flight corridors for economic viability.

Accordingly, prior to issuing a license to operate a launch site at the proposed location, the FAA will ascertain whether it is hypothetically possible to launch at least one type of launch vehicle on at least one trajectory from each launch point at the proposed site while meeting the FAA's collective risk criteria. The FAA wants to ensure that there exists at least one flight corridor or set of impact dispersion areas from a proposed launch site that would contain debris away from population. Launch is a dangerous activity that the FAA will allow to occur only when the risk to people is below an expected casualty (E_c) of 30×10^{-6}. In other words, if there are too many people around a launch site or in a flight corridor the FAA will not license the site.

All this is not to say that the FAA is requiring an applicant for a license to operate a launch site to perform a complete flight safety analysis for a particular launch. The FAA recognizes that an applicant may or may not have customers or a particular launch vehicle in mind. Accordingly, the FAA's launch site location review methods only approximate, on the basis of certain assumptions and recognizing that not all factors need to be taken into account, a full flight safety analysis that would normally be performed for an actual launch. Of course, if an applicant does have a customer who satisfies the FAA's flight safety criteria for launch and obtains a license for launch from the site, that showing would also demonstrate to the FAA that a launch may occur safely from the proposed site, and the FAA could issue a license to operate the launch site on the basis of the actual launch proposed.

The launch site location review applies to both expendable launch vehicles (ELVs) and reusable launch vehicles (RLVs). Detailed methodologies for the launch site location review are only provided for expendable launch vehicles with a flight history. The reusable launch vehicles currently proposed by industry vary quite a bit. Accordingly, the FAA considered it unwise to define a detailed analytical method for determining the suitability of a launch site location for RLVs. An applicant proposing a launch site limited to the launch of reusable launch vehicles would still need to define a flight corridor and conduct a risk analysis if population were present within the flight corridor, but the FAA will review such an analysis on a case-by-case basis, consistent with the principles discussed in this rulemaking.

Similarly, the FAA has chosen not to define a detailed analytical method for determining the suitability of a launch site location for unproven launch vehicles. An applicant proposing a launch site limited to the launch of unproven launch vehicles would have to demonstrate to the FAA that the launch site is safe for the activity planned.

A launch site location review provides an applicant with alternative methods for demonstrating that a proposed launch site satisfies FAA safety requirements. Specifically, the applicant must demonstrate that a flight corridor or set of impact dispersion areas exist that do not encompass populated areas or that do not give rise to an E_c risk of greater than 30×10^{-6}. Each proposed launch point must be evaluated for each type of launch vehicle, whether expendable orbital, guided sub-orbital or unguided sub-orbital, or reusable, that an applicant proposes would be launched from each point.

Each of the three methods for evaluating the acceptability of a launch site's location require an applicant to identify an area, whether a flight corridor or a set of impact dispersion areas, emanating from a proposed launch site. That area identifies the public that the applicant must analyze for risk of impact and harm. An applicant who anticipates customers who use guided orbital launch vehicles must define a flight corridor for a class of vehicles launched from a specific point along a specified trajectory, that extends 5,000 nautical miles from the launch point or until the launch vehicle's instantaneous impact point leaves the Earth's surface, whichever is shorter. For guided sub-orbital launch vehicles, the flight corridor ends at an impact dispersion area of a final stage. An applicant must demonstrate either that there are no populated areas within the flight corridor or that the risk to any population in the corridor does not exceed the FAA's risk criteria. Similarly, for the sub-orbital launch of an unguided vehicle, an applicant must analyze the risks associated with a series of impact dispersion areas around the impact points for spent stages. If there are people in the dispersion areas, the applicant must demonstrate that the expected casualties from stage impacts do not exceed the FAA's risk criteria.

E_c, or casualty expectancy, represents the FAA's measure of the collective risk to a population exposed to the launch of a launch vehicle. The measure represents the expected average number of casualties for a specific launch mission. In other words, if there were thousands of the same mission conducted and all the casualties were added up and the sum divided by the number of missions, the answer and the mission's expected casualty should statistically be the same. This E_c value defines the acceptable collective risk associated with a hypothetical launch from a launch point at a launch site, and, as prescribed by the regulations, shall not exceed an expected average number of casualties of 0.00003 (30×10^{-6}) for each launch point at an applicant's proposed launch site. This E_c value defines acceptable collective risk.

The FAA's methods for identifying a flight corridor or impact dispersion areas distinguish between guided orbital expendable launch vehicles with a flight termination system (FTS), guided sub-orbital expendable launch vehicles with an FTS, and unguided sub-orbital expendable launch vehicles without an FTS.[8] For purposes of part 420, references to a guided expendable launch vehicle, whether orbital or sub-orbital, may be taken to mean that the vehicle has an FTS. References to an unguided sub-orbital may be understood to mean that the vehicle does not possess an FTS.

Part 420 divides guided orbital expendable launch vehicles into four classes, with each class defined by its payload weight capability, as shown in table 2. Sub-orbital expendable launch vehicles are not divided into classes by payload weight, but are categorized as either guided or unguided. Table 3 shows the payload weight and corresponding classes of existing orbital expendable launch vehicles. For a launch site intended for the use of orbital launch vehicles, an applicant

[8] Part 420 does not include a means for analyzing risks posed by a launch site for the launch of unguided suborbital launch vehicles that employ FTS. Historically, few of these vehicles have been launched. In the event an applicant for a license to operate a launch site wishes to operate a launch site only for such vehicles, the FAA will handle the request on a case by case basis. The FAA does note, however, that unguided suborbital launch vehicles that in the past have been launched with an FTS were usually launched with the FTS because the launch was otherwise too close to populated areas for the type of vehicle and trajectory flown.

defines a hypothetical flight corridor from a launch point at the proposed launch site for the largest launch vehicle class anticipated'' which the FAA anticipates will be based on expected customers.

TABLE 2.—ORBITAL EXPENDABLE LAUNCH VEHICLE CLASSES BY PAYLOAD WEIGHT (LBS)

100 nm orbit	Weight class			
	Small	Medium	Medium large	Large
28 degrees inclination*	≤4400	>4400 to ≤11100	>11100 to ≤18500	>18500
90 degrees inclination	≤3300	>3300 to ≤8400	>8400 to ≤15000	>15000

*28 degrees inclination orbit from a launch point at 28 degrees latitude.

TABLE 3.—CLASSIFICATION OF COMMON GUIDED ORBITAL EXPENDABLE LAUNCH VEHICLES

Vehicle	Payload weight (lbs) 100 nm Orbit 28° inc.	Payload weight (lbs) 100 nm Orbit 90° inc.	Class
Conestoga 1229	600	450	Small.
Conestoga 1620	2,250	1,750	Small.
Athena-1	1,755	1,140	Small.
Athena-2	4,390	3,290	Small.
Pegasus	700	N/A	Small.
Pegasus XL	1,015	769	Small.
Scout	560	460	Small.
Taurus	3,100	2,340	Small.
Atlas II	14,500	12,150	Medium/Large.
Atlas IIA	16,050	13,600	Medium/Large.
Atlas IIAS	19,050	16,100	Large.
Atlas IIIA	19,050	15,700	Large.
Atlas IIIB	23,630	20,240	Large.
Atlas V 404	27,550	23,700	Large.
Atlas V 552	44,200	37,400	Large.
Delta 6920	8,780	6,490	Medium.
Delta 7920	11,330	8,590	Medium/Large.
Delta 3	18,280	14,920	Medium/Large.
Delta 4 M	18,600	15,150	Large.
Delta 4 M (5,4)	30,000	23,000	Large.
Delta 4 Heavy	56,900	46,000	Large.
Titan II	N/A	4,200	Medium.
Titan III	31,200	N/A	Large.
Titan IV	47,400	41,000	Large.

Methods for estimating the risk posed by the operation of a launch site for guided orbital and sub-orbital expendable launch vehicles are presented in appendices A, B and C. Appendix A contains instructions for creating a flight corridor for guided orbital and sub-orbital expendable launch vehicles. Appendix B provides an alternative method to appendix A. Appendix B also instructs an applicant how to create a flight corridor for guided expendable launch vehicles, but provides more detailed calculations to employ so that, although an appendix B flight corridor is typically less conservative than that of appendix A, it should prove more representative of actual vehicle behavior. Appendix C contains the FAA's method for applicants to analyze the risk posed by guided expendable launch vehicles within a flight corridor created in accordance with appendix A or B. Unguided sub-orbital expendable launch vehicles are presented in appendix D, which describes how an applicant should estimate impact dispersion areas and analyze the risk in those areas.

Appendix A is less complex, but generates a larger flight corridor than the methodology of appendix B. No local meteorological or vehicle trajectory data are required to estimate a flight corridor under appendix A. Because appendix A provides a more simple methodology, an applicant may want to use it as a screening tool. If an applicant can define a flight corridor for a single trajectory, using appendix A, that does not overfly populated areas, the applicant may satisfy the launch site location review requirements with the least effort. If, however, the corridor includes populated areas, the applicant may create an appendix B flight corridor that may be more narrow, or may conduct a casualty expectancy analysis. An applicant is not required to try appendix A before employing appendix B.

The FAA's location review reflects a number of assumptions designed to keep the review general rather than oriented toward or addressing a particular launch. These assumptions are discussed more fully below, but may be summarized briefly. The location reviews for appendices A and B flight corridors reflect an attempt to ensure that launch failure debris would be contained within a safe area. Successful containment must assume a perfectly functioning flight termination system. A perfectly functioning flight termination system would ensure that any debris created by a launch failure would be contained within a flight corridor. When the high risk event is not launch failure but launch success, as tends to be the case with an unguided sub-orbital expendable launch vehicle that does not employ an FTS, the FAA still proposes a location review based on an assumption of containment.

The approaches provided in the four location review appendices are based on some common assumptions that reflect limitations of the launch site location review analysis. The FAA is not requiring an applicant to analyze the risks posed to the public by toxic materials that might be handled at the proposed site, nor the risk to ships or aircraft from launch debris or planned jettisoning of stages. The FAA recognizes that these assumptions represent a limitation in the launch site location review. The FAA intends that these three risks will be dealt with through pre-flight operational controls and flight commit criteria which are partially addressed through part 420 coordination requirements and which also will be identified as part of a launch license review. All launches that take place from a U.S. launch site whose operation is licensed will either be regulated by the FAA through a launch license or will be U.S. government launches that the government carries out for the government.

The two methods for creating guided expendable launch vehicle flight corridors are intended to account for expendable launch vehicle failure rate, malfunction turn capability, and the expendable launch vehicle guidance accuracy as defined by the impact dispersions of these vehicles. The premise undergirding each of these methods is that debris would be contained within the defined flight corridor or impact dispersion areas. Accordingly, for purposes of a launch site location review, only the populations within the defined areas need to be analyzed for risk. The FAA recognizes that were a flight termination system to fail to destroy a vehicle as intended, a launch vehicle could stray outside its planned flight corridor. That concern will be better accommodated through another forum, namely, the licensing of a launch operator and the review of that launch operator's flight safety system. Because a containment analysis only looks at how far debris would travel in the event an errant vehicle were destroyed, the containment analysis has to assume a perfectly functioning flight termination system. In other words, for purposes of analyzing the acceptability of a launch site's location for launching guided expendable launch vehicles, the FAA will assume that a malfunctioning vehicle will be destroyed and debris will always impact within acceptable boundaries. Accordingly, the FAA does not propose to explore, for purposes of determining the acceptability of a launch site's location, the possibility that a vehicle's flight termination system may fail and that the vehicle could continue to travel toward populated areas. Any proposed site may present such risks—indeed, any proposed launch presents such risks—but they are best addressed in the context of individual launch systems. This working assumption of a perfectly reliable flight termination system will not, of course, apply to the licensing of a launch of a launch vehicle. The FAA will consider the reliability of any particular launch vehicle's FTS in the course of a launch license review. From a practical standpoint, this means that for the launch site location review, both nominal and failure-produced debris would be contained within a flight corridor, obviating the need for risk analyses that address risk outside of a defined flight corridor or set of impact dispersion areas.

Additionally, the FAA does not propose to require an applicant to analyze separately the risks posed by the planned impact of normally jettisoned stages from a guided expendable launch vehicle, except for the final stage of a guided sub-orbital expendable launch vehicle. The FAA does not consider intermediate stage impact analysis necessary to assess the general suitability of a launch point for guided expendable launch vehicles because the impact location of stages is inherently launch vehicle-specific, and the trajectory and timing for a guided expendable launch vehicle can normally be designed so that the risks from nominally jettisoned stages will be kept to acceptable levels. A launch license review will have to ensure that vehicle stages are not going to impact in densely populated areas. Risk calculations performed for launches from federal launch ranges demonstrate a relatively low risk posed by controlled disposition of stages in comparison to the risk posed by wide-spread dispersion of debris due to vehicle failure.

Each of the FAA's approaches to defining flight corridors or impact dispersion areas is designed to analyze the highest risk launch event associated with a particular vehicle technology. This is not meant to imply that lower risk launch events are necessarily acceptable; only that they will not be considered in the course of this review. For a guided orbital expendable launch vehicle, that event is vehicle failure. For an unguided sub-orbital expendable launch vehicle, the launch event of highest risk is vehicle success, namely, the predicted impact of stages. For a guided expendable launch vehicle the overflight risk, which results from a vehicle failure followed by its destruction (assuming no FTS failure), is the dominant risk. Risks from nominally jettisoned debris are subsumed in the overflight risk assessment. For an unguided sub-orbital expendable launch vehicle, the FAA proposes that risk due to stage impact be analyzed instead of the overflight risk. This distinction is necessitated by the fact that the failure rate during thrust is historically significantly lower for unguided vehicles than for guided vehicles. Current unguided expendable launch vehicles with many years of use are highly reliable. They do not employ an FTS; therefore, debris pieces usually consist of vehicle components that are not broken up. Another reason for the difference between analyses is that unguided vehicle stage impact dispersions are significantly larger than guided vehicle impact dispersions. These differences add up to greater risk within an unguided expendable launch vehicle stage impact dispersion area than the areas outside the dispersion areas. Therefore, a risk assessment is only performed on those populations within an unguided expendable launch vehicle stage impact dispersion area.

An applicant must define an area called an overflight exclusion zone (OEZ) around each launch point, and the applicant must demonstrate that the OEZ can be clear of members of the public during a flight. An OEZ defines the area where the public risk criteria of 30×10^{-6} would be exceeded if one person were present in the open. The overflight exclusion zone was estimated from risk computations for each expendable launch vehicle type and class. An applicant must define an OEZ because expendable launch vehicle range rates are slow in the launch area, launch vehicle effective casualty areas, the area within which all casualties are assumed to occur through exposure to debris, are large, and impact dispersion areas are dense with debris so that the presence of one person inside this hazardous area is expected to produce E_c values exceeding the public risk criteria. Accordingly, an applicant must either own the property, demonstrate to the FAA that there are times when people are not present, or that it could clear the public from the overflight exclusion zone prior to flight. Evacuating an overflight exclusion zone for an inland site, might, for example, require an applicant to demonstrate that agreements have been reached with local communities to close any public roads during a launch.

The FAA has made a few changes to the Launch Site NPRM for this final rule. First, the launch site location review regulatory text has been expanded to better map out the launch site location review for both ELVs and RLVs. The appendices remain essentially the same.

Second, the size of the flight corridors that are generated in either appendix A or B are now assumed in appendix C to reflect a three-sigma event. The NPRM had used five-sigma. To review, for purposes of the launch site location review, a flight corridor is an area on the Earth's surface estimated to contain debris of a ballistic coefficient of ≥3 pounds per square foot from nominal and non-nominal flight of a launch vehicle, assuming a perfectly functioning flight termination system. The land encompassed by the flight corridor includes the population most at risk due to a launch. The data used to develop a flight corridor does not directly provide statistical significance. However, the relative risk to any specific populated area can be assumed to vary proportionally with the populated area's distance from the nominal trajectory ground trace. The NPRM assumed the boundaries were five-sigma distances, which proved unwise because the statistical probability of an event occurring between three-sigma and five-sigma is extremely small. The launch site location review procedures are not precise enough for the FAA to claim that a flight corridor contains all of the population at risk at such a low probability level. Assuming that the distance to the flight corridor boundary is three-sigma is a more reasonable assumption.

Third, the multipliers in the launch site location review have been taken out. In the Launch Site NPRM, to add conservatism to the launch site location review, applicants would multiply the final E_c value obtained through either appendix C or appendix D by a multiplier of two and five, respectively. This final rule does not make use of multipliers because the FAA, upon reconsideration, now believes that the procedures for estimating risk in appendices A–D are conservative enough to not require a multiplier at the end of the process.

Lastly, the FAA clarified in the regulatory text that orbital expendable launch vehicles are classified by weight class, based on the weight of payload the launch vehicle can place in a 100-nm orbit, as defined in table 2.

Discussion of Comments

The FAA received comments on the launch site location review from ACTA, Inc; the New Mexico Office for Space Commercialization; Oklahoma Aeronautics and Space Commission; Space Access, LLC; Christopher Shove; and the Texas Aerospace Commission.

ACTA stated that medium to large vehicles launched from Cape Canaveral Air Station (CCAS) do not meet the risk criteria. *ACTA* at 1. The FAA disagrees. Using Appendix B, medium to large vehicles do pass the launch site location review.

ACTA stated that unlike under EWR 127–1, the FAA has decided not to permit any risk above 30×10^{-6}. This coupled with a very conservative approach to risk analysis could prove detrimental to the U.S. industry. *ACTA* at 1. The FAA disagrees. The expected casualty acceptable risk level, 30×10^{-6}, is not new. It is a current requirement for launches. Second, the very conservative approach proposed is conservative because simplifying assumptions were made. In many instances the FAA believes that such approaches adequately demonstrate the acceptability of the site location without the added burden of more complex analysis. It should not prove detrimental because applicants may do a more refined, less conservative analysis. To make this option explicit, sections 420.23 and 420.25, covering the flight corridor and risk analysis, respectively, explicitly state that the FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required in the appendices.

ACTA also states that the risk analysis methodology presented in the document is very simplistic. There are better methods available, albeit more complex, but the NPRM does not allow for any other methodology. ACTA recommended that an applicant be allowed to use equivalent approved analysis methods and processes that have been validated by use at federal ranges involved in ELV and RLV activities. *ACTA* at 2, 6 and 7. The FAA agrees and has modified the launch site location review to allow such methods without a waiver. The analysis methodology is intended to be simplistic and conservative. The actual risks will be less than that estimated by the methodologies provided. In many cases, the site applicant may not have available the inputs necessary to provide a detailed risk analysis. In addition, many launch sites are so remote that they do not need detailed analyses to show that the risk levels are acceptable. New under these final rules is that an applicant has the option of using higher fidelity methodologies.

ACTA states that the NPRM offers no insight into the source of numbers, such as casualty areas, that the FAA directs the license applicant to use. The references should be identified. *ACTA* at 1. Review of the Launch Site NPRM shows that the FAA provided its sources. The NPRM stated, for example, to address the issues raised, that the FAA derived the effective casualty areas in table C–3 from DAMP, a series of risk estimation computer programs used at federal launch ranges, to evaluate the vehicle classes described in table 1, section 420.21. 64 FR at 34353.

ACTA and ACTA staff raised concerns regarding issues not addressed in this rulemaking. ACTA stated that the NPRM did not address launch-related risk from potential toxic releases, from far-field window breakage, or debris risk to ships and aircraft. *ACTA* at 1, 2. ACTA staff added that ignoring the existence of established major air corridors or shipping lanes seems shortsighted. *ACTA* at 9. The FAA disagrees. Air corridors and shipping lanes are not ignored. A launch site operator must have an agreement in place with FAA Air Traffic and the Coast Guard covering those issues before it will get a license.

The FAA agrees that the issues of toxicity and windows breaking should not be ignored for launch safety, and launch -related risk from potential toxic releases, from far-field window breakage, or debris risk to ships and aircraft are covered in launch license application reviews. Toxic and blast risks were not covered in this rulemaking because launching only when circumstances such as wind are favorable can minimize such risks. The FAA considers these issues better addressed through the launch license. Second, debris risk to ships and aircraft are addressed in these regulations. An applicant must conclude agreements with the Coast Guard and the FAA Air Traffic in order to address ship and aircraft risk, and a separate rulemaking addresses these issues with additional specificity.

ACTA states that the level of analysis in the NPRM seems to assume that the applicant will be very naıve, and not have access to good tools or consultant support. *ACTA* at 2. The FAA disagrees. Not all applicants are flight safety specialists. The FAA believes that providing tools and data to conduct risk and other analyses is beneficial to the industry. The proposed appendices take an applicant step by step through the process.

ACTA states that the FAA's lack of methodology for risk analysis in the back azimuth direction other than the exclusion zone implies that there is no back azimuth risk. *ACTA* at 2. The FAA does not wish to imply that there is no back azimuth risk. There is. However, as noted in the NPRM, the launch site location review assumes a perfectly functioning flight safety system. Therefore, population behind the launch site is only addressed if it is within the overflight exclusion zone or within the flight corridor due to wind effects. Otherwise back azimuth population is not reviewed. A launch license applicant will need to adequately address all flight risks in order to receive a license.

ACTA states that the instantaneous impact point (IIP) rates are unrealistically low, particularly late in flight. If only powered flight is considered, the average IIP rate will increase. Using a lower IIP rate inflates the computed risk. *ACTA* at 2. The FAA notes that the IIP range rate data was intended to be conservative but, as discussed in the NPRM, they are not unrealistically low. 64 FR at 34342.

ACTA states that the effective casualty areas seem very high. The casualty area numbers are a prime contributor to the unrealistically high risks computed by these methods. *ACTA* at 2. The FAA disagrees that the casualty area are unrealistically high if one considers, for each piece of debris, its size, the path angle of its trajectory, impact explosions, the size of a person, and debris skip, splatter, and bounce. They are also intended to be conservative. Higher fidelity analyses will be necessary for the launch license application. Also, now that the FAA will permit higher fidelity analyses that produce an equivalent level of safety, the FAA finds that the concern is addressed.

ACTA states that the overflight exclusion zone (OEZ) is designed to protect an individual in the public at a risk level of 30×10^{-6} casualties. ACTA further states that this seems rather loose, and that the Range Commanders Council Standard suggests 1×10^{-7} fatalities and the Eastern Range (ER) and Western Range (WR) have used 1×10^{-6} casualties as an individual risk limit for the general public. *ACTA* at 3. The FAA disagrees. ACTA misunderstood what was stated in the NPRM. The NPRM actually states that an overflight exclusion zone is the area where the collective risk to the public would be greater than 30×10^{-6} if one person were present in the open. 64 FR 34329. The overflight exclusion zone does not incorporate an individual risk standard per se, but is merely an area that must be clear of population for the collective risk standard to be met.

ACTA states that if 30×10^{-6} was used as the basis for developing the distance D_{max}, then D_{max} appears quite conservative for that risk level. *ACTA* at 3. The FAA did not use the criteria of 30×10^{-6} as the basis for developing the distance D_{max}. The basis for D_{max} is the estimated maximum distance from a launch point that debris travels given a worst-case launch vehicle failure and flight termination at 10 seconds into flight.

ACTA also opposed the FAA's use of a ballistic coefficient of three. The NPRM stated that although the FAA proposes to assume a ballistic coefficient of three as the smallest piece of wind sensitive debris hazardous to the public, ballistic coefficient is not directly related to fatality criteria based on the kinetic energy of debris. The ballistic coefficient of three is related to a kinetic energy of 58 ft/lbs, which represents a probability of fatality of 50 percent for a standing person. ACTA states that historically, the national ranges have used impact kinetic energy as a criterion for determining whether an inert fragment may or may not produce a casualty. ACTA has been performing biomechanical simulations, which are still in progress, to investigate these criteria in support of the Air Force federal launch ranges. However, one conclusion is that impact kinetic energy by itself is an inadequate predictor of whether or not an inert impacting fragment will produce a casualty. *ACTA* at 4, 5. The FAA notes that the method suggested is far too complex for the scope of this final rule. This final rule very simply assumes that a hit is a casualty. Note that the risk criterion is based on the generation of a casualty not a fatality.

NMOSC also disagreed with the FAA's statement that a ballistic coefficient of three is related to a kinetic energy of 58 ft/lbs, which represents a probability of fatality of 50 percent for a standing person. NMOSC states that 58 ft–lbs is a better number to use than 11, but asks what is the basis for the 50% lethality claim for 58 ft–lbs and ballistic coefficient of three. Furthermore, sheltering should also be considered. *NMOSC* at 3.

The basis for the 50% lethality claim is for a standing person and is found in the Range Commanders Council (RCC) Supplement to Standard 321–97, ''Common Risk Criteria for National Test Ranges, Inert Debris'', Figure 4–3, on page 4–5. However, the FAA would like to modify its statement made in the NPRM with respect to how ballistic coefficient relates to kinetic energy and the 50% lethality claim. Ballistic coefficient (β) is very difficult to relate to kinetic energy. (β) is equal to an object's weight divided by the product of the object's drag coefficient and it's projected area and expressed in units of lbs/ft^2. Kinetic energy units are joules or ft–lbs/sec. Various combinations of weight, drag coefficient, and projected area can equate to the same β, but each combination would produce a different kinetic energy.

ACTA makes a number of points about launch corridors. First, ACTA states that impulsive velocities imparted to fragments from explosives are ignored throughout. *ACTA* at 6. The FAA did consider whether it was appropriate to address explicitly impulsive velocities but decided that the conservatism incorporated into appendix B obviates the need for including them in the appendix B analysis. Additionally, these analyses are not intended to be high fidelity analyses or require inputs that a launch site applicant may not have. These analyses are believed to be adequate for most coastal site applicants. More detailed analysis will be required from launch operators.

Second, ACTA states that no justification is given for the use of five-sigma for the launch corridor boundaries. *ACTA* at 6. The FAA does agree that the use of five-sigma to define the flight corridor boundary was not appropriate. As noted above, the final rule assumes the boundaries are three-sigma.

Third, ACTA states that there does not appear to be any real probabilistic basis for any of the dispersion analyses. *ACTA* at 6. ACTA is correct. No attempt is made to determine the variations of risk within the corridor. In the downrange direction, the chance of a failure is considered equal at any given point on the flight trajectory. In the crossrange direction, the chance that debris will impact any given point within the flight corridor is based on its distance from the trajectory ground trace. Impacting the boundary of the flight corridor is considered a three-sigma event, and all points in between the trajectory ground trace and the flight corridor boundary vary linearly from zero to three-sigma.

Lastly, ACTA notes that in the risk analysis, the crossrange standard deviations are used to compute E_c. Using downrange risk models such as those found in appendix B, one can choose to vary the crossrange sigma up and down and compute the E_c as a function of sigma. Then a maximum E_c can be obtained within reasonable limits of the possible range of the crossrange sigma. This helps to eliminate the controversy about the determination of the width of the corridor. *ACTA* at 6.

The FAA agrees with ACTA in that the approach would provide a more accurate assessment of risk. If an applicant conducted such an analysis, it might consider offering the analysis as demonstrating an equivalent level of safety. However, the method appears to require an applicant to make several launch corridor computations adjusting the sigma value until an optimum value is found that produces exactly 30×10^{-6} E_c for the enclosed population. The FAA does not believe this is necessary for assessing most launch site locations, and has not adopted the suggested change. The analyses provided by the FAA are presented in a fashion that produces a binary decision. The risk computations for the populations enclosed by the corridor will either pass or fail the E_c criteria. If the resultant E_c is above the threshold the applicant can quickly decide if an azimuth or launch point adjustment will resolve the problem.

ACTA next states that the equation for casualty expectancy in appendix C contains the ratio of the casualty area to the populated area. This ratio should be limited to one, to avoid the possibility of predicting more casualties, given impact, than the number of people in the population center. *ACTA* at 6. The FAA agrees and the change is reflected in the appendix.

In the NPRM's discussion of the launch site location review, the FAA notes that for the sub-orbital launch of an unguided expendable launch vehicle, an applicant would analyze the risks associated with a series of impact dispersion areas around the impact points for spent stages. ACTA staff suggests that the FAA should also be concerned about any population centers within the three-sigma dispersions along the entire trajectory, as is done for orbital launch vehicles. *ACTA* at 8. As discussed in the NPRM, the FAA selected the event of greatest risk for guided and unguided launch vehicles. 64 FR 34353. For proven unguided launch vehicles, that risk stems from success. For purposes of assessing a launch point, the FAA does not believe it is necessary to address failures scenarios for launch points that are going to support proven unguided suborbital launch vehicles. Malfunction scenarios are discounted due to the very low probability of failure in proven unguided suborbital launch vehicles. An unguided suborbital launch vehicle will fly a wind-weighted trajectory in most cases. The impact dispersion areas for the rocket's stages account for the impact points within three-sigma probability of occurrence given the rocket does not experience a malfunction. If a launch point is to be used solely for unproven unguided suborbital launch vehicles, then an applicant must look at failure scenarios.

ACTA staff also believes the FAA should establish criteria for individual risk because it is a significant consideration needed to adequately provide protection for the public. *ACTA* at 9. The FAA does not disagree, and may revise its launch site regulations in the future. At this time, however, the FAA has decided to cover individual risk issues through a launch license, and has determined that the OEZ and other requirements are suitable for making a decision on the suitability of a launch site.

In the NPRM, in justifying the fact that stage impact is not assessed during the launch site location review for orbital launch vehicles, the FAA stated that risk calculations performed for launches from federal launch ranges demonstrate a relatively low risk posed by controlled disposition of stages in comparison to the risk posed by wide-spread dispersion of debris due to vehicle failure. ACTA suggests that this statement be tempered because risks posed by normally jettisoned Delta 2 GEMS are a significant element of concern from VAFB. *ACTA* at 9.

The FAA does not wish to imply that stage disposition is of no concern. Stage disposition is a critical safety issue and will be covered in launch license applications. However, because the location of drop zones is different for every launch vehicle, and because the launch site location review is not meant to assess specific launch vehicles, the FAA has designed the launch site location so that a launch site that does not have safe areas to dispose of stages will not likely pass the launch site location review. Significant population within the flight corridor, particularly near the flight trajectory ground trace, would raise the estimated E_c above the acceptable limit.

ACTA staff had a few comments on definitions. First, the NPRM defined ''flight corridor'' as an area on the Earth's surface estimated to contain the majority of hazardous debris from nominal and non-nominal flight of an orbital or guided suborbital launch vehicle.'' ACTA staff asked what about the other potential 49% of the debris? *ACTA* at 9. The FAA agrees that the definition should not have used the term ''majority'' and the word ''majority'' has been removed from the definition.

Second, the NPRM defined ''instantaneous impact point (IIP)'' as an impact point, following thrust termination of a launch vehicle, calculated in the absence of atmospheric drag effects.'' The definition should acknowledge that several forms of IIP calculations are possible. IIPs can be calculated based on vacuum, drag or oblateness corrections depending on the application. *ACTA* at 9, 10. The FAA agrees. The definition no longer states that it must be calculated in the absence of atmospheric drag effects. However, for purposes of part 420, IIP is calculated in the absence of atmospheric drag.

ACTA staff next commented on proposed section 420.15(b), in which the proposed rule stated ''For launch sites analyzed for expendable launch vehicles, an applicant shall provide each month and any percent wind data used in the analysis.'' ACTA at 10. For percent wind data, ACTA suggests use of mean winds. ACTA also suggests the use of a wind covariance matrix. Mean winds are called out in the launch site location review. An applicant should be able to use worse winds, e.g. three-sigma winds, if it desires. *ACTA* at 10. The FAA does not believe a statistical analysis of winds such as using a wind covariance matrix is necessary to assess a launch point. Wind covariance matrices are also not readily available from the suggested wind data source, so therefore the FAA will not incorporate the suggested changes.

Proposed section 420.23 stated that the FAA will evaluate the adequacy of a launch site location for unproven launch vehicles including all new launch vehicles, whether expendable or reusable, on a case-by-case basis. ACTA requested additional criteria. *ACTA* at 10. The FAA will rely on the goal of the launch site location review—to show that a launch vehicle can be launched safety from a given launch point. Unproven launch vehicles must be looked at carefully due to their inherently high probability of failure.

In the NPRM, the FAA proposed an overflight exclusion zone (OEZ) that an applicant must demonstrate is either unpopulated, is uninhabited at certain times, or from which the public can be excluded during launch. ACTA staff notes that using this overly conservative approach to risk analysis would likely prevent X–33 launches from the Air Force Flight Test Center (AFFTC). *ACTA* at 11. Similarly, NMOSC states that the requirement for, and specifications of, an OEZ should depend on the vehicle's reliability and whether it has multiple stages. NMOSC suggests that it not be required for a highly reliable, non-staging RLV. *NMOSC* at 3. The FAA agrees in part with ACTA and NMOSC. The size or existence of an OEZ for a reliable non-staging RLV, depends on whether any area exists around the launch point where the E_c risk is equal to or greater than 30×10^{-6}, if one member of the public is inside. An overflight exclusion zone may or may not apply to an RLV, depending on the circumstances of a particular case analyzed. The approval of a flight corridor for an RLV, such as the X–33, would be handled on a case-by-case basis.

ACTA staff noted that the appendix A launch area is based on a Delta II. ACTA states that this has several shortcomings because the families of launch vehicles based on Castor-120 SRMs, such as Athena and Taurus, are more representative of those likely to be launched from a non-federal launch site. *ACTA* at 11. The FAA notes that an appendix A launch area is large enough to encompass launch vehicles based on Castor-120 SRMs. Although turning rates for the Athena and Taurus may be higher than Delta II, this is not critical for the appendix A flight corridor lines because appendix A can accommodate the Athena and Taurus turns.

ACTA states that in the launch area, ignoring the IIP displacement caused by a vehicle's malfunction turn rates until 50,000 ft. seems unwise based on the turning potential of most ELVs, especially the Athena and Taurus. *ACTA* at 11. The debris dispersion radius accounts for a number of failure scenarios, including the IIP displacement caused by a vehicle's malfunction turn rate. The debris dispersion radius is the estimated maximum distance from a launch point that debris travels given a worst-case launch vehicle failure and flight termination at 10 seconds into flight.

Other than the debris dispersion radius, ACTA is correct in that malfunction turns and trajectory dispersions are not explicitly accounted for in the launch area computations. The FAA does not believe this is necessary to assess the viability of a launch point. In the launch area, winds are the dominant dispersion effect for low-β debris pieces, accounting for up to 70% of the total launch area dispersion effect. Conservative assumptions in the appendix B method adequately cover the remaining percentage contributions to the overall impact dispersion.

ACTA staff suggests that in the launch area, the FAA should better communicate that the 10 and 100 mile limits are based on IIP and not on present position. *ACTA* at 11. The FAA agrees and has modified appendices A and B accordingly.

ACTA staff notes that for the launch and downrange areas, an applicant is to compute P_i for each populated area using the following equation:

$$P_i = \frac{\left(\dfrac{|y_2 - y_1|}{\sigma_y}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(y_1/\sigma_y\right)^2}{2}\right) + 4 \cdot \exp\left[\frac{-\left(\dfrac{y_1 + y_2}{2\sigma_y}\right)^2}{2}\right] + \exp\left(\frac{-\left(y_2/\sigma_y\right)^2}{2}\right) \right) \cdot \left[\frac{P_f}{C} \cdot \frac{(x_2 - x_1)}{\dot{R}}\right]$$

ACTA suggests that this be replaced by the normal integral with a single footnote saying that it can be approximated using Simpson's rule. *ACTA* at 11. The FAA agrees that there are other ways to approximate the normal integral that are just as accurate as Simpson's rule. An applicant is not precluded from using other ways of computing the normal integral.

Space Access LLC also had a number of comments on the launch site location review. First, Space Access found the proposed rule difficult to accept in two areas. First, flight E_c issues should be outside the scope of site licensing and all flight-related and mission-based calculations are the responsibility of the launch operator. Providing several methods to simplify E_c is confusing, conflicting with other published guidance, and could be considered precedent setting. *Space Access* at 2. Much of what Space Access suggests is already reflected in the final rule. For individual launches, all flight-related and mission-based calculations are part of a launch operator license. The launch site location review is intended, however, to ensure that the FAA does not issue a license that cannot support the launch vehicles intended for launch from the launch site. Providing several methods to simplify E_c is meant to provide flexibility to applicants. Lastly, review of the appendices unearthed no conflicts with other published guidance.

Second, Space Access believes the proposed rule effectively precludes approval of any new commercial launch sites, because under appendix A and C, Cape Canaveral would be disapproved as a launch site for Delta, Atlas, and Titan vehicles if it were not on federal property. *Space Access* at 4. The FAA disagrees. Cape Canaveral would fail the proposed appendix A analysis but would not fail the proposed analysis under appendix B and C. The simplicity of appendix A is designed for launch sites that are in remote locations. Cape Canaveral is not a remote site.

Space Access adds that appendix B and C would not help the shortcomings of appendix A because this method uses the same casualty area numbers, which are the significant driver in the calculations. Space Access also comments that the casualty area provided in Table C–3 is too large and appendix C provided data would appear to be excessively conservative and overwhelms all other calculations. *Space Access* at 4. In response, the casualty area numbers are indeed conservative, but not excessively so. An applicant is also permitted to utilize a more refined analysis and provide a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that provided in the appendices.

Similarly, Space Access states that appendix C may only allow the approval of small launch vehicles. This will encourage more launches of small payloads and therefore increase overall risk to the public by exposing the public to a large number of launches. A normalized risk evaluation, such as risk per pound of payload, minimizes total risk and should be considered in any risk methodology. *Space Access* at 5. The FAA disagrees that the proposed appendix C allows only for the approval of small launch vehicles. Space Access offers no support for this argument.

Space Access further states that the impact of appendix C is that potential launch site operators will fail to get sufficient local and state support, financial and legislative inputs, to work through issues with the FAA and potential launch operators. The enforcement of these proposed rules at this time would negatively affect the development of new safe launch sites for all classes of launch vehicles. *Space Access* at 5. The Texas Aerospace

Commission stated that the proposed rules preclude approval of any new launch sites, which are not already on federal launch ranges. These proposed rules would stop the progress being made in Texas and other states to secure investments and commitments for the development of safe, efficient and modern commercial spaceports. *Texas Aerospace Commission* at 1. Because Space Access and Texas Aerospace Commission do not offer evidence in support of their concerns, the FAA will continue to rely on the reasons it gave in the NPRM. The launch site location review is designed to avoid licensing the operation of a launch site that cannot safely support a launch. The launch site location review should not preclude the licensing of any launch site that can safely support launches.

Space Access suggests that the FAA delete all E_c calculations from the proposed rule for site operators. It comments that the appendix A and C methodology appears to be extremely inaccurate, the appendix B and C methodology lacks the fidelity required for use by launch operators for licensing, and actual vehicle E_c data is the only valid method. *Space Access* at 5. The Texas Aerospace Commission recommends the FAA consult with the RLV developers and proposed launch site operators/developers to establish a safe, less conservative, and simple method of calculating E_c. *Texas Aerospace* at 1. The FAA disagrees, noting that the appendices are designed to offer flexibility in ascertaining whether a site is acceptable. The FAA has determined that a review of a launch site location is a necessary component of any license application process. Moreover, an applicant is not tied to the appendices. For expendable launch vehicles, the FAA will accept other analyses that provides a clear and convincing demonstration that an applicant's proposed method provides an equivalent level of safety to that provided by the appendices. For reusable launch vehicles, an applicant defines a flight corridor that contains the hazardous debris from nominal and non-nominal flight of a reusable launch vehicle. The applicant must provide a clear and convincing demonstration of the validity of its flight corridor.

Space Access states that the launch point, debris dispersion area, and overflight exclusion zone definition and descriptions are of specific concern to a site operator and should be formalized. This guidance will directly benefit potential site operators by providing clear planning and procedures to use for proper land acquisition and site development work. *Space Access* at 5. In response, the FAA agrees that providing clear planning and procedures to use for proper land acquisition and site development work is important. The primary purpose of the launch site location review is to avoid the development of launch sites that can never support launches due to the proximity of population. Note that the debris dispersion area and overflight exclusion zones are only used to assess the adequacy of a launch point to support launches. The actual hazards areas for specific launch vehicles will be determined in the launch license process.

Space Access states that the FAA should delete the discussion of launch area and downrange area from the proposed rule. According to Space Access, these areas should not be of concern to a site operator because a site operator has little or no legal control, liability or responsibility in these areas—the launch operator does. Possible demarcation of responsible areas for a site operator is when a launch vehicle enters into international airspace (100 km or 300,000 feet or the crossing of a vehicle into airspace above international waters). Another possible definition is when takeoff or liftoff occurs. *Space Access* at 6.

The FAA agrees that a launch operator is responsible for the safety of a launch. However, the purpose of the launch site location review is to assess the safety of the launch point, not the policies and procedures of a specific launch operator, and these regulations place certain responsibilities upon a launch site operator. To adequately assess the safety of a launch point, one must look at more than just the local population. Downrange activities must be considered in evaluating the acceptability of the launch location, therefore launch area and downrange area requirements remain in the final rule.

Space Access believes that current reliability data for probability of failure (P_f) should be used for the specific vehicle or class of launch vehicles under consideration. *Space Access* at 6. The FAA would like to point out that an applicant may use probability values that reflect the type of launch vehicle it intends on launching from the launch point. The value must be reasonable. A good value should have a 95% confidence that the actual P_f is equal to or less than the value used.

Space Access believes that all commercial launches should be treated equally from any location. The FAA should not exempt commercial site operators from these rules at federal ranges. No benefits are provided by a federal launch range exemption to these rules. The perception by new commercial launch operators and new commercial site operators is they are being held to a higher standard. *Space Access* at 7; *see also Texas Aerospace* at 1 (all commercial launches should be treated equally from any location). In response, commercial site applicants at federal ranges are not exempted from all requirements of the final rule. If a launch point has already supported a launch of a particular class of launch vehicle, there is no reason for an applicant to repeat a demonstration already made.

Space Access recommends the FAA provide proposed universal rules applicable to all launch sites, i.e. for RLVs and ELVs, as soon as possible instead of making rules applicable only to ELVs. *Space Access* at 7. Similarly, NMOSC believes that since the focus of the launch site location review is expendable launch vehicles, the FAA does not see RLVs as credible launch vehicles. *NMOSC* at 2. In response, the basic public safety goals are the same for ELVs, RLVs, and reentry vehicles. In other words, the level of safety that is required by the FAA is universal. However, the means to achieve public safety with an RLV mission may be different from an ELV mission. The credibility of RLV's is not at issue here. The reason the FAA has well defined methods of assessing a launch site for expendable launch vehicles is because 40 years of empirical data exists to define such methods.

Space Access lastly states that the unproven vehicle exclusion is unjustified. The FAA should provide a clear definition of unproven vehicles. *Space Access* at 7. The FAA has asked the RLV industry for suggestions on what definition they might suggest. Space Access does not provide a suggestion. There are a number of factors that the FAA has considered in whether to provide a precise definition to the term ''unproven.'' NASA, for example, does not consider a vehicle's demonstrated reliability adequate for placing a NASA payload on the vehicle, unless the vehicle has flown at least 14 times. Another approach might be to examine the flight history as an ''unproven'' vehicle and determine that statistical point in which the probability of catastrophic failure can be shown to be equal to or less than some number at the 95% confidence level. Historically, the flights of new vehicles have demonstrated failure rates much higher than design analyses indicated. The data presented for use in the final rule is specifically based on mature vehicles. For these reasons and its concern for public safety, the FAA will address unproven vehicles on a case-by-case basis based on the facts available.

NMOSC also had many comments on the launch site location review. First, for the most part, NMOSC states that the draft requirements do not adequately address the launch of RLVs or unproven vehicles, and is concerned that an operator could spend a lot of money and time preparing an application, only to find that the application is incomplete or the site unacceptable. The FAA should provide more in the way of guidelines for RLV-only sites. *NMOSC* at 1.

The FAA disagrees that an RLV operator has to guess what the FAA will look for in a license application. The FAA's flight safety goals are clear—the risk to the public must be at an acceptable level, that is, an expected casualty of less than or equal to 30×10^{-6}. What is acceptable for RLVs is described in the rule concerning reentry. 65 FR 56617.

The flight safety approach for RLVs and ELVs are different, so naturally a launch point suitable for a RLV may not be suitable for an ELV. The reason the FAA has articulated clear methods of assessing a launch site for ELVs is because 40 years of empirical data exists to promulgate such methods.

In the NPRM, the FAA stated that references to a guided launch vehicle, whether orbital or sub-orbital, may be taken to mean that the vehicle has an FTS. References to an unguided sub-orbital could be understood to mean that the vehicle does not possess an FTS. NMOSC believes that this does not accommodate RLVs very well. *NMOSC* at 2. In response, the FAA did not mean to imply that RLV's would have to have an FTS. This applies only to guided ELV's. The final rule has been modified to clarify this point.

In the NPRM, the FAA stated, as an example, that because a launch licensee will need to assure the adequacy of ground tracking, approval of ground tracking systems will be handled in the launch license process even if a launch site operator provides the service. NMOSC asks what about tracking from space? *NMOSC* at 2. Tracking systems were not a subject of the NPRM. The FAA was only pointing out that flight safety services such as tracking will be assessed for a launch license, not for a launch site operator license. No implication was intended about how tracking is accomplished.

In the NPRM, the FAA states that for the ''semi-automated method'' of plotting on maps, the ''Mercator'' and ''Oblique Mercator'' are adequate cylindrical projections, the ''Lambert-Conformal'' and ''Albers Equal-Area'' are adequate conic projections, and the ''Lambert Azimuthal Equal-Area'' and ''Azimuthal Equidistant'' are adequate plane projections. An applicant may use other maps, but the applicant would be required to demonstrate an equivalent level of accuracy over the required distances. NMOSC suggest the FAA provide clarification on ''equivalent level of accuracy over the required distances.'' *NMOSC* at 2.

