Launch Site Safety Assessment Overview and Update

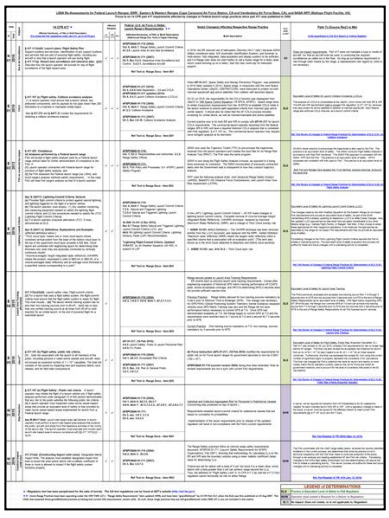
For launches from a Federal launch range, a license applicant typically contracts with the Federal launch range to provide launch services and property to satisfy some of the FAA's regulatory requirements. In accordance with 14 CFR § 415.31, if the FAA has assessed a Federal launch range, through its launch site safety assessment (LSSA), and found that an applicable range safety-related launch service or property satisfies FAA requirements, then the FAA will treat the Federal launch range's launch service or property as that of a license applicant's and not need further demonstration of compliance to the FAA.

Per 14 CFR § 401.5, a *Launch site safety assessment (LSSA)* means an FAA assessment of a Federal launch range to determine if the range meets FAA safety regulations. A difference between range practice and FAA regulations is documented in the LSSA.

The 14 CFR part 417 requirements for the launch of expendable launch vehicles were derived from the safety requirements of the Federal launch ranges. Some Federal launch range practices change over time. As these changes become known, the FAA holds discussions with the Federal ranges to clarify the changes from the previous practices that had been assessed, to determine whether the changes still meet FAA requirements and if that is not the case, identify the possible paths an applicant or current licensee may consider taking to meet those requirements.

A record of these changes is tabulated and maintained in the following "Launch Site Safety re-Assessment Matrix." Hyperlinks to supporting documentation are provided in the matrix. This matrix streamlines the LSSA process by identifying and evaluating some of the known or major changes in range practices that have occurred since the initial LSSA efforts and publication of 14 CFR part 417 in 2006. This matrix will be updated as additional changes in range practices are identified and the changes assessed to determine if an operator must request relief through an equivalent level of safety (ELS) or waiver, or have no impact to the FAA regulations.

The "LSSA reAssessment Matrix" for identified changes in Federal Launch Range Practices, is accompanied by texts from referenced range documentation, for the reader's convenience. Further following is a technical document of the FAA's review of the identified changes to federal range current practices, for determinations of equvalent levels of safety.



LSSreAssess Matrix for changes in Federal Launch Range Practices

LSSA Re-Assessments for Federal Launch Ranges: EWR - Eastern & Western Ranges (Cape Canaveral Air Force Station, CA and Vandenberg Air Force Base, CA), and NASA WFF (Wallops Flight Facility, VA)

Focus is on 14 CFR part 417 requirements affected by changes in Federal launch range practices since part 417 was published in 2006.

