NOTICE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Traffic Organization Policy

N JO 1000.31

Effective Date:
February 6, 2024

Cancellation Date:
February 6, 2025

SUBJ: Application of the Acceptable Level of Risk (ALR) to Space Missions in the National Airspace System (NAS)

1. Purpose of This Notice. This notice establishes the Air Traffic Organization's (ATO's) policy for applying the Acceptable Level of Risk (ALR) as risk acceptance criteria for space missions in the National Airspace System (NAS). ALR and the missions to which ALR can be applied are identified and described in this notice.

2. Audience. This notice applies to all employees and contractors at all levels of the ATO engaged in conducting Safety Risk Management (SRM) for space missions in the NAS and those employees and contractors engaged in the provision of air traffic management and communication, navigation, and surveillance services.

3. Where Can I Find This Notice? This notice is available on the Federal Aviation Administration (FAA) Orders and Notices webpage and on the FAA Air Traffic Plans and Publications webpage.

4. Explanation of Policy Changes.

a. This notice establishes and describes the ATO's application of ALR to space missions in the NAS. FAA Order JO 1000.37, *Air Traffic Organization Safety Management System*, will be amended to include ALR for space missions as an acceptable ATO Safety Management System (SMS) process. Additionally, a new ATO order will be created to provide detail about ALR and the missions to which it can be applied.

b. This notice includes revisions to ALR as detailed in the (canceled) "Safety Risk Management Guidance: Applying the Acceptable Level of Risk (ALR) Approach to Commercial Space Missions in the National Airspace System (NAS)" document. Revisions include:

(1) ALR is applicable to all space missions that satisfy the conditions in Section 9 below. Previously, ALR was applicable only to qualifying commercial space missions.

(2) Debris Response Areas (DRAs) and the associated contingency procedures for use in debris-generating events have been added to ALR.

(3) Capsule re-entries have been recategorized into a non-ALR mission type (see paragraph 9.d.). The existing accepted standard for Department of Defense and National

Aeronautics and Space Administration (NASA) missions will be applied to capsule re-entries until new procedures can be developed and trained to the Air Traffic Control workforce.

5. Applicable Policy and Related Documents.

a. Title 14 of the Code of Federal Regulations (CFR), Chapter III, Commercial Space Transportation, Federal Aviation Administration, Department of Transportation;

b. Letters of Agreement (LOAs) for launch or re-entry activities between the FAA and respective ranges; and

c. *Service Level Agreement (SLA) for Acceptable Level of Risk (ALR) for Commercial Space Operation Implementation between Air Traffic Organization (ATO) and Commercial Space Transportation (AST)*, dated July 17, 2018.

6. Background.

a. The NAS is dynamic, evolving in ways that often affect aviation safety. The expansion of space operations increases the complexity of the system and, like every other operation in the NAS, requires the FAA's continued examination to ensure that safety risk is appropriately managed. Accommodating new entrants into the NAS, while maintaining the accepted level of safety, is a challenge and has led the FAA to take a closer look at its SMS and safety risk acceptance criteria.

b. Aviation and space safety methods and standards have developed over time through the work of different parties operating under different circumstances. The FAA Office of Commercial Space Transportation (AST) and the ATO have separately established public safety risk acceptance criteria that are expressed using different terminology and numerical values. The ATO proposed using ALR to temporarily bridge the differences and accommodate the growth of space launches in the NAS.

c. The FAA SMS Executive Council established the ALR Tactical Team in January 2017 under the Safety Data and Analysis Team to review and, if necessary, refine ALR as proposed by the ATO for commercial space launches with fly-back operations and to consider the application of ALR to all known commercial space launch and re-entry mission types. In June 2017, the FAA SMS Executive Council approved ALR as refined by the ALR Tactical Team for application to commercial space launches with fly-backs. In December 2017, the FAA SMS Executive Council approved additional refinements to ALR and the mission type applicability recommended by the ALR Tactical Team. Due to the complexity of implementing ALR procedures in different operating environments, the FAA SMS Executive Council stipulated that procedures would remain unchanged until ALR procedures were developed and the workforce was trained.

d. In July 2018, ATO and AST signed an SLA for the implementation and use of ALR.

7. Overview.

a. Conceptually, ALR is a way to address air traffic operations that interact with space operations and do not meet existing ATO safety standards. The ATO's current safety standard is a relatively simple risk limit of 1×10^{-9} probability of a catastrophic event to individual operations from each hazard. Conversely, ALR has criteria that combine two limits: a limit of the risk to individual air traffic operations and a limit of overall exposure to the hazard.

b. The FAA uses Aircraft Hazard Areas (AHAs) during launch and re-entry operations to identify areas requiring segregation from other NAS operations. An AHA is a region of airspace in which an occupant of an aircraft would be exposed to a risk of becoming a casualty from an off-nominal event, including falling launch vehicle debris, in excess of the limits under 14 CFR Chapter III. For a given launch or re-entry, the location, extent, and duration of the AHA are computed to meet the 14 CFR § 417 requirement of 1×10^{-6} probability of individual casualty (fatality or serious injury) per aircraft per launch. As they were developed separately by different parties under different circumstances, the ATO's 1×10^{-9} safety standard and the AST's 1×10^{-6} regulation are not directly comparable. Table 1 summarizes these differences.

Table 1: Mapping of AST and ATO Risk Criteria

Element	AST	ATO
Safety Standard	1×10^{-6} for casualty-producing collisions	1×10^{-9} for catastrophic hazards
Period	Per aircraft, per launch / fly-back operation	Per affected flight hour or air traffic operation
Consequence	Casualty of an aircraft occupant	Fatality of an aircraft occupant

c. The AHA is based on risk contours. Risk contours are composed of isolines where the calculated risk to an individual on a given aircraft is constant along each line. The isolines demarcate regions surrounding a launch trajectory that define per-aircraft probabilities of impact with debris capable of causing a casualty to an occupant (see Figure 1).[1]

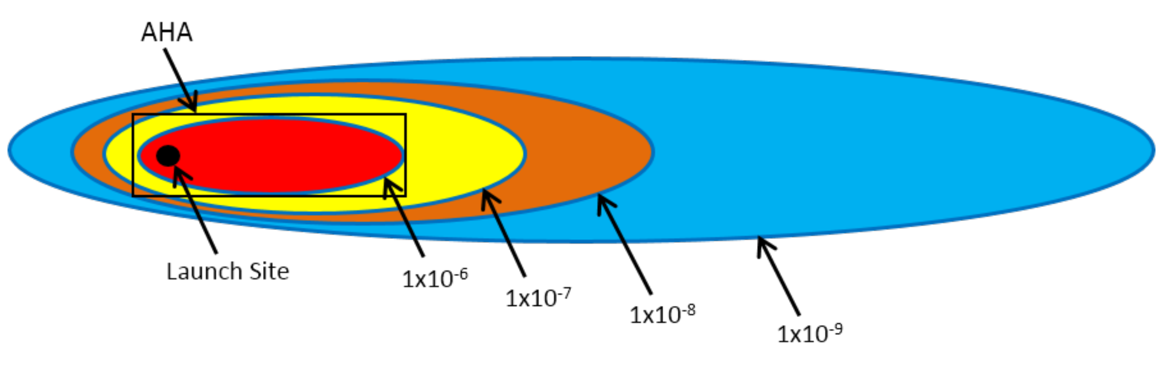

Figure 1: Notional Risk Contours/Isolines and AHA

1. More information regarding AHAs can be found in 14 CFR § 417; FAA Order 7400.2, *Procedures for Handling Airspace Matters*; and *Flight Safety, Range Safety Office Training Manual*, NASA / Wallops Flight Facility.

d. ALR defines an alternative method for accepting individual and collective catastrophic risk to air traffic interacting with space launches. It permits the exposure of individual aircraft to a higher risk than the existing 1×10^{-9} target, but it limits the total number of aircraft exposed until NAS infrastructure, policies, and procedures are updated to fully integrate these launches.

e. ALR has two primary components related to acceptable level of risk: individual risk and collective risk criteria.

(1) **Individual Risk.** Individual risk is the probability that a space launch results in at least one fatality or fatal injury to passengers on an exposed flight. The upper limit of the individual risk of ALR is 1×10^{-7} probability of fatality per air traffic operation during a launch. This means that an acceptable airspace must ensure that exposed aircraft do not experience a probability greater than 1×10^{-7} that at least one passenger experiences a fatality due to a space launch. It was determined that the mitigations that would likely bring down the risk to the level required by the existing ATO standard of 1×10^{-9} would take a number of years to develop and implement. Therefore, ALR is employed when the individual risk from space launches ranges between 1×10^{-9} and 1×10^{-7}. If the individual risk to exposed aircraft during a launch is below 1×10^{-9}, it meets the ATO's existing standard and does not require the application of ALR. On the other hand, if the risk of fatality per exposed flight exceeds 1×10^{-7}, it does not meet ALR's individual upper limit requirement, and hence, ALR cannot be employed.

(2) **Collective Risk.** Collective risk is the expected value of the number of fatal accidents due to space launch debris in the affected regions of the NAS over a specified period of time. By limiting the number of flights exposed to an individual risk level that exceeds the ATO's existing standard of 1×10^{-9}, the collective risk limit ensures with high confidence that no fatal accident will occur in an average human lifespan. With a maximum individual risk of 1×10^{-7} probability of fatality per air traffic operation per launch, the FAA seeks to limit the number of air traffic operations exposed to debris risk such that there is 95 percent confidence that no fatal accident will occur in an average lifetime of 80 years. By implementing a collective risk limit in addition to an individual risk limit, the FAA can confine the exposure rate of a higher individual risk to a smaller number of aircraft flying in the NAS.