As noted in the NPRM, all map projections have inherent distortions. The distortions are virtually unavoidable and are directly related to the techniques for displaying latitude and longitude lines on a flat surface area. The flight corridor methods are primarily sensitive to azimuthal direction and geodetic length of the flight corridor line segments. The launch site location review methods require an applicant to use cylindrical, conic, and plane map projections because they produce only small error with straight-line measurements. Therefore, ''equivalency'' would be based on how well the applicant-proposed map projection preserves the accuracy of scale and direction.

NMOSC suggests the FAA provide corridor standards for vehicles that do not employ destructive termination. *NMOSC* at 3. The FAA disagrees. A flight corridor is a means of defining the population that is at risk due to a launch. Destructive flight termination is not specifically ingrained in the standard provided. The appendices provided corridor standards for ELV's because reliable flight termination systems allow one to determine the worse-case reach of debris due to a failure. Corridors for RLV's are not as straightforward, and are dependent on the technology involved. That is why the FAA has opted for a case-by-case approach. What is of interest are all failures that could lead to exposure of the uninvolved public. Note that a final rule has been published with standards for the operation of RLVs and reentry vehicles. 65 FR 56617.

NMOSC notes that failure probability is a big issue for both this and the RLV NPRM, suggesting that ninety percent (90%) reliability is way too low for an RLV. For purposes of site licensing, NMOSC suggests no lower than ninety nine percent (99%) reliability be assumed for the analyses; this is the proven reliability of the Space Shuttle. *NMOSC* at 3. The FAA disagrees. There are accepted ways to estimating the design reliability of a vehicle and for proving what the reliability is. Unfortunately, historically, design reliability has never been achieved during the first flights of any new vehicle. Proof comes only through verification and validation with empirical flight data. There is no basis for the statement that 90% is too low for an RLV. This number may be well below intended design reliability, but 99% reliability has never been shown for any new RLV. The Shuttle's historic data does not support a value of 99% at any reasonable confidence level. At a 95% confidence level, the shuttle's demonstrated reliability is only about 97%. In any case, RLV flight safety standards are covered in the final rule for RLVs and reentry operations. 65 FR 56617.

Christopher Shove, Ph.D., Senior Consultant, Space Data Systems, Inc, states that for some launch vehicles, the proposed failure rate of 10% is five times greater than those vehicles' historical failure rate. The FAA should use actual failure rates and double them for conservatism. The proposed constant failure rate creates an unfair playing field among different vehicle types by lumping them into one category. *Shove* at 2. The FAA disagrees that for some launch vehicles, the proposed failure rate of 10% is five times greater than those vehicles' historical failure rate. No vehicle has a failure rate of 2% at any reasonable confidence level. The failure rate of 10% was chosen to find an acceptably conservative value while not overly penalizing seasoned launch vehicles. The seasoned launch vehicles currently have failure rates ranging from 2.5% for Ariane to 6.4% for Proton. Doubling any failure rate exceeding 5% would burden the industry by adding unnecessary conservatism at a 95% confidence level.

In the NPRM, after an applicant has computed casualty expectancy for a flight corridor, the proposed regulations required that it be multiplied by a safety factor of two. NMOSC suggested that the FAA eliminate the safety factor and set the standard at 15×10^{-6}. *NMOSC* at 3. As noted above in the summary section, the multiplier has been taken out in the final rule.

NMOSC states that appendix C seems to favor coastal sites because appendix C provides the option for an applicant to further simplify the estimation of casualty expectancy by making worst-case assumptions that would produce a higher value of the corridor E_C compared with the analysis defined in appendix C, subparagraphs (c)(1)–(8). *NMOSC* at 3. The FAA disagrees. The simplifying options in the appendices were directed at launch sites that are remote enough that they pass a test that is simple but extremely conservative. This does not preclude other launch sites. The FAA's concern is that it be demonstrated that operations can be conducted safely from the site. If circumstances are such that it is easier for one site to make this demonstration than another, so be it.

Lastly, NMOSC commented on the proposed requirement that at least two days prior to flight of a launch vehicle, the licensee shall notify local officials and all owners of land adjacent to the launch site of the flight schedule. This should not be required for highly reliable, non-staging RLVs. If it is, what methods of notification are acceptable? *NMOSC* at 3. In response, when RLV's begin to have routine operations that make this requirement unworkable, the FAA will reevaluate the requirement. The intent will remain unchanged, however, which is to ensure that the local community has reasonable notice of upcoming launch activity to make any necessary preparations.

Mr. Shove noted that the FAA states that the proposed rule would allow the FAA to disapprove any launch site request because the applicant could not prove it is safe, which proof, according to scientific method, is impossible. *Shove* at 1. The FAA disagrees. Launch activities take place today from sites that clearly meet these standards. The final rule articulates an objective standard that is quite possible to demonstrate. The FAA is not free to arbitrarily turn down a launch site application. The potential operators of a launch site must demonstrate that operations can be safely conducted from the site. It the applicant can not, then the FAA will not issue a license.

He also questioned whether the FAA definition of sub-orbital launch vehicle would include the vehicles used in programs such as ''Rockets for Schools,'' and thus require those states, schools, and launch areas to apply for a launch site operator license. *Shove* at 2. Such sites would not. If a launch meets the definition of amateur rocket activity, no launch license is required. Similarly, launch sites that support such vehicles do not require a license.

Mr. Shove also states that the U.S. Census Bureau's TIGER files provide the data to create census block polygons. The FAA should allow the use of such data to calculate populated areas, so that greater accuracy can be obtained. Calculating populated areas by block groups may give an inaccurately high population estimate to the detriment of what could be a safe launch area and flight trajectory. *Shove* at 2.

The FAA would like to stress that an applicant is always free to use a more accurate method. The method in the NPRM requires that population be at least at a census block group level. It does not preclude more accurate data. The launch site location review is written so that census block groups are the largest size populated area allowed. An applicant may certainly use census block polygons, which are smaller and therefore allow for a higher fidelity analysis.

Lastly, Mr. Shove commented on the appendix B requirement that an applicant obtain the launch point geodetic latitude on the WGS–84 ellipsoidal Earth model. An applicant may do this using the Global Positioning System. His question is whether this means the single receiver accuracy of ±100 meters, differential GPS with two receiver accuracy of less than a meter, or differential GPS using a base station and a receiver accuracy of ±10 cm? *Shove* at 2.

The launch site location review requires the launch area map scale to be ''not less than 1:250,000 inches per inch.'' An applicant is required to show that the measurement instruments provide the required accuracy. Latitude and longitude can be mechanically measured to four decimal point accuracy on that scale map. Four decimal point accuracy in degrees latitude/longitude at the equator is approximately 36 feet [11 meters].

The Oklahoma Aeronautics and Space Commission (OASC) had one comment on the launch site location review. It requests clarification on what constitutes sounding rockets. There is great variance in the capability of sounding rockets and the altitudes they reach. OASC recommends classification based on altitude and propellant utilized. *Oklahoma Aeronautics and Space Commission* at 1.

A sounding rocket is a common term for suborbital launch vehicles. These final rules adopted today do not use that term. However, suborbital launch vehicles are defined, and mean exactly what their name implies—launch vehicles that do not obtain orbital velocity. The FAA used altitude in the NPRM to classify sounding rockets, but not propellant. The type of propellant used by a sounding rocket was not used as a factor because it is not an important consideration for purposes of the launch site location review.

Don A. Nelson commented that the proposed rules do not specifically address the flight testing of launch vehicles from a proposed launch site. He believed that the FAA must establish an experimental flight-testing category for flights from launch sites under FAA jurisdiction. Anything less would subject the public to very high risks. This is because, historically, all launch vehicles during the flight test period have experienced catastrophic in-flight failures. This unacceptable failure rate requires that all population, including ground and air traffic, be removed from the areas defined by the instantaneous impact points of the nominal and worst-case dispersed trajectories of the flight test vehicle. The flight test corridor must be free of all-high value property and hazardous storage areas. White Sands Missile Range (WSMR) has set the standard for testing experimental launch vehicles within the continental United States. WSMR requires population be removed from the test range, and all ground and air traffic in the test range is prohibited during the flight test. *Don A. Nelson* at 1.

The FAA agrees that the flight safety issues of an unproven vehicle are valid concerns and addresses the issue in the rulemaking governing reentry. 65 FR 56617. Note that the FAA's intent is to ensure that all operations conducted on a launch site are done so in a manner that protects public health and safety and safety of property. The FAA does not intend to allow experimental flight testing under any circumstance which places the public at greater risk. This may mean that the proposed operations are restricted or limited in scope in order to ensure public safety is achieved. These issues will be covered in a launch license application review process.

Kistler Aerospace Corporation commented that treating RLV's on a case-by-case manner is the proper approach and fully justified in light of the new capabilities and operational concepts that will be brought to the industry by reusable launch systems. *Kistler* at 1.

G. License Conditions

Subpart C contains standard terms and conditions of a license. It covers such items as the need for a licensee to operate a launch site in accordance with the representations contained in its license application, the duration of a license, transfer of a license, license modification, and compliance monitoring.

A license may also contain conditions flowing from the various reviews conducted during the application process. For example, a license granted following approval of a launch site location is limited to the launch points analyzed, and the type and class of launch vehicle used in the demonstration of site location safety. An applicant may choose to analyze all three types of launch vehicles in its application. An FAA launch site operator license authorizing the operation of a launch site for launch of an orbital expendable launch vehicle allows the launch of vehicles from the site that were less than or equal to the class of launch vehicle, based on payload weight, used to demonstrate the safety of the site location. If a licensee later wanted to offer the launch site for the launch of a larger class of vehicles or a different type of launch vehicle, such as an unguided sub-orbital launch vehicle, the licensee would be required to request a license modification and demonstrate that the larger vehicle or different type of vehicle could be safely launched from the launch site. Likewise, the addition of a new launch point would require a license modification. The demonstration would be based on the same kinds of analyses used for the original license. In some cases, a licensee might be able to use the safety analyses performed by a launch operator to meet location review requirements.

Discussion of Comments

The agency did not receive any specific comments on the conditions of a license but one change was made in this area between the final rule and the Launch Site NPRM. The section on license modifications has been changed to clarify that changes in operations require prior approval of the FAA

H. Operational Responsibilities

The FAA is imposing certain operational responsibilities on an operator of a launch site. In addition, the FAA distinguishes between activities covered by a license to operate a launch site and those covered by a launch license. Any activity that will be approved as part of a launch license will not be covered in a launch site operator license even if the launch site operator provides the service. For example, because a launch licensee will need to ensure the adequacy of ground tracking, approval of ground tracking systems will be handled in the launch license process even if a launch site operator provides the service. Similarly, in the case of ground safety, a launch site operator may provide fueling for a launch licensee, but safe procedures for fueling will be addressed in the launch license.

The operational requirements being adopted for the operator of a launch site addresses control of public access, scheduling of operations at the site, notifications, recordkeeping, launch site accident response and investigation, and explosive safety. A launch site operator licensee is required to control access to the site. Security guards, fences, or other physical barriers may be used. Anyone entering the site must, on first entry, be informed of the site's safety and emergency response procedures. Alarms or other warning signals are required to alert persons on the launch site of any emergency that might occur when they are on site. If a launch site licensee has multiple launch customers on site at one time, the licensee must have procedures for scheduling their operations so that the activities of one customer do not create hazards for others.

An operator of a launch site has responsibilities regarding explosives, specifically, those dealing with lightning and electric power lines.

The launch site operator is responsible for all initial coordination with the appropriate FAA regional office having jurisdiction over the airspace where launches will take place as well as the U.S. Coast Guard. The FAA's Air Traffic Service and, if applicable the Coast Guard, issues Notices to Airmen and Mariners, respectively, to ensure that they avoid hazardous areas. An FAA Air Route Traffic Control Center also closes airways during a launch window, if necessary. A launch site operator is required to obtain an agreement regarding procedures for coordinating contacts with these agencies for launches from the site. The requirement for coordinating with the Coast Guard might not, of course, always be applicable, for example, for an inland launch site.

The regulatory text has been changed from the Launch Site NPRM to clarify that the Coast Guard and FAA agreements must be completed during the application process, and must be complied with during the term of the license.

A launch site operator licensee must also notify local officials with an interest in the launch. These include officials with responsibilities that might be called into play by a launch mishap, such as fire and emergency response personnel.

A launch site operator is required to develop and implement a launch site accident investigation plan containing procedures for investigating and reporting a launch site accident. This extends similar reporting, investigation and response procedures currently applicable to launch related accidents and incidents to accidents occurring during ground activities at a launch site.

The FAA did not propose the definition of mishap in the Launch Site NPRM. The definition that currently exists in section 401.5 was modified to include launch site accidents.

Of more significance, the accident investigation plan section has been modified to require a licensee to participate in an investigation of a launch accident for launches launched from the launch site, and to cooperate with FAA or National Transportation Safety Board (NTSB) investigations of a launch accident for launches launched from the launch site. This was added because launch mishaps may have a connection with the launch site.

Discussion of Comments

In the NPRM, the FAA stated that a launch site operator is responsible for ground and flight safety under its FAA license, and that the FAA would revisit ground safety issues in its development of rules for launches from non-federal launch sites. ACTA staff noted that ground safety issues are equally critical to this rule because it requires an explosive site plan. *ACTA* at 8. The New Mexico Office for Space Commercialization (NMOSC) suggested that it should be a site operator's responsibility to ensure that procedures are in place to preclude human error accidents involving explosive materials and static discharge events. *NMOSC* at 1.

The FAA disagrees. Most ground safety issues are directly related to operations of a launch operator, not those of a launch site operator. Requirements addressing ground safety procedures are more appropriate requirements for launch operators, since launch operators conduct these types of hazardous operations. Most other risks and phenomena associated with pre-flight operations are typically mitigated by restrictions on the operations. That said, however, nothing precludes a launch site operator from imposing additional requirements on customers on the facility as long as those requirements do not violate FAA requirements or other laws.

NMOSC made the point that ground safety issues would be better left to other agencies such as OSHA, ATF, and state licensing organizations. Vast quantities of liquid oxygen (LO_2), liquid hydrogen (LH_2), and nitrogen tetroxide (N_2O_4), and other materials are shipped and used in interstate commerce. Why single out the launch industry for special regulations? *NMOSC* at 1. The FAA agrees in principal, and has attempted to only add requirements where those other agency regulations do not apply.

LMC had comments concerning whether the proposed requirements might affect launch operators performing services at commercial launch sites, and whether the requirements are consistent with ground and flight safety requirements imposed on launch operators by DOD and NASA at federal launch ranges. The Air Force tailors the standards set forth in EWR 127–1 to each operator prior to such operator entering the federal range for the purposes of conducting launch activities. LMC strongly recommends that the FAA, like the Air Force, employ a case-by-case tailoring of the standards. *NMOSC* at 2.

In response, the FAA has two comments. First, requirements for launch operators are covered in a separate proposal on licensing and safety requirements for launch. Second, for launch site operators, the rules that the FAA is adopting today should be general enough to fit most launch site scenarios. The FAA recognizes, however, that there may be more than one way of meeting a requirement. That is why a prospective applicant is required to consult with the FAA, in accordance with 14 CFR 413.5, before submitting an application. Early consultation enables an applicant to identify unique approaches to meeting regulatory requirements. The FAA and an applicant can then work together to resolve such issues.

The 45SW/SESE commented on the Accident Investigation Plan requirements. It asks what agency or agencies will have responsibility to maintain accident investigation reports and why? *45SW/SESE* at 2. If a launch site accident occurs, the NTSB or FAA will investigate, and will maintain an investigation record. A launch site operator may also conduct an investigation of its own, and will be responsible for maintaining the investigation record in accordance with section 420.61.

ACTA also had comments on the Accident Investigation Plan requirements and suggests that the definition of ''launch site accident'' be clarified by either deleting ''ground'' or changing the definition of ''launch site accident'' to read ''ground or launch activity.'' The NPRM defined ''launch site accident'' as ''an unplanned event occurring during a ground activity at a launch site resulting in a fatality or serious injury (as defined in 49 CFR 830.2) to any person who is not associated with the activity, or any damage estimated to exceed $25,000 to property not associated with the activity.'' *ACTA* at 10. The FAA does not agree with ACTA suggestion. A launch site accident is strictly one that occurs during a ground activity. An accident caused by the flight of a launch vehicle is a launch accident, as defined in 14 CFR 401.5.

LMC commented on the Accident Investigation Plan requirements, requesting clarification of whether the launch site operator or the launch operator accident investigation plans have priority if there were conflicts between plans. *LMC* at 4.

The FAA offers the following guidance. Although no accident investigation plan has priority per se, the applicability of an accident investigation plan depends on the nature of a mishap. Compared to the NPRM, the definition of mishap has been changed in this final rule to accord with another rule governing reentry. 65 FR 56617. A mishap is now defined in section 401.5 as a launch or reentry accident, launch or reentry incident, launch site accident, failure to complete a launch or reentry as planned, or an unplanned event or series of events resulting in a fatality or serious injury (as defined in 49 CFR 830.2), or resulting in greater than $25,000 worth of damage to property. The purpose of this definition is to encompass all incidents that must be reported, responded to, or investigated in some manner by a launch operator, a reentry operator, or launch site operator.

At a launch site operated under an FAA license, the launch site operator would have a launch site accident investigation plan and each launch operator on the launch site would have an individual launch accident investigation plan. Each plan would cover different mishaps, although there is some overlap, as discussed below. Table 4 is also provided as a guide.

A launch site operator's launch site accident investigation plan covers launch site accidents only. A launch site accident is an unplanned event occurring during a ground activity at a launch site resulting in a fatality or serious injury to any person who is not associated with the activity, or any damage estimated to exceed $25,000 to property not associated with the activity. In other words, if a member of the public is injured or property belonging to a member of the public over $25,000 is damaged due to a ground activity on the launch site, a launch site operator must report, respond to, and investigate the mishap. The FAA considers any licensee or its employees, or any licensee customer, contractor, or subcontractor or the employees of any of these persons to be associated with a ground activity. Property not associated with the activity will typically include any property belonging to members of the public. Property associated with the activity includes the property of a launch site operator or launch licensee, or either licensee's customers, contractors or subcontractors.

A launch operator's launch accident investigation plan, on the other hand, covers launch accidents, launch incidents, and other mishaps. Launch accidents and launch incidents are strictly related to the flight of a launch vehicle, not ground activities. So, for launch accidents and launch incidents, there is no overlap with launch site operator reporting requirements.

Where there is overlap in launch operator and launch site operator accident investigation plans is when a mishap occurs on the ground. A launch operator must notify the FAA immediately in the event of a mishap that involves a fatality or serious injury, and within 24 hours in the event of a mishap that does not involve a fatality or serious injury. The person injured does not have to be a member of the public. Also, a launch operator must notify AST or the Washington Operations Center within 24 hours in the event damage is estimated to exceed $25,000 to property not associated with the activity.

In summary, both a launch site operator and a launch operator must report, respond to, and investigate a mishap occurring during a ground activity at a launch site resulting in a fatality or serious injury to any person who is not associated with the activity, or any damage estimated to exceed $25,000 to property not associated with the activity. The reason this type of mishap is covered by both plans is that both a launch site operator and launch operator have a responsibility to protect the public from hazardous ground activities. Note, however, that either the launch site or launch operator may agree to lead one investigation for both.

TABLE 4.—MISHAP INVESTIGATIONS

Event	Launch operator reporting requirement (14 CFR 415.41(b))	Launch site operator reporting requirement (14 CFR 420.59(b))
Launch accident—an unplanned event occurring during the flight of a launch vehicle resulting in the known impact of a launch vehicle, its payload or any component thereof outside designated impact limit lines; or a fatality or serious injury (as defined in 49 CFR 830.2) to any person who is not associated with the flight; or any damage estimated to exceed $25,000 to property not associated with the flight that is not located at the launch site or designated recovery area.	Immediate notification to the Federal Aviation Administration (FAA) Washington Operations Center	None.
Launch incident—an unplanned event occurring during the flight of a launch vehicle, other than a launch accident, involving a malfunction of a flight safety system or failure of the licensee's safety organization, design or operations.	Immediate notification to the Federal Aviation Administration (FAA) Washington Operations Center	None.
Launch site accident—an unplanned event occurring during a ground activity at a launch site resulting in a fatality or serious injury (as defined in 49 CFR 830.2) to any person who is not associated with the activity, or any damage estimated to exceed $25,000 to property not associated with the activity.	Immediate notification to the Federal Aviation Administration (FAA) Washington Operations Center in the event of a fatality or serious injury. Notification within 24 hours to AST or the Washington Operations Center in the event of damage estimated to exceed $25,000 to property not associated with the activity	Immediate notification to the Federal Aviation Administration (FAA) Washington Operations Center.
Other Mishap*: • Failure to complete a to launch as planned. • An unplanned event or series of events resulting in a fatality or serious injury to any person who is associated with the activity. • An unplanned event or series of events resulting in greater than $25,000 worth of damage to a payload, a launch vehicle, a launch support facility or government property located on the launch site.	Immediate notification to the Federal Aviation Administration (FAA) Washington Operations Center in the event of a fatality or serious injury Notification within 24 hours to AST or the Washington Operations Center in the event of failure to complete a launch as planned, or greater than $25,000 worth of damage to a payload, a launch vehicle, a launch support facility or government property located on the launch site.	None.

*Mishap means a launch or reentry accident, launch or reentry incident, launch site accident, failure to complete a launch or reentry as planned, or an unplanned event or series of events resulting in a fatality or serious injury (as defined in 49 CFR 830.2), or resulting in greater than $25,000 worth of damage to property.

IV. Part Analysis

Part 401—Organization and Definitions

Section 401.5 contains definitions of significant terms used in all of Chapter III. The term ''mishap'' has been revised to include launch site accidents as part of the definition of mishap. The term ''mishap'' is a general term for all unplanned events at a launch site or that occur during a launch or reentry resulting in injury, or damage to or loss of equipment or property. Mishaps include but are not limited to launch or reentry accidents, launch or reentry incidents, and launch site accidents. Mishaps also include failure to complete a launch or reentry as planned, or an unplanned event or series of events resulting in a fatality or serious injury (as defined in 49 CFR 830.2), or resulting in greater than $25,000 worth of damage to property.

Part 417—License to Operate a Launch Site

The FAA removes and reserves part 417 and creates part 420 to address licensing and safety requirements for operation of a launch site.

Part 420—License to Operate a Launch Site

Section 420.1 describes the scope of part 420. Part 420 encompasses the information and demonstrations that must be submitted as part of a license application, the bases for license approval, license terms and conditions, and post-licensing requirements with which a licensee must comply to remain licensed.

Section 420.3 specifies the person who must apply for a license to operate a launch site, and the person who must comply with regulations that apply to a licensed launch site operator. Because a launch site operator is someone who offers a launch site to others for launch, only someone proposing such an offer need obtain a license to operate a launch site. A launch operator proposing to launch from its own launch site need only obtain a launch license because a launch license will address safety issues related to a specific launch and because a launch license will encompass ground operations. In response to comments, as discussed earlier, a person operating a launch site that only supports amateur rocket activities does not need a license under part 420.

Section 420.5 adds terms that have not been previously defined by the FAA. These definitions apply in the context of part 420, which governs the licensing and safety requirements for operation of a launch site. These terms do not apply outside part 420. Specifically, the following terms are defined. Unless otherwise noted, they remain unchanged from the definitions proposed in the Launch Site NPRM.

Ballistic Coefficient (β) means the weight (W) of an object divided by the quantity product of the coefficient of drag (C_d) of the object and the area (A) of the object.

$$\beta = \frac{W}{(C_d \cdot A)}$$

A ballistic coefficient is a parameter used to describe flight characteristics of an object.

Compatibility means the chemical property of materials that may be located together without adverse reaction. Compatibility in storage exists when storing materials together does not increase the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident. Compatibility determines whether materials require segregation.

Debris dispersion radius (D_{max}) means the estimated maximum distance from a launch point that debris travels given a worst-case launch vehicle failure and flight termination early in flight. For an expendable launch vehicle, flight termination is assumed to occur at 10 seconds into flight. No assumptions are made for reusable launch vehicles. If an expendable launch vehicle failure occurs shortly after ignition, and a flight termination system is employed, the FAA expects the debris to be contained within an area described by D_{max}.

Downrange area means a portion of a flight corridor beginning where a launch area ends and ending 5,000 nautical miles (nm) from the launch point for an orbital launch vehicle, and ending with an impact dispersion area for a guided sub-orbital launch vehicle.

E,F,G coordinate system means an orthogonal, Earth-fixed, geocentric, right-handed system. The origin of the coordinate system is at the center of an ellipsoidal Earth model. The E-axis is positive directed through the Greenwich meridian. The F-axis is positive directed though 90 degrees east longitude. The EF-plane is coincident with the ellipsoidal Earth model's equatorial plane. The G-axis is normal to the EF-plane and positive directed through the north pole.

E,N,U coordinate system means an orthogonal, Earth-fixed, topocentric, right-handed system. The origin of the coordinate system is at a launch point. The E-axis is positive directed east. The N-axis is positive directed north. The EN-plane is tangent to an ellipsoidal Earth model's surface at the origin and perpendicular to the geodetic vertical. The U-axis is normal to the EN-plane and positive directed away from the Earth.

Effective casualty area (A_c) means the aggregate casualty area of each piece of debris created by a launch vehicle failure at a particular point on its trajectory. The effective casualty area for each piece of debris is the area within which 100 percent of the unprotected population on the ground are assumed to be a casualty, and outside of which 100 percent of the population are assumed not to be a casualty. This area is based on the characteristics of the debris piece including its size, the path angle of its trajectory, impact explosions, and debris skip, splatter, and bounce. An effective casualty area also accounts for the size of a person.

Explosive means any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, detonation or other suitable initiation, undergoes a rapid chemical change that releases large volumes of highly heated gases that exert pressure in the surrounding medium. The term applies to materials that either detonate or deflagrate.

Explosive division has also been added since the Launch Site NPRM and means the hazard class 1 division of an explosive as defined by the United Nations Organization classification system for transport of dangerous goods, and as determined in accordance with 49 CFR part 173, subpart C. The term ''division 1.3 explosive'' was proposed but not adopted because the general terms for hazard class and explosive division have been added instead.

Explosive equivalent means a measure of the blast effects from explosion of a given quantity of material expressed in terms of the weight of trinitrotoluene (TNT) that would produce the same blast effects when detonated.

Explosive hazard facility means a facility at a launch site where solid propellant, liquid propellant, or other explosives are stored or handled. This term has been slightly modified from the Launch Site NPRM to include other explosives other than propellants.

Flight azimuth means the initial direction in which a launch vehicle flies relative to true north expressed in degrees-decimal-degrees. For example, due east is 90 degrees.

Flight corridor means an area on the Earth's surface estimated to contain the hazardous debris from nominal flight of a launch vehicle, and non-nominal flight of a launch vehicle assuming a perfectly functioning flight termination system or other flight safety system. This has been changed from the Launch Site NPRM in two respects. The proposed definition included the phrase ''contain the majority of hazardous debris'' which, as discussed in the comment section, is incorrect. The new definition also makes clear that the flight corridor is based on a perfectly functioning flight termination system.

Guided sub-orbital launch vehicle means a sub-orbital rocket that employs an active guidance system.

Hazard class has been added since the NPRM and means the class of dangerous good defined by the United Nations Organization classification system for transport of dangerous goods, and as determined in accordance with 49 CFR part 173, subpart C.

Impact dispersion area means an area representing an estimated three standard deviation dispersion about a nominal impact point of an intermediate or final stage of a sub-orbital launch vehicle.

Impact dispersion factor means a constant used to estimate, using a stage apogee, a three standard deviation dispersion about a nominal impact point of an intermediate or final stage of a sub-orbital launch vehicle. Intermediate stages include all stages up to the final stage.

Impact dispersion radius (R_i) means a radius that defines an impact dispersion area. It applies to all launch vehicle stages.

Impact range means the distance between a launch point and the impact point of a sub-orbital launch vehicle stage.

Impact range factor means a constant used to estimate, when multiplied by a stage apogee, the nominal impact point of an intermediate or final stage of a suborbital launch vehicle.

Instantaneous impact point (IIP) means an impact point, following thrust termination of a launch vehicle. IIP may be calculated with or without atmospheric drag effects. This is a change from the Launch Site NPRM. The NPRM limited the definition to a vacuum IIP. Note that the analyses of part 420 use vacuum IIP.

Instantaneous impact point (IIP) range rate means a launch vehicle's estimated IIP velocity along the Earth's surface. It is typically abbreviated as R, or R-dot.

Intraline distance means the minimum distance permitted between any two explosive hazard facilities in the ownership, possession or control of one launch site customer. Intraline distance prevents the propagation of an explosion. In other words, with an appropriate intraline distance, an explosive mishap at one explosive hazard facility would not cause an explosive event at another explosive hazard facility. The FAA anticipates that worker safety requirements will dictate protection of employees and anticipates that all licensees will familiarize themselves with those requirements and conform to them in accordance with the law. Unlike distances used to protect the public, intraline distance will not offer workers the same level of protection as the public.

Launch area means, for a flight corridor defined in accordance with appendix A, the portion of a flight corridor from the launch point to a point 100 nm in the direction of the flight azimuth. For a flight corridor defined in accordance with appendix B, a launch area is the portion of a flight corridor from the launch point to the enveloping line enclosing the outer boundary of the last debris dispersion circle.

Launch point means a point on the Earth from which the flight of a launch vehicle begins, and is defined by the point's geodetic latitude, longitude and height on an ellipsoidal Earth model.

Launch site accident means an unplanned event occurring during a ground activity at a launch site resulting in a fatality or serious injury (as defined in 49 CFR 830.2) to any person who is not associated with the activity, or any damage estimated to exceed $25,000 to property not associated with the activity. The FAA considers any licensee or its employees, or any licensee customer, contractor, or subcontractor or the employees of any of these persons to be associated with a ground activity. Property not associated with the activity will typically include any property belonging to members of the public or personal property of employees. Property associated with the activity includes the property of a launch site operator or launch licensee, or either licensee's customers, contractors or subcontractors.

Net explosive weight (NEW) means the total weight, expressed in pounds, of explosive material or explosive equivalency contained in an item. This term is used for applying Q-D criteria to solid propellants and other explosives, and for liquid propellants when explosive equivalency applies. Explosive equivalency applies to liquid propellants when a liquid fuel and a liquid oxidizer are close enough together that their explosive potential combined must be used when determining prescribed distances to the public.

Nominal means, in reference to launch vehicle performance, trajectory, or stage impact point, a launch vehicle flight where all launch vehicle aerodynamic parameters are as expected, all vehicle internal and external systems perform as planned, and there are no external perturbing influences (*e.g.*, winds) other than atmospheric drag and gravity.

Overflight dwell time means the period of time it takes for a launch vehicle's IIP to move past a populated area. For a given populated area, the overflight dwell time is the time period measured along the nominal trajectory IIP ground trace from the time point whose normal with the trajectory intersects the most uprange part of the populated area to the time point whose normal with the trajectory intersects the most downrange part of the populated area.

Overflight exclusion zone means a portion of a flight corridor, which must remain clear of the public during the flight of a launch vehicle.

Populated area means a land area with population. For a part 420 site location risk analysis of a populated area within the first 100 nm of a launch point, a populated area is no greater than a census block group in the United States, and an equivalent size outside the United States. For analysis of a part 420 flight corridor more than 100 nm downrange from the launch point, a populated area is no greater than a 1° x 1° latitude/longitude grid, whether the populated area is in the United States or not.

Population density means the number of people per unit area in a populated area.

Position data means data referring to the current position of a launch vehicle with respect to time using the x, y, z coordinate system.

Public means people or property that are not involved in supporting a licensed launch, and includes those people and property that may be located within the boundary of a launch site, such as visitors, any individual providing goods or services not related to launch processing or flight, and any other launch operator and its personnel. This is a new definition and was added to clarify how the FAA defines the public.

Public area means any area outside a hazard area, and is an area that is not in the possession, ownership or other control of a launch site operator or of a launch site customer who possesses, owns or otherwise controls that hazard area. For purposes of Q–D criteria, the final rules treat any location outside a launch site boundary as a public area for any activity at a launch site. Certain areas within a launch site are also considered public areas for purposes of applying Q–D criteria. For any given launch operator, areas where other launch operators are located are public areas.

Public area distance means the minimum separation distance permitted between a public area and an explosive hazard facility.

Public traffic route distance means the minimum distance permitted between a public highway or railroad line and an explosive hazard facility. This is a new definition. It was necessary to add the definition because explosive division 1.1 explosives were added to the explosive safety requirements. The distance requirements for explosive division 1.1 explosives differentiate between public traffic routes and inhabited buildings, a differentiation not made for explosive division 1.3 explosives.

Trajectory means the position and velocity components as a function of time of a launch vehicle relative to an x, y, z coordinate system, expressed in x, y, z, *x*, *y*, *z*. The *x, y, z* coordinates describe the position of the vehicle both for projecting the proposed flight path and during actual flight. The *x*, *y*, *z* variables describe the velocity of the vehicle.

Unguided sub-orbital launch vehicle means a sub-orbital rocket that does not have a guidance system.

X,Y,Z coordinate system means an orthogonal, Earth-fixed, topocentric, right-handed system. The origin of the coordinate system is at a launch point. The X-axis coincides with the initial launch azimuth and is positive in the downrange direction. The Y-axis is positive to the left looking downrange. The XY-plane is tangent to the ellipsoidal Earth model's surface at the origin and perpendicular to the geodetic vertical. The Z-axis is normal to the XY-plane and positive directed away from the Earth.

ϕ_o,λ_o,$\eta_o$means a latitude, longitude, height system where ϕ_o is the geodetic latitude of a launch point, λ_o is the east longitude of the launch point, and η_o is the height of the launch point above a reference ellipsoid. ϕ_o and λ_o are expressed in degrees-decimal-degrees, which is abbreviated as DDD.

Subpart B contains the criteria and information requirements for obtaining a license to operate a launch site. Section 420.15 specifies the information that an applicant for a launch site operator license must submit as part of its license application. The FAA requires this information to evaluate issues affecting national security and foreign policy, environmental impacts, whether the launch site location could safely be used to conduct launches, explosive site safety, and whether the applicant will operate the launch site safely.

Section 420.15 has been modified slightly from the NPRM. The first and only substantive change is section 420.15(a). It states that an applicant shall identify the name and address of the applicant, and the name, address, and telephone number of any person to whom inquiries and correspondence should be directed. It also requires the applicant to provide the name and location of the proposed launch site, including downrange equipment; and describe the layout of the launch site, including launch points; the types of launch vehicles to be supported at each launch point; the range of launch azimuths planned from each launch point; and the scheduled operational date. The FAA determined that it was necessary to obtain this basic general information from an applicant in order to conduct the licensing process and to review compliance with the requirements of this part. Section 420.15(a) also requires foreign ownership information, as did the Launch Site NPRM's section 420.15(b).

The other changes to section 420.15 are organizational only. Section 420.15(b) contains the environmental review requirements, which replace requirements currently located at sections 417.105–107.

Section 420.15(c) states that an applicant must provide the information necessary for the review of the launch site location. An applicant who is proposing to locate a launch site at an existing launch point at a federal launch range is not required to submit a launch site location review analysis if a launch vehicle of the same type and class as proposed for the launch point has been safely launched from the launch point.

Section 420.15(d) states that an applicant must provide the information necessary for the review of the explosive site plan. If an applicant plans to operate a launch site located on a federal launch range, and if the applicant is required by the federal launch range to comply with the federal launch range's explosive safety requirements, the applicant shall submit the explosive site plan submitted to the federal launch range. The requirement to submit the federal launch range approved explosive site plan is new. The FAA proposed in the Launch Site NPRM that no explosive site plan would have to be submitted. The FAA will not approve the explosive site plan. Rather, the FAA will use it to assess the adequacy of other aspects of an applicant's application, such as the applicant's coordination procedures under section 420.55(a).

Section 420.15(e) requires an applicant to demonstrate how it will satisfy the launch site operation requirements of sections 420.53 through 420.61, and section 420.71. Specifically, a license applicant must show how the applicant proposes to control public access pursuant to section 420.53, how it proposes to comply with the scheduling requirements of section 420.55, and how it proposes to satisfy the notification obligations of section 420.57. The FAA requires this information to ascertain whether an applicant will be able to satisfy the launch site operation performance requirements and for compliance monitoring purposes. With regard to the notification obligations of section 420.57, an applicant must submit its agreements with the U.S. Coast Guard district and the FAA regional air traffic control facility having jurisdiction over the affected airspace to demonstrate satisfaction of the requirements of 420.57(b) and (c). A license applicant must also show how it proposes to comply with the accident investigation requirements of section 420.59, the record requirements of section 420.61, and the requirements governing lightning protection of section 420.71.

Section 420.17 establishes the bases upon which the FAA will make its license determination. This includes the FAA's determination of the adequacy of information provided by the applicant, the conclusions of the environmental and policy reviews, the adequacy of the explosive site plan, and satisfaction of site location requirements. The FAA will notify the applicant of, and allow the applicant to address any deficiencies in the application.

A few changes were made from the NPRM. All were structural, except for section 420.17(a)(2) which now states that one basis for the issuance of a license is that the FAA has completed an analysis of the environmental impacts associated with the proposed operation of the launch site, in accordance with NEPA, 40 CFR Parts 1500–1508, and FAA Order 1050.1D. The NPRM had only stated that the National Environmental Policy Act review must be completed, but the FAA decided that it would be more informative to advise of the full extent of the FAA's review.

Sections 420.19 through 420.29 require an applicant to demonstrate that its proposed launch site location will allow for the safe launch of at least one type of launch vehicle by defining flight corridors or impact dispersion areas and estimating casualty expectancy. The launch site location review remains largely unchanged from the Launch Site NPRM, with a few exceptions, which will be discussed below. The treatment of the launch site location review in this final rule has been enhanced for two reasons. The FAA decided to outline the process more distinctly. Additionally, the FAA decided to clarify what parts of the launch site location review apply to reusable launch vehicles and which do not.

Section 420.19 provides general requirements. To gain approval for a launch site location, an applicant must demonstrate that for each launch point proposed for the launch site, at least one type of expendable or reusable launch vehicle can be flown from the launch point safely. For purposes of the launch site location review, a safe launch must possess a risk level estimated not to exceed an expected average number of 0.00003 casualties (E_c) to the collective member of the public exposed to hazards from the flight ($E_c \leq 30 \times 10^{-6}$).

Types of launch vehicles include orbital expendable launch vehicles, guided sub-orbital expendable launch vehicles, unguided sub-orbital expendable launch vehicles, and reusable launch vehicles. Orbital expendable launch vehicles are further classified by weight class, based on the weight of payload the launch vehicle can place in a 100-nm orbit. If an applicant proposes to have more than one type of launch vehicle flown from a launch point, the applicant must demonstrate that each type of expendable or reusable launch vehicle planned to be flown from the launch point can be flown from the launch point safely. If an applicant proposes to have more than one weight class of orbital expendable launch vehicles flown from a launch point, the applicant must demonstrate that the heaviest weight class planned to be flown from the launch point can be flown from the launch point safely.

The three types of expendable launch vehicles account for the significant distinctions between launch vehicles designed for orbital or sub-orbital flight, and between those with and without guidance systems. Guided orbital expendable launch vehicles typically require an FTS, which means that the greatest risk to the public stems from debris caused by destruction of a vehicle. Guided sub-orbital launch vehicles will be treated similarly to orbital launch vehicles, except for the nominal impact of the final stage. In contrast, current unguided sub-orbital launch vehicles generally have high reliability levels, and therefore create the greatest public risk through nominal stage impact. The launch site location review is designed to account for these differences in public risk.

Section 420.21 provides minimum distance requirements governing the separation of a launch point from a launch site boundary. The distance from any proposed launch point to the closest launch site boundary must be at least as great as the debris dispersion radius of the largest launch vehicle type and weight class proposed for the launch point. For launch sites supporting expendable launch vehicles, an applicant may use the largest distance listed in table 2 for the type and weight class of launch vehicles proposed for the launch point. For launch sites supporting reusable launch vehicles, an applicant must determine the debris dispersion radius that represents the maximum distance from a launch point that debris travels given a worst-case launch vehicle failure in the launch area. An applicant shall clearly and convincingly demonstrate the validity of its proposed radius.

Section 420.23 provides the requirement for applicants to define a flight corridor. The section is divided up into flight corridor requirements for guided orbital expendable launch vehicles, guided sub-orbital expendable launch vehicles, unguided sub-orbital expendable launch vehicles, and reusable launch vehicles. For guided orbital expendable launch vehicles, an applicant must define a flight corridor that encompasses an area that is estimated, in accordance with the requirements of this part, to contain debris with a ballistic coefficient of ≥ 3 pounds per square foot, from any non-nominal flight of a guided orbital expendable launch vehicle from the launch point to a point 5000 nm downrange, or where the IIP leaves the surface of the Earth, whichever is shorter. The IIP for most orbital expendable launch vehicles goes well beyond 5000 nm. The requirement is the same for guided sub-orbital expendable launch vehicles, except that the flight corridor ends with an impact dispersion area for the launch vehicle's last stage where it impacts the Earth's surface. For either type of launch vehicle, the flight corridor includes an overflight exclusion zone where the public risk criteria of $30 \times 10^{-6} \leq$ would be exceeded if one person were present in the open. An applicant must use one of the methodologies provided in appendix A or B to define a flight corridor. These are discussed below.

Because the FAA realizes that applicants may have other methods to determine a flight corridor, the FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix A or B.

Section 420.23(c) addresses unguided sub-orbital expendable launch vehicles. For an unguided sub-orbital expendable launch vehicle, an applicant must define impact dispersion areas that are estimated, in accordance with the requirements of this part, to contain the impact of launch vehicle stages from nominal flight of an unguided sub-orbital expendable launch vehicle from the launch point to impact with the Earth's surface, and an overflight exclusion zone where the public risk criteria of 30×10^{-6} would be exceeded if one person were present in the open. An applicant must follow the methodology provided in appendix D. The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix D.

An important point to note about the launch site location review for unguided sub-orbital launch vehicles is that it is based on the apogee of the unguided suborbital launch vehicle used in the analysis. The apogee used in the analysis must represent the maximum apogee intended to be reached by a launch vehicle launched from the launch point.

Section 420.23(d) addresses reusable launch vehicles. For a reusable launch vehicle, an applicant must define a flight corridor that contains the hazardous debris from nominal and non-nominal flight of a reusable launch vehicle. The applicant must clearly and convincingly demonstrate the validity of the flight corridor.

Section 420.25 provides the requirement for applicants to conduct a risk analysis. If a flight corridor or impact dispersion area contains a populated area, the applicant must estimate the casualty expectation associated with the flight corridor or impact dispersion area. An applicant must use the methodology provided in appendix C to this part for guided orbital or suborbital expendable launch vehicles and appendix D for unguided suborbital launch vehicles. For reusable launch vehicles, the FAA will evaluate the adequacy of an applicant's casualty expectancy analysis on a case-by-case basis. If the estimated expected casualty exceeds 30×10^{-6}, the FAA will not approve the location of the proposed launch point.

Section 420.27 contains the information that an applicant must submit in its application for a launch site location review. The FAA recognizes that not all information is applicable to all analyses.

Section 420.29 contains an important caveat to the launch site location review as discussed so far. The FAA must evaluate the adequacy of a launch site location for unproven launch vehicles on a case-by-case basis. An applicant for a license to operate a launch site for an unproven launch vehicle must provide a clear and convincing demonstration that its proposed launch site location provides an equivalent level of safety to that required by this part. A launch site that is safe for proven launch vehicles may not be safe for new vehicles. The probability of failure is likely to be higher, and the risk to populated areas may increase significantly.

Section 420.31 requires an applicant to complete two agreements necessary for the safety of aircraft and ships during a launch. An applicant must complete an agreement with the local U.S. Coast Guard district to establish procedures for the issuance of a Notice to Mariners prior to a launch and other such measures as the Coast Guard deems necessary to protect public health and safety. An applicant must also complete an agreement with the FAA Air Traffic Control (ATC) office having jurisdiction over the airspace through which launches will take place, to establish procedures for the issuance of a Notice to Airmen prior to a launch and for closing of air routes during the launch window and other such measures as the FAA ATC office deems necessary to protect public health and safety.

If an applicant plans to operate a launch site located on a federal launch range and is using existing federal launch range agreements; the applicant does not have to comply with section 420.31. These agreements are with the U.S. Coast Guard and the FAA ATC office having jurisdiction over the airspace through which launches will take place.

Appendix A

Of the two methods allowing an applicant to demonstrate the existence of a guided expendable launch vehicle flight corridor that satisfies the FAA's risk criteria, appendix A is the simplest of the methods. Appendix A typically offers the more conservative approach in that it produces a larger area for guided orbital and suborbital expendable launch vehicles. In order to achieve the simplicity this approach offers, the FAA based certain decisions regarding the methodology on a series of what it intends as conservative assumptions and on hazard areas previously developed by the federal launch ranges for the guided expendable launch vehicles listed in table 1 of section 420.19.

The greater simplicity of the approach derives from the fact that, unlike the method of appendix B, an applicant need obtain no meteorological data and need not plot the trajectory of a particular launch vehicle. Instead, recognizing that a typical flight corridor consists of a series of fans of decreasing angle extending out from a launch point, appendix A employs a variation on that typical corridor.