ITEM #	ITEM Year	Subject	14 CFR 417 ★ Affected Section(s), w/Title or Brief Description (For actual full FAA regulations under part 417, go to eCFR.gov)	Affected Range(s) ER CCAFS	WR VAFB	WFF	Federal (U.S. Air Force or NASA) Launch Range's Requirement(s) ★★ Affected Section(s), w/Title or Brief Description (Cells hyperlinked to view referenced text)	Noted Change(s) Affecting Respective Range Practice Brief description	ELS, WVR, or N/I?	Path To Ensure Req't is Met (Cells hyperlinked to FAA ELS Report or Federal Register)
N 01	2016	Sea & Air Surveillance	**§ 417.111(b)(6) Launch plans: Flight Safety Plan** Support systems and services. Identification of any support systems and services that are part of ensuring flight safety, including any aircraft or ship that a launch operator will use during flight. **§ 417.111(j) Hazard area surveillance and clearance plan. (j)(2)** Describe how the launch operator will provide for day-of-flight surveillance of the flight hazard area ...	✓	✓	✓	**AFSPCMAN 91-710 (2004):** **Vol. 6, Atch 7,** Range Safety Launch Commit Criteria **A7.2.8**. Launch Area Air and Sea Surveillance **AFSPCMAN 91-711 (2007):** **Ch 5, Sec 5.4.2.** Hazardous Area Surveillance and Control, **5.4.2.1.** Surveillance Aircraft. Ref Text in: Range Docs - Item N01	In 2016, the ER reduced use of helicopters (Sikorsky HH-3 "Jolly") because 45SW Safety considered radar, AIS (Automatic Identification System), and Suretrak (a multi-sensor, fully integrated, data acquisition and display system) to be sufficient, and if a Range User does not want Safety to call a fouled range for a faulty radar return (wave showing up on a radar), then the User could pay for helicopter support.	N/I	Does not impact requirements. Part 417 does not mandate a type or model of aircraft, nor that an aircraft even be used, in conducting the required surveillances as called out in the Rule. As long as surveillance requirement is met through other means by the range, a reassessment with regard to LSSA is not necessary.
E 01	2010	COLA	**§ 417.107 (e) Flight safety, Collision avoidance analysis:** (1) A launch operator must ensure that a launch vehicle, any jettisoned components, and its payload do not pass closer than 200 kilometers to a manned or mannable orbital object .... Also **§ 417.231** and **§ A417.31** contain the requirements for obtaining a collision avoidance analysis.	✓	✓	✓	**AFSPCMAN 91-217 (2010)**: **Ch 4, 4.6.6** Safe Separation – CA and COLA **AFSPCMAN 91-217 updated (2014)**: **Ch 4, 4.4.3** Launch Collision Aviodance (LCOLA) **AFSPCMAN 91-710 (2004)**: **Vol. 6, Atch 7**, Range Safety Launch Commit Criteria **A7.2.3.** Collision Avoidance **AFSPCMAN 91-711 (2007):** **Ch 3, Sec 3.8.18**. Collision Avoidance Analysis Ref Text in: Range Docs - Item E01	When **AFI 91-217**, *Space Safety and Mishap Prevention Program* , was published in 2010 (later updated in 2014), Space wings, in conjunction with the Joint Space Operations Center (JSpOC, USSTRATCOM), were instructed to protect on-orbit *manned spacecraft* and *active satellites* from collision with launched objects. On 22 Jul 2016, the responsibility for the COLA function was reassigned from JSpOC to 18th Space Control Squadron (18 SPCS, AFSPC). Space wings were to obtain Conjunction Assessments from the 18 SPCS to establish COLA holds in the launch windows to ensure safe separation criteria from *manned and active orbital objects.* It should also be noted that the AF COLA process includes screening for orbital debris, as well as manned/mannable and active satellites. Current practice now is for both ER and WR to comply with **AFI 91-217** for launch COLA requirements. The commercial launch operator launching from the federal ranges (ER & WR) will have a required minimum COLA analysis that is consistent with FAA regulation § 417.107 (e). The commercial launch operator may request more stringent analysis at its discretion.	ELS	Equivalent Level of Safety for Launch Collision Avoidance (LCOLA): The analysis of LCOLA is consolidated at the JSpOC, which works with both ER & WR. The ER and WR requirements meet or exceed FAA regulation § 417.107 (e), because they also protect for active satellites in addition to manned spacecraft. Each federal range also enforces COLA closures, as a launch commit criteria. Ref. FAA Review of Changes in Federal Range Practices for Determination of ELS: E-01, for Collision Aviodance
E 02	2013	FSA as conducted by ranges	**§ 417.203 Compliance**, **(d) Analyses performed by a Federal launch range**. FAA will accept a flight safety analysis used by a Federal launch range without need for further demonstration of compliance to the FAA, if: **(1)** Launch operator contracted with Federal launch range for provision of flight safety analysis; and **(2)** the FAA assessed the Federal launch range [via LSSA], and found range's analysis methods satisfy requirements ... In this case, FAA will treat Fed range's analysis as that of a launch operator.	✓	✓	✓	**AFSPCMAN 91-710:** **Vol. 1, Ch 2**, Responsibilities and Authorities: **2.3.5.** Range Safety Offices. **AFSPCMAN 91-711:** **Ch 3**, FSA Policy and Processes: **3.1**. AFSPC Launch Safety Program Ref Text in Range Docs - Item E02	45SW now uses the Trajectory Toolkit (TTK) to pre-process the trajectories received from the launch operators and creates the input files for its Range Risk Analysis Tool (RRAT). The FAA uses the same program. 30SW is now doing the Flight Safety Analysis in-house, as opposed to it being done previously by contractor. The 30SW incorporation of previously contracted tasks onto the Government side is transparent to how they conduct trajectory analysis. WFF uses the following analysis tools: Joint Advanced Range Safety System (JARSS), BlastDFO (for Distance Focus Overpressure), and Launch Area Toxic Risk Assessment (LATRA).	ELS	45 SW's newer practice to pre-process the trajectories is also used by the FAA. The pracitice is an *equivalent level of safety* . The 30SW conducts Flight Safety Analysis in accordance with their FSA Handbook. The 30SW FSA approach is consistent with the 45SW, WFF and the FAA. The practice is an *equivalent level of safety* . WFF's processes are consistent with that used by FAA. The practice is an *equivalent level of safety* . Both FAA and Ranges have adopted like, if not identical, analysis practices, at around the same time. Ref. FAA Review of Changes in Federal Range Practices for Determination of ELS: E-02, for Flight Safety Analysis