8. Parameters and Conditions of ALR.

a. To use ALR, the following parameters and conditions must be applied[2]:

(1) For the purpose of ALR, the method used to compute risk contours must satisfy the following conditions:

(a) Continuous presence of an aircraft, which would allow any flight operations (e.g., maneuvers such as circling / holding patterns and vectoring);

(b) Debris large enough to cause casualty; and

(c) Use of the largest commercially available transport category aircraft.

2. Restrictions do not apply to aircraft operations supporting the launch mission.

(2) No nonparticipating operations are permitted in the AHA.

(3) No operational conditions for all flights in the region corresponding to risk contours of less than 1×10^{-7} (i.e., outside the 1×10^{-7} contour).

(4) To fly in the region between the 1×10^{-6} and the 1×10^{-7} risk contours, the following conditions apply:

(a) For missions with a horizontal component, one of the following conditions must apply:

- Contingency response procedures to a potential debris event need to be in place.
- Flight routes must have an angular difference relative to the launch vehicle path of at least 30 degrees (hovering and circling are not permitted).
- A maximum exposure time equivalent in risk limit to an angular restriction of 30 degrees.

(b) For missions with no horizontal component (i.e., a component of the launch that is not perpendicular to the surface of the earth), an additional area (risk buffer) to the AHA needs to be added to ensure the 1×10^{-7} individual risk limit.

(c) Collectively no more than 6,412 exposed operations in a rolling 12-month period are permitted.[3]

b. An exposed operation, for the purpose of collective risk, is any flight that passes inside the 1×10^{-8} risk contour from launch time until the space vehicle is declared to have entered in orbit, typically less than 10 minutes, and, if applicable, any fly-back is complete (i.e., the reusable portion of the vehicle has landed). See the SLA and LOA referenced in paragraph 6, Applicable Policy and Related Documents, for roles and responsibilities.

c. Failure to implement these specific parameters and conditions as part of the adoption of ALR may result in risk that is not acceptable as specified by ALR. Therefore, these parameters and conditions cannot be applied piecemeal. They all must be applied or ALR cannot be used. In addition, note that ALR's parameters and conditions are not the same as the safety risk mitigations/controls or safety requirements identified, developed, and approved through SRM. ALR's parameters and conditions have to be met in order to apply ALR. When SRM is conducted, it is likely that additional safety risk mitigations/controls or safety requirements will be identified and approved by the appropriate management official. Any safety risk mitigations/controls or safety requirements identified, developed, and approved through SRM do not supplant, nor can they conflict with, ALR's parameters and conditions.

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3. Based on data collected from October 2020 through September 2021, an average of 12 flights are exposed per launch. Per the total exposures permitted, this equates to 534 launches per rolling 12-month period. ALR's collective risk criterion was set by requiring that, with 95 percent confidence, no fatal accidents occur during an average person's lifetime (taken to be 80 years). This leads to a maximum expected rate of one fatal accident per 1,560 years due to any single hazard.

9. Applicability of ALR.

a. When conducting SRM for space missions, ALR may be used as an alternative to the risk acceptance criteria in the ATO SMS Manual. ALR is approved for use with the following conditions:

(1) Missions with a Horizontal Component Using ALR. ALR can be applied to the following mission types using the 30-degree angular restriction or with debris response procedures in the area between the 1×10^{-6} and the 1×10^{-7} risk contours:

- Launch Barge Fly-Back
- Launch Site Fly-Back
- Expendable Launch Without Fly-Back
- Horizontal Orbital
- Captive Carry Orbital (for the launch phase[4])

(2) Missions Without a Horizontal Component Using ALR. The launch or re-entry paths of some mission types do not have a sufficient horizontal component to apply the 30-degree angular restriction. Therefore, for these missions, a risk buffer (or additional area around the AHA) for each launch must be added to the AHA to ensure that the 1×10^{-7} individual risk limit of ALR is met. The AHA with the included risk buffer will be provided to the ATO by AST. In general, based on the knowledge the FAA has today regarding the missions, the following mission types do not allow the application of the angular restriction and thus, would require a risk buffer be added to the AHA:

- Horizontal Suborbital
- Captive Carry Suborbital (for the launch phase)
- Vertical Launch Suborbital Expendable Booster
- Vertical Launch Suborbital Reusable Booster

(3) Missions to Which ALR Cannot Be Applied at This Time. ALR cannot be applied to the following mission types at this time either because the FAA was not able to identify the appropriate parameters, conditions, and restrictions that would allow the application of ALR (and meet the individual risk limit) or there is not enough information known about these mission types to make a determination:

- Capsule Re-entry
- Winged Re-entry
- Stratospheric Manned Balloons
- Balloon Launch
- Point-to-Point
- Tube and Rail Launchers

4. For captive carry missions, the launch phase is the part of the mission after the launch vehicle is released from the aircraft.

(4) For descriptions and diagrams illustrating these mission types, see Appendix A.

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Timothy L. Arel
Chief Operating Officer
Air Traffic Organization

Appendix A. Space Mission Types

1. The sections that follow provide descriptions and diagrams for each of the 15 mission types listed in the Applicability of Acceptable Level of Risk (ALR) section.

2. Launch Barge Fly-Back

a. Mission Summary. The launch with barge fly-back mission type might consist of the following phases: liftoff, main engine cutoff, stage separation and second stage ignition, boostback burn / re-entry / soft touchdown, second stage engine cutoff, and payload separation. The booster stage may separate from the second stage at an altitude between 225,000 feet to 350,000 feet, approximately 25 to 100 miles downrange from the launch site. The booster landing site is typically between 150 and 300 miles from the launch site, but it could be closer. Figure A1 depicts the launch barge fly-back mission type.

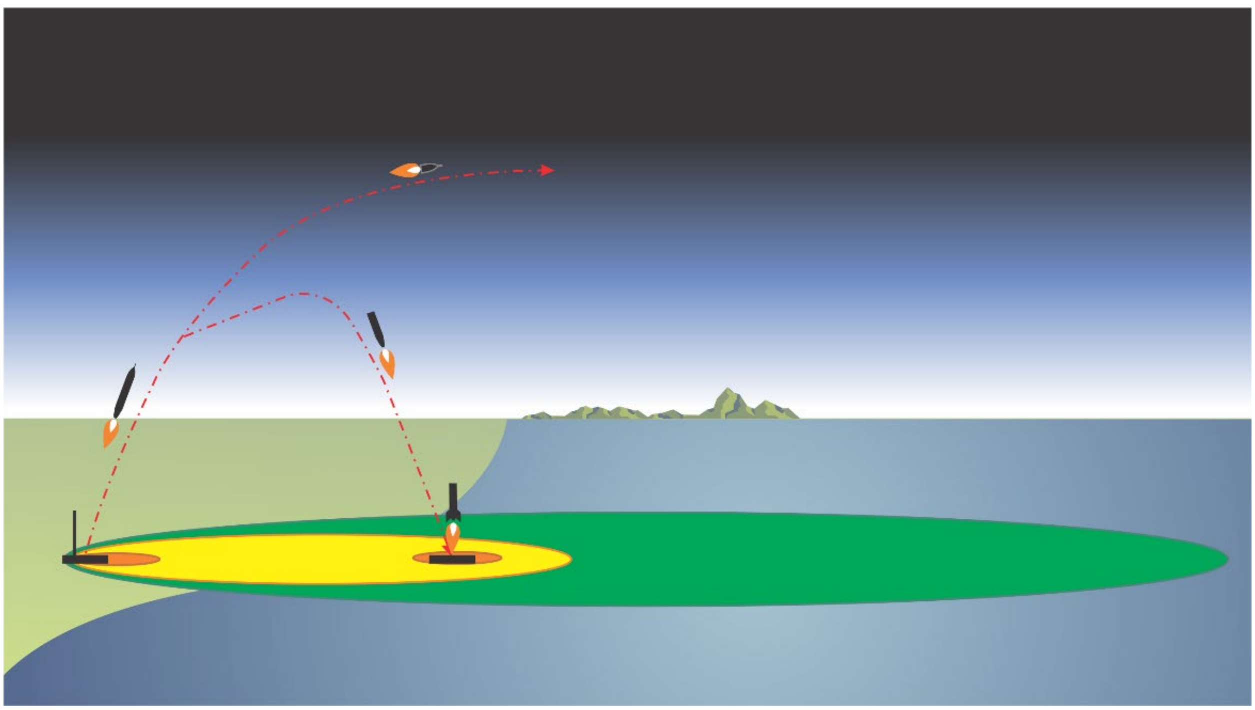

Figure A1: Launch Barge Fly-Back

b. System Examples. Specific examples of vehicles capable of barge fly-back include: SpaceX Falcon 9 (current system) and future concepts Falcon Heavy, the Blue Origin New Glenn, European Ariane 5, and Russian Angara.

c. Risk Contours. The dimensions of the risk contours are variable depending on the mission and vehicle, but they will likely range in width from 20 to 100 miles and in length from hundreds to thousands of miles. In Figure A1, two orange (1×10^{-6}) regions are depicted—one associated with the launch site and the other associated with the barge/touchdown site.