The appendix A flight corridor estimation contains a number of elements, each of which an applicant must define for each of its proposed launch points. An appendix A flight corridor consists of a circular area around a selected launch point, an overflight exclusion zone, a launch area and a downrange area. A flight corridor for a guided orbital expendable launch vehicle ends 5,000 nautical miles from the launch point, and, for a guided suborbital expendable launch vehicle, the flight corridor ends with the impact dispersion area of the launch vehicle's final stage.

Once an applicant has produced an appendix A flight corridor, the applicant must ascertain whether the flight corridor contains population, and, if so, whether the use of the corridor would present unacceptable risk to that population. If no members of the public reside within the corridor, the FAA will approve the proposed location of the site.[9] If the flight corridor is populated, the FAA will require an applicant to perform a risk analysis in accordance with appendix C. If the proposed corridor satisfies the FAA's risk criteria, the FAA will approve the location of the site. If, however, the proposed corridor fails to satisfy the FAA's risk criteria, an applicant has certain options. The applicant may attempt another appendix A flight corridor by selecting a different flight azimuth or by selecting a different launch point at the proposed launch site, or by selecting a different launch vehicle type or class. Or, the applicant may, using the more accurate but more complicated calculations of appendix B, narrow its flight corridor and determine whether that flight corridor satisfies the FAA's risk criteria.

To create a hypothetical flight corridor under appendix A an applicant must first determine from where on the launch site a guided expendable launch vehicle would take flight. That position is defined as a launch point. An applicant must determine the geodetic latitude and longitude of each launch point that it proposes to offer for launch, and select a flight azimuth for each launch point. An applicant should know whether it plans to offer the site for the launch of guided orbital or sub-orbital expendable launch vehicles. If planning for the launch of guided orbital expendable launch vehicles, the applicant must decide what expendable launch vehicle class, as described by payload weight in section 420.19, table 1, best represents the largest expendable launch vehicle class the launch site would support.

Once an applicant has made the necessary decisions regarding location and vehicle class, the next step in creating an appendix A flight corridor is to look up the maximum distance (D_{max}) that debris is expected to travel from a launch point if a worst-case expendable launch vehicle failure were to occur and flight termination action destroyed the expendable launch vehicle at 10 seconds into flight. D_{max} serves as a radius that defines a circular area around the launch point. The FAA has estimated, on the basis of federal launch range experience, the D_{max} for a guided suborbital expendable launch vehicle and for each guided orbital expendable launch vehicle class and provided the results that an applicant should employ in table A–1, appendix A.

The circular area, defined by D_{max}, is part of an overflight exclusion zone. An overflight exclusion zone in an appendix A flight corridor consists of a rectangular area of the length prescribed by table A–2, capped up-range by a semi-circle with radius D_{max} centered on the launch point. Its downrange boundary is defined by an identical semi-circular arc with a radius D_{max} centered on the endpoint prescribed by table A–2. The crossrange boundaries consist of two lines parallel to and to either side of the flight azimuth. Each line is tangent to the uprange and downrange D_{max} circles as shown in appendix A, figure A–1.

An appendix A flight corridor also contains a launch area. The launch area extends from the uprange boundary, which is coextensive with the circle created by the radius D_{max}, to a line drawn perpendicular to the flight azimuth one hundred nautical miles down range of the launch point. The launch area's crossrange boundaries are a function of the lengths of two lines perpendicular to the flight azimuth: one drawn ten nautical miles down range from the launch point and the other line drawn one hundred nautical miles down range from the launch point. Table A–3 provides the lengths of the line segments.

Adjacent to the launch area is the downrange area. For purposes of appendix A, a corridor's downrange area extends from the one hundred nautical miles line to a line, perpendicular to the flight azimuth, that is 5,000 nautical miles downrange from the launch point for the guided orbital expendable launch vehicle classes, and to an impact dispersion area for a guided suborbital expendable launch vehicle corridor. The down range area's crossrange boundaries connect the prescribed endpoints of the perpendicular lines at one hundred nautical miles and 5,000 nautical miles. Table A–3 provides the lengths of the line segments.

An applicant must determine whether the public resides within this flight corridor. If no populated areas exist, an applicant may submit its analysis for the FAA's launch site location review. If there is population located within the flight corridor, the applicant must calculate the risk to the public in accordance with the requirements of appendix C. The expected casualty (E_c) result for the flight corridor must not exceed 30 x 10_{-6} for the applicant to satisfy the location requirements.

Map Requirements and Plotting Methods

To describe a flight corridor and any populated areas within that corridor, an applicant must observe data and methodology requirements for mapping a flight corridor and analyzing populations. These requirements apply to all appendices.

The FAA requires certain geographical data for use in describing flight corridors for each appendix. The geographical data must include the latitude and longitude of each proposed launch point at a launch site, and all populated areas in a flight corridor. The accuracy requirement for the launch area portion of the analyses calls for map scales of no smaller than 1:250,000 inches per inch. The actual map scale will depend on the smallest census block group size in a launch area. The FAA bases its scale requirement on average range rates in the launch area, because range rates have a direct impact on dwell times over populated areas. While in the launch area of a flight corridor, the instantaneous impact point (IIP) ground trace tends to linger over any populated areas, which increases the E_c for an individual populated area. The map scale required by the FAA is large enough to allow an applicant to

[9] An applicant must still obtain written agreements with the FAA Air Traffic Control office having jurisdiction over the airspace where launches will take place and, if appropriate, with the U.S. Coast Guard regarding procedures for coordinating launches with the launch site.

determine the dwell time and size for each applicable populated area.

Using a similar approach, the FAA establishes an accuracy requirement for the downrange area of a flight corridor. A map scale may be no smaller than 1:20,000,000 inches per inch. The scale is to be smaller than that required for the launch area because the dwell times over downrange populated areas are small and the map scale must only be large enough to allow an applicant to determine the dwell time and the size of each populated area downrange. Maps satisfying these accuracy requirements are readily available. For example, civil aeronautical charts are published and distributed by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), and are also published by the Defense Mapping Agency and distributed by NOAA.

Besides scale, appendices A, B, C and D require an applicant to use cylindrical, conic, and plane map projections. The FAA uses these map projections for the analyses because they produce only small error with straight line measurements.

Scale requirements, geographic location of the launch site, and plotting method are the main considerations for choosing a map projection. Of these considerations, the plotting method selected for development and depiction of the flight corridor line segments is the most important. Three plotting methods are provided by appendix A.

The ''mechanical method'' is the least complex, least costly, but also the least accurate of the methods suggested here. The ''semi-automated method'' provides more accurate techniques for determining the endpoint coordinates of each flight corridor line segment. The fully automated method makes use of geographic information system (GIS) software with global mapping data.

Appendix A provides an applicant with equations to perform range and bearing computations for the purpose of plotting a flight corridor on a map. The range and bearing from a launch point are used to determine the latitude and longitude coordinates of a point on the flight corridor. Range and bearing equations are standard geodesic computations, which can be found in most geodesy textbooks.

An applicant may create line segments to describe a flight corridor by using range and bearings from the launch point along various azimuths. Appendix A provides equations to calculate geodetic latitude (+N) and longitude (+E) given the launch point geodetic latitude (+N), longitude (+E), range (nm), and bearing (degrees, positive clockwise from North). The same equations may also be used to calculate an impact dispersion area by substituting a final stage impact point for the launch point. Appendix A also provides equations to calculate the distance of a geodesic between two points.

As noted above, an alternative to range and bearing computations is to use geographic information system (GIS) software with global mapping data. GIS software is an effective tool for constructing and evaluating a flight corridor, and has the advantage of allowing an applicant to create maps of varying scales in the launch and downrange areas. Commercially available GIS products are acceptable to the FAA for use in appendices A, B, C and D if they meet the map and plotting method requirements of paragraph (b) of appendix A. An applicant should note, however, that maps of different scales in GIS software may not match each other. For instance, the coastline of Florida on a U.S. map may not match the coastline on a world map. Applicants shall resolve such contradictions by referring to more accurate maps such as NOAA maps.

Once an applicant has selected a map for displaying a flight corridor's launch area, the line segment lengths may be scaled to the chosen map. Map scale units are actual distance units measured along the Earth's surface per unit of map distance. Most map scale units are given in terms of inches per inch (in/in). An applicant converts appendix A flight corridor line segment distances to the map scale distance by dividing the launch area flight corridor line segment length (inches) by the map scale (in/in). If, for example, an applicant selected a map scale of 250,000 in/in and the line segment for the launch area flight corridor was 1677008 inches, the equivalent scaled length of the line segment for constructing an appendix A launch area is (1677008/250,000) = 6.7 inches of map distance. An applicant would then plot the line segment on the map for display purposes using the scaled line segment length of 6.7 inches. If an applicant were to choose a map with scale units other than inches per inch, the FAA requires a description of the conversion algorithm to inches per inch and sample computations. Also note that the FAA will accept straight lines for distances less than or equal to 7.5 times the map scale on map scales greater than or equal to 1:1,000,000 inches per inch; or straight lines representing 100 nm or less on map scales less than 1:1,000,000 in/in.

Weight Classes for Guided Orbital Expendable Launch Vehicles

Appendix A distinguishes between the guided orbital expendable launch vehicles represented in the appendix on the basis of four separate weight class. These are used to determine the size of the debris dispersion radius around a launch point, and the size of an appendix A flight corridor. The FAA selected the four expendable launch vehicle classes based on the size and characteristics of expendable launch vehicles that currently exist in the U.S. commercial inventory and that should approximate any proposed new expendable launch vehicle as well. An applicant planning to support the launch of guided orbital expendable launch vehicles must choose the largest expendable launch vehicle class anticipated for launch from the chosen launch point. This maximizes the area of the flight corridor. Also, selection of the largest class anticipated lessens the possibility of having to obtain a license modification to accommodate a larger customer than an application may have originally encompassed.

A 100-nm orbit is the standard for inter-class launch vehicle comparison purposes. It is a standard reference orbit used by launch vehicle manufacturers for descriptive purposes and allows the uniform comparison of launch vehicle throw weight capability. The FAA obtained the payload weights for the 28° and 90° orbital inclinations from the ''International Reference Guide to Space Launch Systems,'' S. J. Isakowitz, 2d ed. (1995). They represent capabilities from CCAS and VAFB, respectively.

D_{max} Circle

A radius, maximum distance (D_{max}), is employed to define a circular area about a launch point. The circular area indicates the limits for both flight control and explosive containment following a worst-case expendable launch vehicle failure and flight termination system activation at 10 seconds into flight. The worst-case failure represents a failure response, immediately following first motion, which causes the launch vehicle to fly in the uprange direction on a trajectory that maximizes the impact range. The ten second flight time represents a conservative estimate of the earliest elapsed time after launch that a flight safety officer would be able to detect the malfunction, initiate flight termination action, and actuate the flight termination system on the expendable launch vehicle. The radius is the estimated D_{max} from the launch point that inert debris is expected to travel and beyond which the overpressure from explosive debris is not expected to exceed 0.5 pounds per square inch (psi). D_{max} accounts for the public risk posed by the greater of the wind-induced impact distance of a hazardous piece of inert debris, or the sum of the wind-induced impact distance of an explosive piece of debris and the debris' 0.5 psi overpressure radius from the explosion.

Overflight Exclusion Zone

Table A–2 and figure A–1 define an overflight exclusion zone. Because of the risks the early stages of flight create, the FAA requires an applicant to demonstrate that the public will not be present in this area during a launch. An overflight exclusion zone is an area in close proximity to a launch point where the mission risk is greater than an E_c of 30×10^{-6} if one member of the public is present in the open.

Early in the flight phase expendable launch vehicles have large explosive potential, a low IIP range rate, and an historically higher probability of failure relative to the rest of pre-orbital flight. The relatively simple risk estimation analysis defined by appendix C does not adequately model the true risk during this stage of flight, and does not serve as the basis for determining that the overflight exclusion zone represents an area where the FAA's risk threshold is not satisfied. Instead, the FAA derived the overflight exclusion zone using a high fidelity risk assessment computer program in use by the national ranges. The program is a launch area risk analysis program called DAMP (facility DAMage and Personal injury). DAMP relies on information about a launch vehicle, its trajectory and failure responses, and facilities and populations in the launch area to estimate hit probabilities and casualty expectation. The hazards analyzed by DAMP include impacting inert debris, and blast overpressures and debris projected from impact explosions.

Risk assessments were also conducted for the time of flight immediately after the first major staging event. The results showed a significant decrease in the E_c estimates, and those estimates were within the E_c criteria of 30×10^{-6}. The decrease results from a combination of decreasing dwell times and a significant reduction in the size of an effective casualty area following a major staging event.

The FAA requires that an applicant demonstrate either that the overflight exclusion zone is unpopulated, that there are times when no one is present, or that the public can be excluded from this area during launch. Although a determination of this nature encompasses issues that will be addressed in a launch license, a launch site cannot support safe launches unless overflight of the highest risk area in close proximity to a launch point takes place without the public present.

An applicant must display an overflight exclusion zone on maps in accordance with the requirements of paragraph (b) of appendix A.

Launch Area

As noted at the beginning of this discussion, appendix A employs a series of fans as the shape of the foundation of its flight corridor. The flight corridor fans account for the turning capabilities and wind dispersed debris of a guided expendable launch vehicle. The launch area fans have been divided into two regions, of 60 and 30 degrees, representing the malfunction turn capability of the launch vehicle relative to its velocity in the downrange direction. Each region is represented by the estimated maximum turning capability over a ground-range interval. These angles are the FAA's estimates for the maximum angles that the launch vehicle velocity vector may turn within a five second time period.

The initial fan area is described by a 60° half angle extending ten nautical miles downrange from a launch point. The ten nautical mile threshold represents the FAA's estimate of where a vehicle's maximum turning rate capability is reduced to approximately 30 degrees due to increasing velocity in the downrange direction. A 30° half angle was used to define the secondary fan area beginning 10 nautical mile downrange and ending 100 nautical mile downrange. Once an expendable launch vehicle IIP has reached the 100 nautical mile downrange point, the increasing velocity in the downrange direction continues to reduce the launch vehicle's ability to maneuver through a large malfunction turn.

A 100 nautical mile distance is used as a delimiter between the launch area and the downrange area. From the launch point out to approximately the point where the IIP is 100 nautical miles downrange, most expendable launch vehicles will be subjected to the aerodynamic forces of wind and drag. Once an expendable launch vehicle's IIP has cleared the 100 nm limit, the FAA is willing to assume for purposes of appendix A that most launch vehicles are outside the atmosphere.

Downrange Area

The FAA derived the appendix A flight corridor's downrange area from hazard areas previously developed by federal launch ranges for the weight classes of expendable launch vehicles defined in table 1 of section 420.19. The downrange fan area of the flight corridor is based on turning capabilities and impact dispersions of guided expendable launch vehicles. The size of the fan area is necessary for containing expendable launch vehicle debris in the event that an expendable launch vehicle failure initiates a maximum-rate malfunction turn and the flight termination system must be activated. In the later stages of flight a guided expendable launch vehicle's turn capability is reduced due to increasing velocities in the downrange direction. Therefore, a 10° half angle was used to define the downrange area, which reflects a combination of normal vehicle dispersions and malfunction turns.

The downrange area of a flight corridor begins 100 nm from a launch point and, for the guided orbital expendable launch vehicle weight classes, extends 5,000 nm downrange from the launch point. Overflight dwell times for the flight time remaining after 5,000 nm typically result in an insignificant increase in risk to the public. In general, after an orbital expendable launch vehicle IIP has passed the 5,000 nm point its IIP range rates increase very rapidly as the expendable launch vehicle approaches orbital insertion. As a result, the dwell times decrease significantly, reducing the overflight risk to insignificant levels. For an applicant employing a guided suborbital expendable launch vehicle, a flight corridor ends with the impact dispersion area of a final stage.

Appendix B

Appendix B provides another means for creating a hypothetical flight corridor from an applicant's proposed launch site. As with a flight corridor created pursuant to appendix A, an appendix B corridor identifies the populations, those within the defined flight corridor, that must be analyzed for risk. An appendix B analysis offers an applicant a means to demonstrate whether a flight corridor from its launch site satisfies the FAA's risk criteria for a guided orbital or suborbital expendable launch vehicle. Appendix B allows an applicant to perform a more individualized containment analysis rather than relying on the more conservative estimates the FAA derived for appendix A. Because an appendix B analysis uses actual meteorological data and a trajectory, whether actual or computer simulated, of a real expendable launch vehicle, it produces a flight corridor of greater accuracy than one created in accordance with appendix A. The FAA derived the assumptions and simplifications in the appendix B analysis from expendable launch vehicle data representing historical expendable launch vehicle malfunction behavior.

A flight corridor created using appendix B contains, on its face, the same elements as an appendix A flight corridor, including a circular area around a launch point with a radius of D_{max}, an overflight exclusion zone, a launch area and a downrange area. Appendix B, however, produces and configures the last two elements differently than appendix A. The launch area of an appendix B flight corridor shows where launch vehicle debris would impact in the event of a vehicle failure, and takes into account local meteorological conditions. The downrange area of a flight corridor also shows where launch vehicle debris would impact given a vehicle failure, but takes into account vehicle imparted velocity, malfunctions turns, and vehicle guidance and performance dispersions. Also, like an appendix A flight corridor, the uprange portion of the flight corridor is described by a semi-circle arc that is a portion of either the most uprange dispersion circle, or the overflight exclusion zone, whichever is further uprange.

The appendix B launch area analysis assumes a vehicle failure and destruction at one second intervals along a trajectory z value, which denotes height as measured from the launch point, up to 50,000 feet. An applicant must determine the maximum distance a hazardous piece of debris would travel under local meteorological conditions. The distances that the debris travels provide the boundaries of an appendix B flight corridor's launch area. After a height of 50,000 feet, which is where the FAA estimates, for purposes of this analysis, that debris created by an expendable launch vehicle's destruction has less exposure to atmospheric forces, an applicant shall determine how far harmful debris created by destruction of an expendable launch vehicle would travel based only on malfunction imparted velocity and vehicle dispersion in order to create a downrange area. Although the effects of wind above 50,000 feet are not, in reality, non-existent, once an expendable launch vehicle reaches an altitude of 50,000 feet its velocity vector has pitched down range so that a malfunction turn and explosion velocity, rather than atmospheric drag and wind effects, play the dominant role in determining the dispersion of debris as the debris falls to the surface.

D_{max} Circle

As with an appendix A flight corridor, an applicant must select each launch point at its proposed launch site from which it expects a guided expendable launch vehicle to take flight. An applicant must obtain the latitude and longitude of the launch point to four decimal places. If relying on a guided orbital expendable launch vehicle, the applicant must also select an expendable launch vehicle weight class from section 420.19, table 1, that best represents the largest class each proposed launch point would support. With this information, the applicant then ascertains the D_{max} that debris is expected to travel from a launch point if a mishap were to occur in the first 10 seconds of flight by employing table A–1, appendix A. Table A–1 also provides a maximum distance for guided sub-orbital expendable launch vehicles. The D_{max} distance provided by table A–1 defines a circular area around the launch point.

Overflight Exclusion Zone

That circular area is part of an overflight exclusion zone. Again, an applicant uses information from appendix A to create an overflight exclusion zone. An overflight exclusion zone consists of the circular area defined by the radius D_{max} at the launch point and a corridor of the length prescribed by table A–2. Its downrange boundary is defined by an arc with a radius D_{max} centered on the endpoint prescribed by table A–2. The crossrange boundaries consist of two lines parallel to and to either side of the flight azimuth. Each line is tangent to the uprange and downrange D_{max} circles as shown in appendix A, figure A–1. Creation of an overflight exclusion zone is predetermined by the requirements of appendix A and does not require a trajectory for an actual launch vehicle. As with an appendix A overflight exclusion zone, and for the reasons described in this notice's discussion of appendix A, the FAA requires that the public be excluded from this area during launch.

Launch Vehicle Trajectory

An applicant must also obtain or generate a launch vehicle trajectory. The applicant may use either commercially available software or a trajectory provided by the launch vehicle's manufacturer. Because appendix B is based on equations of motion in three dimensions, the appendix B analysis requires that the trajectory be described using a three axis coordinate system. The FAA recommends that an applicant use a WGS–84 ellipsoidal Earth model[10] as the trajectory coordinate system reference ellipsoid in the appendices, because of its wide availability and its development in accordance with military standards and requirements. The WGS–84 model reflects the most current and the most accurate Department of Defense standards for Earth models. WGS–84 provides a basic reference frame and geometric figure for the Earth and provides a means for relating positions on various local geodetic coordinate systems, including x,y,z, to an Earth-centered, Earth-fixed coordinate system such as the EFG system employed in the appendix B analysis.

The FAA requires time intervals used in the trajectory analysis of no greater than one second for both launch and downrange areas. Data frequency of one second is a compromise between the low data frequency requirements of the launch area, where dwell times are relatively long, and the high frequency requirements of the downrange area, where dwell times are correspondingly shorter. Accordingly, one second time intervals are sufficient to accommodate linear interpolation between trajectory time points, in the launch and downrange areas, and not degrade the accuracy requirements of the analysis.

In the launch area, an applicant's trajectory must include position data in terms of time after liftoff in right-handed x,y,z coordinates centered on the proposed launch point, with the X-axis aligned with the flight azimuth. In the downrange area, the applicant's trajectory must show state vector data in terms of time after liftoff in right-handed x, y, z x, y, z, coordinates, centered on the proposed launch point, with the X-axis aligned with the flight azimuth.

Launch Area

A launch area contains a launch point and an overflight exclusion zone, and constitutes the part of the flight corridor calculated using the effects of atmospheric drag forces on debris produced by a series of hypothetical destructions of an expendable launch vehicle at one second intervals along that trajectory. For purposes of an appendix B analysis, a launch area extends from the further uprange of an OEZ arc or dispersion circle arc downrange to a point on the surface of the Earth that corresponds to the debris impact locations, assuming a failure of the vehicle in flight at a height of 50,000 feet. Typically, federal launch ranges account for five major parameters to

[10] Department of Defense World Geodetic System, Military Standard 2401 (Jan. 11, 1994).

estimate the size of a flight corridor. These include the effects of vehicle-imparted velocity on debris, the change in launch vehicle position and velocity due to a malfunction turn, guidance errors, the ballistic coefficient of debris, and wind. However, imparted velocity, malfunction turn, and trajectory dispersion, although not insignificant, do not play as great a role early in flight as the wind effects on debris. The wind effect on debris, in turn, depends on the ballistic coefficient of the debris. The FAA determined that for purposes of the launch area, of these parameters, launch vehicle debris and meteorological conditions constitute the most significant, and the FAA therefore focuses on these two factors in the launch area.[11]

The FAA requires an applicant to calculate circles that approximate the debris dispersion for each one second time point on a launch vehicle trajectory. The crossrange lines tangent to those circles provide the borders of a launch area. Calculating the circles consists, in general terms, of a two step process. An applicant must first define 15 mean geometric height intervals along the proposed trajectory in order to obtain data, in accordance with subparagraph (c)(4) of appendix B, accounting for the mean atmospheric density, maximum wind speed, fall times and debris dispersions in each of those height intervals. An applicant must then use that data in the calculations in subparagraph (c)(5) to derive the radius applicable to each height interval (z_i). Having obtained that radius, an applicant uses it to describe, pursuant to subparagraph (c)(6), a circle referred to as a debris dispersion circle (D_i), around each one second time interval along the vehicle's trajectory, starting at the launch point. An applicant will then ascertain the crossrange boundaries of a flight corridor's launch area by drawing lines that are tangent to all dispersion circles. The final D_i dispersion circle forms the downrange boundary of a flight corridor's launch area.

The launch area represents the effects of meteorological conditions on how far inert debris with a ballistic coefficient of 3 lb/ft.^{2} would travel. Debris comes in many sizes and shapes, but the FAA does not propose to require an applicant's location review analysis to take all such possibilities into account. A complete analysis for an actual launch entails the determination of the type and size of debris created by each credible failure mode, and the velocity imparted to each piece of debris due to the failure. Instead, for purposes of the appendix B analysis, the FAA categorizes launch vehicle debris by a ballistic coefficient that accounts for the smallest inert debris that may cause harm and that also accounts for the debris most sensitive to wind. A ballistic coefficient reflects the sensitivity of weight and area ratios to drag forces, such as wind dispersion effect.

In addition to knowing what debris is of concern, an applicant must know the local meteorological conditions. The FAA requires an applicant to obtain meteorological data for 15 height intervals in a launch area up to 50,000 feet. Appendix B has an upper limit of 50,000 feet in the launch area containment analysis of debris because winds above this altitude contribute little to drift distance. As noted above, once an expendable launch vehicle reaches an altitude of 50,000 feet its velocity vector has pitched down range so that a malfunction turn and explosion velocity, rather than atmospheric drag and wind effects, play the dominant role in determining the dispersion of debris as the debris falls to the surface. The combination of these two factors significantly reduces the effect of winds on uprange and crossrange dispersion after an expendable launch vehicle reaches 50,000 feet. For altitudes less than 50,000 feet, at the same time as low ballistic coefficient debris pieces are highly sensitive to drag forces, the velocity of an explosion caused by destroying an expendable launch vehicle contributes relatively little to the dispersion effect because the drag produced on these light weight pieces results in a high deceleration so they achieve terminal velocity almost instantaneously and drift with the wind. Therefore, launch vehicle induced explosion-velocities are not considered for the launch area of an appendix B containment analysis. Instead, an applicant uses local statistical wind data by altitude for fifteen height intervals. The data must include altitude, atmospheric density, mean East/West meridianal (u) and North/South zonal wind (v), the standard deviation of u and v wind, a correlation coefficient, the number of observations and the wind percentile.

Data acceptable to the FAA is available from NOAA's National Climatic Data Center (NCDC). NOAA Data Centers, of which the NCDC is the largest, provide long-term preservation of, management, and ready accessibility to environmental data. The Centers are part of the National Environmental Satellite, Data and Information Service. The NCDC data set acceptable to the FAA is the ''Global Gridded Upper Air Statistics, 1980—1995, V1.1, March 1996 (CD–ROM).'' The Global Gridded Upper Air Statistics (GGUAS) CD–ROM data set describes the atmosphere for each month of the represented year on a 2.5 degree global grid at 15 standard pressure levels. NCDC provides compiled mean and standard deviation values for sea level pressure, wind speed, air temperature, dew point, height and density. GGUAS also complies eight-point wind roses. The spatial resolution is a 73 x 144 grid spaced at 2.5 degrees and the temporal resolution is one month.

To simplify the containment analysis, an applicant may use a mean wind of 50%. An applicant may also assume that an applicant's launch pad height is equal to the surface level of the wind measurements provided by the NCDC database. The actual pad height could be lower or higher than the surface level wind measurement height. The difference between the actual pad height and the surface level measurement height is considered insignificant in terms of its effect on the impact dispersion radius.

The FAA notes that the NCDC database will not necessarily contain measurements of winds for any particular launch site proposed. If a launch point is located in the center of a 2.5 degree NCDC weather grid cell, the farthest distance to a grid cell corner would be along a diagonal from the center of the grid cell to a corner of the grid cell. The wind measurements will be no more than approximately 106 nm from the launch point. This distance is close enough for purposes of a location review containment analysis, and occurs only for a grid located on the equator. In general, the topography within approximately 106 nm of a launch point is assumed to be relatively similar with respect to height above mean-sea-level. As the launch point latitude increases the distance from the wind measurement grid point will decrease, which will reduce errors introduced by this assumption.

Having obtained the necessary meteorological data, an applicant would use data from the GGUAS CD–ROM to estimate the mean atmospheric density, maximum wind speed, height interval fall times, and height interval debris dispersions for 15 mean geometric height intervals. Altitude intervals are denoted by the subscript ''j''. An applicant would then calculate the debris dispersion radius (D_i) for each trajectory position whose ''Z'' values,

[11] Note that the determination of the size of D_{max} included considerations of malfunction turns as well.

are less than 50,000 ft. Each trajectory time considered is denoted by the variable subscript ''i''. The initial value of ''i'' is one and the value is increased by increments of one for each subsequent ''Z'' value evaluated. The major dispersion factors are a combination of wind velocity and debris fall time. Because the atmospheric density is a function of altitude and affects the resultant fall time, D_i is estimated by summing the radial dispersions computed for each altitude interval the debris intersects on its descent trajectory. Once all the debris dispersion radii have been calculated, the flight corridor's launch area is produced by plotting each debris dispersion circle on a map, and drawing enveloping lines that enclose the outer boundary of the debris dispersion circles. The uprange portion of the flight corridor is described by a semi-circle arc that is a portion of either the most uprange D_i dispersion circle, or the overflight exclusion zone, whichever is further uprange.[12] The enveloping lines that enclose the final D_i dispersion circle forms the downrange boundary of a flight corridor's launch area.

[12] Note that even if a dispersion circle is further uprange than the overflight exclusion zone, the overflight exclusion zone remains the same. That is, it is not extended uprange.

Downrange Area Containment Analysis

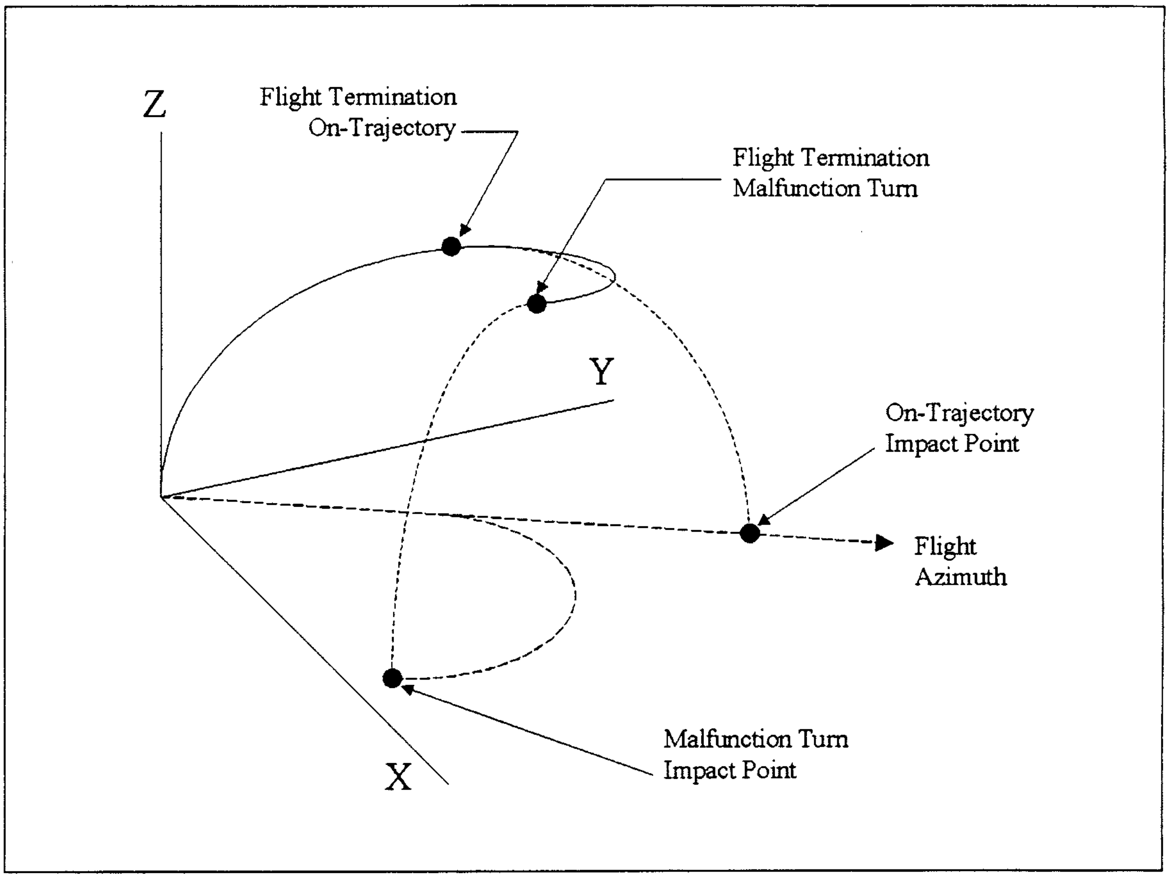
A containment analysis also describes the dimensions of a flight corridor's downrange area. The FAA designed the downrange area analysis to accommodate expendable launch vehicle imparted velocity, malfunction turns, and vehicle guidance and performance dispersions. The analysis to obtain the downrange area of a flight corridor for guided orbital and suborbital expendable launch vehicle trajectories starts with trajectory positions with heights greater than 50,000 feet, that is, the point where the launch area analysis ends. A downrange area for a guided orbital expendable launch vehicle ends 5,000 nautical miles from the launch point, or where the IIP leaves the surface of the earth, whichever is shorter. If an applicant has chosen a guided suborbital expendable launch vehicle for the analysis, the analysis must define the impact dispersion area for the final stage, and that impact dispersion area marks the end of a downrange area.

An applicant computes the crossrange boundaries of the downrange area of a flight corridor by calculating the expendable launch vehicle position after a simulated worst-case four second turn, rotating the launch vehicle state vector to account for vehicle guidance and performance dispersions, and then computing an instantaneous impact point. The locus of IIPs describes the impact boundary.

As a first step, an applicant computes a reduction ratio factor that decreases with increasing launch vehicle range. Secondly, an applicant computes the launch vehicle position after a simulated worst-case four-second malfunction turn for each altitude interval along a trajectory. For purposes of the launch site location review, the FAA relies on a velocity vector malfunction turn angle initially set at 45°. This turn angle is decreased, using a reduction ratio factor, as a function of downrange distance to simulate the constraining effects of increasing velocity in the downrange direction on malfunction turn capability. See figure B–2. The FAA assumes this worst-case delay (4 seconds) result in order to account for the maximum dispersion of the vehicle during the time necessary for a person in charge of destroying a launch vehicle to detect a vehicle failure and cause the vehicle's destruction. Figure B–2 in appendix B depicts the velocity vector movement in the yaw plane of the vehicle body axis coordinate system. Figure 1 below depicts the state vector axes and impact locations for a malfunction turn failure and for an on-trajectory failure.[13]

[13] For clarity, the flight azimuth in the figure is not aligned with the x-axis, as would be the case in the launch site location review.

Figure 1
State Vector Axes and Impact Locations for a Malfunction Turn Failure[13]



The second step described above assumes perfect performance of the launch vehicle up until the beginning of the malfunction turn. In order, however, to account for normal three sigma (3σ) performance and guidance dispersions of the launch vehicle prior to the malfunction turn, the applicant next rotates the trajectory state vector. The trajectory state-vector rotation is accomplished in conjunction with an XYZ to ENU coordinate system transformation. This transformation rotates the X and Y axes about the Z axis. The Z and U axes are coincident. Both position and velocity components are rotated. The FAA intends the trajectory azimuth rotation to account for the normal 3-sigma launch vehicle performance and guidance dispersions that may exist at the beginning of a malfunction turn. The rotation angle decreases from three degrees to one degree as the vehicle proceeds downrange, and the rate of decrease is a function of distance from the launch point. This is done because the trajectory azimuth of an expendable launch vehicle with 3-sigma performance and guidance dispersions early in flight could be approximately ±3 degrees from the nominal flight azimuth. Since this azimuth offset is not considered a failure response, the guidance, navigation, and control system is expected to achieve steering corrections. These corrections will eventually reduce the angular offset later in flight as the launch vehicle targets the mission objectives for orbital insertion. If an expendable launch vehicle has 3-sigma performance and guidance dispersions later in flight, the effects of increasing velocity in the downrange direction limits an expendable launch vehicle's capability to alter the trajectory's azimuth. Launch vehicles in the four expendable launch vehicle weight classes were reviewed to determine the typical range of malfunction-turning rates in the downrange area. The FAA found these rates to be relatively small compared to launch area rates. The FAA uses the three and one degree turn rates because they encompass the turn rates found during the review process.

Before initiating the IIP computations, an applicant must transform the ENU coordinate system to an EFG coordinate system. This EFG coordinate transformation is employed to simplify the IIP computation.

The IIP computations proposed in appendix B are used for determining the IIPs to either side of a trajectory by creating latitude and longitude pairs for the left and right flight corridor boundaries. Connecting the latitude and longitude pairs describes the boundary of the downrange area of a flight corridor. The launch site location review IIP calculations assume the absence of atmospheric drag effects. Equations B46–B69 implement an iterative solution to the problem of determining an impact point. This iterative technique includes checks for conditions that will not result in impact point solutions. The conditions prohibiting impact solutions are: (1) An initial launch vehicle position below the Earth's surface, (2) a trajectory orbit that is not elliptical, but, parabolic or hyperbolic, (3) a positive perigee height, where the trajectory orbit does not intersect the Earth, and (4) the iterative solution does not converge. Any one of the conditions given above will prohibit the computation of an impact point. The iterative approach of equations B46–B69 solves these problems.

Estimating Public Risk

Upon completing a flight corridor, an applicant must estimate the risk to the public within the flight corridor to determine whether that risk falls within acceptable levels. If an applicant demonstrates that no part of the flight corridor is over a populated area, the flight corridor satisfies the FAA's risk thresholds, and an applicant's application may rely on its appendix B analysis. If a flight corridor includes a populated area, an applicant has the option of rotating an appendix B flight corridor using a different launch point or azimuth to avoid population, or of conducting an overflight risk analysis in accordance with appendix C.

Appendix C

Under a launch site location review, once an applicant has created a flight corridor employing either appendix A or B, the applicant must ascertain whether there is population within the flight corridor. If there is no population, the FAA will approve the location of the proposed launch point for the type and weight class of expendable launch vehicle analyzed. If there is population, an applicant must employ appendix C to perform an overflight risk analysis for the corridor. An appendix C risk analysis determines whether or not the risk to the public from a hypothetical launch exceeds the FAA's risk threshold of an estimated expected casualty (E_c) of no more than 30×10^{-6} per launch. The purpose of the E_c analysis as part of the launch site location review is not to determine a value of E_c but rather to confidently demonstrate that E_c is less than the acceptable threshold value.

An appendix C risk analysis estimates the E_c overflight contribution from a single hypothetical launch whose flight termination system is assumed to work perfectly. The analysis takes into account the probability of a vehicle failing throughout its trajectory, dwell times [14] over individual populated areas, and the probability of impact within those areas. The analysis also takes into account the effective casualty area of a vehicle class, the size of the populated area, and the population density of the exposed population.

Estimating E_c for an actual launch takes a large number of variables and considerations into account. The risk analysis provided in appendix C provides a somewhat simpler approach to estimating E_c within the boundaries of a flight corridor than might be necessary in performing a risk analysis for an actual launch. For purposes of determining the acceptability of a launch site's location, the FAA relies only on variables relevant to ensuring that the site itself offers at least one flight corridor sufficiently isolated from population for safety. Accordingly, many of the factors that a launch operator will take into account will not be reflected here.

In brief, in order for an applicant to perform an appendix C risk analysis, the applicant must first determine whether any populated areas are present within an appendix A or B flight corridor. If so, the applicant must obtain area and population data. At this point an applicant has a choice. Appendix C requires that an applicant calculate the probability of impact for each populated area, and then determine an E_c value for each populated area. To obtain the estimated E_c for an entire flight corridor, the applicant adds—or sums—the E_c results for each populated area. If the population within the flight corridor is relatively small, an applicant may wish to conduct a less rigorous analysis by making conservative assumptions. Appendix C also offers the option of analyzing a worst-case flight corridor for those flight corridors where such an approach might save time and analysis. Examples of such simplifications are provided.

Identification and Location of Population

In order to perform an E_c analysis, an applicant must first identify the populated areas within a flight corridor. For the first 100 nautical miles from a launch point downrange a U.S. census block group serves as the maximum size of an individual populated area permitted under an appendix C analysis. The maximum permitted size of an individual populated area beyond 100 nautical miles downrange is a 1 degree latitude $\times$ 1 degree longitude grid. The size of the areas analyzed will play out differently depending on the location of the proposed launch site. For example, if an applicant proposed a coastal site, the applicant would presumably present the FAA with a flight corridor mostly over water. Population may be limited to that of a few islands, minimizing the amount of data and analysis necessary. If an applicant proposes a launch site located further inland, the applicant would need to obtain the area and population of each census block group in the first 100 nm of the flight corridor. This may prove time consuming, although the FAA has alternative approaches that may simplify the process for such applicants. An applicant may also propose to operate a launch site on foreign territory, where U.S. census data does not apply. In that event, the FAA will apply the principles underlying a launch site location review to the available data on a case-by-case basis.

The final regulations require the analysis of populations at the census block group level for the first 100 nm from the launch point in the flight corridor. An applicant shall employ data from the latest census. An applicant must also include population that may not be included in the U.S. census, such as military base personnel. The FAA recognizes a census block group to be a reasonable populated area for analysis because the risk early in flight is greatest due to long dwell times. IIP range rates in a launch area are relatively slow, which exposes the launch area populations to launch vehicle risks for a longer period of time when compared to similar populations in the downrange area. Depending on the launch site and the launch vehicle, a census block group could be exposed to launch vehicle risks for tens of seconds. In contrast to the size of a populated area in the downrange area, the increased risk due to longer dwell times requires a more detailed evaluation of the launch area for E_c purposes. A census block group is an appropriate size for analysis because it is small enough to accommodate the assumption that a populated area contains homogeneously distributed population without grossly distorting the outcome of the E_c estimates, and because the data is readily available for populations in the United States. An applicant may find the need to use only a portion of a census block group, such as when a populated area is divided by a flight corridor boundary. In that case an applicant should use the population density of the block group to reflect the population in that portion of the census block group.

The FAA allows an applicant to evaluate the presence of people in larger increments of area in the downrange area of a flight corridor than in the launch area of a flight corridor. Populations in the downrange area of a flight corridor must be analyzed in areas no greater than $1° \times 1°$ latitude and longitude grid coordinates. Because dwell times downrange are shorter, the risk to the individual populated areas is less and, therefore, the FAA is willing to accept a different degree of accuracy. IIP range rates in the downrange area

[14] Although an applicant who calculates an appendix B flight corridor will know actual dwell times for its E_c analysis, the FAA has supplied a constant to approximate dwell time for an applicant who relies on an appendix A flight corridor.

can achieve speeds of 500 nm/second. Because the longest distance in a grid space would be approximately 85 nm for a grid on the equator, which is where the largest grid area will be found, the launch vehicle IIP dwell time would be less then 0.20 seconds over that grid. This reduces the risk to population in that grid significantly compared with population in the launch area.

The data needed for a downrange area analysis is also readily available. One source for population data in an area no greater than 1° x 1° latitude and longitude grid coordinates is a database of the Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory. The CDIAC database is ''Global Population Distribution (1990), Terrestrial Area and Country Name Information on a One by One Degree Grid Cell Basis.'' This database contains one degree by one degree grid information on the world-wide distribution of population for 1990 and country specific information on the percentage of a country's population present in each grid cell.

The CDIAC obtained its population estimates from the United Nations FAO Yearbook, [15] the Guinness World Data Book,[16] and the Rand McNally World Atlas [17] for approximately 6,000 cities with populations greater than 50,000 inhabitants. The population data was updated by CDIAC to 1990 values with available census data. For the rural population allocation, the CDIAC developed global rural population distribution factors based on national population data, data on approximately 90,000 cities and towns, and the assumption that rural population is proportional to the number of cities and towns within each grid cell for each country.

Probability of Impact

The next step in the process is to ascertain the probability of impact for each populated area. In other words, an applicant must find the probability that debris will land in each populated area within the flight corridor under analysis. For this, the applicant must find the probability of impact in both the crossrange and downrange directions, by employing equation C1 for an appendix A flight corridor for an orbital launch or equations C2 through C4 for an appendix A corridor that describes a suborbital launch. For an analysis based on an appendix B flight corridor, an applicant will employ equation C5 for an orbital launch or equations C6 through C8 for a suborbital launch. For both appendix A and B corridors, the probability of impact (P_i) within a particular populated area is equal to the product of the probability of impact in the downrange (P_x) and cross range (P_y) directions, and the probability of vehicle failure (P_f).

$$P_i = P_y * P_x * P_f$$

The analysis applicable to both appendix A and B flight corridors is the same for the crossrange direction, but employs a different equation to determine the probability of impact in the downrange direction. For an appendix A corridor, the FAA specifies a constant in equation C1 to approximate dwell time for the downrange direction. In equation C5 an applicant will employ actual dwell times obtained from the trajectory generated in accordance with appendix B.

An applicant who relies on an appendix A flight corridor will use equation C1 to determine the probability of impact for a particular populated area in the downrange direction by finding the range rate and assuming a total thrusting time of 643 seconds. Equation C1 reflects the fact that appendix A does not employ trajectory data, and therefore, employs a technique for estimating dwell times as a function of range and range rate to determine the probability of impact in the downrange direction. Table C–2 provides the appendix A flight corridor IIP range intervals and corresponding IIP range rates for use in Equation C1.

To create table C–2, the FAA employed actual trajectory data to determine individual range rates for Atlas, Delta and Titan expendable launch vehicles.

The FAA derived the total average thrusting time of 643 seconds from the data in table 5 below by dividing the difference of the upper value of adjacent IIP ranges by the average IIP range rate corresponding to the largest IIP range and summing the results over the set of IIP ranges.

TABLE 5.—DATA TO DERIVE TOTAL THRUSTING TIME

IIP Range (nm)	IIP Range Rate (nm/s)				Δt(s)
	Delta	Atlas	Titan	Avg	
0–100	1.03	0.85	0.96	0.91	110.50
101–500	3.33	3.77	2.23	3.00	133.33
501–1500	4.17	3.66	2.73	3.20	312.99
1500–2500	9.01	21.74	12.99	17.37	57.59
2501–3000	33.33	50.00	41.67	45.84	10.91
3001–4000	66.67	90.91	83.33	87.12	11.48
4001–5000	166.67	142.86	166.67	154.77	6.46
Total-Δt	....	....	....	643.26	

The ''X'' distances were measured directly off the mapping information source.

An applicant who relies on an appendix B flight corridor will employ equation C5 or equations C6 through C8 depending on whether the flight corridor culminates in an impact dispersion area or not. Equation C5 reflects the fact that, unlike an appendix A flight corridor, the trajectory data used to create an appendix B flight corridor provides downrange instantaneous impact points (IIPs). Accordingly, the dwell time associated with a populated area may be ascertained for the difference between the closest and furthest downrange distances of the populated area. *See* figure C–2.

An applicant may find the following six step procedure helpful in determining for individual populated areas the dwell time that equation C5 calls for. The subscripts do not correspond to subscripts in the appendix.

[15] United Nations FAO Yearbook, Vol. 47, Rome, 1993.

[16] The Guinness World Data Book, Guinness Pub. Ltd., Middlessex, England, 1993.

[17] Rand McNally World Atlas, Rand McNally, New York, 1991.

Step 1: Determine the trajectory time (t_1) associated with the trajectory IIP position (x_1) that immediately precedes the uprange point on the populated area boundary. This is accomplished by locating the IIP points in the vicinity of the populated area, drawing lines normal to the trajectory IIP ground trace, and choosing the trajectory time for the IIP point whose normal is closest to the uprange boundary of the populated area but does not intersect it. The distance from the launch point to x_1 may be determined using the range and bearing equations in appendix A, paragraph (b).

Step 2: Determine the trajectory time (t_2) associated with the trajectory IIP position (x_2) that just exceeds the downrange point on the populated area boundary. This is accomplished by locating the IIP points in the vicinity of the populated area, drawing lines normal to the trajectory IIP ground trace, and choosing the trajectory time for the IIP point whose normal is closest to the downrange boundary of the populated area but does not intersect it. The distance from the launch point to x_2 may be determined using the range and bearing equations in appendix A, section (b).

Step 3: Determine the average IIP range rate ($\bar{\dot{R}}$) for the flight period determined in steps 1 and 2 above.

$$\bar{\dot{R}} = \frac{(x_2 - x_1)}{(t_2 - t_1)} \text{ (units in nm/s)}$$

Step 4: Determine the distance along the nominal trajectory to the uprange point (x_3) on the populated area boundary. This is accomplished by drawing a line normal to the trajectory IIP ground trace and tangent to the uprange boundary of the populated area, and determining the distance along the nominal trajectory IIP ground trace from the launch point to the intersection of the normal and the ground trace.

Step 5: Determine the distance along the nominal trajectory to the downrange point (x_4) on the populated area boundary. This is accomplished by drawing a line normal to the trajectory IIP ground trace and tangent to the downrange boundary of the populated area, and determining the distance along the nominal trajectory IIP ground trace from the launch point to the intersection of the normal and the ground trace.

Step 6: The dwell time (t_d) is estimated by the following equation.

$$t_d = \frac{(x_4 - x_3)}{\bar{\dot{R}}} \text{ (units in seconds)}$$

For either type of flight corridor, an applicant determines the probability of impact in the crossrange direction, (P_y), through a series of steps, of which the first is measuring the distance from the nominal trajectory IIP ground trace to the closest and furthest points in the crossrange direction of the area that contains population. The populated area may consist of a census block group or a 1 degree latitude by 1 degree longitude grid. *See* figure C–1. To determine the distribution of the debris pattern in that populated area, the applicant needs to estimate the standard deviation of debris impacts. For purposes of an appendix C analysis, the crossrange boundaries of a flight corridor represent three standard deviations (3σ) of all debris impacts from normal and malfunction trajectories. To apply this to a populated area, an applicant must first find the distance from the nominal trajectory to the crossrange boundary, measured on a line normal to the trajectory through the geographic center of the populated area, and then divide that distance by three.

Finally, the probability of failure is also an element in calculating the probability of impact. The FAA assigns a failure probability (P_f) constant of $P_f = 0.10$ for guided expendable launch vehicles. This represents what the FAA intends as a conservative estimate of the failure percentage of current expendable launch vehicles, and may be conservative because many current expendable launch vehicles are more reliable. The appendix C process assumes that the probability of impacting within the corridor is one, and the probability of impacting outside the corridor is zero. The flight termination system is assumed to function perfectly in all failure scenarios.

A final variation on computing the probability of impact for a particular populated area is used when computing the probability of impact (P_i) within the impact dispersion area of a guided suborbital expendable launch vehicle. In this case, the probability of success (P_s) is substituted for the probability of failure (P_f), and an applicant shall employ a method similar to that used in appendix D to calculate the probability of impact for any populated areas inside the impact dispersion area. This divergence, the use of probability of success rather than probability of failure, from the variable used for an orbital expendable launch vehicle arises out of the relative risk associated with an impact dispersion area of a guided sub-orbital expendable launch vehicle. The same risks associated with a guided orbital launch are also associated with a guided sub-orbital launch except for the designated impact area for the final stage of the guided sub-orbital launch vehicle. The final stage is intended to return to Earth rather than to enter orbit. On the basis of past history, the risk due to a planned impact in the dispersion area is higher than an unplanned impact. The FAA accordingly requires the use of P_s inside the impact dispersion area rather than P_f for determining the probability of impact in a guided suborbital expendable launch vehicle's impact dispersion area.

Totaling Risk of All Populated Areas in Flight Corridor

The E_c estimate for a flight corridor is a summation of the risk to each populated area and results in an estimate of E_c inside the corridor, E (Corridor). This means that an applicant estimates E_c for each individual populated area within a flight corridor, using the following equation:

$$E_{ck} = P_i \cdot \left(\frac{A_c}{A_k}\right) \cdot N_k$$

P_i is the probability of hitting the populated area. A_c is the effective casualty area of the vehicle and may be obtained from table C–3. A_k is the area of the populated area. N_k is the population in A_k, and is obtained from census data. The label ''k'' is used to identify the individual populated area. The summed E_c for all populated areas added together is the E_c (Corridor).

The FAA requires an applicant to use an effective casualty area specific to an expendable launch vehicle class and range when performing the E_c calculation. An effective casualty area (A_c) means the aggregate casualty area of each piece of debris created by a launch vehicle failure at particular points on its trajectory. The casualty area for each piece of debris is the area within which 100 percent of the unprotected population on the ground is assumed to be a casualty. This area is based on the characteristics of the debris piece including its size, the path angle of its trajectory, impact explosions, and debris skip, splatter, and bounce. In each of the vehicle classes, the A_c decreases, resulting in a smaller casualty area, as a function of distance downrange because vehicle size and explosive potential decreases as explosive propellant is consumed and expended stages are ejected during vehicle flight.

An effective casualty area as a function of time-after-liftoff is provided in table C–3 for expendable launch vehicle classes listed in table 1 of section 420.19. The FAA derived the effective casualty areas in table C–3 from DAMP, a series of risk estimation computer programs used at federal launch ranges, to evaluate the vehicle classes described in table 1, section 420.19. DAMP considers other factors besides debris characteristics, such as the size of a standing person, which increases the casualty area, and sheltering, which would tend to decrease the casualty area. Because considering sheltering has a greater effect than considering the size of a standing person, and was not assumed in table C–3, the effective casualty areas in table C–3 are conservative with regards to those factors.

An applicant calculates casualty expectancy for each populated area within a flight corridor. After the casualty expectancies have been estimated for all populated areas, the E_c values are summed to obtain the total corridor risk.

The FAA will not approve the proposed launch site location if the estimated expected casualty exceeds 30×10^{-6}. An applicant may either modify its proposal, or if the flight corridor used was generated by the method in appendix A, use the typically less conservative but more accurate method in appendix B to narrow the flight corridor and perform another appendix C overflight risk analysis. An applicant may employ specified variations to the analysis described above. Six variations are identified in appendix C. The first four variations permit an applicant to make conservative assumptions that would lead to an overestimation of the corridor E_c compared with the more detailed process described. Although appendix C's approach simplifies a typical launch safety analysis somewhat by providing conservative default parameters to use, it may also prove unnecessarily complex for applicants proposing launch sites with launch corridors encompassing extremely few people. For those situations, appendix C, through subparagraphs (c)(1)–(8), provides the option for an applicant to further simplify the estimation of casualty expectancy by making worst-case assumptions that produce a higher value of the corridor E_c compared with the analysis otherwise defined by appendix C. This may be particularly useful when an applicant believes E_c is well below the acceptable value.[18]

These variations allow an applicant to assume that P_x and P_y have a value of 1.0 for all populated areas, or combine populated areas into one or more larger populated areas and use the greatest population density of the component populated areas for the combined area or areas. An applicant may also assume P_y has a value of one for any given populated area, or, for any given P_x sector, assume P_y has a value of one and use a worst case population density for the sector. A P_x sector is an area spanning the width of a flight corridor and bounded by two time points on the trajectory IIP ground trace. All four of these reduce the number of calculations required for applicants with little population within a flight corridor.

Another option permitted by appendix C is for an applicant who would otherwise fail the baseline analysis to perform a more refined EC analysis by negating the baseline approach's overestimation of the probability of impact in each populated area. If the flight corridor includes populated areas that are irregular in shape, the equations for probability of impact in appendix C may cause E_c to be overestimated. This is because the result of the P_i computation for each populated area represents the probability of impacting within a rectangular area that bounds the populated area. As shown in figure C–1 of appendix C, the length of two sides of the rectangle would be $x_2 - x_1$, and the length of the other two sides would be y_2—y_1. Populated areas used to support the appendix C analysis must be no bigger than a U.S. census block group for the first 100 nautical miles from a launch point and no bigger than a 1 degree latitude x 1 degree longitude grid (1° x 1° grid) beyond 100 nautical miles downrange. Whether the populated area is a census block group, a 1° x 1° grid, or a land mass such as a small island, it will not likely be a rectangle. Even a 1° x 1° grid near the equator, which approximates a rectangle, will not line up with the trajectory ground trace. Thus, a portion of the P_i rectangle includes area outside the populated area being evaluated. The probability of impacting in the rectangle is higher than impacting just in the populated area being evaluated. The value of the probability of impact calculated in accordance with appendix C will thus likely be overestimated.

One approach permitted by appendix C is to divide any given populated area into smaller rectangles, determine P_i for each individual rectangle, and sum the individual impact probabilities to determine P_i for the entire populated area. A second approach permitted by appendix C is, for a given populated area, to use the ratio of the populated area to the area of the original P_i rectangle.

If the estimated expected casualty exceeds 30×10^{-6}, the FAA will not approve the proposed launch site location. In that event, the only remaining options for an applicant would be to rely on one of its potential customers obtaining a launch license for launch from the proposed site.

Appendix D

Appendix D contains the FAA's method for determining the acceptability of the location of a launch site for launching unguided suborbital expendable launch vehicles. Appendix D describes how to define an overflight exclusion zone and each impact dispersion area to be analyzed for risk for a representative launch vehicle. Appendix D also describes how to estimate whether risk to the public, measured by expected casualty, falls within the FAA's threshold of acceptable risk. In short, the approach requires an applicant to define an overflight exclusion zone around a launch point, determine the impact point for each spent stage and then define an impact dispersion area around each impact point. If populated areas are located in the impact dispersion areas and cannot be excluded by altering the launch azimuth, the FAA requires a risk analysis that demonstrates that risk to the public remains within acceptable levels.

As a first step, an applicant selects which launch points at the proposed launch site would be used for the launch of an unguided suborbital expendable launch vehicle. An applicant must also then select an existing suborbital expendable launch vehicle, for which apogee data is available, whose final stage apogee represents the maximum altitude of any unguided suborbital expendable launch vehicle intended for launch from that launch point. The applicant would then plot the distance, which is referred to as the impact range, from the launch point to the nominal impact point on the azimuth for each stage. Employing the impact dispersion radius of each stage, the applicant would define an impact dispersion area around each nominal impact point.

The methodology for the impact dispersion area requirements is grounded in three assumptions which reflect current practice. For purposes of this location review, the FAA assumes

[18] As noted above, the purpose of the E_c analysis as part of the launch site location review is not to determine a value of E_c but rather to confidently demonstrate that E_c is less than the acceptable threshold value.

that unguided suborbital expendable launch vehicles are not equipped with a flight termination system, and that public risk criteria are accordingly met through the implementation of a wind weighting system, launch procedures and restrictions, and the proper selection of a launch azimuth and elevation angles. These aspects are currently reflected in FAA guidelines and will be addressed in its regulations for launches from non-federal launch sites. The cumulative launch experience in unguided suborbital expendable launch vehicles demonstrates that risk to the public from launches of these vehicles is attributable to planned stage impact during a successful flight. Controlling these risks solely through measures implemented prior to flight rather than relying on active measures during flight, as is the case for a vehicle equipped with an FTS, has provided historically an acceptable approach to protection of the public. Accordingly, the appendix D analysis should adequately address the general suitability of each launch point for unguided suborbital expendable launch vehicle launches up to the altitude proposed. Operational requirements imposed on a launch licensee through license conditions should adequately address risks posed by the actual launch of unguided suborbital expendable launch vehicles.

The location review for a launch point that will support unguided suborbital expendable launch vehicles also assumes that intermediate and final stages impact the Earth within three standard deviations (3σ) of each nominal, no wind, impact point. This means that an appendix D analysis does not account for failures outside of three standard deviations from each intended impact point.

It also means that an appendix D analysis does not simulate an actual launch in actual wind conditions. For actual launches, wind weighting can be used to obtain the nominal, no wind, impact point for the final stage only. In order to ensure that the launch meets E_c, ship hit, and aircraft hit probabilities, launch operators compute the wind drifted impact points of all stages using the launcher settings determined through wind weighting so that intermediate stage impacts are determined just prior to launch. Although appendix D does not address this fact directly, it does show whether at least some launches can be conducted depending on the wind conditions.

Defining an Overflight Exclusion Zone and Impact Dispersion Areas

The areas an applicant will analyze for risk to the public posed by the launch of an unguided suborbital expendable launch vehicle consist of an overflight exclusion zone and stage impact dispersion areas. Having selected a launch point and a launch vehicle for which empirical data is available, an applicant must define each zone and area using the methodology provided. An overflight exclusion zone shall consist of a circle with a radius of 1600 feet centered on a launch point. An overflight exclusion zone is the area which must be free of the public during a launch. Creation of each impact dispersion area involves several more steps. For each stage of the analyzed vehicle an applicant must identify the nominal stage impact point on the azimuth where the stage is supposed to land, and draw a circle around that point, using the range and bearing equations of appendix A or geographic information system (GIS) software. That circle describes the impact dispersion area, and an applicant defines an impact dispersion area for each stage.

An applicant must at the outset provide the geodetic latitude and longitude of a launch point that it proposes to offer for launch, and select a flight azimuth. Once an applicant has selected a launch point location and azimuth, the next step is to determine a 1600 foot radius overflight exclusion zone for that launch point. As with an overflight exclusion zone created pursuant to appendices A and B, an applicant must show that the public would be cleared from its overflight exclusion zone prior to launch. Although suborbital vehicles have a very low likelihood of failure, failure is more likely to occur in the early stages of the launch. Consequently, the FAA is guarding against that risk through requiring an applicant to show the ability to evacuate an overflight exclusion zone. As with the flight corridors of appendices A and B, the FAA bases the size of the overflight exclusion zone on the maximum distance that debris is expected to travel from a launch point if a mishap were to occur very early in flight. The FAA has estimated the D_{max} for an unguided suborbital expendable launch vehicle, and the result is 1600 feet. Accordingly, an applicant would define an appendix D overflight exclusion zone as a circle with a radius of 1600 feet.

Because an applicant must choose the maximum altitude anticipated of a suborbital expendable launch vehicle for launch from its site, an applicant needs to acquire the apogee of each stage of a representative vehicle. An applicant need not possess full information regarding a specific representative launch vehicle. All that is necessary is the apogee of each stage. The apogee height must be obtained from an actual launch conducted at an 84° elevation angle. If needed, data is available from the FAA. The FAA has compiled apogee data from past launches from Wallops Flight Facility for a range of launch vehicles and payloads. This data will be provided to an applicant upon request and may be used to perform the analysis.

An applicant then defines impact dispersion areas for each stage's nominal impact point. Having selected a launch vehicle most representative of what the applicant intends for launch from the proposed launch point, an applicant will use either its own empirical apogee data or data from one of the vehicles in the FAA's data base. Whether an applicant uses vehicle apogee data obtained from the FAA or from elsewhere, the applicant must employ the range and dispersion factors to determine the location of each nominal impact point and the size of each impact dispersion area.

Under appendix D, an applicant would estimate the impact range and dispersion parameters by multiplying the apogee of a launch vehicle intended for the prospective launch site by factors. Impact range and impact dispersion factors are derived from launch vehicle pedigrees of sounding rockets used by NASA Wallops Flight Facility in its sounding rocket program.[19] The factors provide estimators of staging data for an unguided vehicle launched at a standard launcher elevation, which is the angle between the launch vehicle's major axis (x) and the ground, of 84°. The appendix defines the relationship between the apogee of a launch vehicle stage, an impact range and a 3σ dispersion radius of a stage. This relationship is expressed as two constants, which vary with the altitude of the apogee, an impact range factor and an impact dispersion factor.

To locate each nominal impact point, an applicant will calculate the impact range for the final stage and all other stages. An impact range describes the distance between an applicant's proposed launch point and the nominal impact point of a stage, or, in other words, its estimated landing spot along

[19] These vehicles include Nike Orion, Black Brant IX, Black Brant XI, and Black Brant XII. They are representative of the current launch vehicle inventory and should approximate any proposed new launch vehicle.

the azimuth selected for analysis. For this estimation, an applicant would employ the FAA's impact range factors of 0.4 or 0.7 as multipliers for the apogee of the stage. If an apogee is less than 100 kilometers, the applicant shall employ 0.4 as the impact range factor for that stage. If the apogee of a stage is 100 kilometers or more, the applicant shall use 0.7 as a multiplier. In plotting the impact points on a map, an applicant shall employ the plotting methods provided by appendix A.

An impact dispersion radius describes the impact dispersion area of a stage. The FAA relies on an estimated impact dispersion radius of three standard deviations (3σ) because significant population, such as a densely populated city, in areas within distances up to 3σ of the impact point could cause significant public risk. An applicant shall obtain the radius of the impact dispersion area by multiplying the stage apogee by the FAA's impact dispersion factor of 0.4 for an apogee less than 100 kilometers and of 0.7 for an apogee of 100 kilometers or more. The final stage would typically produce the largest impact dispersion area.

Once an applicant determines the impact dispersion radii, the applicant must plot each impact dispersion area on a map in accordance with the requirements of paragraph (b). This is depicted in figure D–1. An applicant may then determine if flight azimuths exist which do not affect populated areas. If all potential flight azimuths contain impact dispersion areas, which encompass populated areas, then the FAA requires an E_c estimation of risk.

Public Risk E_c Estimation

The FAA will approve a launch point in accordance with this appendix if there exists a set of impact dispersion areas for a representative launch vehicle in which the sum of risk to the public does not exceed the FAA's acceptable risk threshold. An overflight exclusion zone must contain no people. If a populated area is present within the impact dispersion areas, an applicant shall estimate the risk to the public posed by possible stage impact. An applicant must then determine whether its estimated risk satisfies the FAA requirement of an E_c of no more than 30×10^{-6}. The E_c estimation is performed by computing the sum of the risk for the impact of each stage and accounting for each populated area located within a 3σ dispersion of an impact point. The equation used to accomplish this is the same as that used in the impact probability computation in appendix C. Unlike, however, the method in appendix C, which accounts for an impact due to a failure, the probability of a stage impact occurring is $P_s = 1 - P_f$, where P_s is the probability of success, and P_f is the probability of failure. For the purposes of the launch site location review, a constant of 0.98 is used for the probability of success for unguided suborbital expendable launch vehicles. The probability of success is used in place of P_f in calculating both the crossrange and downrange probability of impact.

The location review for launch points intended for the launch of unguided suborbital expendable launch vehicles differs from the review of the location of launch points intended for the launch of guided orbital and suborbital expendable launch vehicles. In analyzing whether risk remains at acceptable levels, E_c equations in appendix D rely on the probability of success rather than the probability of failure. The use of stage impact probability, typified as the probability of success (P_s), for suborbital expendable launch vehicles is necessary because stage impacts are high probability events which occur near the launch point with dispersions which may overlap or be adjacent to the launch point. The difference between the methods of appendices A, B and C and appendix D reflects the fundamental differences between the likely dominant source of risk to the public from guided and unguided vehicles and the methods that have been developed for guarding public safety against the risks created by each type of vehicle. In other words, the methods for defining impact dispersion areas and for conducting an impact risk assessment for an unguided vehicle are premised on the risks posed by a successful flight, that is, the planned deposition of stages and debris. In contrast, the methodology for developing a flight corridor and associated risk methodology for guided vehicles assumes that the likely major source of risk to the public arises out of a failure of a mission and the ensuing destruction of the vehicle.[20]

The high degree of success recorded for unguided expendable launch vehicles renders the probability of success the greater source of risk. Because of their relative simplicity of operation, the failure rate, over time, for unguided expendable launch vehicles has amounted to between one and two percent. At this level of reliability, the FAA believes that its primary focus of concern for assessing the safety of a launch site should be the more likely event, namely, the public's exposure to the planned impact of vehicle stages and other vehicle components, such as fairings, rather than the risk posed by exposure to debris resulting from a failure. Success is the high risk event. Although failure rates are low for unguided expendable launch vehicles, their spent stages have large impact dispersions. Moreover, the FAA's impact dispersion area estimations generally produce impact dispersion areas large enough to encompass most of the populations exposed to a possible failure as well as to a nominal flight, thus ensuring the inclusion of any large, densely populated area in the analysis. Thus, all but a small percentage of populated area will be analyzed to some extent, albeit using impact probabilities based on success.

For appendix D, the FAA assumes that the stage impact dispersion in both the downrange and cross range directions are equal. This is a valid assumption for assessing a launch site for suborbital expendable launch vehicles because their trajectories produce near circular dispersions. NASA data on sounding rocket impact dispersion supports this conclusion.

The impact dispersion area is based on a 3σ dispersion. Appendix D uses the effective casualty area data, table D–1, which contains information similar to appendix C, table C–3. This data represents the estimation of the area produced by both suborbital expendable launch vehicle inert pieces. The risk estimation approach in appendix D has the applicant calculate the probability of impact for each populated area, and then determining an E_c value for each populated area. To obtain the estimated E_c for an entire impact dispersion area, the applicant adds the E_c results for each populated area. If the population within the impact dispersion area is relatively small, an applicant may wish to conduct a less rigorous analysis by making conservative assumptions. Appendix D offers the option of analyzing a worst-case impact dispersion area for those locations where such an approach might save time and analysis, similar to the approach of appendix C.

The final section in subpart B is section 420.31. It requires an applicant to complete an agreement with the local U.S. Coast Guard district to establish procedures for the issuance of a Notice to Mariners prior to a launch and other such measures as the Coast Guard deems necessary to protect public health and safety. An applicant must also complete an agreement with the FAA Air Traffic Control (ATC) office having jurisdiction over the airspace

[20] The one exception is the impact dispersion area for a guided suborbital launch vehicle. That area is analyzed assuming launch success.

through which launches will take place, to establish procedures for the issuance of a Notice to Airmen prior to a launch and for closing of air routes during the launch window and other such measures as the FAA regional office deems necessary to protect public health and safety.

These two provisions clarify from the Launch Site NPRM that the FAA and Coast Guard agreements must be completed as a requirement for a license. Section 420.31(c) adds that an applicant that plans to operate a launch site located on a federal launch range does not have to enter into those agreements if the applicant is using existing federal launch range agreements with the U.S. Coast Guard and the FAA ATC office having jurisdiction over the airspace through which launches will take place.

Subpart C contains license term and conditions. Section 420.41 specifies the authority granted to a launch site operator by a license and the licensee's obligation to comply with representations contained in the license application as well as the FAA's license terms and conditions. The provision limits a licensee's authorization to the launch points on the launch site and to the types of launch vehicles used to demonstrate the safety of the launch site location, and, for orbital launch vehicles, to vehicles no larger than the weight class analyzed. The provision also clarifies the licensee's obligation to comply with any other laws or regulations applicable to its licensed activities and identifies certain rights that are not conveyed by a launch site operator license.

Section 420.43 specifies the duration of a license to operate a launch site, the grounds for shortening the term, and that a license may be renewed.

Section 420.45 provides the procedures that an applicant must follow to obtain FAA approval for the transfer of an existing license to operate a launch site.

Section 420.47 specifies the procedures that the FAA will follow to modify a license through a license order or written approval, and the procedures that a launch site operator licensee must follow to obtain an FAA license modification. A licensee must obtain a license modification if the licensee proposes to operate the launch site in a manner not authorized by its license. This means, among other things, that if a representation in the license application regarding an issue material to public safety is no longer accurate or does not describe the licensee's operation or intended operation of the site, a licensee must obtain a license modification. This is because the representations a licensee makes in its application become part of the terms and conditions of its license. A licensee must obtain FAA approval prior to modifying its operations. In the event of special circumstance and where safety warrants, the FAA will work with a licensee to accommodate any timing problems.

Section 420.47 also specifies the procedures for a licensee to obtain and the FAA to issue a license modification. The FAA may modify a license using a written approval rather than a license order. This may occur, for example, in cases where the change addresses an activity or condition that was represented in the license application but not spelled out in a license order.

Section 420.49 imposes an obligation on a launch site operator licensee, its customers, and its contractors to cooperate with the FAA in compliance monitoring of licensed activities. This requirement recognizes an FAA compliance monitor's need to observe operations conducted by all parties at the site and to have access to records and personnel if the FAA is to be assured that public safety is being protected.

Subpart D contains the responsibilities of a licensee. Section 420.51 describes a licensee's obligation to operate its launch site in accordance with the representations in its license application, 49 U.S.C. Subtitle IX, ch. 701 and the FAA's regulations.

Section 420.53 requires a launch site operator licensee to control public access to the launch site and to protect the public present at the launch site. The regulation seeks to protect the public from the consequences of flight and pre-flight activities by separating the public from hazardous launch procedures. The public could also be at risk if allowed to enter the launch site or move about without adequate safeguards. This provision requires the licensee to prevent the public from gaining unauthorized access to the launch site. The applicant will be given broad discretion in selecting the method for controlling access. The provision will also hold the licensee responsible for informing members of the public of safety precautions before entry and for warning of emergencies on-site. A licensee will also be responsible for escorting the public between hazard areas not otherwise controlled by a launch operator at the launch site, and employing warning signals or alarms to notify persons on the launch site of any emergency.

Section 420.55 requires a licensee to develop and implement procedures to schedule operations to ensure that each operation carried out by a customer at the launch site does not create the potential for a mishap that could result in harm to the public because of the proximity of the operations, in time or place, to operations of any other customer. Customers include any launch operator, and any contractor, subcontractor or customer of the launch site operator's customer at the launch site. This requirement is necessary to ensure that the operations of one launch site customer do not interact with the operations of another customer to create a public safety hazard at the launch site or beyond. For example, the testing of equipment using radio frequency transmissions could trigger ordnance used by someone elsewhere on the site if the two launch preparation activities are not coordinated or warnings issued. Likewise, hazardous operations by one customer with the potential to reach another customer must be coordinated by the launch site operator. A launch site operator is required to ensure that all customers at the site are informed of procedures and adhere to scheduling requirements before commencing operations at the launch site.

Section 420.57 establishes notification requirements for a licensee. The licensee is responsible for notifying customers of any limitations on use of the site. This provision ensures that customer activities are compatible with other activities at the launch site. It also ensures that limitations on the use of facilities provided to customers by a launch site operator are communicated to the customer. Examples include the maximum quantity of propellant allowed in a facility, or weight limitations on lifting devices within the facility. The licensee will be responsible for maintaining agreements with the Coast Guard to arrange for issuance of Notices to Mariners prior to launch and with the regional FAA ATC office for Notices to Airmen and closure of air routes. In addition, the licensee will notify local officials and landowners adjacent to the launch site of the flight schedule. This provision places an on-going responsibility on the site operator licensee for establishing notification procedures, rather than on the numerous launch licensees whose involvement with the launch site may be more sporadic and temporary. The requirement does, however, leave open the option of a launch licensee implementing the procedures established by the launch site operator.

Section 420.59 requires a licensee to develop and implement a launch site accident investigation plan containing procedures for reporting, investigating and responding to a launch site accident. The provision extends reporting, investigation and response procedures currently applicable to launch related accidents and incidents to accidents occurring during ground activities at a launch site.

A launch site operator may satisfy the requirements of section 420.59 by using accident investigation procedures developed in accordance with the requirements of the U.S. Occupational Safety and Health Administration (OSHA) at 29 CFR 1910.119 and 120, and the U.S. Environmental Protection Agency (EPA) at 40 CFR part 68, to the extent that the procedures include the elements required by section 420.59.[21] The FAA wishes to ease the regulatory burden here and in other parts of the final regulations where other federal regulatory agencies impose requirements on launch site operators.

OSHA's standard at 29 CFR 1910.119 includes provisions for investigating incidents and emergency response. *See* 29 CFR 1910.119(m) and (n). In addition, 29 CFR 1910.120, hazardous waste operations and emergency response (HAZWOPER), provides for emergency response planning for operations involving hazardous materials, including those listed by the Department of Transportation under 49 CFR 172.101.[22] Launch operators and launch site operators in compliance with these requirements will be taking steps to protect the public as well as their workers.

EPA's requirements at 40 CFR 68 also include standards for incident investigation and emergency response. *See* 40 CFR 68.60, 68.81, 68.90, and 68.180. For both the OSHA and EPA requirements, compliance with 42 U.S.C. 11003, Emergency Planning and Community Right-to-Know, satisfies many of the emergency response provisions.

Section 420.59(e) is new since the Launch Site NPRM, and states that a launch site accident investigation plan must contain procedures for participating in an investigation of a launch accident for launches that take place from the launch site. This provision also requires the licensee to cooperate with FAA or National Transportation Safety Board (NTSB) investigations of a launch accident for launches that take place from the launch site. The FAA believes that any investigation of a launch accident must have the participation of the launch site operator. The FAA requests comment on this new provision.

Section 420.61 provides the requirements for launch site operator retention of records, data, and other material needed to verify that launch site operator operations are conducted in accordance with representations contained in the license application, and for record production in the event of launch site accident investigation, or compliance monitoring.

Sections 420.63 through 420.69 contains the FAA's explosive facility siting standards for the protection of the public from launch site explosive hazards created by liquid and solid propellants and other explosives. These standards shall be used by an applicant to site facilities that support activities involving liquid and solid propellants and other explosives, or facilities potentially exposed to such activities, and to document the layout of these facilities.[23]

Section 420.63(a) requires a launch site operator to ensure that the configuration of the launch site is in accordance with the licensee's explosive site plan, and that its explosive site plan is in compliance with the requirements of sections 420.65–420.69. Section 420.63 identifies items that must be in an explosive site plan. The explosive site plan must include a scaled map or maps that show the location of all proposed explosive hazard facilities where solid and liquid propellants would be stored or handled.[24] An applicant must identify the class and division for each solid propellant and other explosive and the hazard and compatibility group for each liquid propellant.

In addition to the location of explosive hazard facilities, the map or maps must indicate actual and minimum allowable distances between each explosive hazard facility and other explosive hazard facilities and each public area, including the launch site boundary. One means by which an applicant could show that the distances are at least the minimum required is by drawing a circle or arc with a radius equal to the minimum allowed distance centered on each explosive hazard facility.

In addition to containing maps, an explosive site plan should also describe, through tables or lists, the maximum quantities of liquid and solid propellants and other explosives to be located at each explosive hazard facility, and the activities to be conducted within each explosive hazard facility.

Pursuant to section 420.63(b), a licensee operating a launch site located on a federal launch range does not have to demonstrate compliance with the requirements of §§ 420.65–420.69 if the licensee is in compliance with the federal launch range's explosive safety requirements. As proposed in the Launch Site NPRM, this provision stated that a launch site operator did not have to comply with the FAA's explosive safety requirements. Out of concern that this might be misinterpreted as permitting a launch site operator not to comply with either the range requirements, which are substantially similar to those contained in this part, or those of the FAA, the FAA wishes to clarify that it only intended that a launch site operator not have to demonstrate compliance to the FAA where a launch site operator demonstrates explosive safety to a federal launch range. Federal launch ranges have separate rules which are either identical or similar to the rules proposed, or require mitigation measures which otherwise ensure safety. The FAA only wishes to see, in accordance with section 420.15(d)(2), the launch site operator's explosive site plan submitted to the federal launch range.

In accordance with section 420.63(c), for explosive siting issues not otherwise addressed by the requirements of sections 420.65–420.69, a launch site operator must clearly and convincingly demonstrate a level of safety equivalent to that otherwise required by part 420. This provision is new since the Launch Site NPRM, and has been added because the explosive siting requirements are designed to codify only core explosive siting standards. The FAA realizes that some launch site siting scenarios will involve safety issues not otherwise addressed in this rulemaking. Thus, this provision was added to make clear that explosive siting issues outside the provisions issued with this rulemaking will be resolved in accordance with the requirements of safety. DOD Standard

[21] The EPA's requirements in 40 CFR 68 apply to ''incidents which resulted in, or could reasonably have resulted in a catastrophic release.'' 40 CFR 68.60(a). OSHA's requirements in 29 CFR 1910.119 are similar, applying to ''each incident which resulted in, or could reasonably have resulted in a catastrophic release of a highly hazardous chemical in the workplace'' 29 CFR 1910.119(m)(1).

[22] Hazardous materials in AST regulations, section 401.5, are defined as hazardous materials as defined in 49 CFR Sec. 172.101.

[23] An analysis may include evaluations of blast hazards; fragment hazards; protective construction; grounding, bounding and lightning protection systems; electrical installations; natural or man-made terrain features; or other mission or local requirements.

[24] Areas where solid propellants and other explosives would be stored must be included in the plan even though ATF requirements apply. Applicants with magazines where solid propellants and other explosives are to be stored must obtain an ATF permit and meet ATF quantity-distance requirements. The FAA will use the information to ensure that those of its requirements unrelated to storage are satisfied and to coordinate with AFT when necessary.

6055.9 is perhaps the best example of a standard governing many more explosive safety issues than those addressed to date in this part.

In order to demonstrate compliance with the explosive site standards, a launch site operator applicant first determines those areas at its proposed launch site where solid or liquid propellant and other explosives will be stored or handled, and which the FAA designates as explosive hazard facilities. Explosive hazard facilities may include payload processing facilities, launch pads, propellant storage or transfer tanks, and solid rocket motor assembly buildings. A launch site operator must then determine the types and maximum quantity of propellants and other explosives to be located at each explosive hazard facility. For solid propellants and other explosives, the applicant determines the total weight, expressed in pounds, of explosive material to be contained in the items that will be located at each explosive hazard facility. For liquid propellants, the applicant determines either the explosive equivalency of a fuel and oxidizer combination if fuels and oxidizers would be located together at, what is referred to as, incompatible distances; or, if fuels and oxidizers would not be located together, an applicant would determine the net weight in pounds of liquid propellant in each explosive hazard facility.

The next step for a launch site operator applicant would be to determine the minimum allowable separation distance between each explosive hazard facility and all other explosive hazard facilities, the launch site boundary, and other public areas such as the launch complex of another launch operator, public railways and highways running through the launch site, and any visitor centers. The distances between explosive hazard facilities are important to ensure that an explosive event in one explosive hazard facility would not cause an explosive event in another explosive hazard facility. The distances between explosive hazard facilities and public areas are important to ensure that the public is protected from blast, debris, and thermal hazards. Exact distances must be given between the wall or corner of the facility closest to the closest wall or corner of other explosive hazard facilities and public areas. Minimum allowable distances are determined using tables in appendix E. These tables reflect distances based on the type and quantity of propellant or other explosive to be located within an explosive hazard facility. Determining the minimum allowable distance between two explosive hazard facilities is accomplished by applying the applicable criteria to each and then separating them by at least the greater distance prescribed for each explosive hazard facility. For example, if a certain amount of explosive division 1.3 solid propellant would be located at explosive hazard facility A, and twice as much explosive division 1.3 solid propellant would be located at explosive hazard facility B, the prescribed distance generated by explosive hazard facility B would serve as the minimum distance permitted between explosive hazard facility A and explosive hazard facility B.

The criteria for determining the minimum required distances between each explosive hazard facility and all other explosive hazard facilities and each public area, including the launch site boundary, are contained in section 420.65 for solid propellants and other solid explosives and section 420.67 for liquid propellants. Section 420.69 includes rules for when liquid and solid propellants and other explosives are located together.

Section 420.65 covers quantity determinations and minimum required distances for explosive hazard facilities where solid propellants and other solid explosives would be handled. Under section 420.65(a), an applicant first determines the maximum total quantity, by class and division, of explosive in each explosive hazard facility where solid propellants and other solid explosives would be handled. The total quantity of explosives in an explosive hazard facility shall be the maximum total weight, expressed in pounds, of explosive material in the contents of the explosive hazard facility. For example, if a facility could hold up to ten solid rocket motors of a particular type, even though it might only rarely hold that many motors, the applicant would calculate the total weight of division 1.3 explosive material in the ten motors.

Section 420.65(b) addresses the situation where explosive divisions 1.1 and 1.3 explosives are located in the same explosive hazard facility. The section states that when explosive divisions 1.1 and 1.3 explosives are planned to be located in the same explosive hazard facility, the total quantity of explosive shall be considered division 1.1 for quantity-distance determinations, or, the applicant may add the net explosive equivalent weight of the division 1.3 items to the net weight of division 1.1 items to determine the total quantity of explosives. This latter provision will decrease the required distance.

Once a launch site operator has determined the total quantity of solid propellants and other solid explosives in each explosive hazard facility, section 420.65(c) requires a launch site operator to separate each explosive hazard facility where solid propellants and other solid explosives will be handled from all other explosive hazard facilities and each public area, including the launch site boundary, in accordance with the minimum separation distances contained in table E–1 in appendix E. Table E–1 provides two distances for each quantity and division level. The first, a public area distance, is the minimum distance permitted between a public area and an explosive hazard facility. The second, an intraline distance, is the minimum distance permitted between any two explosive hazard facilities used by one launch site customer. Other explosive hazard facilities may constitute public areas, because the definition of public area includes any area in the possession or ownership, or otherwise under the control of a launch site operator's other customers. Distance calculations would be made accordingly.

Section 420.65(d) provides separation rules. Section 420.65(d)(1) states that a launch site operator shall employ no less than the applicable public area distance to separate an explosive hazard facility from each public area and from the launch site boundary. Section 420.65(d)(2) states that a launch site operator shall employ no less than an intraline distance to separate an explosive hazard facility from all other explosive hazard facilities that will be used by a single customer.

Section 420.65(d)(3) allows a launch site operator to employ no less than 60% of the applicable public area distance, or the public traffic route distance, to separate an explosive hazard facility from a public area that consists only of a public highway or railroad line, for explosive division 1.1 only. This is new since the Launch Site NPRM and was included because explosive division 1.1 explosives have been added. This option does not apply to explosive division 1.3 because for explosive division 1.3 explosives, the public traffic route distance is the same as the public area distance. Public traffic route distance can be applied to division 1.1 explosives when a public area consists of airplane taxiways, open recreational facilities not possessing structures, and public traffic routes. Streets and roads within the licensee's control are not considered public highways unless they are used for through traffic other than that related to the work of the launch site.

Section 420.65(d)(4) allows a launch site operator to use linear interpolation for NEW quantities between table entries.

Finally, section 420.65(d)(5) states that a launch site operator shall measure separation distance from the closest debris or explosive hazard source in an explosive hazard facility. For example, for a building, a launch site operator would measure from the wall or corner of the facility closest to the closest wall or corner of other explosive hazard facilities and public areas. When solid rocket motors or motor segments are freestanding, an applicant would measure from the closest motor or motor segment. An acceptable way to demonstrate that minimum distance requirements are met is to draw a circle or arc centered on the closest source of debris or hazard showing that no other explosive hazard facility or public area is within the distance permitted.

Note that Q–D requirements address siting of facilities, not operational control of hazard areas. During actual operations, the existence and size of a hazard area is dependent on the actual amount of explosive material in an explosive hazard facility.

Section 420.67 remains unchanged from the Launch Site NPRM, and covers quantity determinations and distance requirements for explosive hazard facilities that support the storage or handling of liquid propellants. In addition to applying to distances between an explosive hazard facility and other explosive hazard facilities and public areas, distance requirements may apply within an explosive hazard facility as well.

Liquid propellants are classified and separated differently than solid propellants and other solid explosives. Where solid propellants and other solid explosives are classified by class and division, each liquid propellant is assigned to one of three hazard groups and one of two compatibility groups. A hazard group categorizes liquid propellants according to the hazards they cause. Hazard group 1 represents a fire hazard, hazard group 2 represents a more serious fire hazard, and, because a liquid propellant in hazard group 3 can rupture a storage container, it represents a fragmentation hazard. Each liquid propellant also falls into one of two compatibility groups. Liquid propellants are compatible when storing them together does not increase the probability of an accident or, for a given quantity of propellant, the magnitude of the effects of such an accident. Propellants in the same compatibility group do not increase the probability or magnitude of an accident. Group A represents oxidizers such as LO2 and N2O4, and group C represents fuels such as RP–1 and LH2. Appendix E provides the hazard and compatibility groups for current launch vehicle liquid propellants in table E–3.

Explosive equivalency serves as another source of difference between the treatment of solid explosives and liquid propellants. Only if fuels and oxidizers are to be located within certain distances of each other do the separation requirements designed to account for the hazardous consequences of their potential combination apply. That combination is measured in terms of explosive equivalency. Explosive equivalency for liquid propellants is a measure of the blast effects from explosion of a given quantity of fuel and oxidizer mixture expressed in terms of the weight of TNT that would produce the same blast effects when detonated. Fuels should not be located near oxidizers if possible. The significance of the hazard groups and compatibility groups is that if fuels are located far enough from oxidizers, the minimum distance requirements to public areas and other explosive hazard facilities depend only on the quantity and hazard group of the individual liquid propellants. If operational requirements require fuels and oxidizers to be located near each other, that is, at less than the minimum public area and incompatible distances contained in tables E–4, E–5 and E–6, the explosive equivalency of the incompatible propellants must be calculated and used to determine the distances required by table E–7 to other explosive hazard facilities and public areas.

Appendix E contains four distance tables with separation requirements for liquid propellants. Tables E–4, E–5 and E–6 contain separation distances for hazard groups 1, 2, and 3, respectively. Table E–7 contains separation distances for when fuels and oxidizers are located less than prescribed distances apart so that explosive equivalency applies. Table E–7 contains distances similar to those for explosive division 1.1 solid explosives. This is because the ''explosive equivalency'' of a fuel and oxidizer mixture is measured in terms of its equivalent explosive blast effect to TNT, which is a class 1.1 explosive. Table E–7 also prescribes public area and intraline distances.

Tables E–4, E–5, and E–6 have two distances listed for each quantity of liquid propellant by hazard group. The first, a ''public area and incompatible'' distance, is the minimum distance permitted between a given quantity of liquid propellant and a public area. The distance is also the same distance by which incompatible propellants must be separated (e.g., the minimum distance between a fuel and an oxidizer) for explosive equivalency and table E–7 not to apply to the distance calculations. The second distance, an ''intragroup and compatible'' distance, is the distance by which propellants in the same hazard group, or propellants in the same compatibility group must be separated (e.g. the minimum distance between two fuels) to avoid adding the quantity of each propellant container being separated in calculating distances. This is because if two propellant tanks are far enough apart, they cannot react with one another, even were a mishap to occur. This introduces the third difference between liquid propellant separation requirements and the requirements for solid propellants and other explosives.

The third area where liquid propellant separation requirements are different than those for solid propellants and other explosives may be found in calculations of the quantity of liquid propellant that determines the distance relationship with other explosive hazard facilities and public areas. Quantity calculations may depend on distance. As an example, suppose one was determining the minimum distance required between a tank farm having many containers of fuel, and a launch site boundary. If the containers were all close together the applicant would simply take the total amount of fuel, look up the ''public area and incompatible'' distance in the table that corresponded to the hazard group of the fuel, and ensure that the distance between the closest wall or corner of the explosive hazard facility and the launch site boundary was at least the distance listed in the table. However, if the containers were separated from each other so that the distance between each container met the minimum ''intragroup and compatible'' [25] distance in the table, the total quantity of propellant to be used for the ''public area'' distance determination is only the quantity in each container. Therefore, as discussed below, although quantity determination requirements may be found in section 420.67(a), and section 420.67(b) contains distance determination requirements, quantity determinations for liquid propellants may depend on distances between containers.

Like the procedure for solid propellant quantity and distance determinations, an applicant's first step in siting liquid propellants would be to

[25] The category is called ''intragroup and compatible'' to cover propellants that are in different hazard groups but are still compatible.

determine the quantity of liquid propellant or, if applicable, the explosive equivalent of the liquid propellant to be located in each explosive hazard facility. An applicant determines this through three steps specified in section 420.67(a). First, section 420.67(a)(1) requires that the quantity of propellant in a tank, drum, cylinder, or other container is the net weight in pounds of the propellant in that container. The weight of liquid propellant in associated piping must be included in the determination of quantity to any point where positive means, such as shutoff valves, are provided for interrupting the flow through the pipe, or for interrupting a reaction in the pipe in the event of a mishap.