3. Launch Site Fly-Back

a. Mission Summary. The launch site fly-back mission type is similar to the barge fly-back mission. Figure A2 depicts the launch site fly-back mission type.

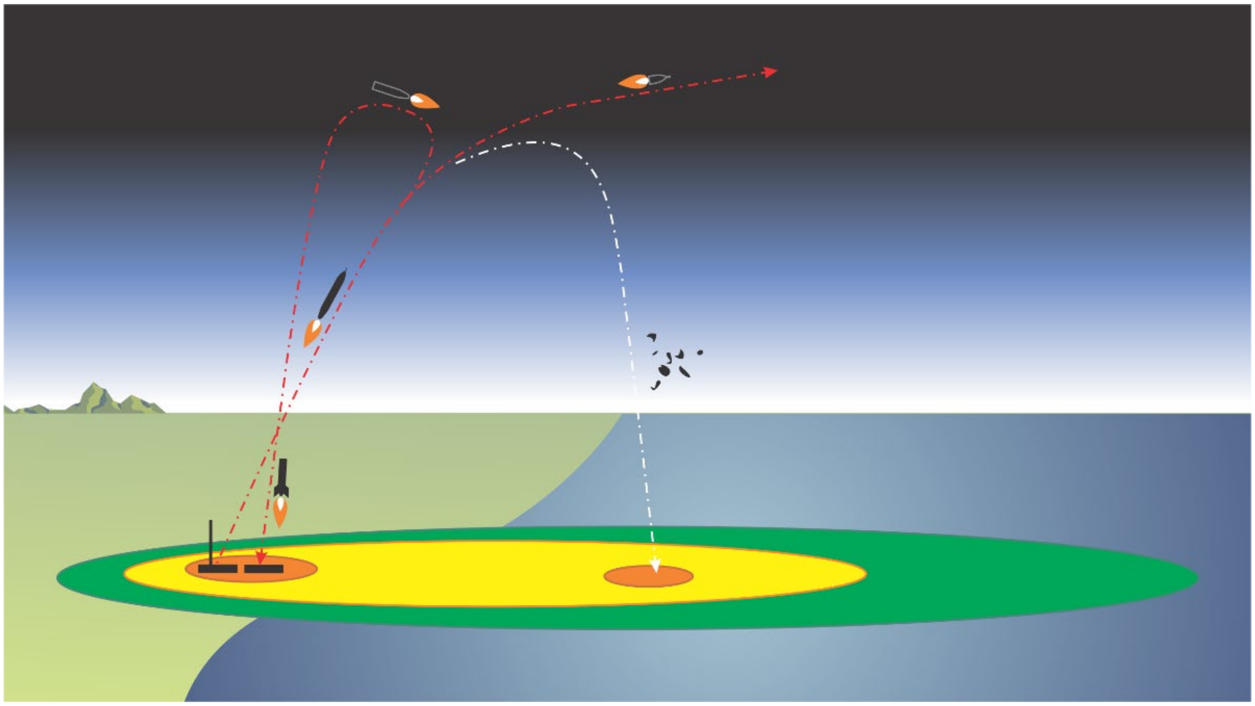

Figure A2: Launch Site Fly-Back

b. System Examples. Specific examples of vehicles capable of launch site fly-back include: SpaceX Falcon 9 (current system) and future concepts Falcon Heavy, the European Ariane 5, and Russian Angara.

c. Risk Contours. The configuration of the risk contours differs from that of the barge fly-back mission type, since fly-back in this case is to the launch site. However, in Figure A2, the second (rightmost) orange region accounts for possible jettisoned items such as payload fairings.

4. Expendable Launch Without Fly-Back

a. Mission Summary. Expendable launch vehicles (ELVs) are designed to be used only once, "expended" during a single flight to carry a payload into space. ELV components are not recovered for reuse after launch. Typically, the vehicle consists of several rocket stages, which are jettisoned during the vehicle ascent. Therefore, in practice, there may be multiple risk contours. Figure A3 depicts the expendable launch without fly-back mission type.

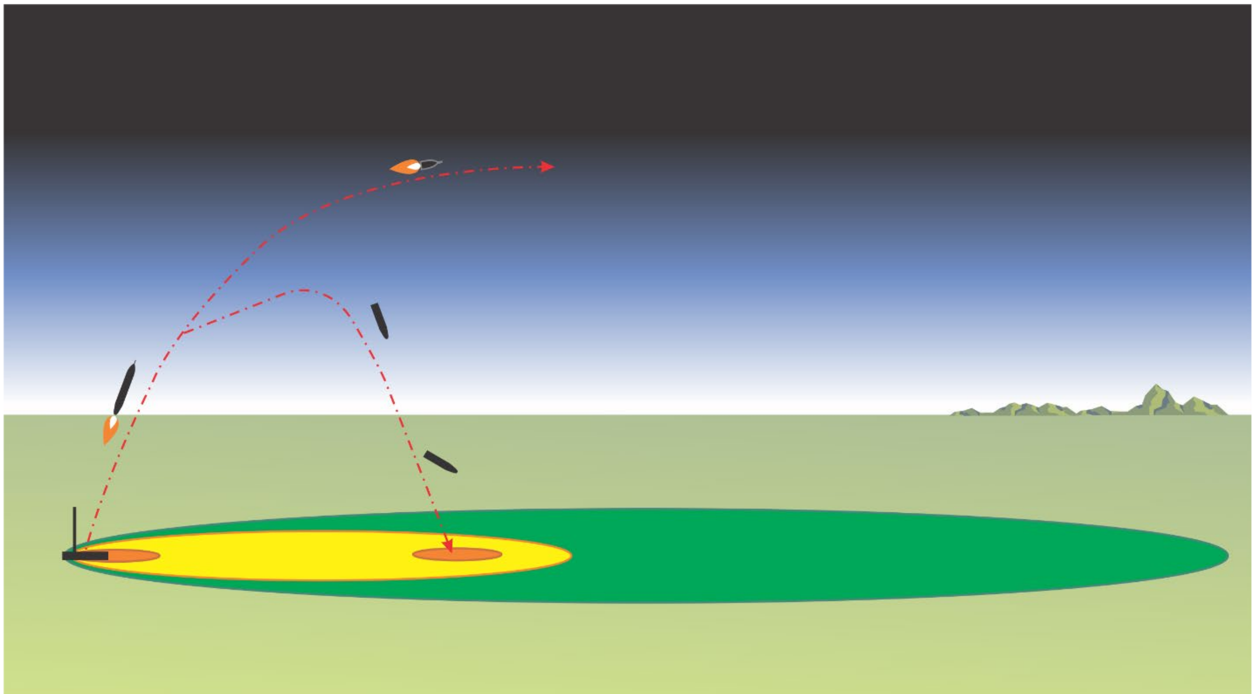

Figure A3: Expendable Launch Without Fly-Back

b. System Examples. There are numerous operational examples of this mission type including: United Launch Alliance (Lockheed Martin-Boeing joint venture) Atlas V and Delta IV, Orbital ATK Minotaur, SpaceX Falcon 9, Titan, European Ariane, Chinese Long March (Changzheng) rocket, Russian Proton, and R-7 (including Semyorka, Molniya, Vostok, Voskhod, and Soyuz).

c. Risk Contours. In Figure A3, there are two 1×10^{-6} risk contours—one associated with launch and another associated with the jettison of a rocket stage. The position and number of contours depends on vehicle and mission specifics. For example, in the case of SpaceX, stage jettison may occur at an altitude between 225,000 to 350,000 feet, although this varies across the industry. Similarly, jettison may occur as close as 25 miles downrange from the launch site or hundreds of miles downrange. The actual point of ground impact for various stages may be hundreds or thousands of miles downrange.

5. Horizontal Orbital

a. Mission Summary. In concept, this mission type would involve a rocket-powered, winged launch vehicle that takes off from a runway and accelerates to earth orbit. For the purposes of this report, the re-entry portion of a horizontal orbital operation is classified as its own mission type (winged re-entry), and is described separately in another section. This follows because computed risks may be different for "takeoff-to-orbit" and "re-entry-landing" phases. Figure A4 depicts the horizontal orbital mission type.