Next, section 420.67(a)(2) applies when two or more containers of compatible propellants are stored together in an explosive hazard facility. When liquid propellants are compatible, the quantity of propellant used to determine the minimum separation distance between the explosive hazard facility and other explosive hazard facilities and public areas shall be the total quantity of liquid propellant in all containers unless either the containers are separated one from the other by the ''intragroup and compatible'' distance contained in appendix E, table E–4, E–5 or E–6, depending on the hazard group, or the containers are subdivided by intervening barriers to prevent their mixing. In those two cases, the quantity of propellant in the explosive hazard facility requiring the greatest separation distance must be used to determine the minimum separation distance between the explosive hazard facility and all other explosive hazard facilities and public areas.

Finally, section 420.67(a)(3) applies to quantity determinations when two or more containers of incompatible liquid propellants are stored together in an explosive hazard facility. If each container is not separated from every other container by the ''public area and incompatible'' distances identified in appendix E, tables E–4, E–5 and E–6, an applicant must determine the total quantity of explosives by calculating the explosive equivalent in pounds of the combined liquids, using formulas contained in table E–2, to determine the minimum separation distance between the explosive hazard facility and other explosive hazard facilities and public areas. If the containers are, in fact, to be separated one from the other by the appropriate ''incompatible'' distance, an applicant would determine the minimum separation distance to another explosive hazard facility or public area using the quantity of propellant within the explosive hazard facility requiring the greatest separation distance.

Section 420.67(a)(4) requires an applicant to convert liquid propellant quantities from gallons to pounds using conversion factors in table E–3, and the equation provided.

After an applicant has determined the quantity of liquid propellant or, if applicable, the explosive equivalent of the liquid propellants to be located in each explosive hazard facility, an applicant must then determine the separation distances between each explosive hazard facility and public areas. Section 420.67(b) specifies the rules by which an applicant determines the separation distances between propellants within explosive hazard facilities, and between explosive hazard facilities and public areas. An applicant would first use table E–3 to determine hazard and compatibility groups. An applicant would then separate propellants from each other and from each public area using at least the distances provided by tables E–4 through E–7.

Section 420.67(b)(1) requires that an applicant measure minimum separation distances from the container, building, or positive cutoff point in piping which is closest to each public area or explosive hazard facility requiring separation.

Section 420.67(b)(2) imposes a minimum separation distance between compatible propellants. An applicant measures the separation distance between compatible propellants using the ''intragroup and compatible'' distance for the propellant quantity and group that requires the greater distance prescribed by tables E–4, E–5, and E–6. The distance between any two propellants is computed by first determining what the minimum required distance is for each propellant based on the quantity and hazard group of that propellant. The one requiring the greater distance is controlling for the pair.

Section 420.67(b)(3) applies to the minimum separation distance between incompatible propellants. An applicant must measure the separation distance between propellants of different compatibility groups using the ''public area and incompatible'' distance for the propellant quantity and group that requires the greater distance prescribed by tables E–4, E–5, and E–6, unless the propellants of different compatibility groups are subdivided by intervening barriers to prevent their mixing. If intervening barriers are to be present, the minimum separation distance shall then be the ''intragroup and compatible'' distance for the propellant quantity and group that requires the greater distance prescribed by tables E–4, E–5, and E–6.

Section 420.67(b)(4) applies to the separation of liquid propellants from public areas. A launch site operator shall separate these propellants from public areas using no less than the ''public area'' distance prescribed by tables E–4, E–5, and E–6.

Section 420.67(b)(5) applies to propellants where explosive equivalents apply prescribed by subparagraph (a)(3). A launch site operator shall separate each explosive hazard facility that will contain propellants where explosive equivalents apply from all other explosive hazard facilities that are under the control of the same customer using at least the intraline distance in table E–7. The minimum separation distance from public areas is the public area distance in table E–7.

Section 420.69 specifies the rules to be used when solid and liquid propellants are located together, such as at launch pads and test stands. This provision has changed since the Launch Site NPRM. The Launch Site NPRM allowed applicants to site an explosive hazard facility where solid and liquid propellants were to be located together based on either the liquid propellants or solid propellants alone. As discussed in the comments section above, this is not always appropriate.

Section 420.69 now provides three options for a launch site operator proposing an explosive hazard facility where solid and liquid propellants are to be located together. First, an applicant may determine the minimum separation distances required for the liquid propellants and then add the minimum separation distances required for the solid propellants, treating the solid propellants as explosive division 1.1.

The second option is similar in that a launch site operator would determine the minimum separation distances required for the liquid propellants and then add the minimum separation distances required for the solid propellants. However, in this option, a launch site operator that knows the explosive equivalent of the explosive division 1.3 solid propellants may use it instead of treating the solid propellants as explosive division 1.1.

The third option for a launch site operator is to conduct an analysis of the maximum credible event (MCE), or the worst case explosion that is expected to occur. If it shows that an explosion due to the liquid propellants will not cause a simultaneous explosion of the solid propellants, and an explosion due to the solid propellants will not cause a simultaneous explosion of the liquid propellants, the distance between the explosive hazard facility and all other explosive hazard facilities and public areas should be based on the MCE.

Section 420.71(a) requires a launch site operator to ensure that the public is not exposed to hazards due to the initiation of explosives by lightning. Unless an explosive hazard facility has a lightning warning system to permit termination of operations and withdrawal of the public to public area distance prior to the incidence of an electrical storm, or the explosive hazard facility is to contain explosives that cannot be initiated by lightning, it must have a lightning protection system to ensure explosives are not initiated by lightning. A lightning protection system shall include an air terminal to intentionally attract a lightning strike, a low impedance path—called a down conductor—connecting an air terminal to an Earth electrode system, and an Earth electrode system to dissipate the current from a lightning strike to ground.

A lightning protection system shall also include measures for bonding and surge protection. For bonding, all metallic bodies shall be bonded to ensure that voltage potentials due to lightning are equal everywhere in the explosive hazard facility. Fences within six feet of the lightning protection system shall have bonds across gates and other discontinuations and shall be bonded to the lightning protection system. Railroad tracks that run within six feet of the lightning protection system shall be bonded to the lightning protection system. For surge protection, a lightning protection system shall include surge protection for all metallic power, communication, and instrumentation lines coming into an explosive hazard facility to reduce transient voltages due to lightning to a harmless level.

Lightning protection systems shall be visually inspected semiannually and shall be tested once each year for electrical continuity and adequacy of grounding. A record of results obtained from the tests, including action taken to correct deficiencies noted, must be maintained at the explosive hazard facility.

Section 420.71(b) requires a launch site operator to ensure that electric power lines on the launch site meet the distance requirements provided. A full discussion of explosive hazard mitigation measures is provided in the general preamble above.

Paperwork Reduction Act

This rule contains an information collection requirement. As required by the Paperwork Reduction Act of 1995, (44 U.S.C. 3507(d), the U.S. Department of Transportation submitted the information collection requirements to the Office of Management and Budget (OMB) for its review and assignment of an OMB control number. The agency received no comments on the paperwork burden. According to the regulations implementing the Paperwork Reduction Act of 1995 (5 CFR 1320.8(b)(2)(vi), an agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless an agency displays a currently valid OMB control number. The OMB control number for this information collection is 2120–0644.

Regulatory Evaluation Summary

Final changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs each Federal agency to propose or adopt a regulation only if the agency makes a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (19 U.S.C. section 2531–2533) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards. Where appropriate, agencies are directed to use those international standards as the basis of U.S. standards. And fourth, the Unfunded Mandates Reform Act of 1995 requires agencies to prepare a written assessment of the costs, benefits and other effects of proposed or final rules. This requirement applies only to rules that include a Federal mandate on State, local or tribal governments or the private sector, likely to result in a total expenditure of $100 million or more in any one year (adjusted for inflation.)

In conducting these analyses, FAA has determined this rule: (1) Has benefits which do justify its costs, is not a ''significant regulatory action'' as defined in the Executive Order; (2) will not have a significant impact on a substantial number of small entities; (3) does not affect international trade; and (4) does not impose an unfunded mandate on state, local, or tribal governments, or on the private sector.

The FAA has placed these analyses in the docket and summarized them below. The Federal Aviation Administration (FAA) is amending its commercial space licensing regulations to add licensing requirements for the operation of a launch site. The final rule will provide launch site operators with licensing and operating requirements to protect the public from the risks associated with operations at a launch site. The FAA currently issues licenses to launch site operators on a case-by-case approach. Elements of that approach are reflected in the guidelines, ''Site Operators License Guidelines for Applicants,'' which describe the information that applicants provide the FAA for a license to operate a launch site. The FAA's interpretation and implementation of the guidelines constitute another element of the case-by-case approach and additional elements, such as policy review, not reflected in the guidelines.

The final rule represents quantifiable changes in costs compared to the guidelines (current practice) in the following two areas. They are the launch site location review and approval and the launch site operations review and approval. The FAA has estimated the costs and cost savings of these changes under two different cost scenarios over a 10-year period discounted at 7 percent in 2000 dollars. The total 10-year undiscounted cost savings is estimated to be between $93,000 and $172,000 (or between $65,000 and $124,000, discounted). The most burdensome cost scenario (where net cost savings is the least) to the industry will result in the costs to the launch site operators of $3,000 (or $2,000, discounted) for the launch site location reviews and approval provisions and a cost savings of $12,000 (or $9,000, discounted) for the launch site operations review and approval provisions. Although there will be no cost impact to the FAA, there will be cost savings to the FAA from the most burdensome cost scenario of $114,000 or $84,000 discounted.

There are significant nonquantifiable benefits in two areas. First, the final rule eliminates overlapping responsibilities. Second, the final rule provides increased details and specificity, which are not present in the guidelines.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) establishes ''as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the business, organizations, and governmental jurisdictions subject to regulation.'' To achieve that principle, the Act requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The Act covers a wide-range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule will have a significant economic impact on a substantial number of small entities. If the determination is that it will, the agency must prepare a regulatory flexibility analysis as described in the Act.

However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the 1980 act provides that the head of the agency may so certify and an regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

Potentially Affected Entities

Entities who are licensed, or have begun the licensing process, were contacted to determine their size and to gain insight into the impacts of the final regulations on the licensing process. Spaceport Florida Authority (SFA), Spaceport Systems International, L.P. (SSI), the Virginia Commonwealth Space Flight Authority (VCSFA), and the Alaska Aerospace Development Corporation (AADC) are all licensed to operate launch sites.

The Virginia Commonwealth Space Flight Authority (VCSFA) is a not-for-profit subdivision of the Commonwealth of Virginia, responsible for oversight of the activities of the Virginia Commercial Space Flight Center (VCSFC). The VCSFC is located within the boundaries of the Wallops Flight Facility (WFF). As a subdivision of the Commonwealth of Virginia, the VCSFA is empowered by the Acts of the General Assembly to do all things necessary to carry out its mission of stimulating economic growth and education through commercial aerospace activities.

The Spaceport Florida Authority (SFA) was created by Florida's Governor and Legislature as the nation's first state government space agency. The authority was established to develop space-related enterprise, including launch activities, industrial development and education-related projects. SFA operates Spaceport Florida (SPF), located on Cape Canaveral Air Station.

Launch site operator California Spaceport is located on Vandenberg Air Force Base. The launch site is operated and managed by Spaceport Systems International, L.P. who is in partnership with ITT Federal Services Corporation (ITT FSC). ITT FSC is one of the largest U.S.-based technical and support services contractors in the world.

The Kodiak Launch Complex is being built by the Alaska Aerospace Development Corporation. AADC is a public corporation created by the State of Alaska to develop aerospace related economic and technical opportunities for the state.

Definition of Small Entities

The Small Business Administration has defined small business entities relating to space vehicles [SIC codes 3761, 3764 and 3769] as entities comprising fewer than 1000 employees. Although the above mentioned entities have fewer than 1000 employees in their immediate segment of the business, they are affiliated with/or funded by state governments and large parent companies. The VCSFA is a not-for-profit subdivision of the Commonwealth of Virginia; the SFA is a government space agency; the SSI is affiliated with ITT FSC; and AADC is a government sponsored corporation.

The FAA conducted the required review of this final rule and determined that they will not have a significant economic impact on a substantial number of small entities. Accordingly, pursuant to the regulatory Flexibility Act, U.S.C. 605(b), the Federal Aviation Administration certifies that this rule will not have a significant economic impact on a substantial number of small entities.

International Trade Impact Assessment

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards or related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards. In addition, consistent with the Administration's belief in the general superiority and desirability of free trade, it is the policy of the Administration to remove or diminish to the extent feasible, barriers to international trade, including both barriers affecting the export of American goods and services to foreign countries and barriers affecting the import of foreign goods and services into the United States.

The Licensing and Safety Requirements for Operation of a Launch Site (14 CFR part 420) will not constitute a barrier to international trade, including the export of U.S. goods and services out of the United States. The final rule affects launch sites that are currently located or being proposed within the United States.

The final rule is not expected to affect trade opportunities for U.S. firms doing business overseas or for foreign firms doing business in the United States.

Unfunded Mandates Reform Act Assessment

The Unfunded Mandates Reform Act of 1995 (the Act), enacted as Pub. L. 104–4 on March 22, 1995, is intended, among other things, to curb the practice of imposing unfunded Federal mandates on State, local, and tribal governments.

Title II of the Act requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in a $100 million or more expenditure (adjusted annually for inflation) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a ''significant regulatory action.''

This final rule does not meet the cost thresholds described above. Furthermore, this final rule will not impose a significant cost or uniquely affect small governments. Therefore, the requirements of Title II of the Unfunded Mandates Reform Act of 1995 do not apply.

Executive Order 13132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action will not have a substantial direct effect on the States, or the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, we determined that this final rule does not have federalism implications.

Environmental Assessment

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental assessment (EA) or environmental impact statement (EIS). In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(i), regulatory documents which cover administrative or procedural requirements qualify for a categorical exclusion. Sections in subpart B of part 420 would require an applicant to submit sufficient environmental information for the FAA to comply with NEPA and other applicable environmental laws and regulations during the processing of each license application. Accordingly, the FAA proposes that this rule qualifies for a categorical exclusion because no significant impacts to the environment are expected to result from finalization or implementation of its administrative provisions for licensing.

Energy Impact

The energy impact of the rulemaking action has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) and Public Law 94–163, as amended (42 U.S.C. 6362). It has been determined that it is not a major regulatory action under the provisions of the EPCA.

List of Subjects in 14 CFR Parts 401, 417, and 420

Confidential business information, Environmental protection, Organization and functions, Reporting and recordkeeping requirements, Rockets, Space transportation and exploration.

The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends Chapter III of Title 14 of the Code of Federal Regulations to read as follows:

PART 401—ORGANIZATION AND DEFINITIONS

1. The authority citation for part 401 continues to read as follows:

Authority: 49 U.S.C. 70101–70121.

§ 401.5 [Amended]

2. Section 401.5 is amended by adding the words ''launch site accident,'' after the word ''incident.''

PART 417—[REMOVED AND RESERVED]

3. Part 417 is removed and reserved.

4. Subchapter C of Chapter III, title 14, Code of Federal Regulations, is amended by adding a new part 420 to read as follows:

PART 420—LICENSE TO OPERATE A LAUNCH SITE

Subpart A—General

Sec.

Subpart B—Criteria and Information Requirements for Obtaining a License

Subpart C—License Terms and Conditions

Subpart D—Responsibilities of a Licensee

Authority: 49 U.S.C. 70101–70121.

Subpart A—General

§ 420.1 Scope.

This part prescribes the information and demonstrations that must be provided to the FAA as part of a license application, the bases for license approval, license terms and conditions, and post-licensing requirements with which a licensee shall comply to remain licensed. Requirements for preparing a license application are contained in part 413 of this subchapter.

§ 420.3 Applicability.

This part applies to any person seeking a license to operate a launch site or to a person licensed under this part. A person operating a site that only supports amateur rocket activities, as defined in 14 CFR 401.5, does not need a license under this part to operate the site.

§ 420.5 Definitions.

For the purpose of this part.

Ballistic coefficient means the weight of an object divided by the quantity product of the coefficient of drag of the object and the area of the object.

Compatibility means the chemical property of materials that may be located together without increasing the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

Debris dispersion radius (D_{max}) means the estimated maximum distance from a launch point that debris travels given a worst-case launch vehicle failure and flight termination early in flight. For an expendable launch vehicle, flight termination is assumed to occur at 10 seconds into flight.

Downrange area means a portion of a flight corridor beginning where a launch area ends and ending 5,000 nautical miles from the launch point, or where the IIP leaves the surface of the Earth, whichever is shorter, for an orbital launch vehicle; and ending with an impact dispersion area for a guided sub-orbital launch vehicle.

E,F,G coordinate system means an orthogonal, Earth-fixed, geocentric, right-handed system. The origin of the coordinate system is at the center of an ellipsoidal Earth model. The E-axis is positive directed through the Greenwich meridian. The F-axis is positive directed though 90 degrees east longitude. The EF-plane is coincident with the ellipsoidal Earth model's equatorial plane. The G-axis is normal to the EF-plane and positive directed through the north pole.

E,N,U coordinate system means an orthogonal, Earth-fixed, topocentric, right-handed system. The origin of the coordinate system is at a launch point. The E-axis is positive directed east. The N-axis is positive directed north. The EN-plane is tangent to an ellipsoidal Earth model's surface at the origin and perpendicular to the geodetic vertical. The U-axis is normal to the EN-plane and positive directed away from the Earth.

Effective casualty area (A_c) means the aggregate casualty area of each piece of debris created by a launch vehicle failure at a particular point on its trajectory. The effective casualty area for each piece of debris is the area within which 100 percent of the unprotected population on the ground are assumed to be a casualty, and outside of which 100 percent of the population are assumed not to be a casualty. An effective casualty area accounts for the characteristics of the debris piece, including its size, the path angle of its trajectory, impact explosions, and debris skip, splatter, and bounce. An effective casualty area also accounts for the size of a person.

Explosive means any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, detonation or other suitable initiation, undergoes a rapid chemical change that releases large volumes of highly heated gases that exert pressure in the surrounding medium. The term applies to materials that either detonate or deflagrate.

Explosive division means the division within hazard class 1 of an explosive as defined in the United Nations Organization classification system for transport of dangerous goods, and as determined in accordance with 49 CFR part 173, subpart C.

Explosive equivalent means a measure of the blast effects from explosion of a given quantity of material expressed in terms of the weight of trinitrotoluene (TNT) that would produce the same blast effects when detonated.

Explosive hazard facility means a facility at a launch site where solid propellant, liquid propellant, or other explosives are stored or handled.

Flight azimuth means the initial direction in which a launch vehicle flies relative to true north expressed in degrees-decimal-degrees.

Flight corridor means an area on the Earth's surface estimated to contain the hazardous debris from nominal flight of a launch vehicle, and non-nominal flight of a launch vehicle assuming a perfectly functioning flight termination system or other flight safety system.

Guided suborbital launch vehicle means a suborbital rocket that employs an active guidance system.

Hazard class means the class of an explosive as defined by the United Nations Organization classification system for transport of dangerous goods, and as determined in accordance with 49 CFR part 173, subpart C.

Impact dispersion area means an area representing an estimated three standard deviation dispersion about a nominal impact point of an intermediate or final stage of a suborbital launch vehicle.

Impact dispersion factor means a constant used to estimate, using a stage apogee, a three standard deviation dispersion about a nominal impact point of an intermediate or final stage of a suborbital launch vehicle.

Impact dispersion radius (R_i) means a radius that defines an impact dispersion area.

Impact range means the distance between a launch point and the impact point of a suborbital launch vehicle stage.

Impact range factor means a constant used to estimate, when multiplied by a stage apogee, the nominal impact point of an intermediate or final stage of a suborbital launch vehicle.

Instantaneous impact point (IIP) means an impact point, following thrust termination of a launch vehicle. IIP may be calculated with or without atmospheric drag effects.

Instantaneous impact point (IIP) range rate means a launch vehicle's estimated IIP velocity along the Earth's surface.

Intraline distance means the minimum distance permitted between any two explosive hazard facilities in the ownership, possession or control of one launch site customer.

Launch area means, for a flight corridor defined in accordance with appendix A of this part, the portion of a flight corridor from the launch point to a point 100 nautical miles in the direction of the flight azimuth. For a flight corridor defined in accordance with appendix B of this part, a launch area is the portion of a flight corridor from the launch point to the enveloping line enclosing the outer boundary of the last debris dispersion circle.

Launch point means a point on the Earth from which the flight of a launch vehicle begins, and is defined by its geodetic latitude, longitude and height on an ellipsoidal Earth model.

Launch site accident means an unplanned event occurring during a ground activity at a launch site resulting in a fatality or serious injury (as defined in 49 CFR 830.2) to any person who is not associated with the activity, or any damage estimated to exceed $25,000 to property not associated with the activity.

Net explosive weight (NEW) means the total weight, expressed in pounds, of explosive material or explosive equivalency contained in an item.

Nominal means, in reference to launch vehicle performance, trajectory, or stage impact point, a launch vehicle flight where all launch vehicle aerodynamic parameters are as expected, all vehicle internal and external systems perform as planned, and there are no external perturbing influences (e.g., winds) other than atmospheric drag and gravity.

Overflight dwell time means the period of time it takes for a launch vehicle's IIP to move past a populated area. For a given populated area, the overflight dwell time is the time period measured along the nominal trajectory IIP ground trace from the time point whose normal with the trajectory intersects the most uprange part of the populated area to the time point whose normal with the trajectory intersects the most downrange part of the populated area.

Overflight exclusion zone means a portion of a flight corridor which must remain clear of the public during the flight of a launch vehicle.

Populated area means a land area with population.

Population density means the number of people per unit area in a populated area.

Position data means data referring to the current position of a launch vehicle with respect to flight time expressed through the X, Y, Z coordinate system.

Public means people and property that are not involved in supporting a licensed launch, and includes those people and property that may be located within the boundary of a launch site, such as visitors, any individual providing goods or services not related to launch processing or flight, and any other launch operator and its personnel.

Public area means any area outside a hazard area and is an area that is not in the possession, ownership or other control of a launch site operator or of a launch site customer who possesses, owns or otherwise controls that hazard area.

Public area distance means the minimum distance permitted between a public area and an explosive hazard facility.

Public traffic route distance means the minimum distance permitted between a public highway or railroad line and an explosive hazard facility.

Trajectory means the position and velocity components as a function of time of a launch vehicle relative to an x, y, z coordinate system, expressed in x, y, z, $\dot{x}$, $\dot{y}$, $\dot{z}$.

Unguided sub-orbital launch vehicle means a sub-orbital rocket that does not have a guidance system.

X, Y, Z coordinate system means an orthogonal, Earth-fixed, topocentric, right-handed system. The origin of the coordinate system is at a launch point. The x-axis coincides with the initial launch azimuth and is positive in the downrange direction. The y-axis is positive to the left looking downrange. The xy-plane is tangent to the ellipsoidal earth model's surface at the origin and perpendicular to the geodetic vertical. The z-axis is normal to the xy-plane and positive directed away from the earth.

ϕ_0,λ_0,h_0 means a latitude, longitude, height system where ϕ_0 is the geodetic latitude of a launch point, λ_0 is the east longitude of the launch point, and h_0 is the height of the launch point above the reference ellipsoid. ϕ_0 and λ_0 are expressed in degrees-decimal-degrees.

§§ 420.6–420.14 [Reserved]

Subpart B—Criteria and Information Requirements for Obtaining a License

§ 420.15 Information requirements.

(a) General. (1) *Launch site operator.* An applicant shall identify the name and address of the applicant, and the name, address, and telephone number of any person to whom inquiries and correspondence should be directed.

(2) *Launch site.* An applicant shall provide the name and location of the proposed launch site and include the following information:

(i) A list of downrange equipment;

(ii) A description of the layout of the launch site, including launch points;

(iii) The types of launch vehicles to be supported at each launch point;

(iv) The range of launch azimuths planned from each launch point; and

(v) The scheduled operational date.

(3) *Foreign ownership.* Identify foreign ownership of the applicant, as follows:

(i) For a sole proprietorship or partnership, all foreign owners or partners;

(ii) For a corporation, any foreign ownership interest of 10 percent or more; and

(iii) For a joint venture, association, or other entity, any foreign entities participating in the entity.

(b) *Environmental.* An applicant shall provide the FAA with information for the FAA to analyze the environmental impacts associated with the operation of the proposed launch site. The information provided by an applicant must be sufficient to enable the FAA to comply with the requirements of the National Environment Policy Act, 42 U.S.C. 4321 *et seq.* (NEPA), the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA, 40 CFR parts 1500–1508, and the FAA's Procedures for Considering Environmental Impacts, FAA Order 1050.1D. An applicant shall submit environmental information concerning a proposed launch site not covered by existing environmental documentation, and other factors as determined by the FAA.

(c) *Launch site location.* (1) Except as provided by paragraph (c)(2) of this section, an applicant shall provide the information necessary to demonstrate compliance with §§ 420.19–420.29.

(2) An applicant who is proposing to locate a launch site at an existing launch point at a federal launch range is not required to comply with paragraph (c)(1) of this section if a launch vehicle of the same type and class as proposed for the launch point has been safely launched from the launch point.

(d) *Explosive site plan.* (1) Except as provided by paragraph (d)(2) of this section, an applicant shall submit an explosive site plan that complies with §§ 420.63, 420.65, 420.67, and 420.69.

(2) If an applicant plans to operate a launch site located on a federal launch range, and if the applicant is required by the federal launch range to comply with the federal launch range's explosive safety requirements, the applicant shall submit the explosive site plan submitted to the federal launch range.

(e) *Launch site operations.* An applicant shall provide the information necessary to demonstrate compliance with the requirements of §§ 420.53, 420.55, 420.57, 420.59, 420.61, and 420.71.

§ 420.17 Bases for issuance of a license.

(a) The FAA will issue a license under this part when the FAA determines that:

(1) The application provides the information required by § 420.15;

(2) The FAA has completed an analysis of the environmental impacts associated with the proposed operation of the launch site, in accordance with NEPA, 40 CFR parts 1500–1508, and FAA Order 1050.1D;

(3) The launch site location meets the requirements of §§ 420.19, 420.21, 420.23, 420.25, 420.27, and 420.29;

(4) The applicant has completed the agreements required by § 420.31;

(5) The application demonstrates that the applicant shall satisfy the requirements of §§ 420.53, 420.55, 420.57, 420.59, 420.61 and 420.71;

(6) The explosive site plan meets the criteria of §§ 420.63, 420.65, 420.67 and 420.69; and

(7) Issuing a license would not jeopardize foreign policy or national security interests of the United States.

(b) The FAA advises an applicant, in writing, of any issue arising during an application review that would lead to denial. The applicant may respond in writing, submit additional information, or amend its license application.

§ 420.19 Launch site location review—general.

(a) To gain approval for a launch site location, an applicant shall demonstrate that for each launch point proposed for the launch site, at least one type of expendable or reusable launch vehicle can be flown from the launch point safely. For purposes of the launch site location review:

(1) A safe launch must possess a risk level estimated, in accordance with the requirements of this part, not to exceed an expected average number of 0.00003 casualties (E_c) to the collective member of the public exposed to hazards from the flight ($E_c \leq 30 \times 10^{-6}$).

(2) Types of launch vehicles include orbital expendable launch vehicles, guided sub-orbital expendable launch vehicles, unguided sub-orbital expendable launch vehicles, and reusable launch vehicles. Orbital expendable launch vehicles are further classified by weight class, based on the weight of payload the launch vehicle can place in a 100-nm orbit, as defined in table 1.

(b) If an applicant proposes to have more than one type of launch vehicle flown from a launch point, the applicant shall demonstrate that each type of expendable or reusable launch vehicle planned to be flown from the launch point can be flown from the launch point safely.

(c) If an applicant proposes to have more than one weight class of orbital expendable launch vehicles flown from a launch point, the applicant shall demonstrate that the heaviest weight class planned to be flown from the launch point can be flown from the launch point safely.

TABLE 1 OF § 420.19.—ORBITAL EXPENDABLE LAUNCH VEHICLE CLASSES BY PAYLOAD WEIGHT (LBS)

100 nm orbit	Weight class			
	Small	Medium	Medium large	Large
28 degrees inclination*	≤4400	>4400 to ≤11100	>11100 to ≤18500	>18500
90 degrees inclination	≤3300	>3300 to ≤8400	>8400 to ≤15000	>15000

* 28 degrees inclination orbit from a launch point at 28 degrees latitude.

§ 420.21 Launch site location review—launch site boundary.

(a) The distance from any proposed launch point to the closest launch site boundary must be at least as great as the debris dispersion radius of the largest launch vehicle type and weight class proposed for the launch point.

(b) For a launch site supporting any expendable launch vehicle, an applicant shall use the largest distance provided by table 2 for the type and weight class of any launch vehicle proposed for the launch point.

(c) For a launch site supporting any reusable launch vehicle, an applicant shall determine the debris dispersion radius that represents the maximum distance from a launch point that debris travels given a worst-case launch vehicle failure in the launch area. An applicant must clearly and convincingly demonstrate the validity of its proposed debris dispersion radius.

TABLE 2 OF § 420.21.—MINIMUM DISTANCE FROM LAUNCH POINT TO LAUNCH SITE BOUNDARY (FEET)

Orbital expendable launch vehicle class			Type of suborbital launch vehicle		
Small	Medium	Medium large	Large	Guided	Unguided
7300	9300	10600	13000	8000	1600

§ 420.23 Launch site location review—flight corridor.

(a) *Guided orbital expendable launch vehicle.* For a guided orbital expendable launch vehicle, an applicant shall define a flight corridor that:

(1) Encompasses an area that the applicant estimates, in accordance with the requirements of this part, to contain debris with a ballistic coefficient of ≥ 3 pounds per square foot, from any non-nominal flight of a guided orbital expendable launch vehicle from the launch point to a point 5000 nm downrange, or where the IIP leaves the surface of the Earth, whichever is shorter;

(2) Includes an overflight exclusion zone where the public risk criteria of 30×10^{-6} would be exceeded if one person were present in the open; and

(3) Uses one of the methodologies provided in appendix A or B of this part. The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix A or B of this part.

(b) *Guided sub-orbital expendable launch vehicle.* For a guided sub-orbital expendable launch vehicle, an applicant shall define a flight corridor that:

(1) Encompasses an area that the applicant estimates, in accordance with the requirements of this part, to contain debris with a ballistic coefficient of ≥ 3 pounds per square foot, from any non-nominal flight of a guided sub-orbital expendable launch vehicle from the launch point to impact with the earth's surface;

(2) Includes an impact dispersion area for the launch vehicle's last stage;

(3) Includes an overflight exclusion zone where the public risk criteria of 30×10^{-6} would be exceeded if one person were present in the open; and

(4) Uses one of the methodologies provided in appendices A or B to this part. The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix A or B of this part.

(c) *Unguided sub-orbital expendable launch vehicle.*

(1) For an unguided sub-orbital expendable launch vehicle, an applicant shall define the following using the methodology provided by appendix D of this part:

(i) Impact dispersion areas that the applicant estimates, in accordance with the requirements of this part, to contain the impact of launch vehicle stages from nominal flight of an unguided sub-orbital expendable launch vehicle from the launch point to impact with the earth's surface; and

(ii) An overflight exclusion zone where the public risk criteria of 30×10^{-6} would be exceeded if one person were present in the open.

(2) The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix D of this part.

(3) An applicant shall base its analysis on an unguided suborbital launch vehicle whose final launch vehicle stage apogee represents the intended use of the launch point.

(d) *Reusable launch vehicle.* For a reusable launch vehicle, an applicant shall define a flight corridor that contains the hazardous debris from nominal and non-nominal flight of a reusable launch vehicle. The applicant must provide a clear and convincing demonstration of the validity of its flight corridor.

§ 420.25 Launch site location review—risk analysis.

(a) If a flight corridor or impact dispersion area defined by section 420.23 contains a populated area, the applicant shall estimate the casualty expectation associated with the flight corridor or impact dispersion area. An applicant shall use the methodology provided in appendix C to this part for guided orbital or suborbital expendable launch vehicles and appendix D for unguided suborbital launch vehicles. The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix C or D of this part. For a reusable launch vehicle, an applicant must provide a clear and convincing demonstration of the validity of its risk analysis.

(b) If the estimated expected casualty exceeds 30×10^{-6}, the FAA will not approve the location of the proposed launch point.

§ 420.27 Launch site location review—information requirements.

An applicant shall provide the following launch site location review information in its application:

(a) A map or maps showing the location of each launch point proposed, and the flight azimuth, IIP, flight corridor, and each impact range and impact dispersion area for each launch point;

(b) Each launch vehicle type and any launch vehicle class proposed for each launch point;

(c) Trajectory data;

(d) Wind data, including each month and any percent wind data used in the analysis;

(e) Any launch vehicle apogee used in the analysis;

(f) Each populated area located within a flight corridor or impact dispersion area;

(g) The estimated casualty expectancy calculated for each populated area within a flight corridor or impact dispersion area;

(h) The effective casualty areas used in the analysis;

(i) The estimated casualty expectancy for each flight corridor or set of impact dispersion areas; and

(j) If populated areas are located within an overflight exclusion zone, a demonstration that there are times when the public is not present or that the applicant has an agreement in place to evacuate the public from the overflight exclusion zone during a launch.

§ 420.29 Launch site location review for unproven launch vehicles.

An applicant for a license to operate a launch site for an unproven launch vehicle shall provide a clear and convincing demonstration that its proposed launch site location provides an equivalent level of safety to that required by this part.

§ 420.31 Agreements.

(a) Except as provided by paragraph (c) of this section, an applicant shall complete an agreement with the local U.S. Coast Guard district to establish procedures for the issuance of a Notice to Mariners prior to a launch and other such measures as the Coast Guard deems necessary to protect public health and safety.

(b) Except as provided by paragraph (c) of this section, an applicant shall complete an agreement with the FAA Air Traffic Control (ATC) office having jurisdiction over the airspace through which launches will take place, to establish procedures for the issuance of a Notice to Airmen prior to a launch and for closing of air routes during the launch window and other such measures as the FAA ATC office deems necessary to protect public health and safety.

(c) An applicant that plans to operate a launch site located on a federal launch range does not have to comply with section 420.31 if the applicant is using existing federal launch range agreements with the U.S. Coast Guard and the FAA ATC office having jurisdiction over the airspace through which launches will take place.

§§ 420.32–420.40 [Reserved]

Subpart C—License Terms and Conditions

§ 420.41 License to operate a launch site—general.

(a) A license to operate a launch site authorizes a licensee to operate a launch site in accordance with the representations contained in the licensee's application, with terms and conditions contained in any license order accompanying the license, and subject to the licensee's compliance with 49 U.S.C. subtitle IX, ch. 701 and this chapter.

(b) A license to operate a launch site authorizes a licensee to offer its launch site to a launch operator for each launch point for the type and any weight class of launch vehicle identified in the license application and upon which the licensing determination is based.

(c) Issuance of a license to operate a launch site does not relieve a licensee of its obligation to comply with any other laws or regulations; nor does it confer any proprietary, property, or exclusive right in the use of airspace or outer space.

§ 420.43 Duration.

A license to operate a launch site remains in effect for five years from the date of issuance unless surrendered, suspended, or revoked before the expiration of the term and is renewable upon application by the licensee.

§ 420.45 Transfer of a license to operate a launch site.

(a) Only the FAA may transfer a license to operate a launch site.

(b) The FAA will transfer a license to an applicant who has submitted an application in accordance with 14 CFR part 413, satisfied the requirements of § 420.15, and obtained each approval required by § 420.17 for a license.

(c) The FAA may incorporate by reference any findings made part of the record that supported a prior related licensing determination.

§ 420.47 License modification.

(a) Upon application or upon its own initiative, the FAA may modify a license to operate a launch site at any time by issuing a license order that adds, removes, or modifies a license term or condition to ensure compliance with the Act and the requirements of this chapter.

(b) After a license to operate a launch site has been issued, a licensee shall apply to the FAA for modification of its license if:

(1) The licensee proposes to operate the launch site in a manner that is not authorized by the license; or

(2) The licensee proposes to operate the launch site in a manner that would make any representation contained in the license application that is material to public health and safety or safety of property no longer accurate and complete.

(c) An application to modify a license shall be prepared and submitted in accordance with part 413 of this chapter. The licensee shall indicate any part of its license or license application that would be changed or affected by a proposed modification.

(d) The FAA approves a modification request that satisfies the requirements of this part.

(e) Upon approval of a license modification, the FAA issues either a written approval to the licensee or a license order modifying the license if a stated term or condition of the license is changed, added, or deleted. A written approval has the full force and effect of a license order and is part of the licensing record.

§ 420.49 Compliance monitoring.

A licensee shall allow access by and cooperate with federal officers or employees or other individuals authorized by the FAA to observe any activities of the licensee, its customers, its contractors, or subcontractors, associated with licensed operation of the licensee's launch site.

Subpart D—Responsibilities of a Licensee

§ 420.51 Responsibilities—general.

(a) A licensee shall operate its launch site in accordance with the representations in the application upon which the licensing determination is based.

(b) A licensee is responsible for compliance with 49 U.S.C. Subtitle IX, ch. 701 and for meeting the requirements of this chapter.

§ 420.53 Control of public access.

(a) A licensee shall prevent unauthorized access to the launch site, and unauthorized, unescorted access to explosive hazard facilities or other hazard areas not otherwise controlled by a launch operator, through the use of security personnel, surveillance systems, physical barriers, or other means approved as part of the licensing process.

(b) A licensee shall notify anyone entering the launch site of safety rules and emergency and evacuation procedures prior to that person's entry unless that person has received a briefing on those rules and procedures within the previous year.

(c) A licensee shall employ warning signals or alarms to notify any persons at the launch site of any emergency.

§ 420.55 Scheduling of launch site operations.

(a) A licensee shall develop and implement procedures to schedule operations to ensure that each operation carried out by a customer at the launch site does not create the potential for a mishap that could result in harm to the public because of the proximity of the operations, in time or place, to operations of any other customer. A customer includes any launch operator, and any contractor, subcontractor or customer of the launch site operator's customer at the launch site.

(b) A licensee shall provide its launch site scheduling requirements to each customer before the customer begins operations at the launch site.

§ 420.57 Notifications.

(a) A licensee shall notify each launch operator and any other customer of any limitations on the use of the launch site. A licensee shall also communicate limitations on the use of facilities provided to customers by the launch site operator.

(b) A licensee shall maintain its agreement, made in accordance with § 420.31(a), with the local U.S. Coast Guard district.

(c) A licensee shall maintain its agreement, made in accordance with § 420.31(b), with the FAA ATC office having jurisdiction over the airspace through which launches will take place.

(d) At least two days prior to flight of a launch vehicle, the licensee shall notify local officials and all owners of land adjacent to the launch site of the flight schedule.

§ 420.59 Launch site accident investigation plan.

(a) *General.* A licensee shall develop and implement a launch site accident investigation plan that contains the licensee's procedures for reporting, responding to, and investigating launch site accidents, as defined by § 420.5, and for cooperating with federal officials in case of a launch accident. The launch site accident investigation plan must be signed by an individual authorized to sign and certify the application in accordance with § 413.7(c) of this chapter.

(b) *Reporting requirements.* A launch site accident investigation plan shall provide for—

(1) Immediate notification to the Federal Aviation Administration (FAA) Washington Operations Center in the event of a launch site accident.

(2) Submission of a written preliminary report to the FAA, Associate Administrator for Commercial Space Transportation, within five days of any launch site accident. The report must include the following information:

(i) Date and time of occurrence;

(ii) Location of the event;

(iii) Description of the event;

(iv) Number of injuries, if any, and general description of types of injuries suffered;

(v) Property damage, if any, and an estimate of its value;

(vi) Identification of hazardous materials, as defined by § 401.5 of this chapter, involved in the event;

(vii) Any action taken to contain the consequences of the event; and

(viii) Weather conditions at the time of the event.

(c) *Response plan.* A launch site accident investigation plan shall contain procedures that—

(1) Ensure the consequences of a launch site accident are contained and minimized;

(2) Ensure data and physical evidence are preserved;

(3) Require the licensee to report to and cooperate with FAA or National Transportation Safety Board (NTSB) investigations and designate one or more points of contact for the FAA or NTSB; and

(4) Require the licensee to identify and adopt preventive measures for avoiding recurrence of the event.

(d) *Investigation plan.* A launch site accident investigation plan must contain—

(1) Procedures for investigating the cause of a launch site accident;

(2) Procedures for reporting launch site accident investigation results to the FAA; and

(3) Delineated responsibilities, including reporting responsibilities for personnel assigned to conduct investigations and for any one retained by the licensee to conduct or participate in investigations.

(e) *Launch accidents.* A launch site accident investigation plan shall contain—

(1) Procedures for participating in an investigation of a launch accident for launches launched from the launch site;

(2) Require the licensee to cooperate with FAA or National Transportation Safety Board (NTSB) investigations of a launch accident for launches launched from the launch site.

(f) *Applicability of other accident investigation procedures.* Accident investigation procedures developed in accordance with 29 CFR 1910.119 and 40 CFR part 68 will satisfy the requirements of paragraphs (c) and (d) of this section to the extent that they include the elements required by paragraphs (c) and (d) of this section.

§ 420.61 Records.

(a) A licensee shall maintain all records, data, and other material needed to verify that its operations are conducted in accordance with representations contained in the licensee's application. A licensee shall retain records for three years.

(b) In the event of a launch or launch site accident, a licensee shall preserve all records related to the event. Records shall be retained until completion of any federal investigation and the FAA advises the licensee that the records need not be retained.

(c) A licensee shall make available to federal officials for inspection and copying all records required to be maintained under the regulations.

§ 420.63 Explosive siting.

(a) Except as otherwise provided by paragraph (b) of this section, a licensee shall ensure that the configuration of the launch site is in accordance with an explosive site plan, and that the licensee's explosive site plan is in compliance with the requirements of §§ 420.65—420.69. The explosive site plan shall include:

(1) A scaled map that shows the location of all proposed explosive hazard facilities at the proposed launch site and that shows actual and minimal allowable distances between each explosive hazard facility and all other explosive hazard facilities and each public area, including the launch site boundary;

(2) A listing of the maximum quantities of liquid and solid propellants and other explosives to be located at each explosive hazard facility, including the class and division for each solid explosive and the hazard and compatibility group for each liquid propellant; and

(3) A description of each activity to be conducted in each explosive hazard facility.

(b) A licensee operating a launch site located on a federal launch range does not have to comply with the requirements in §§ 420.65–420.69 if the licensee is in compliance with the federal launch range's explosive safety requirements.

(c) For explosive siting issues not otherwise addressed by the requirements of §§ 420.65–420.69, a launch site operator must clearly and convincingly demonstrate a level of safety equivalent to that otherwise required by part 420.

§ 420.65 Handling of solid propellants.

(a) A launch site operator shall determine the maximum total quantity of solid propellants and other solid explosives by class and division, in accordance with 49 CFR part 173, Subpart C, to be located in each explosive hazard facility where solid propellants or other solid explosives will be handled.

(b) When explosive divisions 1.1 and 1.3 explosives are located in the same explosive hazard facility, the total quantity of explosive shall be treated as division 1.1 for quantity-distance determinations; or, a launch site operator may add the net explosive equivalent weight of the division 1.3 items to the net weight of division 1.1 items to determine the total quantity of explosives.

(c) A launch site operator shall separate each explosive hazard facility where solid propellants and other solid explosives are handled from all other explosive hazard facilities, each public area and the launch site boundary by a distance no less than those provided for each quantity and explosive division in appendix E, table E–1.

(d) A launch site operator shall follow the following separation rules:

(1) A launch site operator shall employ no less than the applicable public area distance to separate an explosive hazard facility from each public area and from the launch site boundary.

(2) A launch site operator shall employ no less than an intraline distance to separate an explosive hazard facility from all other explosive hazard facilities used by a single customer.

(3) For explosive division 1.1 only, a launch site operator may employ no less than 60% of the applicable public area distance, or the public traffic route distance, to separate an explosive hazard facility from a public area that consists only of a public highway or railroad line.

(4) A launch site operator may use linear interpolation for NEW quantities between table entries.

(5) A launch site operator shall measure separation distance from the closest debris or explosive hazard source in an explosive hazard facility.

§ 420.67 Storage or handling of liquid propellants.

(a) For an explosive hazard facility where liquid propellants are handled or stored, a launch site operator shall determine the total quantity of liquid propellant and, if applicable pursuant to paragraph (a)(3) of this section, the explosive equivalent of liquid propellant in each explosive hazard facility in accordance with the following:

(1) The quantity of liquid propellant in a tank, drum, cylinder, or other container is the net weight in pounds of the propellant in the container. The determination of quantity shall include any liquid propellant in associated piping to any point where positive means are provided for interrupting the flow through the pipe, or interrupting a reaction in the pipe in the event of a mishap.

(2) Where two or more containers of compatible liquid propellants are handled or stored together in an explosive hazard facility, the total quantity of propellant to determine the minimum separation distance between the explosive hazard facility and all other explosive hazard facilities and each public area shall be the total quantity of liquid propellant in all containers, unless:

(i) The containers are separated one from the other by the appropriate distance as provided by paragraph (b)(2) of this section; or

(ii) The containers are subdivided by intervening barriers, such as diking, that prevent mixing.

(iii) If paragraph (a)(2)(i) or (ii) of this section apply, a launch site operator shall use the quantity of propellant requiring the greatest separation distance pursuant to paragraph (b) of this section to determine the minimum separation distance between the explosive hazard facility and all other explosive hazard facilities and each public area.

(3) Where two or more containers of incompatible liquid propellants will be handled or stored together in an explosive hazard facility, a launch site operator shall determine the explosive equivalent in pounds of the combined liquids, using the formulas provided in appendix E, table E–2, to determine the minimum separation distance between the explosive hazard facility and other explosive hazard facilities and public areas unless the containers are separated one from the other by the appropriate distance as determined in paragraph (b)(3) of this section. A launch site operator shall then use the quantity of liquid propellant requiring the greatest separation distance to determine the minimum separation distance between the explosive hazard facility and all other explosive hazard facilities and each public area.

(4) A launch site operator shall convert quantities of liquid propellants from gallons to pounds using the conversion factors provided in appendix E, table E–3 and the following equation:

Pounds of propellant = gallons x density of propellant (pounds per gallon).

(b) A launch site operator shall use appendix E, table E–3 to determine hazard and compatibility groups and shall separate liquid propellants from each other and from each public area using distances no less than those provided in appendix E, tables E–4 through E–7 in accordance with the following:

(1) A launch site operator shall measure minimum separation distances from the hazard source in an explosive hazard facility, such as a container, building, segment, or positive cutoff point in piping, closest to each explosive hazard facility.

(2) A launch site operator shall measure the minimum separation distance between compatible liquid propellants using the ''intragroup and compatible'' distance for the propellant quantity and hazard group that requires the greater distance prescribed by appendix E, tables E–4, E–5, and E–6.

(3) A launch site operator shall measure the minimum separation distance between liquid propellants of different compatibility groups using the ''public area and incompatible'' distance for the propellant quantity and hazard group that requires the greater distance provided in appendix E, tables E–4, E–5, and E–6, unless the propellants of different compatibility groups are subdivided by intervening barriers that prevent mixing. If such barriers are present, the minimum separation distance shall be the ''intragroup and compatible'' distance for the propellant quantity and group that requires the greater distance provided in appendix E, tables E–4, E–5, and E–6.

(4) A launch site operator shall separate liquid propellants from each public area using a distance no less than the ''public area and incompatible'' distance provided in appendix E, tables E–4, E–5, and E–6.

(5) A launch site operator shall separate each explosive hazard facility that contains liquid propellants where explosive equivalents apply pursuant to paragraph (a)(3) of this section from all other explosive hazard facilities of a single customer using the intraline distance provided in appendix E, table E–7, and from each public area using the public area distance provided in appendix E, table E–7.

§ 420.69 Solid and liquid propellants located together.

(a) A launch site operator proposing an explosive hazard facility where solid and liquid propellants are to be located together shall determine the minimum separation distances between the explosive hazard facility and other explosive hazard facilities and public areas in accordance with one method provided in paragraphs (b), (c), or (d) of this section.

(b) A launch site operator shall determine the minimum separation distances between the explosive hazard facility and all other explosive hazard facilities and public areas required for the liquid propellants in accordance with section 420.67(b)(5), and add the minimum separation distances between the explosive hazard facility and all other explosive hazard facilities and public areas required for the solid propellants in accordance with section 420.65, treating the solid propellants as explosive division 1.1.

(c) A launch site operator shall determine the minimum separation distances between the explosive hazard facility and all other explosive hazard facilities and public areas required for the liquid propellants in accordance with section 420.67(b)(5), and add the minimum separation distances between the explosive hazard facility and all other explosive hazard facilities and public areas required for the solid propellants in accordance with section 420.65, using the explosive equivalent of the explosive division 1.3.

(d) A launch site operator shall conduct an analysis of the maximum credible event (MCE), or the worst case explosion that is expected to occur. If the MCE shows that there will be no simultaneous explosion reaction of the liquid propellant tanks and the solid propellant motors, then the minimum distance between the explosive hazard facility and all other explosive hazard facilities and public areas must be based on the MCE.

§ 420.71 Lightning protection.

(a) *Lightning protection.* A licensee shall ensure that the public is not exposed to hazards due to the initiation of explosives by lightning.

(1) *Elements of a lighting protection system.* Unless an explosive hazard facility meets the conditions of paragraph (a)(3) of this section, all explosive hazard facilities shall have a lightning protection system to ensure explosives are not initiated by lightning. A lightning protection system shall meet the requirements of this paragraph and include the following:

(i) *Air terminal.* An air terminal to intentionally attract a lightning strike.

(ii) *Down conductor.* A low impedance path connecting an air terminal to an earth electrode system.

(iii) *Earth electrode system.* An earth electrode system to dissipate the current from a lightning strike to ground.

(2) *Bonding and surge protection.* A lightning protection system must meet the requirements of this paragraph and include the following:

(i) *Bonding.* All metallic bodies shall be bonded to ensure that voltage potentials due to lightning are equal everywhere in the explosive hazard facility. Any fence within six feet of a lightning protection system shall have a bond across each gate and other discontinuations and shall be bonded to the lightning protection system. Railroad tracks that run within six feet of the lightning protection system shall be bonded to the lightning protection system.

(ii) *Surge protection.* A lightning protection system shall include surge protection to reduce transient voltages due to lightning to a harmless level for all metallic power, communication, and instrumentation lines entering an explosive hazard facility.

(3) *Circumstances where no lightening protection system is required.* No lightning protection system is required for an explosive hazard facility when a lightning warning system is available to permit termination of operations and withdrawal of the public to public area distance prior to an electrical storm, or for an explosive hazard facility containing explosives that cannot be initiated by lightning. If no lightning protection system is required, a licensee must ensure the withdrawal of the public to a public area distance prior to an electrical storm.

(4) *Testing and inspection.* Lightning protection systems shall be visually inspected semiannually and shall be tested once each year for electrical continuity and adequacy of grounding. A licensee shall maintain at the explosive hazard facility a record of results obtained from the tests, including any action taken to correct deficiencies noted.

(b) *Electrical power lines.* A licensee shall ensure that electric power lines at its launch site meet the following requirements:

(1) Electric power lines shall be no closer to an explosive hazard facility than the length of the lines between the poles or towers that support the lines unless an effective means is provided to ensure that energized lines cannot, on breaking, come in contact with the explosive hazard facility.

(2) Towers or poles supporting electrical distribution lines that carry between 15 and 69 KV, and unmanned electrical substations shall be no closer to an explosive hazard facility than the public area distance for that explosive hazard facility.

(3) Towers or poles supporting electrical transmission lines that carry 69 KV or more, shall be no closer to an explosive hazard facility than the public area distance for that explosive hazard facility.

Issued in Washington, DC on September 29, 2000.

Patricia G. Smith,

Associate Administrator for Commercial Space Transportation.

Appendix A to Part 420—Method for Defining a Flight Corridor

(a) Introduction

(1) This appendix provides a method for constructing a flight corridor from a launch point for a guided suborbital launch vehicle or any one of the four classes of guided orbital launch vehicles from table 1, § 420.19, without the use of local meteorological data or a launch vehicle trajectory.

(2) A flight corridor includes an overflight exclusion zone in a launch area and, for a guided suborbital launch vehicle, an impact dispersion area in a downrange area. A flight corridor for a guided suborbital launch vehicle ends with the impact dispersion area, and, for the four classes of guided orbital launch vehicles, 5000 nautical miles (nm) from the launch point.

(b) Data requirements

(1) Maps. An applicant shall use any map for the launch site region with a scale not less than 1:250,000 inches per inch in the launch area and 1:20,000,000 inches per inch in the downrange area. As described in paragraph (b)(2), an applicant shall use a mechanical method, a semi-automated method, or a fully-automated method to plot a flight corridor on maps. A source for paper maps acceptable to the FAA is the U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

(i) Projections for mechanical plotting method. An applicant shall use a conic projection. The FAA will accept a ''Lambert-Conformal'' conic projection. A polar aspect of a plane-azimuthal projection may also be used for far northern launch sites.

(ii) Projections for semi-automated plotting method. An applicant shall use cylindrical, conic, or plane projections for semi-automated plotting. The FAA will accept ''Mercator'' and ''Oblique Mercator'' cylindrical projections. The FAA will accept ''Lambert-Conformal'' and ''Albers Equal-Area'' conic projections. The FAA will accept ''Lambert Azimuthal Equal-Area'' and ''Azimuthal Equidistant'' plane projections.

(iii) Projections for fully-automated plotting method. The FAA will accept map projections used by geographical information system software scaleable pursuant to the requirements of paragraph (b)(1).

(2) Plotting Methods.

(i) Mechanical method. An applicant may use mechanical drafting equipment such as pencil, straight edge, ruler, protractor, and compass to plot the location of a flight corridor on a map. The FAA will accept straight lines for distances less than or equal to 7.5 times the map scale on map scales greater than or equal to 1:1,000,000 inches per inch (in/in); or straight lines representing 100 nm or less on map scales less than 1:1,000,000 in/in.

(ii) Semi-automated method. An applicant may employ the range and bearing techniques in paragraph (b)(3) to create latitude and longitude points on a map. The FAA will accept straight lines for distances less than or equal to 7.5 times the map scale on map scales greater than or equal to 1:1,000,000 inches per inch (in/in); or straight lines representing 100 nm or less on map scales less than 1:1,000,000 in/in.

(iii) Fully-automated method. An applicant may use geographical information system software with global mapping data scaleable in accordance with paragraph (b)(1).

(3) Range and bearing computations on an ellipsoidal Earth model.

(i) To create latitude and longitude pairs on an ellipsoidal Earth model, an applicant shall use the following equations to calculate geodetic latitude (+N) and longitude (+E) given the launch point geodetic latitude (+N), longitude (+E), range (nm), and bearing (degrees, positive clockwise from North).

(A) Input. An applicant shall use the following input in making range and bearing computations. Angle units must be in radians.

$$\phi_1 = \text{Geodetic latitude of launch point (radians)}$$

$$= \phi_1\,(\text{DDD}) \cdot \frac{\pi}{180}\ (\text{radians per degree})$$

$$\lambda_1 = \text{Longitude of launch point (DDD)}$$

$$= \lambda\,(\text{DDD}) \cdot \frac{\pi}{180}\ (\text{radians per degree})$$

$$S = \text{Range from launch point (nm)}$$

$$= S\,(\text{DDD}) \cdot \frac{\pi}{180}\ (\text{radians per degree})$$

$$\alpha_{12} = \text{Azimuth bearing from launch point (deg)}$$

$$= \alpha_{12}(\text{DDD}) \cdot \frac{\pi}{180}\ (\text{radians per degree})$$

(B) Computations. An applicant shall use the following equations to determine the latitude (ϕ_2) and longitude (λ_2) of a target point situated ‘‘S’’ nm from the launch point on an azimuth bearing (α_{12}) degrees.

$$f = 1 - \frac{b}{a} \qquad \text{(Equation A1)}$$

where:

a = WGS–84 semi-major axis (3443.91846652 nmi)

b = WGS–84 semi-minor axis (3432.37165994 nmi)

$$\varepsilon^2 = \frac{\left(a^2 - b^2\right)}{b^2} \qquad \text{(Equation A2)}$$

$$\theta = \frac{S}{b}\ (\text{radians}) \qquad \text{(Equation A3)}$$

$$\beta_1 = \tan^{-1}\left[\frac{\left(b \cdot \sin\phi_1\right)}{\left(a \cdot \cos\phi_1\right)}\right] \qquad \text{(Equation A4)}$$

$$g = \left(\cos\beta_1\right)\left(\cos\alpha_{12}\right) \qquad \text{(Equation A5)}$$

$$h = \left(\cos\beta_1\right)\left(\sin\alpha_{12}\right) \qquad \text{(Equation A6)}$$

$$m = \frac{\left[1 + \left(\frac{\varepsilon^2}{2}\right)\sin^2\beta_1\right]\left[1 - h^2\right]}{2} \qquad \text{(Equation A7)}$$

$$n = \frac{\left[1 + \left(\frac{\varepsilon^2}{2}\right)\sin^2\beta_1\right]\left[\left(\sin^2\beta_1\right)(\cos\theta) + g\cdot\left(\sin\beta_1\right)(\sin\theta)\right]}{2} \qquad \text{(Equation A8)}$$

$$L = h\cdot\left[-f\cdot\theta + 3\cdot f^2\cdot n\cdot\sin\theta + \frac{3\cdot f^2\cdot m\cdot(\theta - \sin\theta\cdot\cos\theta)}{2}\right]\text{(radians)} \qquad \text{(Equation A9)}$$

$$M = m\cdot\varepsilon^2 \qquad \text{(Equation A10)}$$

$$N = n\cdot\varepsilon^2 \qquad \text{(Equation A11)}$$

$$A_1 = N\cdot\sin\theta \qquad \text{(Equation A12)}$$

$$A_2 = \left(\frac{M}{2}\right)(\sin\theta\cdot\cos\theta - \theta) \qquad \text{(Equation A13)}$$

$$A_3 = \left(\frac{5}{2}\right)\left(N^2\cdot\sin\theta\cdot\cos\theta\right) \qquad \text{(Equation A14)}$$

$$A_4 = \left(\frac{M^2}{16}\right)\left(11\cdot\theta - 13\cdot\sin\theta\cdot\cos\theta - 8\cdot\theta\cdot\cos^2\theta + 10\cdot\sin\theta\cdot\cos^3\theta\right) \qquad \text{(Equation A15)}$$

$$A_5 = \left(\frac{M\cdot N}{2}\right)\left(3\cdot\sin\theta + 2\cdot\theta\cdot\cos\theta - 5\cdot\sin\theta\cdot\cos^2\theta\right) \qquad \text{(Equation A16)}$$

$$\delta = \theta - A_1 + A_2 + A_3 + A_4 + XA_5\text{(radians)} \qquad \text{(Equation A17)}$$

$$\sin\beta_2 = \sin\beta_1\cdot\cos\delta + g\cdot\sin\delta \qquad \text{(Equation A18)}$$

$$\cos\beta_2 = \left[h^2 + \left(g\cdot\cos\delta - \sin\beta_1\cdot\sin\delta\right)^2\right]^{\frac{1}{2}} \qquad \text{(Equation A19)}$$

$$\phi_2 = \left\{\tan^{-1}\left[\frac{\left(a\cdot\sin\beta_2\right)}{\left(b\cdot\cos\beta_2\right)}\right]\right\}\cdot\left(\frac{180}{\pi}\right)\text{(geodetic latitude of target point, DDD)} \qquad \text{(Equation A20)}$$

$$\Lambda = \tan^{-1}\left[\frac{\left(\sin\delta\cdot\sin\alpha_{12}\right)}{\left(\cos\beta_1\cdot\cos\delta - \sin\beta_1\cdot\sin\delta\cdot\cos\alpha_{12}\right)}\right] \qquad \text{(Equation A21)}$$

$$\lambda_2 = \left(\lambda_1 + \Lambda + L\right)\left(\frac{180}{\pi}\right)\text{(longitude of target point, DDD)} \qquad \text{(Equation A22)}$$

(ii) To create latitude and longitude pairs on an ellipsoidal Earth model, an applicant shall use the following equations to calculate the distance (S) of the geodesic between two points (P_1 and P_2), the forward azimuth (α_{12}) of the geodesic at $P_{1,}$ and the back azimuth (α_{21}) of the geodesic at $P_{2,}$ given the geodetic latitude (+N), longitude (+E) of P_1 and P_2. Azimuth is measured positively clockwise from North.

(A) Input. An applicant shall use the following input. Units must be in radians.

$$\phi_1 = \text{Geodetic latitude of launch point (radians)}$$
$$= \phi_1(\text{DDD}) \cdot \frac{\pi}{180}(\text{radians per degree})$$
$$\lambda_1 = \text{Longitude of launch point (DDD)}$$
$$= \lambda_1(\text{DDD}) \cdot \frac{\pi}{180}(\text{radians per degree})$$
$$S = \text{Range from launch point (nm)}$$
$$= S(\text{DDD}) \cdot \frac{\pi}{180}(\text{radians per degree})$$
$$\alpha_{12} = \text{Azimuth bearing from launch point (deg)}$$
$$= \alpha_{12}(\text{DDD}) \cdot \frac{\pi}{180}(\text{radians per degree})$$

(B) Computations. An applicant shall use the following equations to determine the distance (S), the forward azimuth (α_{12}) of the geodesic at P_1, and the back azimuth (α_{12}) of the geodesic at P_2.

$$f = 1 - \frac{b}{a} \qquad (\text{Equation A23})$$

where:

a = WGS–84 semi-major axis (3443.91846652 nmi)
b = WGS–84 semi-minor axis (3432.37165994 nmi)

$$L = \lambda_2 - \lambda_1 \qquad (\text{Equation A24})$$

$$\beta_1 = \tan^{-1}\left[\frac{(b \cdot \sin\phi_1)}{\alpha \cdot \cos\phi_1}\right] \qquad (\text{Equation A25})$$

$$\beta_2 = \tan^{-1}\left[\frac{(b \cdot \sin\phi_2)}{\alpha \cdot \cos\phi_2}\right] \qquad (\text{Equation A26})$$

$$A = \sin\beta_1 \cdot \sin\beta_2 \qquad (\text{Equation A27})$$

$$B = \cos\beta_1 \cdot \cos\beta_2 \qquad (\text{Equation A28})$$

$$\cos\delta = A + B \cdot \cos L \qquad (\text{Equation A29})$$

$$n = \frac{(a-b)}{(a+b)} \qquad (\text{Equation A30})$$

$$(\beta_2 - \beta_1) = (\phi_2 - \phi_1) + 2 \cdot \left\lfloor A \cdot \left(n + n^2 + n^3\right) - B \cdot \left(n - n^2 + n^3\right)\right\rfloor \cdot \sin(\phi_2 - \phi_1)\,\text{radians} \qquad (\text{Equation A31})$$

$$\sin\delta = \left\{ \left(\sin L \cdot \cos\beta_2\right)^2 + \left[\sin\left(\beta_2 - \beta_1\right) + 2 \cdot \cos\beta_2 \cdot \sin\beta_1 \cdot \sin^2\left(L/2\right)\right]^2 \right\}^{\frac{1}{2}} \qquad \text{(Equation A32)}$$

$$\delta = \tan^{-1}\left(\frac{\sin\delta}{\cos\delta}\right) \text{evaluated in positive radians} \le \pi \qquad \text{(Equation A33)}$$

$$c = \frac{B \cdot \sin L}{\sin\delta} \qquad \text{(Equation A34)}$$

$$m = 1 - c^2 \qquad \text{(Equation A35)}$$

$$S = b \cdot \left\{ \begin{array}{l} \delta \cdot \left[1 + f + f^2\right] + A \cdot \left[\left(f + f^2\right) \cdot \sin\delta - \left(f^2 \cdot \delta^2\right)/\left(2 \cdot \sin\delta\right)\right] \\ -\left(m/2\right)\left[\left(f + f^2\right)\left(\delta + \sin\delta \cdot \cos\delta\right) - \left(f^2 \cdot \delta^2\right)/\left(\tan\delta\right)\right] \\ -\left(A^2 \cdot f^2/2\right) \cdot \sin\delta \cdot \cos\delta \\ +\left(f^2 \cdot m^2/16\right)\left[\delta + \sin\delta \cdot \cos\delta - 2 \cdot \sin\delta \cdot \cos^3\delta - 8\delta^2/\left(\tan\delta\right)\right] \\ +\left(A^2 \cdot m \cdot f^2/2\right)\left[\sin\delta \cdot \cos^2 + \delta + \delta^2/\left(\sin\delta\right)\right] \text{ in the same units as "a" and "b"} \end{array} \right\} \qquad \text{(Equation A36)}$$

$$\Lambda = L + c \cdot \left\{ \begin{array}{l} \delta \cdot \left(f + f^2\right) - \left(A \cdot f^2/2\right)\left[\sin\delta + 2\delta^2/\left(\sin\delta\right)\right] \\ +\left(m \cdot f^2/4\right)\left[\sin\delta\cos\delta - 5\delta + 4\delta^2/\left(\tan\delta\right)\right] \end{array} \right\} \text{radians} \qquad \text{(Equation A37)}$$

$$\alpha_{12} = \tan^{-1}\left\{ \frac{\left(\cos\beta_2 \cdot \sin\Lambda\right)}{\left[\sin\left(\beta_2 - \beta_1\right) + 2 \cdot \cos\beta_2 \cdot \sin\beta_1 \cdot \sin^2\left(\Lambda/2\right)\right]} \right\} \cdot \left(\frac{180}{\pi}\right) \text{degrees} \qquad \text{(Equation A38)}$$

$$\alpha_{21} = \tan^{-1}\left\{ \frac{\left(-\cos\beta_1 \cdot \sin\Lambda\right)}{\left[2 \cdot \cos\beta_1 \cdot \sin\beta_2 \cdot \sin^2\left(\Lambda/2\right) - \sin\left(\beta_2 - \beta_1\right)\right]} \right\} \cdot \left(\frac{180}{\pi}\right) \text{degrees} \qquad \text{(Equation A39)}$$

(c) Creation of a Flight Corridor

(1) To define a flight corridor, an applicant shall:

(i) Select a guided suborbital or orbital launch vehicle, and, for an orbital launch vehicle, select from table 1 of § 420.19 a launch vehicle weight class that best represents the launch vehicle the applicant plans to support at its launch point;

(ii) Select a debris dispersion radius (D_{max}) from table A–1 corresponding to the guided suborbital launch vehicle or orbital launch vehicle class selected in paragraph (c)(1)(i);

(iii) Select a launch point geodetic latitude and longitude; and

(iv) Select a flight azimuth.

(2) An applicant shall define and map an overflight exclusion zone using the following method:

(i) Select a debris dispersion radius (D_{max}) from table A–1 and a downrange distance (D_{OEZ}) from table A–2 to define an overflight exclusion zone for the guided suborbital launch vehicle or orbital launch vehicle class selected in paragraph (c)(1)(i).

(ii) An overflight exclusion zone is described by the intersection of the following boundaries, which are depicted in figure A–1:

(A) An applicant shall define an uprange boundary with a half-circle arc of radius D_{max} and a chord of length twice D_{max} connecting the half-circle arc endpoints. The uprange boundary placement on a map has the chord midpoint positioned on the launch point with the chord oriented along an azimuth ±90°from the launch azimuth and the half-circle arc located uprange from the launch point.

(B) An applicant shall define the downrange boundary with a half-circle arc of radius D_{max} and a chord of length twice D_{max} connecting the half-circle arc endpoints. The downrange boundary placement on a map has the chord midpoint intersecting the nominal flight azimuth line at a distance D_{OEZ} inches downrange with the chord oriented along an azimuth ±90°from the launch azimuth and the half-circle arc located downrange from the intersection of the chord and the flight azimuth line.

(C) Crossrange boundaries of an overflight exclusion zone are defined by two lines segments. Each is parallel to the flight azimuth with one to the left side and one to the right side of the flight azimuth line. Each line connects an uprange half-circle arc endpoint to a downrange half-circle arc endpoint as shown in figure A–1.

(iii) An applicant shall identify the overflight exclusion zone on a map that meets the requirements of paragraph (b).

(3) An applicant shall define and map a flight corridor using the following method:

(i) In accordance with paragraph (b), an applicant shall draw a flight corridor on one or more maps with the D_{max} origin centered on the intended launch point and the flight corridor centerline (in the downrange direction) aligned with the initial flight azimuth. The flight corridor is depicted in figure A–2 and its line segment lengths are tabulated in table A–3.

(ii) An applicant shall define the flight corridor using the following boundary definitions:

(A) An applicant shall draw an uprange boundary, which is defined by an arc-line GB (figure A–2), directly uprange from and centered on the intended launch point with radius D_{max}.

(B) An applicant shall draw line CF perpendicular to and centered on the flight azimuth line, and positioned 10 nm downrange from the launch point. The applicant shall use the length of line CF provided in table A–3 corresponding to the guided suborbital launch vehicle or orbital launch vehicle class selected in paragraph (c)(1)(i).

(C) An applicant shall draw line DE perpendicular to and centered on the flight azimuth line, and positioned 100 nm downrange from the launch point. The applicant shall use the length of line DE provided in table A–3 corresponding to the guided suborbital launch vehicle or orbital launch vehicle class selected in paragraph (c)(1)(i).

(D) Except for a guided suborbital launch vehicle, an applicant shall draw a downrange boundary, which is defined by line HI and is drawn perpendicular to and centered on the flight azimuth line, and positioned 5,000 nm downrange from the launch point. The applicant shall use the length of line HI provided in table A–3 corresponding to the orbital launch vehicle class selected in paragraph (c)(1)(i).

(E) An applicant shall draw crossrange boundaries, which are defined by three lines on the left side and three lines on the right side of the flight azimuth. An applicant shall construct the left flight corridor boundary according to the following, and as depicted in figure A–3 :

(1) The first line (line BC in figure A–3) is tangent to the uprange boundary arc, and ends at endpoint C of line CF, as depicted in figure A–3;

(2) The second line (line CD in figure A–3) begins at endpoint C of line BC and ends at endpoint D of line DH, as depicted in figure A–3;

(3) For all orbital launch vehicles, the third line (line DH in figure A–3) begins at endpoint D of line CD and ends at endpoint H of line HI, as depicted in figure A–3; and

(4) For a guided suborbital launch vehicle, the line DH begins at endpoint D of line CD and ends at a point tangent to the impact dispersion area drawn in accordance with paragraph (c)(4) and as depicted in figure A–4.

(F) An applicant shall repeat the procedure in paragraph (c)(3)(ii)(E) for the right side boundary.

(iii) An applicant shall identify the flight corridor on a map that meets the requirements of paragraph (b).

(4) For a guided suborbital launch vehicle, an applicant shall define a final stage impact dispersion area as part of the flight corridor and show the impact dispersion area on a map, as depicted in figure A–4, in accordance with the following:

(i) An applicant shall select an apogee altitude (H_{ap}) for the launch vehicle final stage. The apogee altitude should equal the highest altitude intended to be reached by a guided suborbital launch vehicle launched from the launch point.

(ii) An applicant shall define the impact dispersion area by using an impact range factor [$IP(H_{ap})$] and a dispersion factor [$DISP(H_{ap})$] as shown below:

(A) An applicant shall calculate the impact range (D) for the final launch vehicle stage. An applicant shall set D equal to the maximum apogee altitude (H_{ap}) multiplied by the impact range factor as shown below:

$$D = H_{ap} \cdot IP\left(H_{ap}\right) \qquad \text{(Equation A40)}$$

where: $IP(H_{ap}) = 0.4$ for an apogee less than 100 km; and $IP(H_{ap}) = 0.7$ for an apogee 100 km or greater.

(B) An applicant shall calculate the impact dispersion radius (R) for the final launch vehicle stage. An applicant shall set R equal to the maximum apogee altitude (H_{ap}) multiplied by the dispersion factor as shown below:

$$R = H_{ap} \cdot DISP\left(H_{ap}\right) \qquad \text{(Equation A41)}$$

where: $DISP(H_{ap}) = 0.05$

(iii) An applicant shall draw the impact dispersion area on a map with its center on the predicted impact point. An applicant shall then draw line DH in accordance with paragraph (c)(3)(ii)(E)(4).

(d) Evaluate the Flight Corridor

(1) An applicant shall evaluate the flight corridor for the presence of any populated areas. If an applicant determines that no populated area is located within the flight corridor, then no additional steps are necessary.

(2) If a populated area is located in an overflight exclusion zone, an applicant may modify its proposal or demonstrate that there are times when no people are present or that the applicant has an agreement in place to evacuate the public from the overflight exclusion zone during a launch.

(3) If a populated area is located within the flight corridor, an applicant may modify its proposal and create another flight corridor pursuant to appendix A, use appendix B to narrow the flight corridor, or complete a risk analysis in accordance with appendix C.

TABLE A–1.—DEBRIS DISPERSION RADIUS (D_{max}) (IN)

Orbital launch vehicles				Suborbital launch vehicles
Small	Medium	Medium large	Large	Guided
87,600 (1.20 nm)	111,600 (1.53 nm)	127,200 (1.74 nm)	156,000 (2.14 nm)	96,000 (1.32 nm)

TABLE A–2.—OVERFLIGHT EXCLUSION ZONE DOWNRANGE DISTANCE (D_{oez}) (IN)

Orbital launch vehicles				Suborbital launch vehicles
Small	Medium	Medium large	Large	Guided
240,500 (3.30 nm)	253,000 (3.47 nm)	310,300 (4.26 nm)	937,700 (12.86 nm)	232,100 (3.18 nm)

Table A-3: Flight Corridor Line Segment Lengths

D_{max} (in)		Line Segment Lengths (x 10^6 inches)		
Orbital Launch Vehicles		$\overline{CF}$	$\overline{DE}$	$\overline{HI}$
Small	87600 (1.20 nm)	2.87620 (39.45 nm)	8.59452 (117.87 nm)	128.566 (1763.27 nm)
Medium	111,600 (1.53 nm)	2.97220 (40.76 nm)	8.64252 (118.53 nm)	128.566 (1763.27 nm)
Med-Large	127,200 (1.74 nm)	3.03460 (41.62 nm)	8.67372 (118.96 nm)	128.566 (1763.27 nm)
Large	156,000 (2.14 nm)	3.14979 (43.20 nm)	8.73131 (119.75 nm)	128.566 (1763.27 nm)
Suborbital Launch Vehicles		$\overline{CF}$	$\overline{DE}$	$\overline{HI}$
Guided	96,000 (1.32 nm)	2.90980 (39.91 nm)	8.61132 (118.10 nm)	N/A

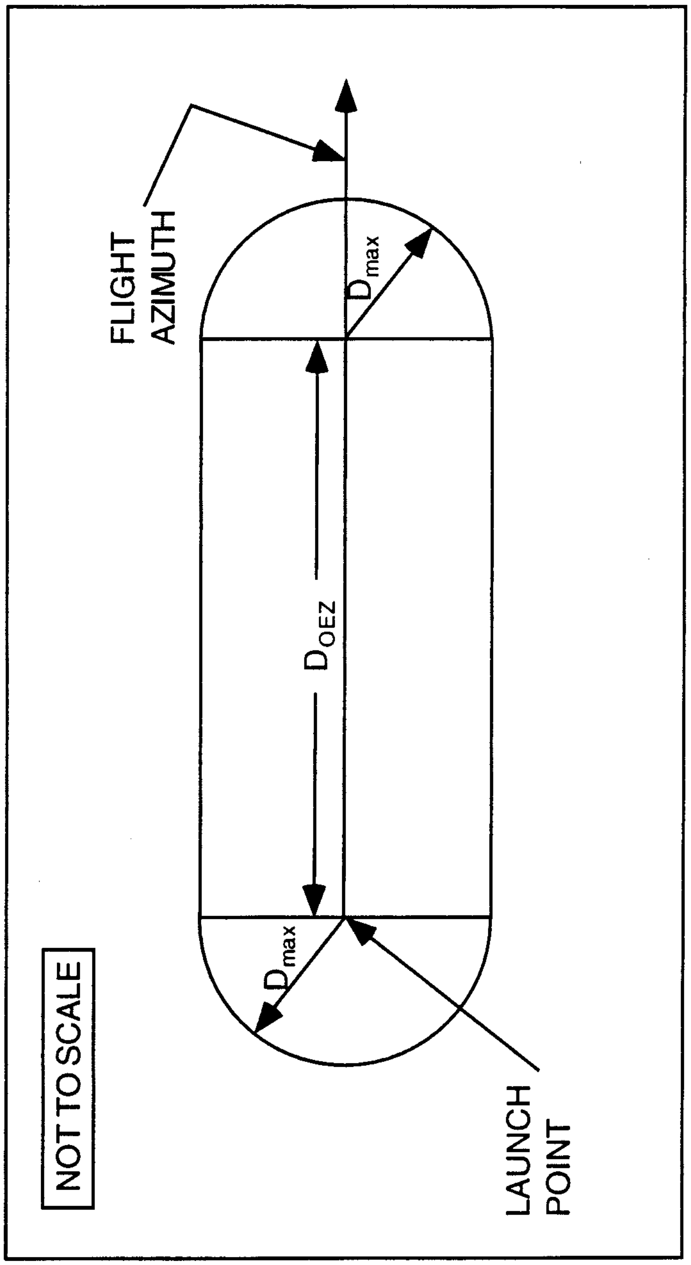


Figure A-1
Overflight Exclusion Zone

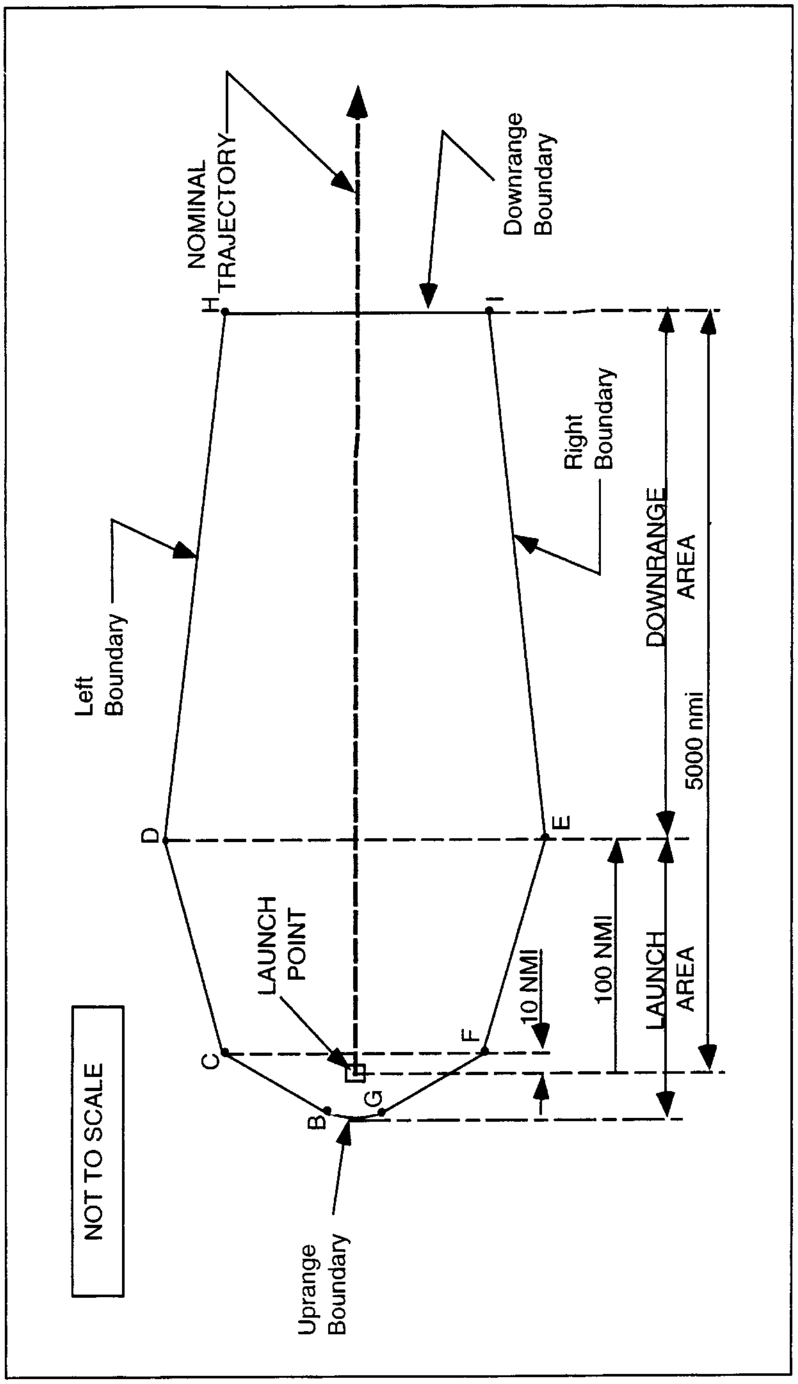


Figure A-2
Flight Corridor

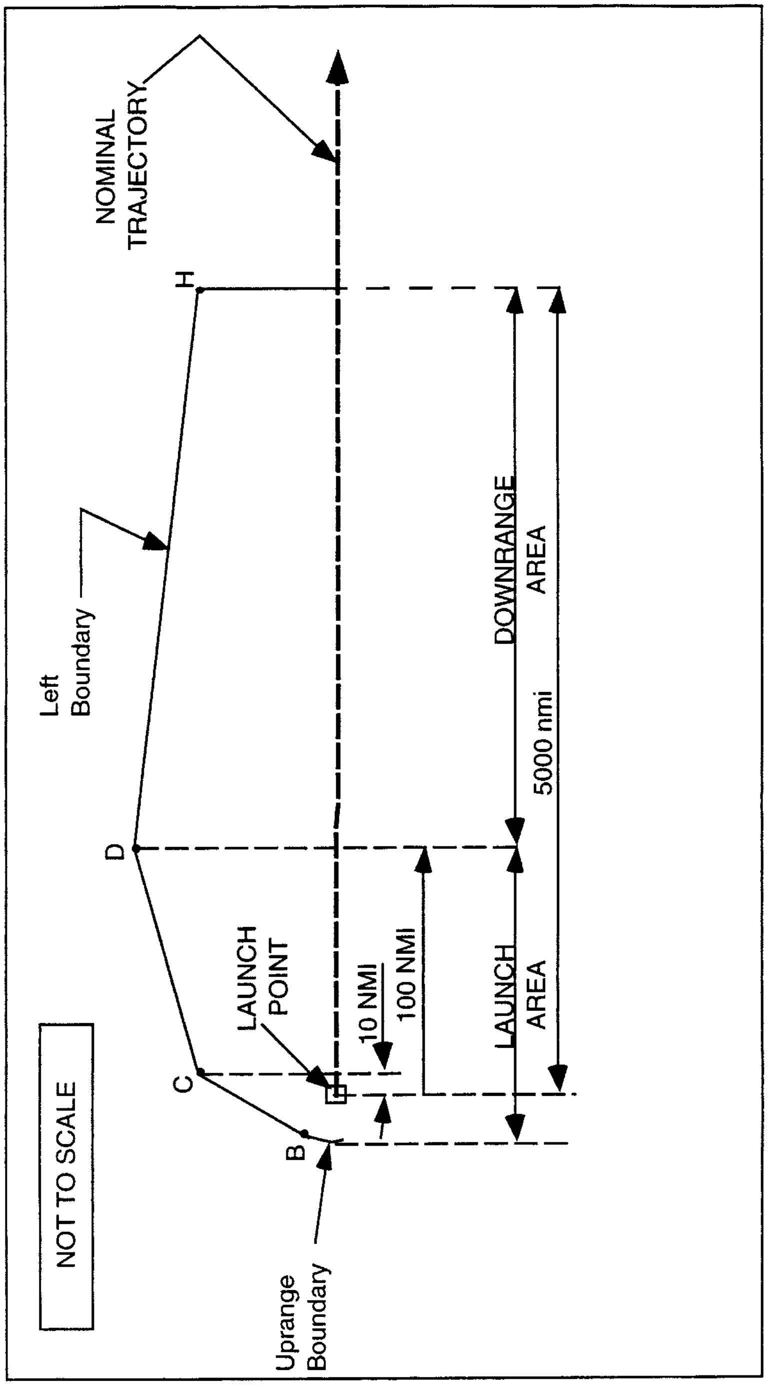


Figure A-3
Construction of Left Boundary of Flight Corridor

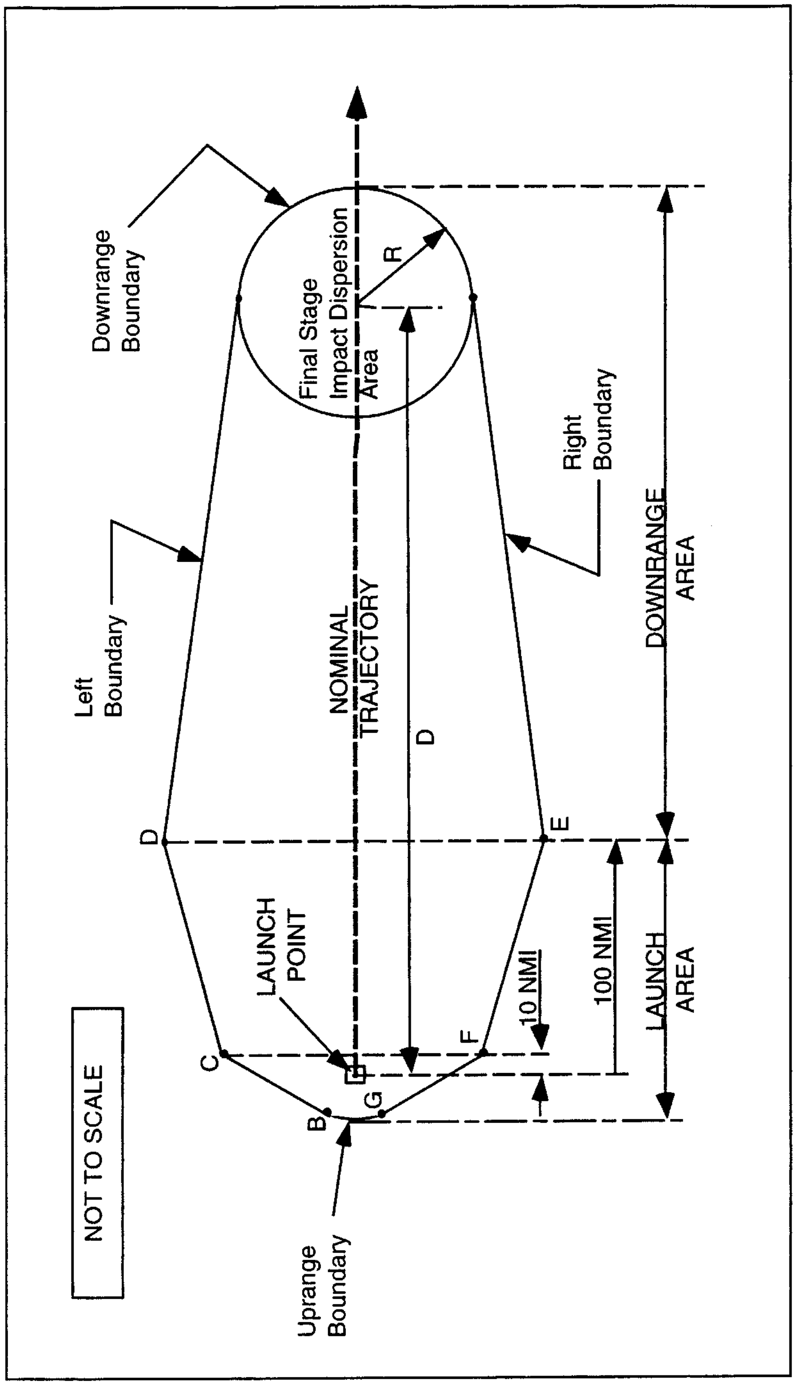


Figure A-4
Flight Corridor for Guided Sub-Orbital Launch Vehicles

Appendix B to Part 420—Method for Defining a Flight Corridor

(a) Introduction

(1) This appendix provides a method to construct a flight corridor from a launch point for a guided suborbital launch vehicle or any one of the four weight classes of guided orbital launch vehicles from table 1, § 420.19, using local meteorological data and a launch vehicle trajectory.

(2) A flight corridor is constructed in two sections—one section comprising a launch area and one section comprising a downrange area. The launch area of a flight corridor reflects the extent of launch vehicle debris impacts in the event of a launch vehicle failure and applying local meteorological conditions. The downrange area reflects the extent of launch vehicle debris impacts in the event of a launch vehicle failure and applying vehicle imparted velocity, malfunctions turns, and vehicle guidance and performance dispersions.

(3) A flight corridor includes an overflight exclusion zone in the launch area and, for a guided suborbital launch vehicle, an impact dispersion area in the downrange area. A flight corridor for a guided suborbital launch vehicle ends with an impact dispersion area and, for the four classes of guided orbital launch vehicles, 5,000 nautical miles (nm) from the launch point, or where the IIP leaves the surface of the Earth, whichever is shorter.

(b) Data Requirements

(1) Launch area data requirements. An applicant shall satisfy the following data requirements to perform the launch area analysis of this appendix. The data requirements are identified in table B–1 along with sources where data acceptable to the FAA may be obtained.

(i) An applicant must select meteorological data that meet the specifications in table B–1 for the proposed launch site.

TABLE B–1.—LAUNCH AREA DATA REQUIREMENTS

Data category	Data item	Data source
Meteorological Data	Local statistical wind data as a function of altitude up to 50,000 feet. Required data include: altitude (ft), atmospheric density (slugs/ft^3), mean East/West meridianal (u) and North/South zonal (v) wind (ft/sec), standard deviation of u and v wind (ft/sec), correlation coefficient, number of observations and wind percentile (%).	These data may be obtained from: Global Gridded Upper Air Statistics, Climate Applications Branch National Climatic Data Center.
Nominal Trajectory Data	State vector data as function of time after liftoff in topocentric launch point centered X,Y,Z,X,Y,Z coordinates with the X-axis aligned with the flight azimuth. Trajectory time intervals shall not be greater than one second. XYZ units are in feet and X,Y,Z units are in ft/sec.	Actual launch vehicle trajectory data; or trajectory generation software that meets the requirements of paragraph (b)(1)(ii).
Debris Data	A fixed ballistic coefficient equal to 3 lbs/ft^2 is used for the launch area.	N/A.
Geographical Data	Launch point geodetic latitude on a WGS–84 ellipsoidal Earth model.	Geographical surveys or Global Positioning System.
	Launch point longitude on an ellipsoidal Earth model.	
	Maps using scales of not less than 1:250,000 inches per inch within 100 nm of a launch point and 1:20,000,000 inches per inch for distances greater than 100 nm from a launch point.	Map types with scale and projection information are listed in the Defense Mapping Agency, Public Sale, Aeronautical Charts and Publications Catalog. The catalog and maps may be ordered through the U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

(ii) For a guided orbital launch vehicle, an applicant shall obtain or create a launch vehicle nominal trajectory. An applicant may use trajectory data from a launch vehicle manufacturer or generate a trajectory using trajectory simulation software. Trajectory time intervals shall be no greater than one second. If an applicant uses a trajectory computed with commercially available software, the software must calculate the trajectory using the following parameters, or clearly and convincingly demonstrated equivalents:

(A) Launch location:

(*1*) Launch point, using geodetic latitude and longitude to four decimal places; and

(*2*) Launch point height above sea level.