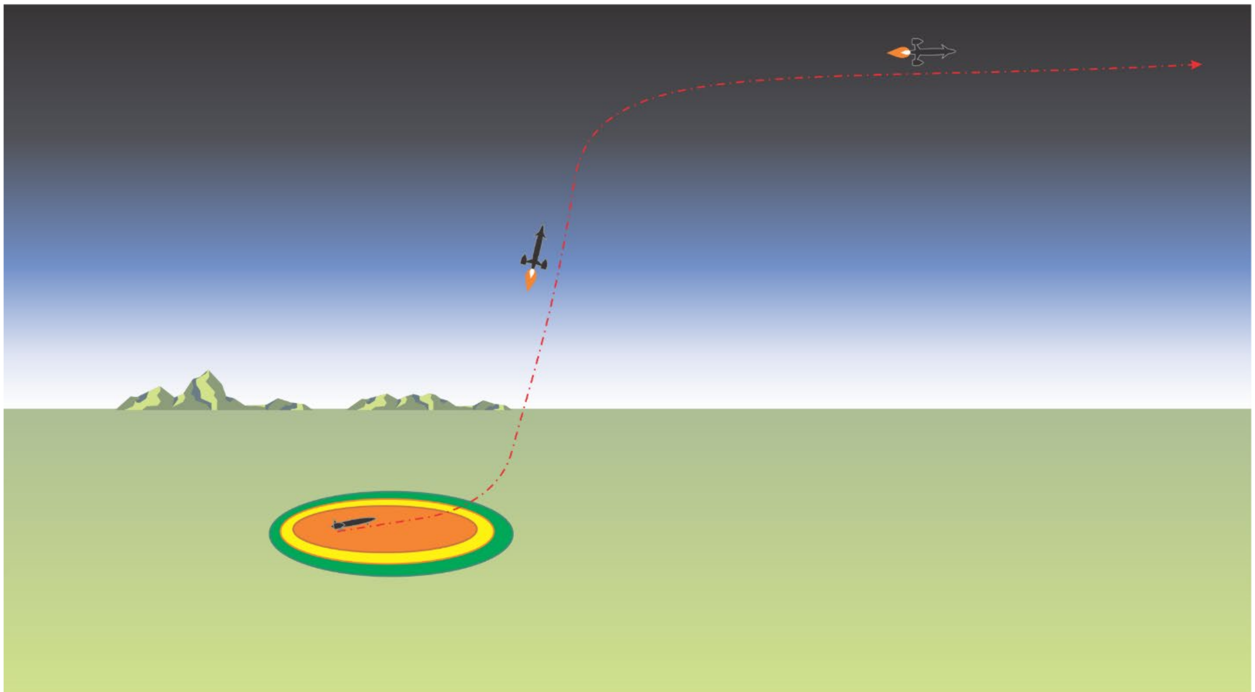

Figure A4: Horizontal Orbital

b. System Examples. Future concept.

c. Risk Contours. The dimensions of the representative risk contours are not well defined, as no operational vehicles or prototypes exist. However, if contours are required, they are likely to be of the same order of magnitude as vertical launch vehicles—20 to 50 miles wide and hundreds or thousands of miles long.

6. Captive Carry Orbital

a. Mission Summary. The captive carry orbital mission type might include the following phases: aircraft/rocket climb-to-launch altitude (captive carry phase), rocket ignition/launch, carrier aircraft return to aerodrome/spaceport, jettison of stages, and rocket entry into orbit. The carrier aircraft may execute a circling climb to reach the launch altitude of 40,000 to 60,000 feet. Figure A5 depicts the captive carry orbital mission type.

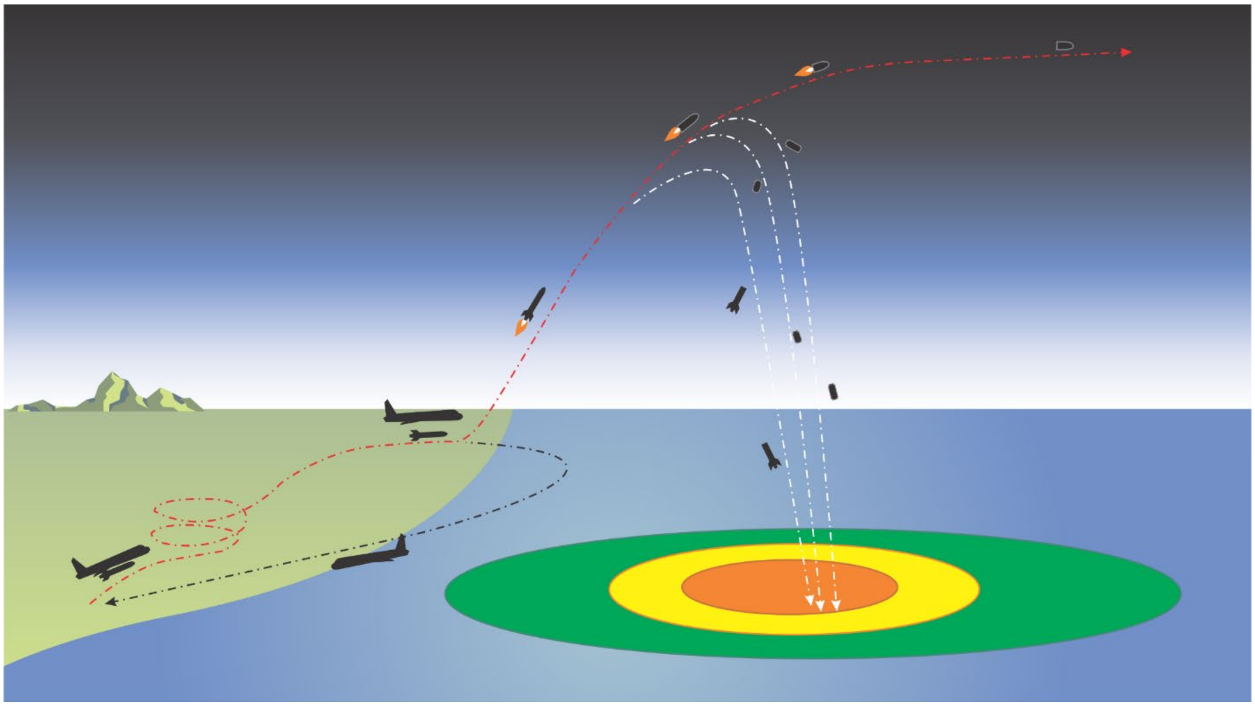

Figure A5: Captive Carry Orbital

b. System Examples. Examples of this mission type include:

(1) Virgin Orbit Launcher One. The carrier aircraft, a Boeing 747-400, transports Launcher One to an altitude of 35,000 feet before release. The Launcher One consists of an expendable two-stage rocket. After release, Launcher One ignites its main stage, 73,500 pounds of force (lbf) LOX/RP-1 rocket. According to company information, this engine will fire for about three minutes. After main stage separation, the upper stage 5,000 lbf rocket carries the payload to orbit. Stratolaunch is anticipated to use a similar concept.

(2) Generation Orbit, GOLauncher 2/3. The GOLauncher 2 carrier aircraft is a modified Gulfstream IV. According to company information, the Launcher2 is an expendable two-stage rocket that transports payloads up to 40 kilograms to low-earth orbit. GOLauncher 3 Mini uses a larger transport aircraft, such as the DC-10. The Launcher 3 is an all-liquid rocket capable of transporting payloads of up to 150 kilograms to sun synchronous orbit. GOLauncher 3 Heavy uses an all-liquid rocket capable of transporting payloads up to 500 kilograms to sun synchronous orbit.

(3) Cube Cab, Carrier Aircraft Lockheed F104. Rocket characteristics are in development, but according to company information the target market is for payloads up to 5 kilograms.

c. Risk Contours. In Figure A5, the point at which the rocket is released and separated from the aircraft is where the red and black dashed lines diverge, which is when the rocket engine ignites. Current designs have a demonstrated probability of less than 1×10^{-6} for vehicle failure prior to engine ignition, so risk contours are not computed for this region.

d. In the diagram, the risk contours are skewed toward the point of rocket engine ignition. However, separate risk contours may also be computed for the area associated with stage drops. In other words, for some operations there could be multiple 1×10^{-6} regions, as there can be for multi-stage vertically launched vehicles. While staging times and altitudes for multi-stage vehicles are highly variable, generally staging is separated by hundreds of thousands of feet in altitude. Hypothetically, the region associated with 1×10^{-6} casualty risk would be 20 to 40 miles wide and up to 100 miles long. The outermost region (green) may be 30 to 100 miles wide and hundreds or thousands of miles long.

7. Horizontal Suborbital

a. Mission Summary. For this report, the horizontal suborbital mission type might include the following phases: horizontal takeoff, powered ascent, coast to altitude, vehicle re-entry, glide and circle, and horizontal landing. Total flight time may be approximately 60 minutes, reaching or possibly exceeding 100 kilometers above sea level. Figure A6 depicts the horizontal suborbital mission type.

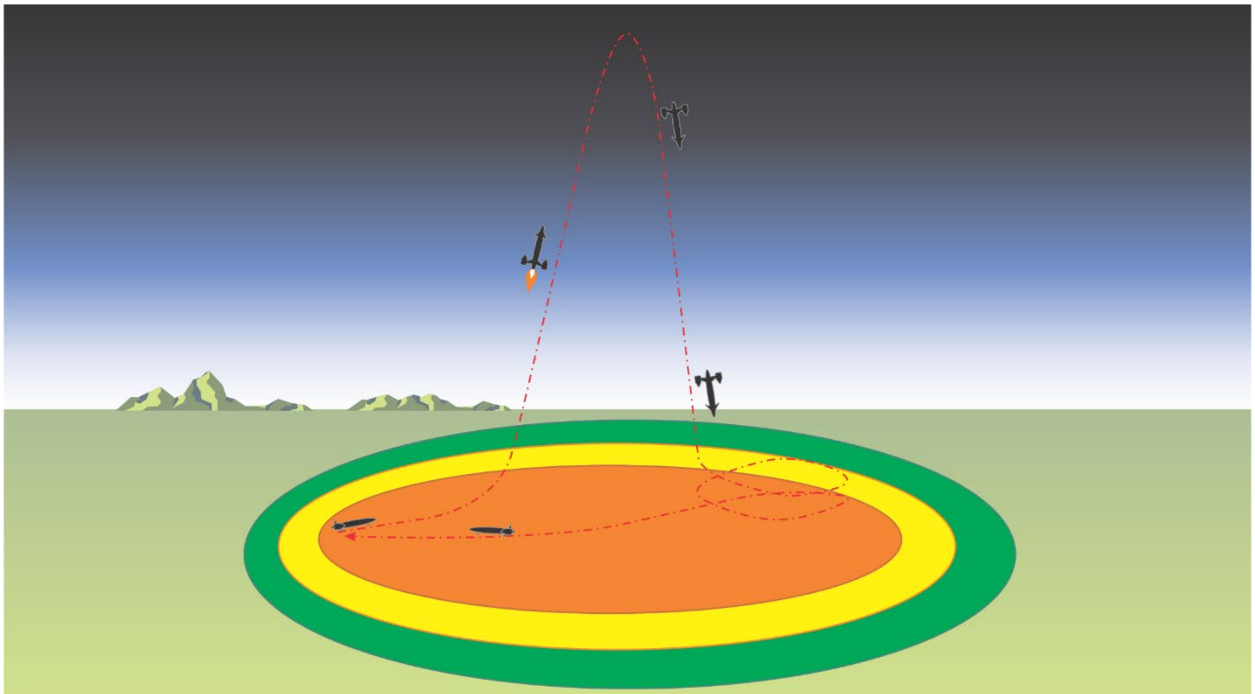

Figure A6: Horizontal Suborbital

b. System Examples. An example of a vehicle operating under this mission type is the now-halted XCOR Lynx launch vehicle.

c. Risk Contours. While the illustrated risk contours are meant to be circular (in perspective), no operational vehicles for this mission type exist, so this representation is an approximation. The size of the contours depends on the vehicle and mission details, but they will likely be the same order of magnitude as vertical suborbital launch vehicles—20 to 50 miles in radius.

8. Captive Carry Suborbital (for the launch phase)

a. Mission Summary. The captive carry suborbital mission type might include the following phases: aircraft / space vehicle climb-to-launch altitude (captive carry phase), space vehicle ignition/launch, carrier aircraft return to aerodrome/spaceport, space vehicle powered ascent and coast to altitude, space vehicle re-entry, glide and circling maneuver to reduce altitude, and return to aerodrome/spaceport for horizontal landing. The maximum space vehicle altitude would be approximately 100 kilometers. Figure A7 depicts the captive carry suborbital mission type.

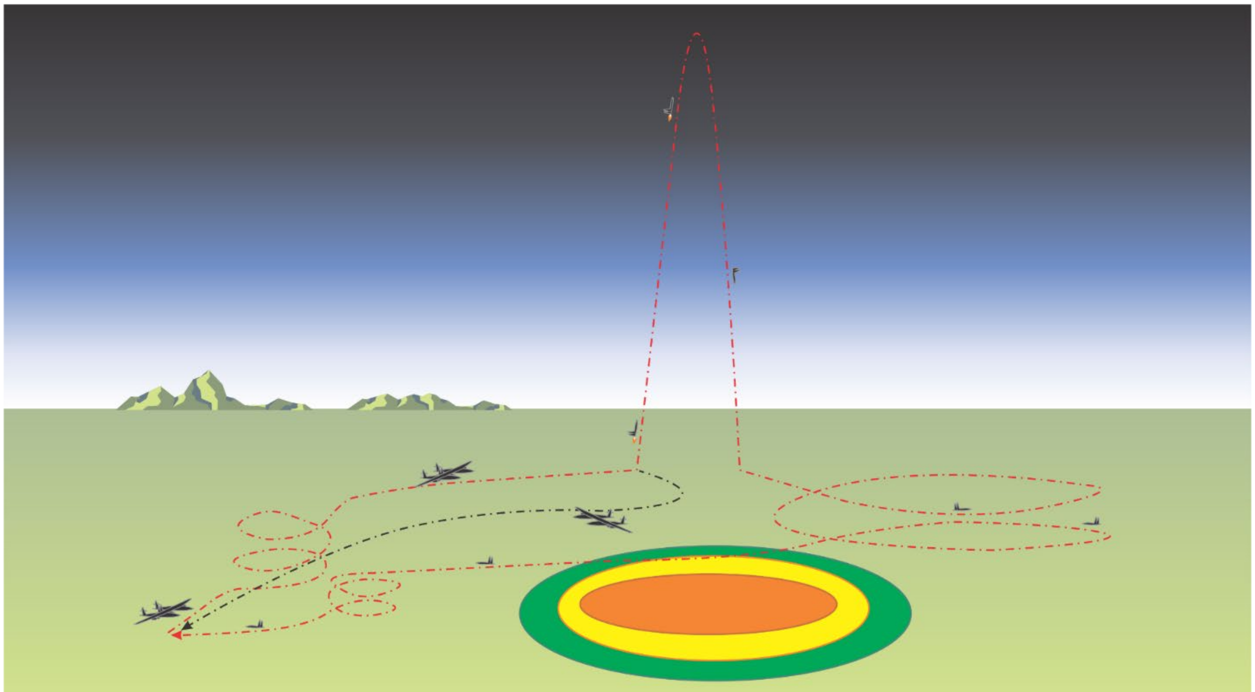

Figure A7: Captive Carry Suborbital

b. System Examples. Examples include WhiteKnightTwo carrying Virgin Galactic SpaceShipTwo. SpaceShipTwo is a piloted vehicle.

c. Risk Contours. The risk contours in Figure A7 are hypothetical, but they would likely be 15 to 20 miles in radius for the orange region and up to 50 miles in radius for the green region. In practice, the configuration of the contours would depend on the particular space vehicle and its mission. For example, the figure assumes that for the captive carry mission phase, the operator would establish compliance with Title 14 of the Code of Federal Regulations (CFR), Chapter III, by demonstrating that the probability of vehicle failure is less than 1×10^{-6}. In this case, risk contours would not be required.

d. In the figure, the orange region is depicted as beneath the apex of the flight. This represents the mission phase where the vehicle is either thrusting or re-entering. The vehicle has the most dwell time in this region, thus the highest risk is typically in this area. The space vehicle "glide and circling maneuver" may be associated with its own set of risk contours, again depending on the vehicle and mission. If the glider has demonstrated a vehicle failure probability less than 1×10^{-6}, then contours would not be computed.

9. Vertical Launch Suborbital Expendable Booster

a. Mission Summary. The vertical launch suborbital expendable booster mission involves a non-reusable rocket used to carry payloads on a roughly parabolic trajectory. These systems may have one or multiple stages. Figure A8 depicts the vertical launch suborbital expendable booster mission type.

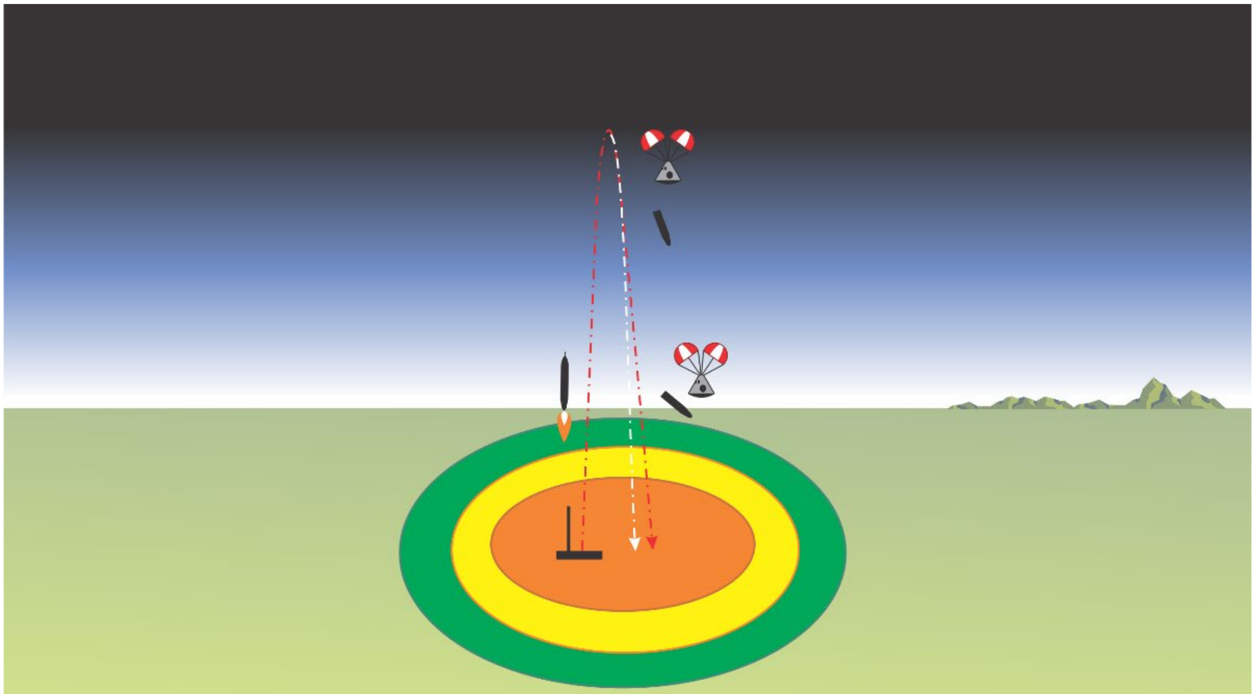

Figure A8: Vertical Launch Suborbital Expendable Booster

b. System Examples. An example of this mission type is a sounding rocket—a research rocket designed to carry instruments from 50 to 1,500 kilometers above the earth's surface. Examples of sounding rockets include: Aerobee, Astrobee, Black Brant, and Mesquito.

c. Risk Contours. The dimensions of risk contours vary depending on the vehicle and mission, and range from between 5 to 50 miles in diameter. The apex altitude depends on the size of the vehicle and ranges between 10,000 and 650,000 feet.