(B) Ellipsoidal Earth:

(*1*) Mass of Earth;

(*2*) Radius of Earth;

(*3*) Earth flattening factor; and

(*4*) Gravitational harmonic constants (J2, J3, J4).

(C) Vehicle characteristics:

(*1*) Mass as a function of time;

(*2*) Thrust as a function of time;

(*3*) Specific impulse (I_{SP}) as a function of time; and

(*4*) Stage dimensions.

(D) Launch events:

(*1*) Stage burn times; and

(*2*) Stage drop-off times.

(E) Atmosphere:

(*1*) Density as a function of altitude;

(*2*) Pressure as a function of altitude;

(*3*) Speed of sound as a function of altitude; and

(*4*) Temperature as a function of altitude.

(F) Winds:

(1) Wind direction as a function of altitude; and

(2) Wind magnitude as a function of altitude.

(I) Aerodynamics: drag coefficient as a function of mach number for each stage of flight showing subsonic, transonic and supersonic mach regions for each stage.

(iii) An applicant shall use a ballistic coefficient (β) of 3 lbs/ft^2 for debris impact computations.

(iv) An applicant shall satisfy the map and plotting requirements for a launch area of appendix A, paragraph (b).

(2) Downrange area data requirements. An applicant shall satisfy the following data requirements to perform the downrange area analysis of this appendix.

(i) The launch vehicle weight class and method of generating a trajectory used in the launch area shall be used by an applicant in the downrange area as well. Trajectory time intervals must not be greater than one second.

(ii) An applicant shall satisfy the map and plotting data requirements for a downrange area of appendix A, paragraph (b).

(c) Construction of a Launch Area of a Flight Corridor

(1) An applicant shall construct a launch area of a flight corridor using the processes and equations of this paragraph for each trajectory position. An applicant shall repeat these processes at time points on the launch vehicle trajectory for time intervals of no greater than one second. When choosing wind data, an applicant shall use a time period of between one and 12 months.

(2) A launch area analysis must include all trajectory positions whose Z-values are less than or equal to 50,000 ft.

(3) Each trajectory time is denoted by the subscript ''i''. Height intervals for a given atmospheric pressure level are denoted by the subscript ''j'.

(4) Using data from the GGUAS CD–ROM, an applicant shall estimate the mean atmospheric density, maximum wind speed, height interval fall times and height interval debris dispersions for 15 mean geometric height intervals.

(i) The height intervals in the GGUAS source data vary as a function of the following 15 atmospheric pressure levels expressed in millibars: surface, 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 10. The actual geometric height associated with each pressure level varies depending on the time of year. An applicant shall estimate the mean geometric height over the period of months selected in subparagraph (1) of this paragraph for each of the 15 pressure levels as shown in equation B1.

$$\overline{H}_j = \frac{\sum_{m=l}^{k} h_m \cdot n_m}{\sum_{m=1}^{k} n_m} \qquad \text{(Equation B1)}$$

where:

H_j = mean geometric height h_m = geometric height for a given month n_m = number of observations for a given month

k = number of wind months of interest

(ii) The atmospheric densities in the source data also vary as a function of the 15 atmospheric pressure levels. The actual atmospheric density associated with each pressure level varies depending on the time of year. An applicant shall estimate the mean atmospheric density over the period of months selected in accordance with subparagraph (1) of this paragraph for each of the 15 pressure levels as shown in equation B2.

$$\bar{\rho}_j \frac{\sum_{m=1}^{k} \rho_m \cdot n_m}{\sum_{m=1}^{k} n_m} \qquad \text{(Equation B2)}$$

where:

ρ_j = mean atmospheric density

ρ_m = atmospheric density for a given month
n_m = number of observations for a given month
k = number of wind months of interest

(iii) An applicant shall estimate the algebraic maximum wind speed at a given pressure level as follows and shall repeat the process for each pressure level.

(A) For each month, an applicant shall calculate the monthly mean wind speed ($\overline{W}_{az}$) for 360 azimuths using equation B3;

(B) An applicant shall select the maximum monthly mean wind speed from the 360 azimuths;

(C) An applicant shall repeat subparagraphs (c)(4)(iii)(A) and (B) for each month of interest; and

(D) An applicant shall select the maximum mean wind speed from the range of months. The absolute value of this wind is designated W_{max} for the current pressure level.

(iv) An applicant shall calculate wind speed using the means for winds from the West (u) and winds from the North (v). An applicant shall use equation B3 to resolve the winds to a specific azimuth bearing.

$$\overline{W}_{az} = u \cdot \cos(90 - az) + v \cdot \sin(90 - az) \qquad \text{(Equation B3)}$$

where:

az = wind azimuth
u = West zonal wind component
v = North zonal wind component
$\overline{W}_{az}$ = mean wind speed at azimuth for each month

(v) An applicant shall estimate the interval fall time over a height interval assuming the initial descent velocity is equal to the terminal velocity (V_T). An applicant shall use equations B4 through B6 to estimate the fall time over a given height interval.

$$\Delta H_j = \overline{H}_{j+1} - \overline{H}_j \qquad \text{(Equation B4)}$$

$$V_{Tj} = \left[\frac{\dfrac{2 \cdot \beta}{\left(\bar{\rho}_{j+1} + \bar{\rho}_j\right)}}{2} \right]^{0.5} \qquad \text{(Equation B5)}$$

$$t_j = \frac{\Delta H_j}{V_{Tj}} \qquad \text{(Equation B6)}$$

where:

ΔH_{Tj}= height difference between two mean geometric heights
β= ballistic coefficient
ρx= mean atmospheric density for the corresponding mean geometric heights
V_{Tj} = terminal velocity

(vi) An applicant shall estimate the interval debris dispersion (D_j) by multiplying the interval fall time by the algebraic maximum mean wind speed (W_{max}) as shown in equation B7.

$$D_j = t_j \cdot W_{max} \qquad \text{(Equation B7)}$$

(5) Once the Dj are estimated for each height interval, an applicant shall determine the total debris dispersion (D_i) for each Z_i using a linear interpolation and summation exercise, as shown below in equation B8. An applicant shall use a launch point height of zero equal to the surface level of the nearest GGUAS grid location.

$$D_i = D_j \cdot \left(\frac{Z_i - \overline{H}_i}{H_{j+1} - \overline{H}_i} \right) + \sum_{n=1}^{j-1} D_n \qquad \text{(Equation B8)}$$

where:

n = number of height intervals below jth height interval

(6) Once all the D_i radii have been calculated, an applicant shall produce a launch area flight corridor in accordance with the requirements of subparagraphs (c)(6)(i)–(iv).

(i) On a map meeting the requirements of appendix A, paragraph (b), an applicant shall plot the X_i position location on the flight azimuth for the corresponding Z_i position;

(ii) An applicant shall draw a circle of radius D_i centered on the corresponding X_i position; and

(iii) An applicant shall repeat the instructions in subparagraphs (c)(6)(i)–(ii) for each D_i radius.

(iv) The launch area of a flight corridor is the enveloping line that encloses the outer boundary of the D_i circles as shown in Fig. B–1. The uprange portion of a flight corridor is described by a semi-circle arc that is a portion of either the most uprange D_i dispersion circle, or the overflight exclusion zone (defined by subparagraph (c)(7)), whichever is further uprange.

(7) An applicant shall define an overflight exclusion zone in the launch area in accordance with the requirements of appendix A, subparagraph (c)(2).

(8) An applicant shall draw the launch area flight corridor and overflight exclusion zone on a map or maps that meet the requirements of table B–1.

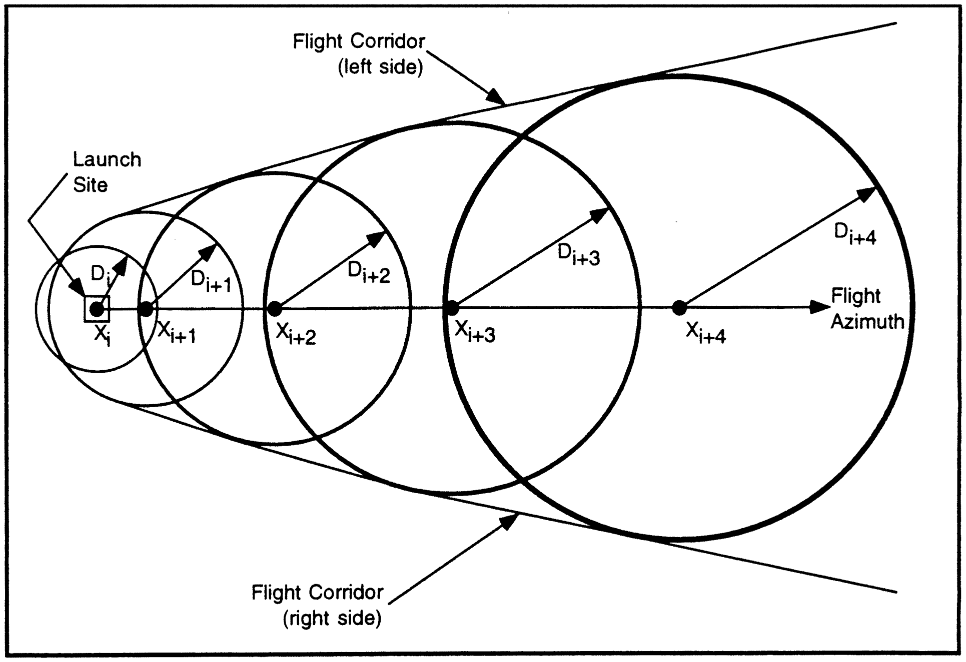


Figure B - 1: Launch Area of a Flight Corridor

(d) Construction of a Downrange Area of a Flight Corridor

(1) The downrange area analysis estimates the debris dispersion for the downrange time points on a launch vehicle trajectory. An applicant shall perform the downrange area analysis using the processes and equations of this paragraph.

(2) The downrange area analysis shall include trajectory positions at a height (the Z_i-values) greater than 50,000 feet and nominal trajectory IIP values less than or equal to 5,000 nm. For a guided suborbital launch vehicle, the final IIP value for which an applicant must account is the launch vehicle final stage impact point. Each trajectory time shall be one second or less and is denoted by the subscript ''i'.

(3) An applicant shall compute the downrange area of a flight corridor boundary in four steps, from each trajectory time increment: determine a reduction ratio factor; calculate the launch vehicle position after simulating a malfunction turn; rotate the state vector after the malfunction turn in the range of three degrees to one degree as a function of X_i distance downrange; and compute the IIP of the resulting trajectory. The locus of IIPs describes the boundary of the downrange area of a flight corridor. An applicant shall use the following subparagraphs, (d)(3)(i)–(v), to compute the downrange area of the flight corridor boundary:

(i) Compute the downrange Distance to the final IIP position for a nominal trajectory as follows:

(A) Using equations B30 through B69, determine the IIP coordinates (ϕ_{max}, λ_{max}) for the nominal state vector before the launch vehicle enters orbit where α in equation B30 is the nominal flight azimuth angle measured from True North.

(B) Using the range and bearing equations of appendix A, paragraph (b)(3), determine the distance (S_{max}) from the launch point coordinates (ϕ_{lp}, λ_{lp}) to the IIP coordinates (ϕ_{max}, λ_{max}) computed in accordance with (3)(i)(A) of this paragraph.

(C) The distance for S_{max} may not exceed 5000 nm. In cases when the actual value exceeds 5000 nm the applicant shall use 5000 nm for S_{max}.

(ii) Compute the reduction ratio factor (F_n) for each trajectory time increment as follows:

(A) Using equations B30 through B69, determine the IIP coordinates (ϕ_i, λ_i) for the nominal state vector where α in equation B30 is the nominal flight azimuth angle measured from True North.

(B) Using the range and bearing equations of appendix A, paragraph (b)(3), determine the distance (S_i) from the launch point coordinates (ϕ_{lp}, λ_{lp}) to the IIP coordinates (ϕ_i, λ_i) computed in (3)(ii)(A) of this paragraph.

(C) The reduction ratio factor is:

$$F_{ri} = \left(1 - \frac{S_i}{S_{max}}\right) \qquad \text{(Equation B9)}$$

(iii) An applicant shall compute the launch vehicle position and velocity components after a simulated malfunction turn for each X_i using the following method.

(A) Turn duration (Δt) = 4 sec.

(B) Turn angle (θ)

$$\theta = (F_{ri}) * 45 \text{ degrees.} \qquad \text{(Equation B10)}$$

The turn angle equations perform a turn in the launch vehicle's yaw plane, as depicted in figure B–2.

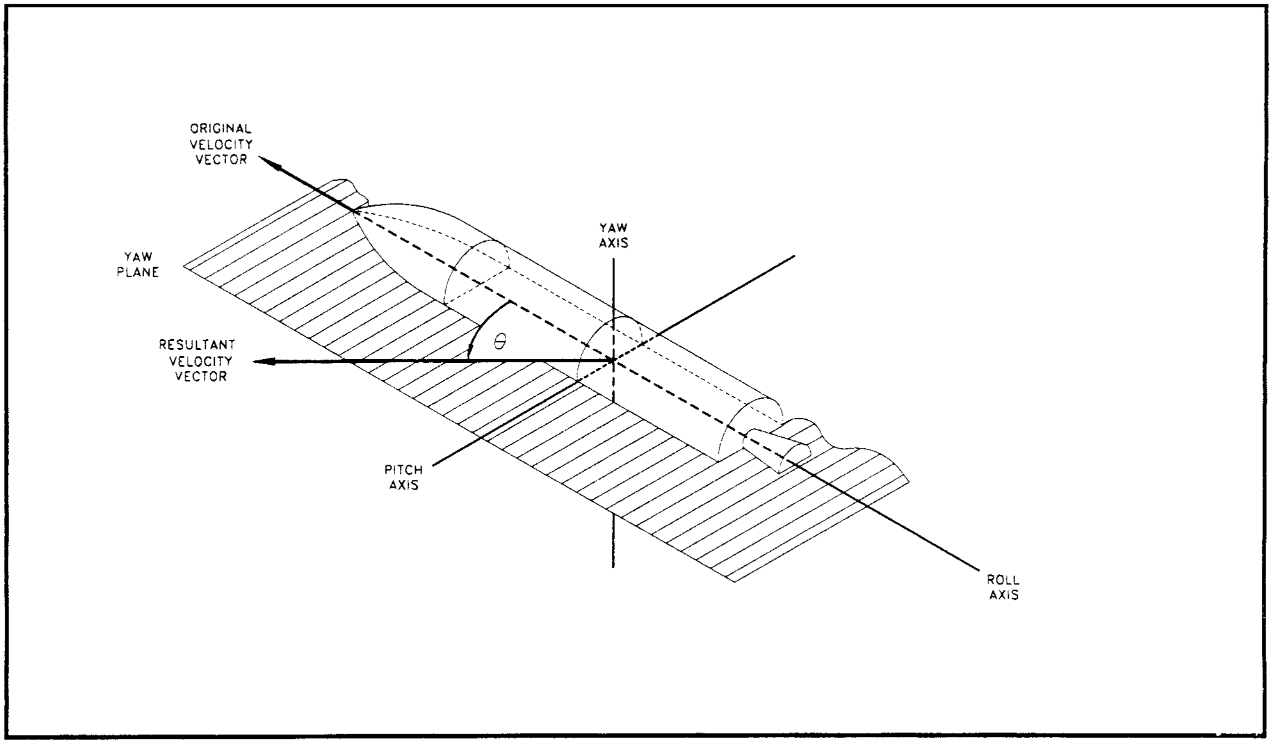


Figure B-2: Velocity Vector Turn Angle in Yaw Plane

(C) Launch vehicle velocity magnitude at the beginning of the turn (V_b) and velocity magnitude at the end of the turn (V_e)

$$V_b = \left(\dot{X}_1^2 + \dot{Y}_i^2 + \dot{Z}_i^2\right)^{0.5} \text{ ft/sec} \qquad \text{(Equation B11)}$$

$$V_e = \left(\dot{X}_{i+5}^2 + \dot{Y}_{i+5}^2 + \dot{X}_{i+5}^2\right)^{0.5} \text{ ft/sec} \qquad \text{(Equation B12)}$$

(D) Average velocity magnitude over the turn duration (V)

$$\overline{V}_i = \frac{(V_b + V_e)}{2} \text{ ft/sec} \qquad \text{(Equation B13)}$$

(E) Velocity vector path angle (γ_i) at turn epoch

$$\gamma_i = \tan^{-1}\left[\frac{\dot{Z}_i}{\left(\dot{X}_i^2 + \dot{Y}_i^2\right)^{0.5}}\right] \qquad \text{(Equation B14)}$$

(F) Launch vehicle position components at the end of turn duration

$$X_{90L} = X_i + \overline{V}_i \cdot \Delta t \cdot \cos\left(\frac{-\theta}{2}\right) \cdot \cos(\gamma_i)$$

$$X_{90R} = X_i + \overline{V}_i \cdot \Delta t \cdot \cos\left(\frac{\theta}{2}\right) \cdot \cos(\gamma_i)$$

$$Y_{90L} = Y_i + \overline{V}_i \cdot \Delta t \cdot \sin\left(\frac{-\theta}{2}\right)$$

$$Y_{90R} = Y_i + \overline{V}_i \cdot \Delta t \cdot \sin\left(\frac{\theta}{2}\right)$$

$$Z_{90L} = Z_i + \overline{V}_i \cdot \Delta t \cdot \cos\left(\frac{-\theta}{2}\right) \cdot \sin(\gamma_i) - \left(\frac{1}{2}\right) \cdot g_1 \cdot \Delta t^2 \qquad \text{(Equations B15 - B20)}$$

$$Z_{90R} = Z_i + \overline{V}_i \cdot \Delta t \cdot \cos\left(\frac{\theta}{2}\right) \cdot \sin(\gamma_i) - \left(\frac{1}{2}\right) \cdot g_1 \cdot \Delta t^2$$

where: $g_1 = 32.17405$ ft/sec^2

(G) Launch vehicle velocity components at the end of turn duration

$$\dot{X}_{90L} = (X_{90L} - X_i)/\Delta t$$

$$\dot{X}_{90R} = (X_{90R} - X_i)/\Delta t$$

$$\dot{Y}_{90L} = \left|(Y_{90L} - Y_i)/\Delta t\right|$$

$$\dot{Y}_{90R} = (-1) \cdot \left|(Y_{90R} - Y_i)/\Delta t\right| \qquad \text{(Equations B21 - B26)}$$

$$\dot{Z}_{90L} = (Z_{90L} - Z_i)/\Delta t$$

$$\dot{Z}_{90R} = (Z_{90R} - Z_i)/\Delta t$$

(iv) An applicant shall rotate the trajectory state vector at the end of the turn duration to the right and left to define the right-lateral flight corridor boundary and the left-lateral flight corridor boundary, respectively. An applicant shall perform the trajectory rotation in conjunction with a trajectory transformation from the X_{90}, Y_{90}, Z_{90}, $\dot{X}_{90}$, $\dot{Y}_{90}$, $\dot{Z}_{90}$, components to E, N, U, $\dot{E}$, $\dot{N}$, $\dot{U}$. The trajectory subscripts ''R'' and ''L'' from equations B15 through B26 have been discarded to reduce the number of equations. An applicant shall transform from to E,N,U,$\dot{E}$,$\dot{N}$,$\dot{U}$ to E,F,G,$\dot{E}$,$\dot{F}$,$\dot{G}$. An applicant shall use the equations of paragraph (d)(3)(iv)(A)–(F) to produce the EFG components necessary to estimate each instantaneous impact point.

(A) An applicant must calculate the flight angle (α)

$$\Delta\alpha_i = 3 - 2 \cdot f_1 \cdot (1 - F_{ri}) \qquad \text{(Equation B27)}$$

$$\alpha_{Li} = (\text{Flight Azimuth} - \Delta\alpha_i)$$

for left lateral boundary computations (Equation B28)

- OR

$$\alpha_{Ri} = (\text{Flight Azimuth} - \Delta\alpha_i)$$

for right lateral boundary computations (Equation B29)

where: $$f_1 = \begin{Bmatrix} 0.0: F_{ri} \geq 0.8 \\ 1.0: F_{ri} < 0.8 \end{Bmatrix}$$

(B) An applicant shall transform X_{90},Y_{90},Z_{90} to E,N,U

$$\begin{aligned} E &= X_{90}\sin(\alpha) - Y_{90}\cos(\alpha) \\ N &= X_{90}\cos(\alpha) + Y_{90}\sin(\alpha) \qquad \text{(Equations B30 - B32)} \\ U &= Z_{90} \end{aligned}$$

(C) An applicant shall transform to $\dot{X}_{90}$, $\dot{Y}_{90}$, $\dot{Z}_{90}$ to $\dot{E}$, $\dot{N}$, $\dot{U}$.

$$\begin{aligned} \dot{E} &= \dot{X}_{90}\sin(\alpha) - \dot{Y}_{90}\cos(\alpha) \\ \dot{N} &= \dot{X}_{90}\cos(\alpha) + \dot{Y}_{90}\sin(\alpha) \qquad \text{(Equations B33 - B35)} \\ \dot{U} &= \dot{Z}_{90} \end{aligned}$$

(D) An applicant shall transform the launch point coordinates ($\phi_0\lambda_0,h_0$) to E_0,F_0,G_0

$$R = a_E\left\{1 - e^2\left[\sin^2(\phi_0)\right]\right\}^{-0.5}$$

where:

$$\begin{aligned} a_E &= 20925646.3255 \text{ ft} \\ e^2 &= 0.00669437999013 \\ E_0 &= (R + h_0)\cos(\phi_0)\cos(\lambda_0) \qquad \text{(Equations B36 - B39)} \\ F_0 &= (R + h_0)\cos(\phi_0)\sin(\lambda_0) \\ G_0 &= \left[R(1 - e^2) + h_0\right]\sin(\phi_0) \end{aligned}$$

(E) An applicant shall transform E,N,U to E_{90},F_{90},G_{90}

$$\begin{aligned} E_{90} &= E\cos(270 - \lambda_0) + N\cos(90 - \phi_0)\sin(270 - \lambda_0) - U\sin(90 - \phi_0)\sin(270 - \lambda_0) \qquad \text{(Equations B40 - B42)} \\ F_{90} &= E\sin(270 - \lambda_0) + N\cos(90 - \phi_0)\cos(270 - \lambda_0) - U\sin(90 - \phi_0)\cos(270 - \lambda_0) \\ G_{90} &= N\sin(90 - \phi_0) + U\cos(90 - \phi_0) + G_0 \end{aligned}$$

(F) An applicant shall transform to $\dot{E},\dot{N},\dot{U}$ TO $\dot{E},\dot{F},\dot{G}$

$$\begin{aligned} \dot{E}_{90} &= \dot{E}\cos(270 - \lambda_0) + \dot{N}\cos(90 - \phi_0)\sin(270 - \lambda_0) - \dot{U}\sin(90 - \phi_0)\sin(270 - \lambda_0) \qquad \text{(Equations B43 - B45)} \\ \dot{F}_{90} &= \dot{E}\sin(270 - \lambda_0) + \dot{N}\cos(90 - \phi_0)\cos(270 - \lambda_0) - \dot{U}\sin(90 - \phi_0)\cos(270 - \lambda_0) \\ \dot{G}_{90} &= \dot{N}\sin(90 - \phi_0) + \dot{U}\cos(90 - \phi_0) \end{aligned}$$

(v) The IIP computation implements an iterative solution to the impact point problem. An applicant shall solve equations B46 through B69, with the appropriate substitutions, up to a maximum of five times. Each repetition of the equations provides a more accurate prediction of the IIP. An applicant shall use the required IIP computations of paragraphs (d)(3)(v)(A)–(W) below. An applicant shall use this IIP computation for both the left-and right-lateral offsets. The IIP computations will result in latitude and longitude pairs for the left-lateral flight corridor boundary and the right-lateral flight corridor boundary. An applicant shall use the lines connecting the latitude and longitude pairs to describe the entire downrange area boundary of the flight corridor up to 5000 nm or a final stage impact dispersion area.

(A) An applicant shall approximate the radial distance ($r_{k,l}$) from the geocenter to the IIP. The distance from the center of the Earth ellipsoid to the launch point shall be used for the initial approximation of $r_{k,l}$ as shown in equation B46.

$$r_{k,1} = \left(E_0^2 + F_0^2 + G_0^2\right)^{0.5} \qquad \text{(Equation B46)}$$

(B) An applicant shall compute the radial distance (r) from the geocenter to the launch vehicle position.

$$r = \left(E_{90}^2 + F_{90}^2 + G_{90}^2\right)^{0.5} \qquad \text{(Equation B47)}$$

If $r < r_{k,l}$ then the launch vehicle position is below the Earth's surface and an impact point cannot be computed. An applicant must restart the calculations with the next trajectory state vector.

(C) An applicant shall compute the inertial velocity components.

$$\dot{E}l_{90} = \dot{E}_{90} - \omega \cdot F_{90}$$
$$\dot{F}l_{90} = \dot{F}_{90} + \omega \cdot E_{90} \qquad \text{(Equations B48-B49)}$$

where: $\omega = 4.178074\times10^{-3}$ deg/sec

(D) An applicant shall compute the magnitude of the inertial velocity vector.

$$v_0\left(\dot{E}I_{90}^2 + \dot{F}I_{90}^2 + \dot{G}_{90}^2\right)^{0.5} \qquad \text{(Equation B50)}$$

(E) An applicant shall compute the eccentricity of the trajectory ellipse multiplied by the cosine of the eccentric anomaly at epoch (ε_c).

$$\varepsilon_c = \left(\frac{r \cdot v_0^2}{K}\right) - 1 \qquad \text{(Equation B51)}$$

where: $K = 1.407644\times10^{16}$ ft³/sec²

(F) An applicant shall compute the semi-major axis of the trajectory ellipse (a^t).

$$a_t = \frac{r}{1-\varepsilon_c} \qquad \text{(Equation B52)}$$

If a_t 0 or a_t then the trajectory orbit is not elliptical, but is hyperbolic or parabolic, and an impact point cannot be computed. The launch vehicle has achieved escape velocity and the applicant may terminate computations.

(G) An applicant shall compute the eccentricity of the trajectory ellipse multiplied by the sine of the eccentric anomaly at epoch (ε_s).

$$\varepsilon_s = \frac{\left(E_{90}\dot{E}I_{90} + F_{90}\dot{F}I_{90} + G_{90}\dot{G}_{90}\right)}{\left(K \cdot a_t\right)^{0.5}} \qquad \text{(Equation B53)}$$

(H) An applicant shall compute the eccentricity of the trajectory ellipse squared ε^2).

$$\varepsilon^2 = \left(\varepsilon_c^2 + \varepsilon_s^2\right) \qquad \text{(Equation B54)}$$

If $a_t(1-\varepsilon) - a_E] > 0$ and $\varepsilon \geq 0$ then the trajectory perigee height is positive and an impact point cannot be computed. The launch vehicle has achieved Earth orbit and the applicant may terminate computations.

(I) An applicant shall compute the eccentricity of the trajectory ellipse multiplied by the cosine of the eccentric anomaly at impact (ε_{c_k}).

$$\varepsilon_{c_k} = \frac{\left(a_t - r_{k,1}\right)}{a_t} \qquad \text{(Equation B55)}$$

(J) An applicant shall compute the eccentricity of the trajectory ellipse multiplied by the sine of the eccentric anomaly at impact (ε_{s_k}).

$$\varepsilon_{s_k} = -\left(\varepsilon^2 - \varepsilon^2{}_{c_k}\right)^{0.5} \qquad \text{(Equation B56)}$$

If $\varepsilon_{s_k} < 0$ then the trajectory orbit does not intersect the Earth's surface and an impact point cannot be computed. The launch vehicle has achieved Earth orbit and the applicant may terminate computations.

(K) An applicant shall compute the cosine of the difference between the eccentric anomaly at impact and the eccentric anomaly at epoch ($\Delta\varepsilon_{c_k}$).

$$\Delta\varepsilon_{c_k} = \frac{\left(\varepsilon_{c_k} \cdot \varepsilon_c\right) + \left(\varepsilon_{s_k} \cdot \varepsilon_s\right)}{\varepsilon^2} \qquad \text{(Equation B57)}$$

(L) An applicant shall compute the sine of the difference between the eccentric anomaly at impact and the eccentric anomaly at epoch ($\Delta\varepsilon_{s_k}$).

$$\Delta\varepsilon_{s_k} = \frac{\left(\varepsilon_{s_k} \cdot \varepsilon_c\right) - \left(\varepsilon_{c_k} \cdot \varepsilon_s\right)}{\varepsilon^2} \qquad \text{(Equation B58)}$$

(M) An applicant shall compute the f-series expansion of Kepler's equations.

$$f_2 = \frac{\left(\Delta\varepsilon_{c_k} - \varepsilon_c\right)}{\left(l - \varepsilon_c\right)} \qquad \text{(Equation B59)}$$

(N) An applicant shall compute the g-series expansion of Kepler's equations.

$$g_2 = \left(\Delta\varepsilon_{s_k} + \varepsilon_s - \varepsilon_{s_k}\right)\left(\frac{a_t^3}{K}\right)^{0.5} \qquad \text{(Equation B60)}$$

(O) An applicant shall compute the E,F,G coordinates at impact (E_i,F_i,G_i).

$$E_k = f_2 \cdot E_{90} + g_2 \cdot \dot{E}l_{90}$$
$$F_k = f_2 \cdot F_{90} + g_2 \cdot \dot{F}l_{90} \qquad \text{(Equations B61-B63)}$$
$$G_k = f_2 \cdot G_{90} + g_2 \cdot \dot{G}_{90}$$

(P) An applicant shall approximate the distance from the geocenter to the launch vehicle position at impact ($r_{k,2}$).

$$r_{k,2} = \frac{a_E}{\left[\left(\frac{e^2}{1-e^2}\right)\left(\frac{G_k}{r_{k,1}}\right)^2 + 1\right]^{0.5}} \qquad \text{(Equation B64)}$$

where:
a_E = 20925646.3255 ft
e^2 = 0.00669437999013

(Q) An applicant shall let $r_{k+1,1} = r_{k,2}$, substitute $r_{k+1,1}$ for $r_{k,1}$ in equation B55 and repeat equations B55—B64 up to four more times increasing ''k'' by an increment of one on each loop (e.g. $k\varepsilon\{1, 2, 3, 4, 5\}$). If $|r_{5,1} - r_{5,2}| > 1$ then the iterative solution does not converge and an impact point does not meet the accuracy tolerance of plus or minus one foot. An applicant must try more iterations, or restart the calculations with the next trajectory state vector.

(R) An applicant shall compute the difference between the eccentric anomaly at impact and the eccentric anomaly at epoch ($\Delta\varepsilon$).

$$\Delta\varepsilon = \tan^{-1}\left(\frac{\Delta\varepsilon_{s_5}}{\Delta\varepsilon_{c_5}}\right) \qquad \text{(Equation B65)}$$

(S) An applicant shall compute the time of flight from epoch to impact (t).

$$t = \left(\Delta\varepsilon + \varepsilon_s - \varepsilon_{s_5}\right)\left(\frac{a_t^3}{K}\right)^{0.5} \qquad \text{(Equation B66)}$$

(T) An applicant shall compute the geocentric latitude at impact (ϕ').

$$\phi'_i = \sin^{-1}\left(\frac{G_5}{r5,2}\right) \qquad \text{(Equation B67)}$$

Where: $+90° > \phi'_i > -90°$

(U) An applicant shall compute the geodetic latitude at impact (ϕ).

$$\phi_i = \tan^{-1}\left[\frac{\tan\left(\phi'_i\right)}{\left(1-e^2\right)}\right] \qquad \text{(Equation B68)}$$

Where: $+90° > \phi_i > -90°$

(V) An applicant shall compute the East longitude at impact (λ).

$$\lambda_i = \tan^{-1}\left(\frac{F_5}{E_5}\right) - \omega t \qquad \text{(Equation B69)}$$

(W) If the range from the launch point to the impact point is equal to or greater than 5000 nm, an applicant shall terminate IIP computations.

(4) For a guided suborbital launch vehicle, an applicant shall define a final stage impact dispersion area as part of the flight corridor and show the area on a map using the following procedure:

(i) For equation B70 below, an applicant shall use an apogee altitude (H_{ap}) corresponding to the highest altitude reached by the launch vehicle final stage in the applicant's launch vehicle trajectory analysis done in accordance with paragraph (b)(1)(ii).

(ii) An applicant shall define the final stage impact dispersion area by using a dispersion factor [$DISP(H_{ap})$] as shown below. An applicant shall calculate the impact dispersion radius (R) for the final launch vehicle stage. An applicant shall set R equal to the maximum apogee altitude (H_{ap}) multiplied by the dispersion factor as shown below:

$$R = H_{ap} \cdot DISP\left(H_{ap}\right) \qquad \text{(Equation B70)}$$

where: $DISP(H_{ap}) = 0.05$

(5) An applicant shall combine the launch area and downrange area flight corridor and any final stage impact dispersion area for a guided suborbital launch vehicle.

(i) On the same map with the launch area flight corridor, an applicant shall plot the latitude and longitude positions of the left and right sides of the downrange area of the flight corridor calculated in accordance with subparagraph (d)(3).

(ii) An applicant shall connect the latitude and longitude positions of the left side of the downrange area of the flight corridor sequentially starting with the last IIP calculated on the left side and ending with the first IIP calculated on the left side. An applicant shall repeat this procedure for the right side.

(iii) An applicant shall connect the left sides of the launch area and downrange portions of the flight corridor. An applicant shall repeat this procedure for the right side.

(iv) An applicant shall plot the overflight exclusion zone defined in subparagraph (c)(7).

(v) An applicant shall draw any impact dispersion area on the downrange map with the center of the impact dispersion area on the launch vehicle final stage impact point obtained from the applicant's launch vehicle trajectory analysis done in accordance with subparagraph (b)(1)(ii).

(e) Evaluate the Launch Site

(1) An applicant shall evaluate the flight corridor for the presence of populated areas. If no populated area is located within the flight corridor, then no additional steps are necessary.

(2) If a populated area is located in an overflight exclusion zone, an applicant may modify its proposal or demonstrate that there are times when no people are present or that the applicant has an agreement in place to evacuate the public from the overflight exclusion zone during a launch.

(3) If a populated area is located within the flight corridor, an applicant may modify its proposal or complete an overflight risk analysis in accordance with appendix C.

Appendix C to Part 420—Risk Analysis

(a) Introduction

(1) This appendix provides a method for an applicant to estimate the expected casualty (E_c) for a launch of a guided expendable launch vehicle using a flight corridor generated either by appendix A or appendix B. This appendix also provides an applicant options to simplify the method where population at risk is minimal.

(2) An applicant shall perform a risk analysis when a populated area is located within a flight corridor defined by either appendix A or appendix B. If the estimated expected casualty exceeds 30×10^{-6}, an applicant may either modify its proposal, or if the flight corridor used was generated by the appendix A method, use the appendix B method to narrow the flight corridor and then redo the overflight risk analysis pursuant to this appendix. If the estimated expected casualty still exceeds 30×10^{-6}, the FAA will not approve the location of the proposed launch point.

(b) Data Requirements

(1) An applicant shall obtain the data specified by subparagraphs (b)(2) and (3) and summarized in table C–1. Table C–1 provides sources where an applicant may obtain data acceptable to the FAA. An applicant must also employ the flight corridor information

from appendix A or B, including flight azimuth and, for an appendix B flight corridor, trajectory information.

(2) Population data. Total population (N) and the total landmass area within a populated area (A) are required. Population data up to and including 100 nm from the launch point are required at the U.S. census block group level. Population data downrange from 100 nm are required at no greater than 1° × 1° latitude/longitude grid coordinates.

(3) Launch vehicle data. Launch vehicle data consist of the launch vehicle failure probability (P_f), the launch vehicle effective casualty area (A_c), trajectory position data, and the overflight dwell time (t_d). The failure probability is a constant ($P_f = 0.10$) for a guided orbital or suborbital expendable launch vehicle. Table C–3 provides effective casualty area data based on IIP range. Trajectory position information is provided from distance computations provided by this appendix for an appendix A flight corridor, or trajectory data used in appendix B for an appendix B flight corridor. The dwell time (t_d) may be determined from trajectory data produced when creating an appendix B flight corridor.

TABLE C–1.—OVERFLIGHT ANALYSIS DATA REQUIREMENTS

Data category	Data item	Data source
Population Data	Total population within a populated area (N)	Within 100 nm of the launch point: U.S. census data at the census block-group level. Downrange from 100 nm beyond the launch point, world population data are available from:
	Total landmass area within the populated area (A).	Carbon Dioxide Information Analysis Center (CDIAC) Oak Ridge National Laboratory Database—Global Population Distribution (1990), Terrestrial Area and Country Name Information on a One by One Degree Grid Cell Basis (DB1016 (8–1996)
Launch Vehicle Data	Failure probability—$P_f = 0.10$	N/A.
	Effective casualty area (A_c)	See table C–3.
	Overflight dwell time	Determined by range from the launch point or trajectory used by applicant.
	Nominal trajectory data (for an appendix B flight corridor only).	See appendix B, table B–1.

(c) Estimating Corridor Casualty Expectation

(1) A corridor casualty expectation [E_C(Corridor)] estimate is the sum of the expected casualty measurement of each populated area inside a flight corridor.

(2) An applicant shall identify and locate each populated area in the proposed flight corridor.

(3) An applicant shall determine the probability of impact in each populated area using the procedures in subparagraphs (5) or (6) of this paragraph. Figures C–1 and C–2 illustrate an area considered for probability of impact (P_i) computations by the dashed-lined box around the populated area within a flight corridor, and figure C–3 illustrates a populated area in a final stage impact dispersion area. An applicant shall then estimate the E_C for each populated area in accordance with subparagraphs (7) and (8) of this paragraph.

(4) The P_i computations do not directly account for populated areas whose areas are bisected by an appendix A flight corridor centerline or an appendix B nominal trajectory ground trace. Accordingly, an applicant must evaluate P_i for each of the bisections as two separate populated areas, as shown in figure C–4, which shows one bisection to the left of an appendix A flight corridor's centerline and one to its right.

(5) Probability of impact (P_i) computations for a populated area in an appendix A flight corridor. An applicant shall compute P_i for each populated area using the following method:

(i) For the launch and downrange areas, but not for a final stage impact dispersion area for a guided suborbital launch vehicle, an applicant shall compute P_i for each populated area using the following equation:

$$P_i = \frac{\left(\frac{|y_2 - y_1|}{\sigma_y}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(y_1/\sigma_y\right)^2}{2}\right) + 4\cdot\exp\left[\frac{-\left(\frac{y_1+y_2}{2\sigma_y}\right)^2}{2}\right] + \exp\left(\frac{-\left(y_2/\sigma_y\right)^2}{2}\right) \right) \cdot \left[\frac{P_f}{C}\cdot\frac{(x_2 - x_1)}{\dot{R}}\right] \quad \text{(Equation C1)}$$

where:

x_1, x_2 = closest and farthest downrange distance (nm) along the flight corridor centerline to the populated area (see figure C–1)

y_1, y_2 = closest and farthest cross range distance (nm) to the populated area measured from the flight corridor centerline (see figure C–1)

σ_y = one-third of the cross range distance from the centerline to the flight corridor boundary (see figure C–1)

exp = exponential function (e^x)

P_f = probability of failure = 0.10

R = IIP range rate (nm/sec) (see table C–2)

C = 643 seconds (constant)

TABLE C–2.—IIP RANGE RATE VS. IIP RANGE

IIP range (nm)	IIP range rate (nm/s)
0–75	0.75
76–300	1.73
301–900	4.25
901–1700	8.85
1701–2600	19.75
2601–3500	42.45
3501–4500	84.85
4501–5250	154.95

(ii) For each populated area within a final stage impact dispersion area, an applicant shall compute P_i using the following method:

(A) An applicant shall estimate the probability of final stage impact in the x and y sectors of each populated area within the final stage impact dispersion area using equations C2 and C3:

$$P_x = \frac{\left(\frac{|x_2 - x_1|}{\sigma_x}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(x_1/\sigma_x\right)^2}{2}\right) + 4 \cdot \exp\left[\frac{-\left(\frac{x_1 + x_2}{2\sigma_x}\right)^2}{2}\right] + \exp\left(\frac{-\left(x_2/\sigma_x\right)^2}{2}\right)\right) \qquad \text{(Equation C2)}$$

where:

X_1, X_2 = closest and farthest downrange distance, measured along the flight corridor centerline, measured from the nominal impact point to the populated area (see figure C–3)

σ_x = one-third of the impact dispersion radius (see figure C–3)

exp = exponential function (e^x)

$$P_y = \frac{\left(\frac{|y_2 - y_1|}{\sigma_y}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(y_1/\sigma_y\right)^2}{2}\right) + 4 \cdot \exp\left[\frac{-\left(\frac{y_1 + y_2}{2\sigma_y}\right)^2}{2}\right] + \exp\left(\frac{-\left(y_2/\sigma_y\right)^2}{2}\right)\right) \qquad \text{(Equation C3)}$$

where:

y_1, y_2 = closest and farthest cross range distance to the populated area measured from the flight corridor centerline (see figure C–3)

σ_y = one-third of the impact dispersion radius (see figure C–3)

exp = exponential function (e^x)

(B) If a populated area intersects the impact dispersion area boundary so that the x_2 or y_2 distance would otherwise extend outside the impact dispersion area, the x_2 or y_2 distance should be set equal to the impact dispersion area radius. The x_2 distance for populated area A in figure C–3 is an example. If a populated area intersects the flight azimuth, an applicant shall solve equation C3 by obtaining the solution in two parts. An applicant shall determine, first, the probability between $y_1 = 0$ and $y_2 = a$ and, second, the probability between $y_1 = 0$ and $y_2 = b$, as depicted in figure C–4. The probability P_y is then equal to the sum of the probabilities of the two parts. If a populated area intersects the line that is normal to the flight azimuth on the impact point, an applicant shall solve equation C2 by obtaining the solution in two parts in the same manner as with the values of x.