10. Vertical Launch Suborbital Reusable Booster

a. Mission Summary. The vertical launch suborbital reusable booster mission type differs from the previous case in that the booster is recovered for reuse. Phases for this mission type might include: liftoff, rocket/capsule separation, booster rocket powered landing, and capsule parachute landing. Figure A9 depicts the vertical launch suborbital reusable booster mission type.

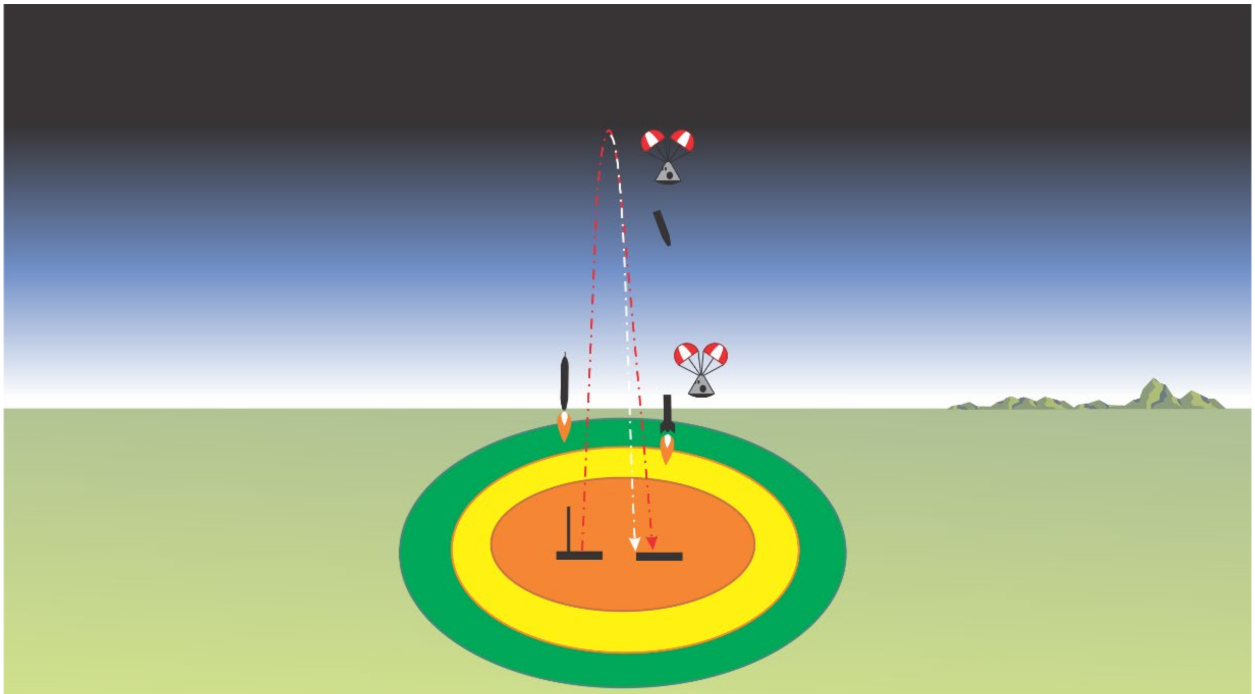

Figure A9: Vertical Launch Suborbital Reusable Booster

b. System Examples. An example of this mission type is the Blue Origin New Shepard vehicle.

c. Risk Contours. For current example vehicles, the risk contours range from 15 to 50 miles in radius. The apex altitude is most likely to be above 100 kilometers above sea level.

11. Capsule Re-entry

a. Mission Summary. The capsule re-entry mission type encompasses parachute or powered re-entry vehicles. Figure A10 depicts the capsule re-entry mission type.

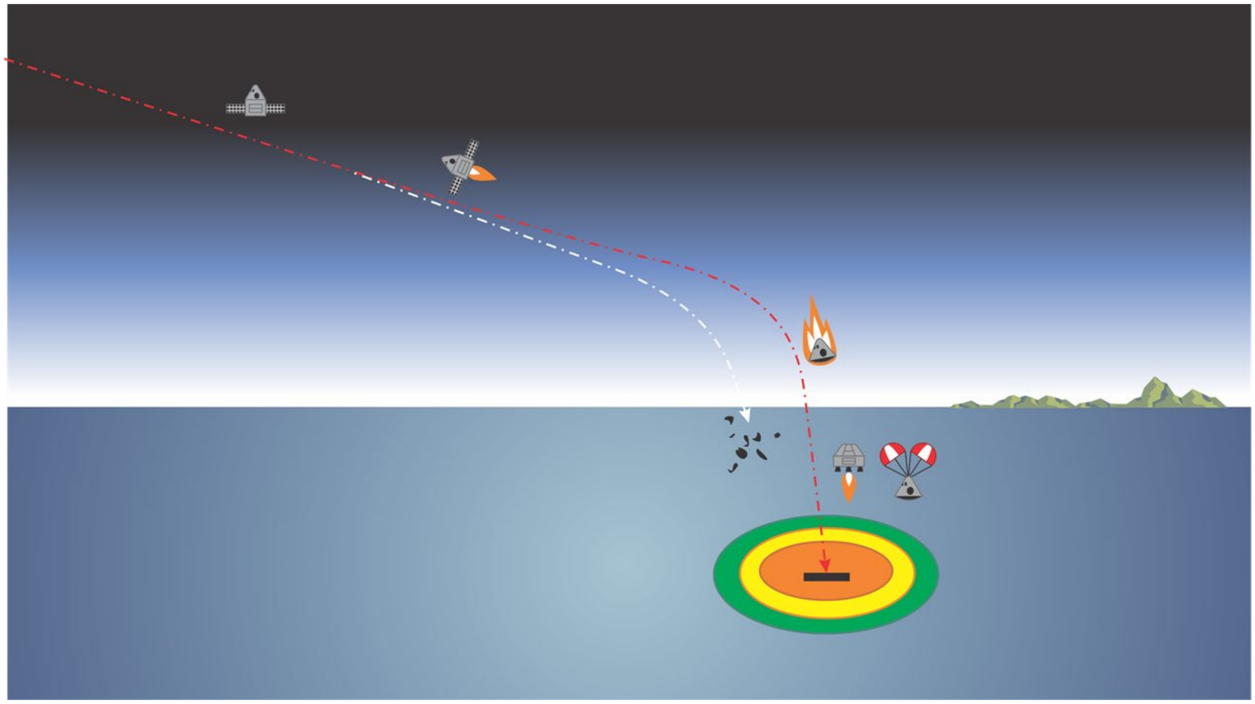

Figure A10: Capsule Re-entry

b. System Examples. Russian RKK Energia Soyuz spacecraft, SpaceX Dragon, and Orbital ATK Antares are examples involving capsule re-entry today. The Boeing CST-100 Starliner capsule is a future concept.

c. Risk Contours. Risk contours associated with capsule re-entry may be highly variable depending on the demonstrated accuracy of the vehicle de-orbit burn. The green contour may range from 100 by 150 miles to 200 by 400 miles. The extent of the contours is primarily driven by the probability and characteristics of potential vehicle breakup at high altitude.

12. Winged Re-entry

a. Mission Summary. In concept, this mission type would involve a rocket powered winged re-entry vehicle that returns for a horizontal landing. Figure A11 depicts the winged re-entry mission type.

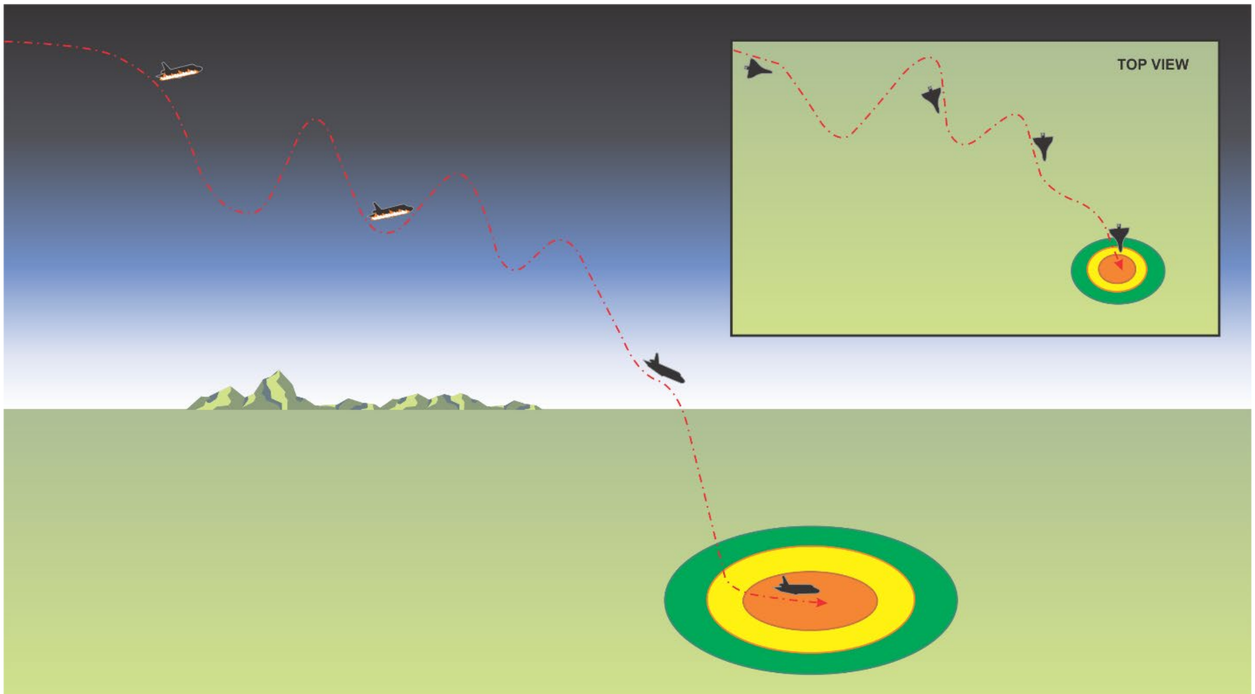

Figure A11: Winged Re-entry

b. System Examples. Examples include the Sierra Nevada Corporation DreamChaser, Boeing Phantom Express, and the National Aeronautics and Space Administration Space Shuttle.

c. Risk Contours. The Aircraft Hazard Area (AHA) is calculated for the landing portion of the mission. The vehicle makes turns that are not always predictable and the AHA does not extend to the phase of flight in which the turns are made.