(C) An applicant shall calculate the probability of impact for each populated area using equation C4 below:

$$P_I = P_s \cdot P_x \cdot P_y \qquad \text{(Equation C4)}$$

where: $P_s = 1 - P_f = 0.90$

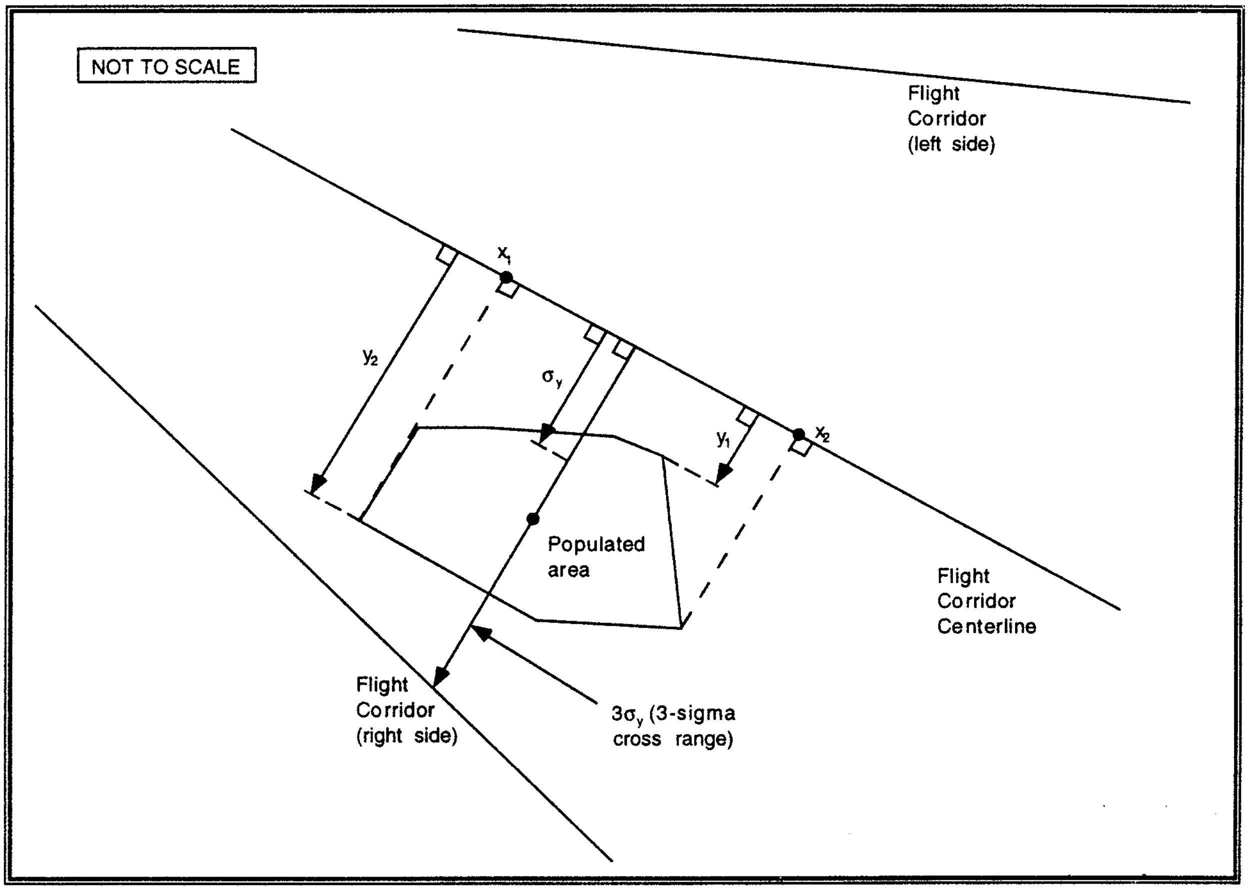


Figure C-1: Analysis of an Appendix A Flight Corridor

(6) Probability of impact computations for a populated area in an appendix B flight corridor. An applicant shall compute P_i using the following method:

(i) For the launch and downrange areas, but not for a final stage impact dispersion area for a guided suborbital launch vehicle, an applicant shall compute P_i for each populated area using the following equation:

$$P_i = \frac{\left(\frac{|y_2 - y_1|}{\sigma_y}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(y_1 / \sigma_y \right)^2}{2} \right) + 4 \cdot \exp\left[\frac{-\left(\frac{y_1 + y_2}{2\sigma_y} \right)^2}{2} \right] + \exp\left(\frac{-\left(y_2 / \sigma_y \right)^2}{2} \right) \right) \cdot \left(\frac{P_f}{t} \cdot t_d \right) \qquad \text{(Equation C5)}$$

where:

y_1, y_2 = closest and farthest cross range distance (nm) to a populated area measured from the nominal trajectory IIP ground trace (see figure C–2)

σ_y = one-third of the cross range distance (nm) from nominal trajectory to the flight corridor boundary (see figure C–2)

exp = exponential function (e^x)

P_f = probability of failure = 0.10

t = flight time from lift-off to orbital insertion (seconds)

t_d = overflight dwell time (seconds)

(ii) For each populated area within a final stage impact dispersion area, an applicant shall compute P_i using the following method:

(A) An applicant shall estimate the probability of final stage impact in the x and y sectors of each populated area within the final stage impact dispersion area using equations C6 and C7:

$$P_x = \frac{\left(\frac{|x_2 - x_1|}{\sigma_x}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(x_1 / \sigma_x \right)^2}{2} \right) + 4 \cdot \exp\left[\frac{-\left(\frac{x_1 + x_2}{2\sigma_x} \right)^2}{2} \right] + \exp\left(\frac{-\left(x_2 / \sigma_x \right)^2}{2} \right) \right) \qquad \text{(Equation C6)}$$

where:

x_1, x_2 = closest and farthest downrange distance, measured along nominal trajectory IIP ground trace, measured from the nominal impact point to the populated area (see figure C–3)

σ_x = one-third of the impact dispersion radius (see figure C–3)

exp = exponential function (e^x)

$$P_y = \frac{\left(\frac{|y_2 - y_1|}{\sigma_y}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(y_1 / \sigma_y \right)^2}{2} \right) + 4 \cdot \exp\left[\frac{-\left(\frac{y_1 + y_2}{2\sigma_y} \right)^2}{2} \right] + \exp\left(\frac{-\left(y_2 / \sigma_y \right)^2}{2} \right) \right) \qquad \text{(Equation C7)}$$

where:

y_1, y_2 = closest and farthest cross range distance to the populated area measured from the nominal trajectory IIP ground trace (see figure C–3)

σ_y = one-third of the impact dispersion radius (see figure C–3)

exp = exponential function (e^x)

(B) If a populated area intersects the impact dispersion area boundary so that the x_2 or y_2 distance would otherwise extend outside the impact dispersion area, the x_2 or y_2 distance should be set equal to the impact dispersion area radius. The x_2 distance for populated area A in figure C–3 is an example. If a populated area intersects the flight azimuth, an applicant shall solve equation C7 by obtaining the solution in two parts. An applicant shall determine, first, the probability between y_1 = 0 and y_2 = a and, second, the probability between y_1 = 0 and y_2 = b, as depicted in figure C–4. The probability P_y is then equal to the sum of the probabilities of the two parts. If a populated area intersects the line that is normal to the flight azimuth on the impact point, an applicant shall solve equation C6 by obtaining the solution in two parts in a similar manner with the values of x.

(C) An applicant shall calculate the probability of impact for each populated area using equation C8 below:

$$P_1 = P_s \cdot P_x \cdot P_y \qquad \text{(Equation C8)}$$

where: $P_s = 1 - P_f = 0.90$

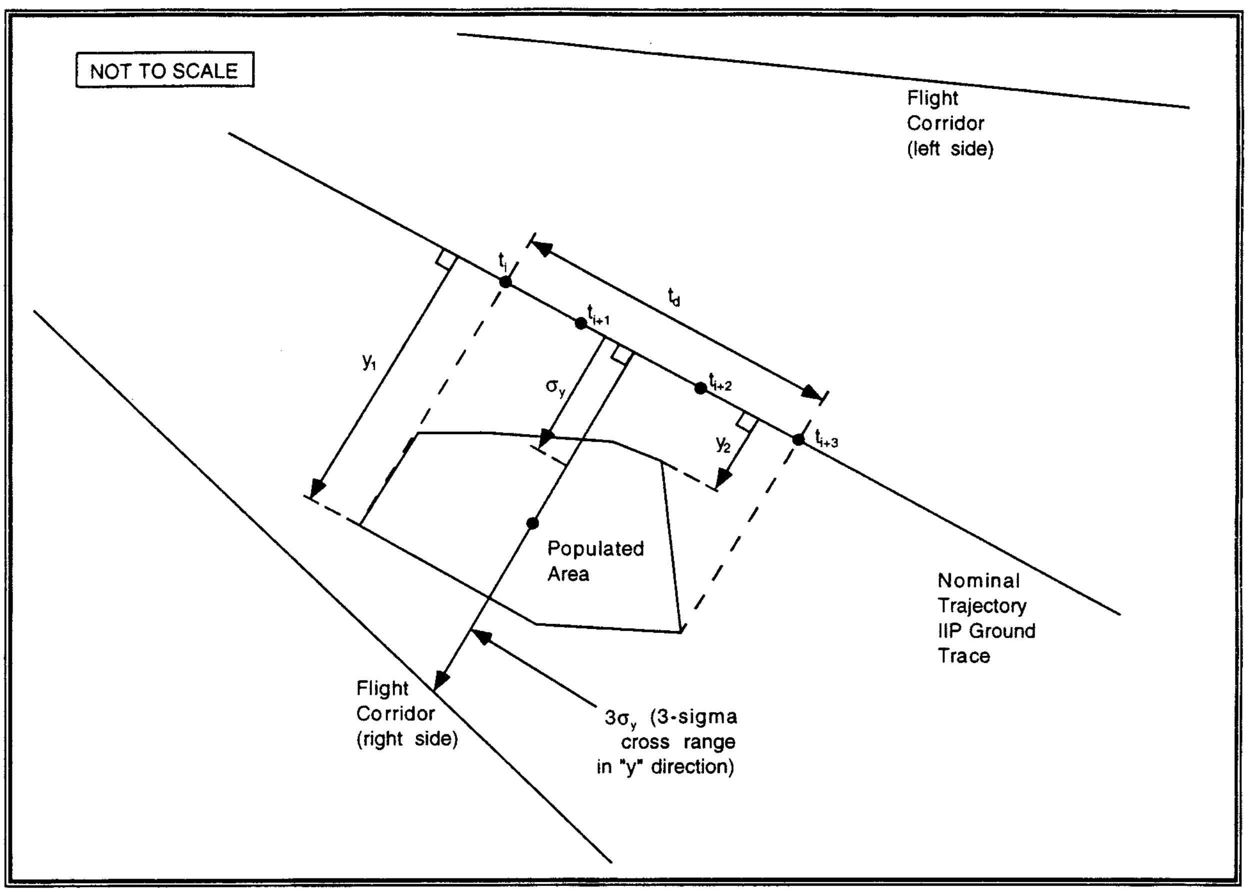


Figure C-2: Analysis of an Appendix B Flight Corridor

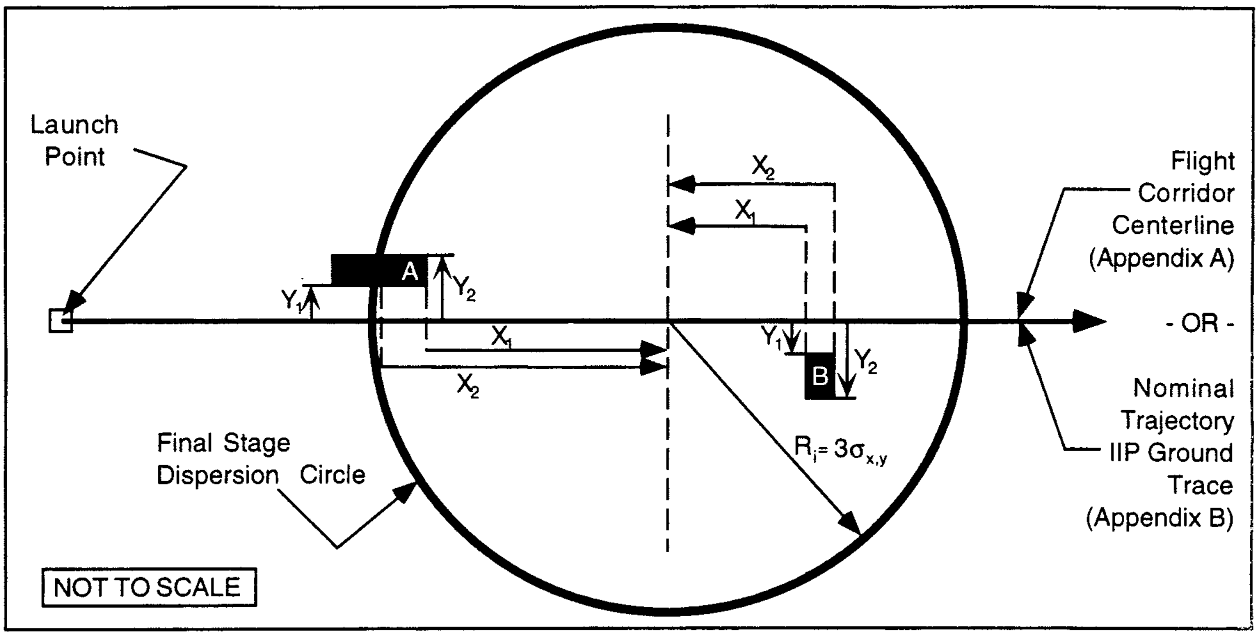


Figure C-3: Appendix A and B Final Stage Impact Risk Analysis

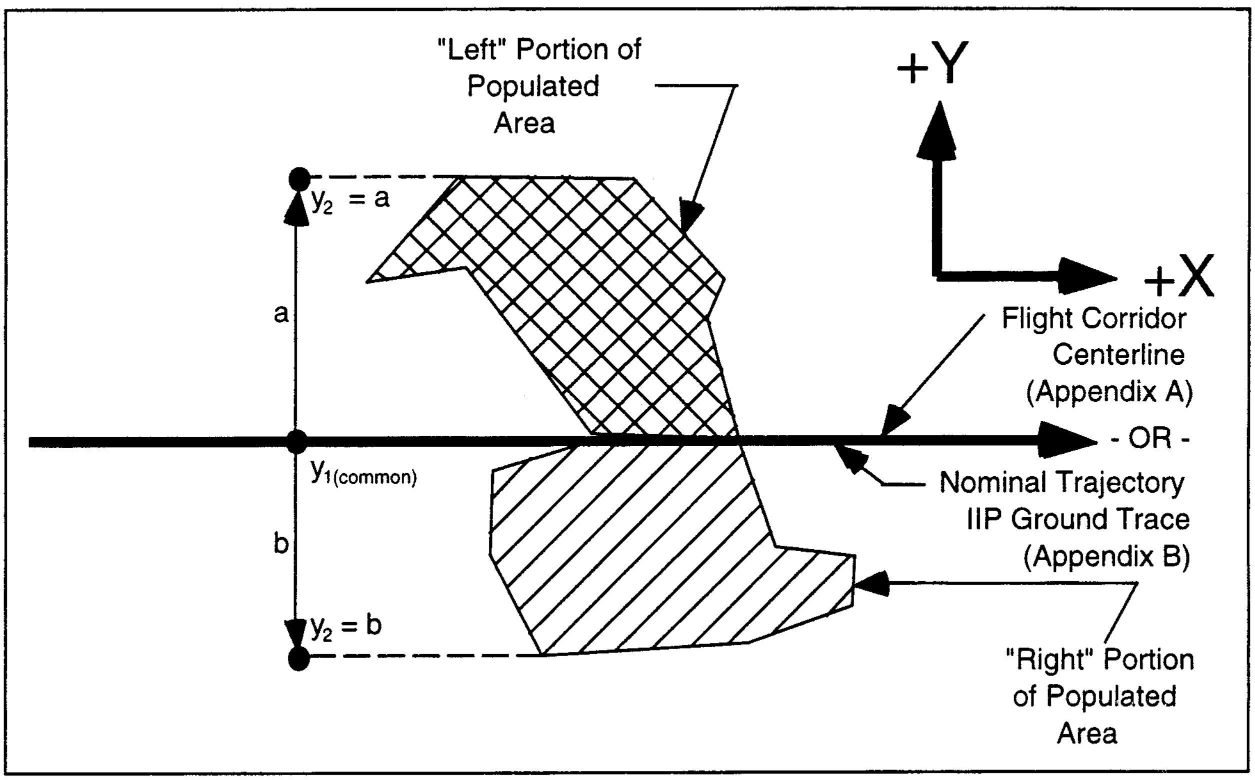


Figure C-4: Flight Azimuth Intersecting a Populated Area

(7) Using the P_i calculated in either subparagraph (c)(5) or (6) of this paragraph, an applicant shall calculate the casualty expectancy for each populated area within the flight corridor in accordance with equation C9. E_{ck} is the casualty expectancy for a given populated area as shown in equation C9, where individual populated areas are designated with the subscript "k".

$$E_{ck} = P_i \cdot \left(\frac{A_c}{A_k}\right) \cdot N_k \qquad \text{(Equation C9)}$$

where:
A_c = casualty area (from table C–3)
A_k = populated area
N_k = population in A_k

TABLE C–3.—EFFECTIVE CASUALTY AREA (MILES²) AS A FUNCTION OF IIP RANGE (NM)

IIP Range (nmi)	Orbital launch vehicles: Small	Medium	Medium large	Large	Suborbital launch vehicles: Guided
0–49	0.43	0.53	0.71	1.94	0.43
50–1749	0.13	0.0022	0.11	0.62	0.13
1750–5000	3.59×10^{-6}	8.3×10^{-4}	1.08×10^{-1}	7.17×10^{-1}	3.59×10^{-6}

(8) An applicant shall estimate the total corridor risk using the following summation of risk:

$$Ec(\text{Corridor}) = \left(\sum_{k=1}^{n} E_{c_k} \right) \qquad \text{(Equation C10)}$$

(9) Alternative casualty expectancy (E_C) analyses. An applicant may employ specified variations to the analysis defined by subparagraphs (c)(1)–(8). Those variations are identified in subparagraphs (9)(i) through (vi) of this paragraph. Subparagraphs (i) through (iv) permit an applicant to make conservative assumptions that would lead to an overestimation of the corridor E_C compared with the analysis defined by subparagraphs (c)(1)–(8). In subparagraphs (v) and (vi), an applicant that would otherwise fail the analysis prescribed by subparagraphs (c)(1)–(8) may avoid (c)(1)–(8)'s overestimation of the probability of impact in each populated area. An applicant employing a variation shall identify the variation used, show and discuss the specific assumptions made to modify the analysis defined by subparagraphs (c)(1)–(8), and demonstrate how each assumption leads to overestimation of the corridor E_C compared with the analysis defined by subparagraphs (c)(1)–(c)(8).

(i) Assume that P_x and P_y have a value of 1.0 for all populated areas.

(ii) Combine populated areas into one or more larger populated areas, and use a population density for the combined area or areas equal to the most densely populated area.

(iii) For any given populated area, assume P_y has a value of one.

(iv) For any given P_x sector (an area spanning the width of a flight corridor and bounded by two time points on the trajectory IIP ground trace) assume P_y has a value of one and use a population density for the sector equal to the most densely populated area.

(v) For a given populated area, divide the populated area into smaller rectangles, determine P_i for each individual rectangle, and sum the individual impact probabilities to determine P_i for the entire populated area.

(vi) For a given populated area, use the ratio of the populated area to the area of the P_i rectangle from the subparagraph (c)(1)–(8) analysis.

(d) Evaluation of Results

(1) If the estimated expected casualty does not exceed $30\text{x}10^{-6}$, the FAA will approve the launch site location.

(2) If the estimated expected casualty exceeds 30×10^{-6}, then an applicant may either modify its proposal, or, if the flight corridor used was generated by the appendix A method, use the appendix B method to narrow the flight corridor and then perform another appendix C risk analysis.

Appendix D to Part 420—Impact Dispersion Areas and Casualty Expectancy Estimate for an Unguided Suborbital Launch Vehicle

(a) Introduction

(1) This appendix provides a method for determining the acceptability of the location of a launch point from which an unguided suborbital launch vehicle would be launched. The appendix describes how to define an overflight exclusion zone and impact dispersion areas, and how to evaluate whether the public risk presented by the launch of an unguided suborbital launch vehicle remains at acceptable levels.

(2) An applicant shall base its analysis on an unguided suborbital launch vehicle whose final launch vehicle stage apogee represents the intended use of the launch point.

(3) An applicant shall use the apogee of each stage of an existing unguided suborbital launch vehicle with a final launch vehicle stage apogee equal to the one proposed, and calculate each impact range and dispersion area using the equations provided.

(4) This appendix also provides a method for performing an impact risk analysis that estimates the expected casualty (E_c) within each impact dispersion area. This appendix provides an applicant options to simplify the method where population at risk is minimal.

(5) If the estimated E_c is less than or equal to 30×10^{-6}, the FAA will approve the launch point for unguided suborbital launch vehicles. If the estimated E_c exceeds 30×10^{-6}, the proposed launch point will fail the launch site location review.

(b) Data Requirements

(1) An applicant shall employ the apogee of each stage of an existing unguided suborbital launch vehicle whose final stage apogee represents the maximum altitude to be reached by unguided suborbital launch vehicles launched from the launch point. The apogee shall be obtained from one or more actual flights of an unguided suborbital launch vehicle launched at an 84 degree elevation.

(2) An applicant shall satisfy the map and plotting data requirements of appendix A, paragraph (b).

(3) Population data. An applicant shall use total population (N) and the total landmass area within a populated area (A) for all populated areas within an impact dispersion area. Population data up to and including 100 nm from the launch point are required at the U.S. census block group level. Population data downrange from 100 nm are required at no greater than 1° x 1° latitude/longitude grid coordinates.

(c) Overflight Exclusion Zone and Impact Dispersion Areas

(1) An applicant shall choose a flight azimuth from a launch point.

(2) An applicant shall define an overflight exclusion zone as a circle with a radius of 1600 feet centered on the launch point.

(3) An applicant shall define an impact dispersion area for each stage of the suborbital launch vehicle chosen in accordance with subparagraph (b)(1) in accordance with the following:

(i) An applicant shall calculate the impact range for the final launch vehicle stage (D_n). An applicant shall set D_n equal to the last stage apogee altitude (H_n) multiplied by an impact range factor [$IP(H_n)$] in accordance with the following:

$$D_n = H_n \cdot IP(H_n) \qquad \text{(Equation D1)}$$

where:
$IP(H_n)$ = 0.4 for an apogee less than 100 km, and
$IP(H_n)$ = 0.7 for an apogee of 100 km or greater.

(ii) An applicant shall calculate the impact range for each intermediate stage (D_i), where i ε {1, 2, 3, . . . (n − 1)}, and where n is the total number of launch vehicle stages. Using the apogee altitude (H_i) of each intermediate stage, an applicant shall use equation D1 to compute the impact range of each stage by substituting H_i for H_n. An applicant shall use the impact range factors provided by equation D1.

(iii) An applicant shall calculate the impact dispersion radius for the final launch vehicle stage (R_n). An applicant shall set R_n equal to the last stage apogee altitude (H_n) multiplied by an impact dispersion factor [DISP(H_n)] in accordance with the following:

$$R_n = H_n \cdot \mathrm{DISP}(H_n) \qquad \text{(Equation D2)}$$

where:

DISP(H_n) = 0.4 for an apogee less than 100 km, and

DISP(Hn) = 0.7 for an apogee of 100 km or greater.

(iv) An applicant shall calculate the impact dispersion radius for each intermediate stage (R_i), where i ε {1, 2, 3, . . . (n − 1)} and where n is the total number of launch vehicle stages. Using the apogee altitude (H_i) of each intermediate stage, an applicant shall use equation D2 to compute an impact dispersion radius of each stage by substituting H_i for H_n. An applicant shall use the dispersion factors provided by equation D2.

(4) An applicant shall display an overflight exclusion zone, each intermediate and final stage impact point (D_i through D_n), and each impact dispersion area for the intermediate and final launch vehicle stages on maps in accordance with paragraph (b)(2).

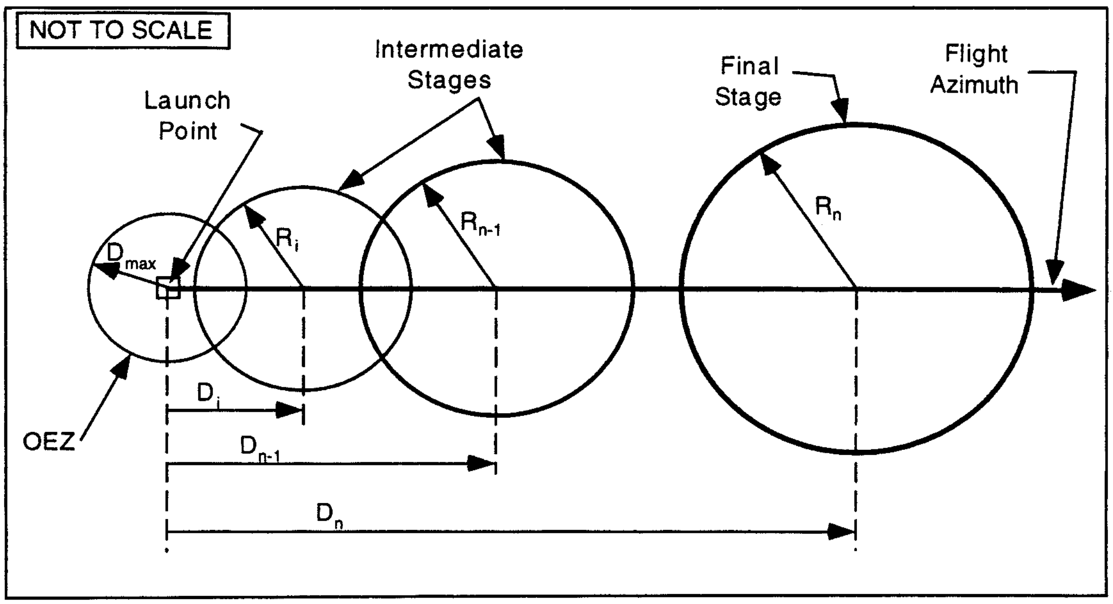


Figure D-1
Unguided Suborbital Launch Vehicle Overflight Exclusion Zone and Impact Dispersion Areas

(d) Evaluate the Overflight Exclusion Zone and Impact Dispersion Areas

(1) An applicant shall evaluate the overflight exclusion zone and each impact dispersion area for the presence of any populated areas. If an applicant determines that no populated area is located within the overflight exclusion zone or any impact dispersion area, then no additional steps are necessary.

(2) If a populated area is located in an overflight exclusion zone, an applicant may modify its proposal or demonstrate that there are times when no people are present or that the applicant has an agreement in place to evacuate the public from the overflight exclusion zone during a launch.

(3) If a populated area is located within any impact dispersion area, an applicant may modify its proposal and define a new overflight exclusion zone and new impact dispersion areas, or perform an impact risk analysis in accordance with paragraph (e).

(e) Impact Risk Analysis

(1) An applicant shall estimate the expected average number of casualties, E_C, within the impact dispersion areas according to the following method:

(i) An applicant shall calculate the E_c by summing the impact risk for the impact dispersion areas of the final launch vehicle stage and all intermediate stages. An applicant shall estimate E_c for the impact dispersion area of each stage by using equations D3 through D7 for each of the populated areas located within the impact dispersion areas.

(ii) An applicant shall estimate the probability of impacting inside the X and Y sectors of each populated area within each impact dispersion area using equations D3 and D4:

$$P_x = \frac{\left(\frac{x_2}{\sigma_x} - \frac{x_1}{\sigma_x}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(\frac{x_1}{\sigma_x}\right)^2}{2} \right) + 4 \cdot \exp\left[\frac{-\left(\frac{x_1 + x_2}{2\sigma_x}\right)^2}{2} \right] + \exp\left(\frac{-\left(\frac{x_2}{\sigma_x}\right)^2}{2} \right) \right) \qquad \text{(Equation D3)}$$

where:

x_1, x_2 = closest and farthest downrange distance to populated area (see figure D–2)
σ_x = one-third of the impact dispersion radius (see figure D–2)
exp = exponential function (e^x)

$$P_y = \frac{\left(\frac{|y_2|}{\sigma_y} - \frac{|y_1|}{\sigma_y}\right)}{6\sqrt{2\pi}} \cdot \left(\exp\left(\frac{-\left(y_1/\sigma_y\right)^2}{2}\right) + 4\cdot\exp\left[\frac{-\left(\frac{y_1+y_2}{2\sigma_y}\right)^2}{2}\right] + \exp\left(\frac{-\left(y_2/\sigma_y\right)^2}{2}\right)\right) \qquad \text{(Equation D4)}$$

where:

y_1, y_2 = closest and farthest cross range distance to the populated area (see figure D–2)
σ_y = one-third of the impact dispersion radius (see figure D–2)
exp = exponential function (e^x)

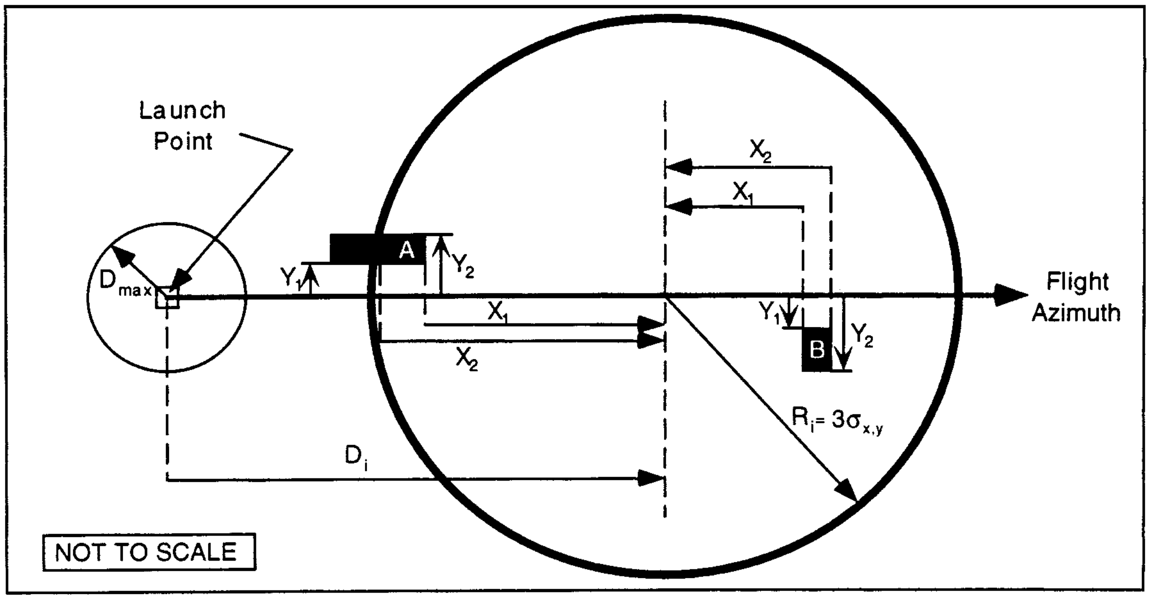


Figure D-2
Intermediate and Final Stage Impact Risk Analysis

(iii) If a populated area intersects the impact dispersion area boundary so that the x_2 or y_2 distance would otherwise extend outside the impact dispersion area, the x_2 or y_2 distance should be set equal to the impact dispersion area radius. The x_2 distance for populated area A in figure D–2 is an example.

(iv) If a populated area intersects the flight azimuth, an applicant shall solve equation D4 by obtaining the solution in two parts. An applicant shall determine, first, the probability between y_1 = 0 and y_2 = a and, second, the probability between y_1 = 0 and y_2 = b, as depicted in figure D–3. The probability P_y is then equal to the sum of the probabilities of the two parts. If a populated area intersects the line that is normal to the flight azimuth on the impact point, an applicant shall solve equation D3 by obtaining the solution in two parts in the same manner as with the values of x.

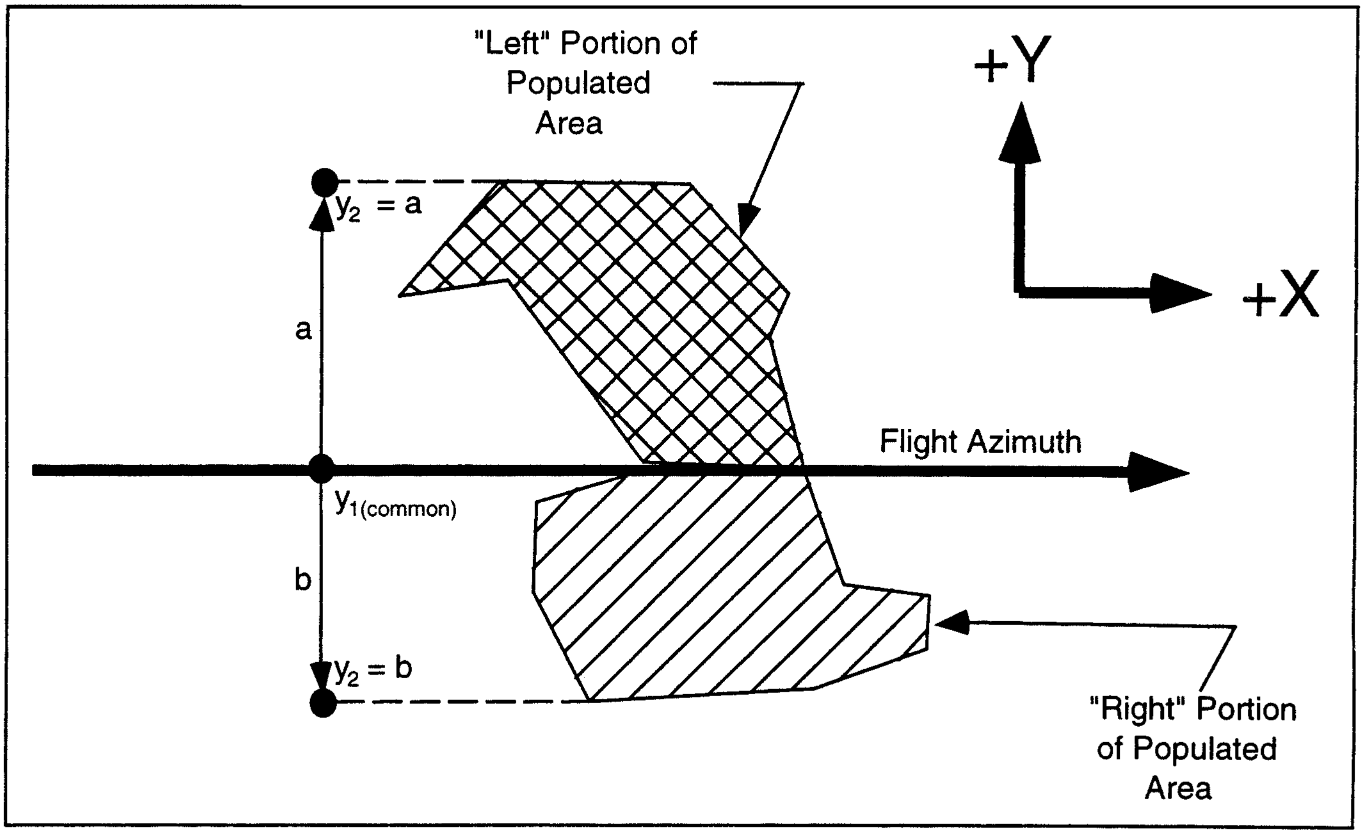


Figure D-3
Flight Azimuth Intersecting a Populated Area

(v) An applicant shall calculate the probability of impact (P_i) for each populated area using the following equation:

$$P_i = P_s \cdot P_x \cdot P_y \qquad \text{(Equation D5)}$$

where:
P_s = probability of success = 0.98

(vi) An applicant shall calculate the casualty expectancy for each populated area. E_{ck} is the casualty expectancy for a given populated area as shown in equation D6, where individual populated areas are designated with the subscript "k".

$$E_{ck} = P_i \cdot \left(\frac{A_c}{A_k}\right) \cdot N_k \qquad \text{(Equation D6)}$$

where:
k { {1, 2, 3, . . . , n}
A_c = casualty area (from table D–1)
A_k = populated area
N_k = population in A_k

TABLE D–1.—EFFECTIVE CASUALTY AREA (A_c) VS. IMPACT RANGE

Impact range (nm)	Effective casualty area (miles²)
0–4	9×10^{-3}
5–49	9×10^{-3}
50–1,749	1.1×10^{-5}
1,750–4,999	3.6×10^{-6}
5,000–more	3.6×10^{-6}

(vii) An applicant shall estimate the total risk using the following summation of risk:

$$Ec(\text{Corridor}) = \left(\sum_{k=1}^{n} E_{c_k}\right) \qquad \text{(Equation D7)}$$

(viii) Alternative casualty expectancy (E_c) analysis. An applicant may employ specified variations to the analysis defined by subparagraphs (d)(1)(i)–(vii). Those variations are identified in subparagraphs (viii)(A) through (F) of this paragraph. Subparagraphs (A) through (D) permit an applicant to make conservative assumptions that would lead to an overestimation of E_c compared with the analysis defined by subparagraphs (d)(1)(i)–(vii). In subparagraphs (E) and (F), an applicant that would otherwise fail the analysis prescribed by subparagraphs (d)(1)(i)–(vii) may avoid (d)(1)(i)–(vii)'s overestimation of the probability of impact in each populated area. An applicant employing a variation shall identify the variation used, show and discuss the specific assumptions made to modify the analysis defined by subparagraphs (d)(1)(i)–(vii), and demonstrate how each assumption leads to overestimation of the corridor E_c compared with the analysis defined by subparagraphs (d)(1)(i)–(vii).

(A) Assume that P_x and P_y have a value of 1.0 for all populated areas.

(B) Combine populated areas into one or more larger populated areas, and use a population density for the combined area or areas equal to the most densely populated area.

(C) For any given populated area, assume P_x has a value of one.

(D) For any given populated area, assume P_y has a value of one.

(E) For a given populated area, divide the populated area into smaller rectangles, determine P_i for each individual rectangle, and sum the individual impact probabilities to determine P_i for the entire populated area.

(F) For a given populated area, use the ratio of the populated area to the area of the P_i rectangle used in the subparagraph (d)(1)(i)–(vii) analysis.

(2) If the estimated expected casualty does not exceed 30×10^{-6}, the FAA will approve the launch point.

(3) If the estimated expected casualty exceeds 30×10^{-6}, then an applicant may modify its proposal and then repeat the impact risk analysis in accordance with this appendix D. If no set of impact dispersion areas exist which satisfy the FAA's risk threshold, the applicant's proposed launch site will fail the launch site location review.

Appendix E to Part 420—Tables for Explosive Site Plan

TABLE E–1.—QUANTITY DISTANCE REQUIREMENTS FOR SOLID EXPLOSIVES

Quantity (lbs.) (over)	Quantity (lbs.) (not over)	Public area distance (ft.) for division 1.1	Public area distance (ft.) for division 1.3	Intraline distance (ft.) for division 1.1	Intraline distance (ft.) for division 1.3
0	1,000	1,250	75	$D = 18 W^{1/3}$	50
1,000	5,000		115		75
5,000	10,000		150		100
10,000	20,000		190		125
20,000	30,000		215		145
30,000	40,000	$D = 40 W^{1/3}$	235		155
40,000	50,000		250		165
50,000	60,000		260		175
60,000	70,000		270		185
70,000	80,000		280		190
80,000	90,000		195		195
90,000	100,000		300		200
100,000	200,000	$D=2.42 W^{0.577}$	375		250
200,000	250,000		413		275
250,000	300,000	$D = 50 W^{1/3}$	450		300
300,000	400,000		525		350
400,000	500,000		600		400
500,000	1,000,000		800		500
Greater than 1,000,000		$D = 50 W^{1/3}$	$D = 8 W^{1/3}$	$D = 5 W^{1/3}$	

"D" equals the minimum separation distance in feet.
"W" equals the NEW of propellant.

TABLE E–2.—LIQUID PROPELLANT EXPLOSIVE EQUIVALENTS

Propellant combinations	Explosive equivalent
LO_2/LH_2	The larger of: $8W^{2/3}$ where W is the weight of LO_2/LH_2, or 14% of W.
LO_2/LH_2 + LO_2/RP–1	Sum of (20% for LO_2/RP–1) + the larger of: $8W^{2/3}$ where W is the weight of LO_2/LH_2, or 14% of W.
LO_2/R–1	20% of W up to 500,000 pounds plus 10% of W over 500,000 pounds, where W is the weight of LO_2RP–1.
N_2O_4/N_2H_4 (or UDMH or UDMH/N_2H_4 Mixture)	10% of W, where W is the weight of the propellant.

TABLE E–3.—PROPELLANT HAZARD AND COMPATIBILITY GROUPINGS AND FACTORS TO BE USED WHEN CONVERTING GALLONS OF PROPELLANT INTO POUNDS

Propellant	Hazard group	Compatibility group	Pounds/ gallon	At temperature °F
Hydrogen Peroxide	II	A	11.6	68
Hydrazine	III	C	8.4	68
Liquid Hydrogen	III	C	0.59	−423
Liquid Oxygen	II	A	9.5	−297
Nitrogen Tetroxide	I	A	12.1	68
RP–1	I	C	6.8	68
UDMH	III	C	6.6	68
UDMH/Hydrazine	III	C	7.5	68

TABLE E–4.—HAZARD GROUP I

Pounds of propellant: Over	Pounds of propellant: Not over	Public area and incompatible: Distance in feet	Intragroup and compatible: Distance in feet	Pounds of propellant: Over	Pounds of propellant: Not over	Public area and incompatible: Distance in feet	Intragroup and compatible: Distance in feet
0	100	30	25	5,000	6,000	80	60
100	200	35	30	6,000	7,000	85	65
200	300	40	35	7,000	8,000	85	65
300	400	45	35	8,000	9,000	90	70
400	500	50	40	9,000	10,000	90	70
500	600	50	40	10,000	15,000	95	75
600	700	55	40	15,000	20,000	100	80
700	800	55	45	20,000	25,000	105	80
800	900	60	45	25,000	30,000	110	85
900	1,000	60	45	30,000	35,000	110	85
1,000	2,000	65	50	35,000	40,000	115	85
2,000	3,000	70	55	40,000	45,000	120	90
3,000	4,000	75	55	45,000	50,000	120	90
4,000	5,000	80	60	50,000	60,000	125	95
60,000	70,000	130	95	500,000	600,000	185	140
70,000	80,000	130	100	600,000	700,000	190	145
80,000	90,000	135	100	700,000	800,000	195	150
90,000	100,000	135	105	800,000	900,000	200	150
100,000	125,000	140	110	900,000	1,000,000	205	155
125,000	150,000	145	110	1,000,000	2,000,000	235	175
150,000	175,000	150	115	2,000,000	3,000,000	255	190
175,000	200,000	155	115	3,000,000	4,000,000	265	200
200,000	250,000	160	120	4,000,000	5,000,000	275	210
250,000	300,000	165	125	5,000,000	6,000,000	285	215
300,000	350,000	170	130	6,000,000	7,000,000	295	220
350,000	400,000	175	130	7,000,000	8,000,000	300	225
400,000	450,000	180	135	8,000,000	9,000,000	305	230
450,000	500,000	180	135	9,000,000	10,000,000	310	235

TABLE E–5.—HAZARD GROUP II

Pounds of propellant: Over	Pounds of propellant: Not over	Public area and incompatible: Distance in feet	Intragroup and compatible: Distance in feet	Pounds of propellant: Over	Pounds of propellant: Not over	Public area and incompatible: Distance in feet	Intragroup and compatible: Distance in feet
0	100	60	30	50,000	60,000	250	125
100	200	75	35	60,000	70,000	255	130
200	300	85	40	70,000	80,000	260	130
300	400	90	45	80,000	90,000	265	135
400	500	100	50	90,000	100,000	270	135
500	600	100	50	100,000	125,000	285	140
600	700	105	55	125,000	150,000	295	145
700	800	110	55	150,000	175,000	305	150
800	900	115	60	175,000	200,000	310	155
900	1,000	120	60	200,000	250,000	320	160
1,000	2,000	130	65	250,000	300,000	330	165
2,000	3,000	145	70	300,000	350,000	340	170
3,000	4,000	150	75	350,000	400,000	350	175
4,000	5,000	160	80	400,000	450,000	355	180
5,000	6,000	165	80	450,000	500,000	360	180
6,000	7,000	170	85	500,000	600,000	375	185
7,000	8,000	175	85	600,000	700,000	385	190
8,000	9,000	175	90	700,000	800,000	395	195
9,000	10,000	180	90	800,000	900,000	405	200
10,000	15,000	195	95	900,000	1,000,000	410	205
15,000	20,000	205	100	1,000,000	2,000,000	470	235
20,000	25,000	215	105	2,000,000	3,000,000	505	255
25,000	30,000	220	110	3,000,000	4,000,000	535	265
30,000	35,000	225	110	4,000,000	5,000,000	555	275
35,000	40,000	230	115	5,000,000	6,000,000	570	285
40,000	45,000	235	120	6,000,000	7,000,000	585	295
45,000	50,000	240	120	7,000,000	8,000,000	600	300
				8,000,000	9,000,000	610	305
				9,000,000	10,000,000	620	310

TABLE E–6.—HAZARD GROUP III

Pounds of propellant		Public area and incompatible	Intragroup and compatible	Pounds of propellant		Public area and incompatible	Intragroup and compatible
Over	Not over	Distance in feet	Distance in feet	Over	Not over	Distance in feet	Distance in feet
0	100	600	30	60,000	70,000	1,200	130
100	200	600	35	70,000	80,000	1,200	130
200	300	600	40	80,000	90,000	1,200	135
300	400	600	45	90,000	100,000	1,200	135
400	500	600	50	100,000	125,000	1,800	140
500	600	600	50	125,000	150,000	1,800	145
600	700	600	55	150,000	175,000	1,800	150
700	800	600	55	175,000	200,000	1,800	155
800	900	600	60	200,000	250,000	1,800	160
900	1,000	600	60	250,000	300,000	1,800	165
1,000	2,000	600	65	300,000	350,000	1,800	170
2,000	3,000	600	70	350,000	400,000	1,800	175
3,000	4,000	600	75	400,000	450,000	1,800	180
4,000	5,000	600	80	450,000	500,000	1,800	180
5,000	6,000	600	80	500,000	600,000	1,800	185
6,000	7,000	600	85	600,000	700,000	1,800	190
7,000	8,000	600	85	700,000	800,000	1,800	195
8,000	9,000	600	90	800,000	900,000	1,800	200
9,000	10,000	600	90	900,000	1,000,000	1,800	205
10,000	15,000	1,200	95	1,000,000	2,000,000	1,800	235
15,000	20,000	1,200	100	2,000,000	3,000,000	1,800	255
20,000	25,000	1,200	105	3,000,000	4,000,000	1,800	265
25,000	30,000	1,200	110	4,000,000	5,000,000	1,800	275
30,000	35,000	1,200	110	5,000,000	6,000,000	1,800	285
35,000	40,000	1,200	115	6,000,000	7,000,000	1,800	295
40,000	45,000	1,200	120	7,000,000	8,000,000	1,800	300
45,000	50,000	1,200	120	8,000,000	9,000,000	1,800	305
50,000	60,000	1,200	125	9,000,000	10,000,000	1,800	310

TABLE E–7.—DISTANCES WHEN EXPLOSIVE EQUIVALENTS APPLY

TNT equivalent weight of propellants	Distance in feet	
Not over	To public area	Intraline unbarricaded
100	1250	80
200	1250	100
300	1250	120
400	1250	130
500	1250	140
600	1250	150
700	1250	160
800	1250	170
900	1250	180
1,000	1250	190
1,500	1250	210
2,000	1250	230
3,000	1250	260
4,000	1250	280
5,000	1250	300
6,000	1250	320
7,000	1250	340
8,000	1250	360
9,000	1250	380
10,000	1250	400
15,000	1250	450
20,000	1250	490
25,000	1,250	530
30,000	1,250	560
35,000	1,310	590
40,000	1,370	620
45,000	1,425	640
50,000	1,475	660
55,000	1,520	680
60,000	1,565	700
65,000	1,610	720
70,000	1,650	740
75,000	1,685	770
80,000	1,725	780
85,000	1,760	790
90,000	1,795	800
95,000	1,825	820
100,000	1,855	830
125,000	2,115	900
150,000	2,350	950
175,000	2,565	1,000
200,000	2,770	1,050

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