13. Stratospheric Manned Balloons

a. Mission Summary. Figure A12 depicts the stratospheric manned balloon mission type. Stratospheric manned balloon missions might consist of the following phases: liftoff from launch site, balloon/payload ascent to altitude, maintaining position, descent, and arrival at landing site. Under current designs, payloads may be kept in a specified area for a period ranging from hours to days or longer, at altitudes of up to 46 kilometers. In the descent phase shown in Figure A12, the payload separates from the balloon and descends to earth via parachute or parawing. The distance between the liftoff and landing site may be as much as several hundred miles.

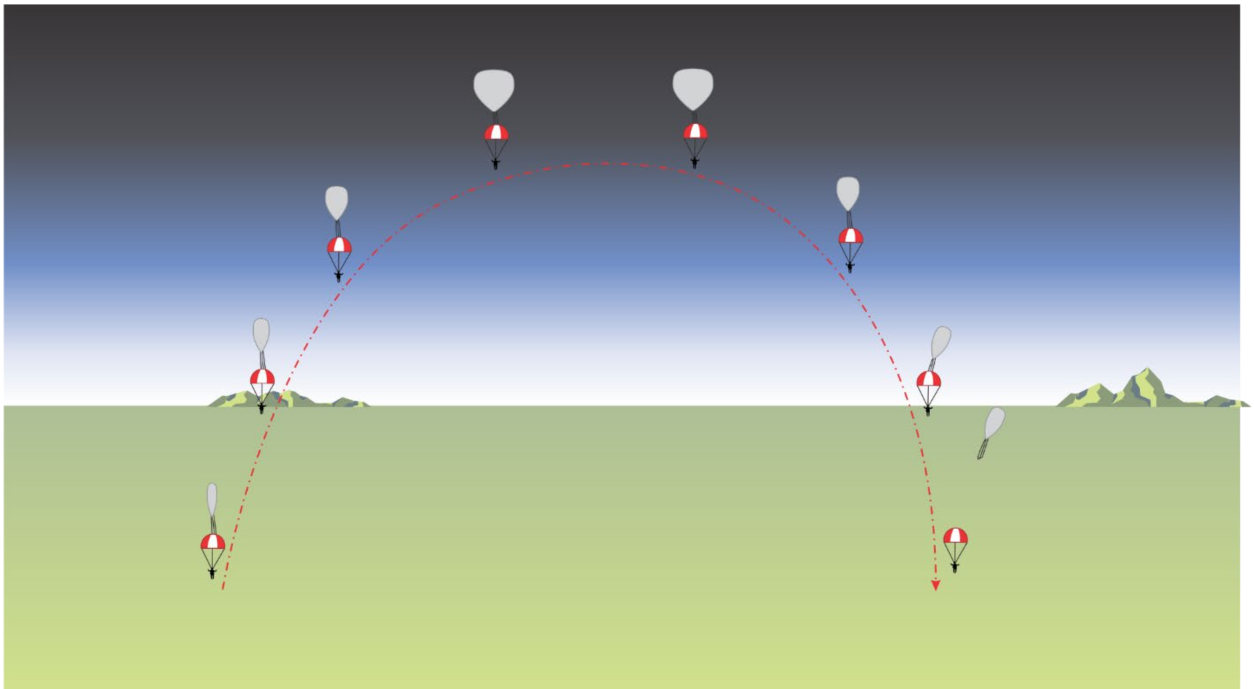

Figure A12: Stratospheric Manned Balloon

b. System Examples. An example is the World View Voyager. There are current unmanned concepts that share similar mission profiles, such as World View Stratollite Flight Services, but they are similar to what is expected for manned concepts. Test flights of the World View Stratollite are conducted under 14 CFR Part 101 without an AHA. The operator anticipates continuing the practice for commercial operations of the Voyager.

c. Risk Contours. In Figure A12 (and under current concepts) the payload would not have its own propulsion system or propellant, and therefore, the team does not envision that an AHA or risk contours would be computed for this mission type, since a credible mechanism for generating debris at altitude has not been identified.

14. Balloon Launch

a. Mission Summary. Balloon launches might include the following phases: balloon floating ascent to launch point, rocket engine ignition and launch, balloon drop and recovery, rocket cruise phase, rocket descent segment, and rocket recovery. The apex of the balloon flight is highly variable, possibly between 80,000 and 180,000 feet. The point of rocket launch could be between 50,000 and 100,000 feet. Figure A13 depicts the balloon launch mission type.

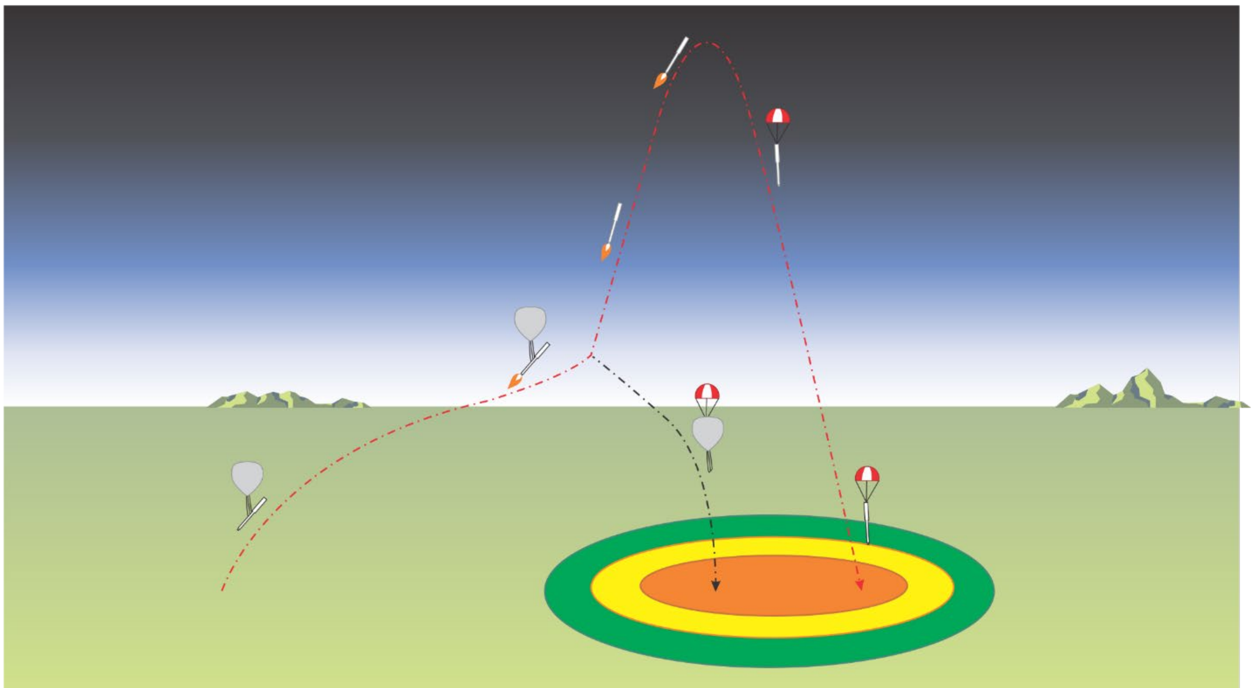

Figure A13: Balloon Launch

b. System Examples. An example of this mission type is Zero2Infinity SpaceBloostar (Spain).

c. Risk Contours. The risk contour positions and dimensions are poorly defined due to the uncertainty involved in balloon navigation, possibly on the order of 20 to 50 miles in radius.

15. Point-to-Point

a. Mission Summary. Under some current concepts, point-to-point launch vehicles may be similar in appearance to aircraft but meet the legislated definition of a suborbital launch vehicle. They would possibly launch horizontally to minimize the time and resources involved in loading and unloading passengers and cargo. Typical operational phases for this mission type might include: takeoff or liftoff from the launch site (may be either horizontal takeoff or vertical launch), ascent and transition to space, re-entry, and return to landing site (may be either powered flight, unpowered flight, or ballistic return). Figure A14 depicts the point-to-point mission type.

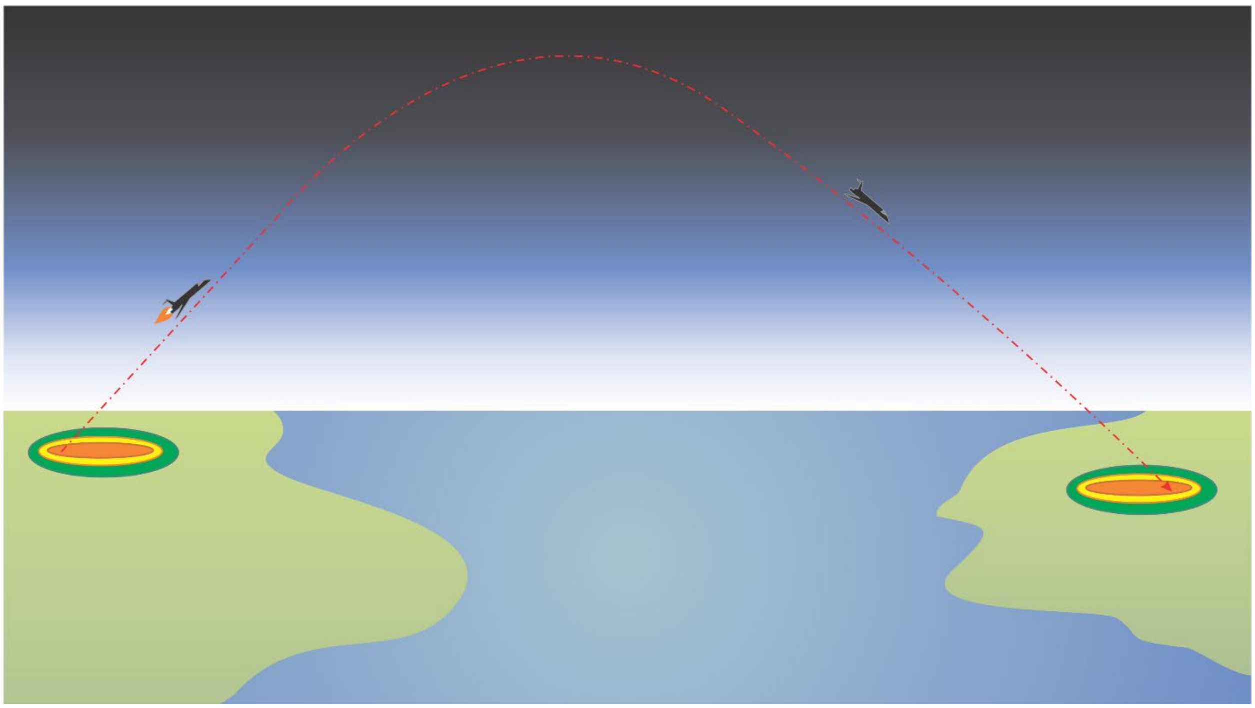

Figure A14: Point-to-Point

b. System Examples. There are no known current examples of this mission type.

c. Risk Contours. In Figure A14, two sets of risk contours are depicted, one for the departure site and one for the arrival site. The configuration and size of the contours would depend on the mission details (e.g., horizontal or vertical launch, whether the landing is powered or unpowered, the possible characteristics of vehicle breakup during liftoff and landing).

16. Tube and Rail Launchers

a. Mission Summary. There are several possible variants of this mission type, but in general, they might involve the following phases: (1) launch that may not involve propulsion generated from the vehicle itself (e.g., launch may be accomplished via a rail gun using electromagnetic force to accelerate the vehicle or an airtight tube with a magnetically levitated vehicle); (2) ascent (which may involve an onboard propulsion system such as a scramjet); and (3) ascent to orbit (during which the payload is fired into orbit). These designs are seen as potentially advantageous in that they would require much less propellant than traditional liquid or solid fuel rocket designs. Figure A15 depicts the tube and rail launcher mission type.

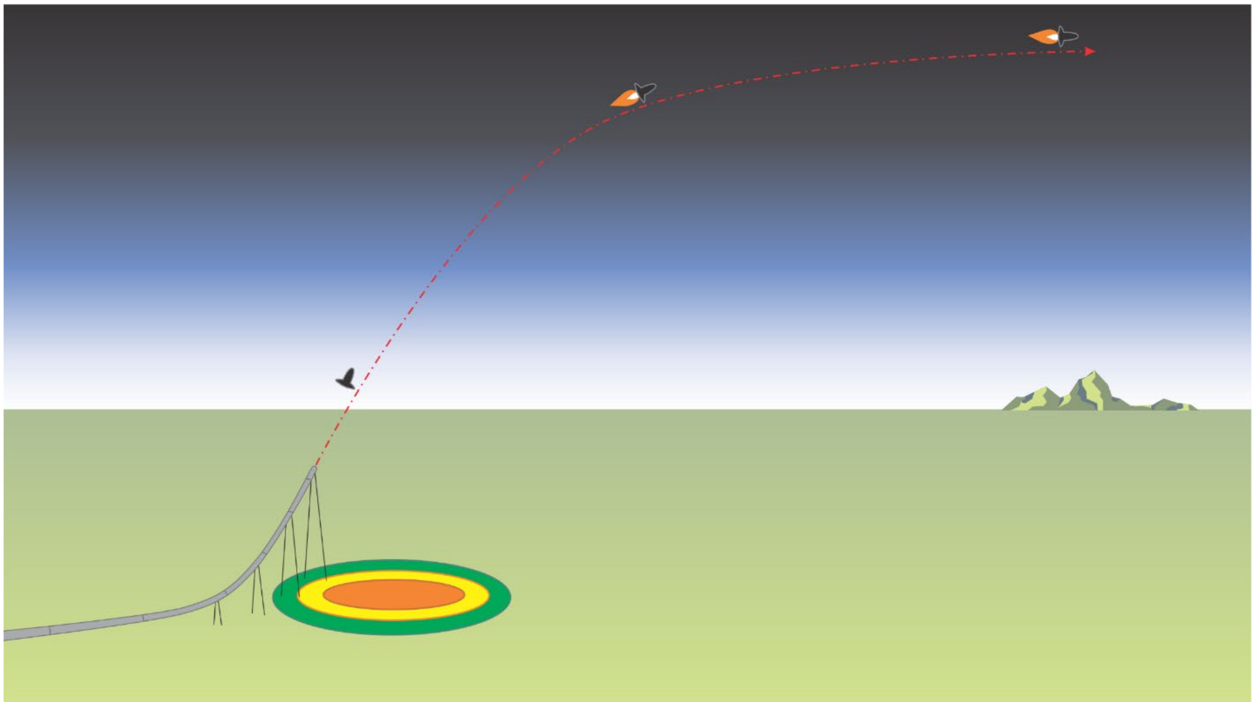

Figure A15: Tube and Rail Launchers

b. System Examples. There are no known examples of this mission type.

c. Risk Contours. The configuration of risk contours would depend on the mission specifics. For example, if an additional source of propulsion is required to achieve orbit, then the contours may be different that those depicted in Figure A15.

Appendix B. Glossary

1. Acceptable Level of Risk (ALR). ALR defines an alternative method for accepting individual and collective catastrophic risk. It permits the exposure of specific aircraft to higher risk, but it limits the total number of aircraft exposed until National Airspace System (NAS) infrastructure, policies, and procedures are updated. This concept is not intended to conflict with other Safety Management System language that determines whether hazards of some severity would occur at unacceptable likelihoods.

2. Aircraft Hazard Area (AHA). A type of temporary airspace restriction that defines an area of airspace that the Office of Commercial Space Transportation (AST), the launch operator, or the federal range operator computes in advance of a launch or re-entry operation—that is associated with the proposed trajectory that protects from falling debris in the event of a failure, as well as areas where expected events like splashdowns and stage jettisons will take place. These areas represent the boundaries of airspace closed to the flying public to ensure that the probability of impact (Pi) with debris capable of causing a casualty for aircraft does not exceed 1×10^{-6}. (Source: Title 49 of the Code of Federal Regulations (CFR) § 417.107.)

3. Collective Risk. The expected value of the number of fatal accidents due to space launch debris in the affected regions of the NAS over a specified time period.

4. Contour. An outline, especially one representing or bounding the shape or form of something. Synonyms: *isoline* and *contour line*.

5. Debris Response Area (DRA). Areas of airspace that may be activated in response to unplanned falling debris in the NAS. (Source: Pilot/Controller Glossary (PCG) in Federal Aviation Administration (FAA) Order JO 7110.65, *Air Traffic Control*.)

6. Expected Value. A predicted value of a variable, calculated as the sum of all possible values each multiplied by the probability of its occurrence.

7. Exposed Operation. Any flight that passes inside the 1×10^{-8} risk contour from launch time until the space vehicle is declared to have entered in orbit, typically less than 10 minutes, and, if applicable, any fly-back is complete (i.e., the reusable portion of the vehicle has landed). The terms "exposed operation" and "exposed flight" are synonymous.

8. Fly-Back. Any attempt to return a stage or component of a launch vehicle to the surface of the earth intact before it reaches orbit.

9. Individual Risk. The probability that an exposed flight will be involved in a fatal accident caused by space launch debris during a launch operation.

10. Risk Buffer. The area of airspace that is added to an AHA by AST to ensure that the 1×10^{-7} individual risk limit of ALR for those missions to which the 30-degree angular restriction cannot be applied is met. The risk buffer essentially expands the AHA that the Air Traffic Organization applies.

11. Route. A defined path, consisting of one or more courses in a horizontal plane, which aircraft traverse over the surface of the earth. (Source: PCG in FAA Order JO 7110.65.)