LSSA Re-Assessments for Federal Launch Ranges: EWR - Eastern & Western Ranges (Cape Canaveral Air Force Station, CA and Vandenberg Air Force Base, CA), and NASA WFF (Wallops Flight Facility, VA)
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ITEM #	ITEM Year	Subject	14 CFR 417 ★ Affected Section(s), w/Title or Brief Description (For actual full FAA regulations under part 417, go to eCFR.gov)	Affected Range(s) ER CCAFS	Affected Range(s) WR VAFB	Affected Range(s) WFF	Federal (U.S. Air Force or NASA) Launch Range's Requirement(s) ★★ Affected Section(s), w/Title or Brief Description (Cells hyperlinked to view referenced text)	Noted Change(s) Affecting Respective Range Practice Brief description	ELS, WVR, or N/I?	Path To Ensure Req't is Met (Cells hyperlinked to FAA ELS Report or Federal Register)
E 03	2014	Lightning Commit Criteria	**Apx G (G417); Lightning Commit Criteria, General** **(a)** Provides flight commit criteria to protect against natural lightning and lightning triggered by the flight of a launch vehicle. **(b)** The launch operator must employ: (1) Any weather monitoring and measuring equipment needed to satisfy the lightning flight commit criteria; and (2) Any procedures needed to satisfy the LFCC [Lightning Flight Commit Criteria]. **(c)** If a launch operator proposes alternative LFCC, it must... demonstrate an ELS. **Apx G (G417.3): Definitions, Explanations and Examples** [affected definitions below:] "*Thick cloud layer* means one or more cloud layers whose combined vertical extent from the base of the bottom cloud layer to the top of the uppermost cloud layer exceeds 4,500 feet. Cloud layers are combined with neighboring layers for determining total thickness only when they are physically connected by vertically continuous clouds" "*Volume-averaged, height integrated radar reflectivity (VAHIRR)* means the product, expressed in units of dBZ-km or dBZ-kft, of a volume-averaged radar reflectivity and an average cloud thickness in a specified volume corresponding to a point."	✓	✓		**AFSPCMAN 91-710:** **Vol. 6, Atch 7**, Range Safety Launch Commit Criteria: **7.2.5.** Natural and Triggered Lightning: **7.2.5.4**. Natural and Triggered Lightning Launch Commit Criteria: **45 SWI 15-101 (2 Dec 2015),** **Sec 6.7** Range Safety Natural and Triggered Lightning Launch Commit Criteria (LCC), and **Atch 14** Lightning Launch Commit Criteria, Lightning Advisory Panel (LAP) Recommendation. **"Lightning Flight-Commit Criteria, Updated 11/01/13"**: by 45 Weather Squadron (45 WS), in support of LAP Ref Text in: Range Docs - Item E03	In the LAP's "Lightning Launch Commit Criteria" -- 45 WS made changes to lightning launch commit criteria: Complete removal of *Volume Average Height Integrated Radar Reflectivity* (VAHIRR) technique, replaced by improved *Maximum Radar Reflectivity* (MRR); and a change to Thick Cloud overlay rule: 1. **45SWI 15-101, A14.2** Definitions -- The VAHIRR technique has been removed entirely from the LLCC document, and replaced with the MRR. Added Definition: "Maximum radar reflectivity (MRR) means the largest radar reflectivity within a specified volume that is associated with an evaluation point." [This term also shows up in the Anvil Cloud (attached & detached) and Debris cloud sections] 2. **45SWI 15-101, sec. A14.10.4** -- Thick Cloud layer rule.	**ELS**	Equivalent Level of Safety for Lightning Launch Comit Criteria (LLCC) The changes made by the 45th Weather Squadron for the Eastern Range do not impact FAA requirements and provide an equivalent level of safety. As part of the EWR, Vandenberg AFB is already updating its respective LLCC's to reflect these changes. Also, the updated LLCC approaches as described here are easily transferable to any other federal range (e.g., Wallops Flight Facility, or Reagan Test Site), if they choose to adopt these approaches for their respective operations. In all instances, the approaches as described by the range do not impact FAA requirements and they do provide an equivalent level of safety. Formalizing changes to the FAA's Lightning Flight Commit Criteria requires the FAA to initiate a rulemaking activity. The equivalent level of safety evaluation and process will suffice for these and future changes until a rulemaking activity is completed. Ref. FAA Review of Changes in Federal Range Practices for Determination of ELS: E-03, Lightning Flight Commit Criteria
E 04	2015	Launch Area Tracking *(Re-visited)*	**417.113(c)(2)(iii)** Launch safety rules, Flight-commit criteria. **(2)** For a launch that uses a flight safety system, the flight-commit criteria must ensure that the flight safety system is ready for flight. This must include... **(iii)** The launch vehicle tracking system has no less than two tracking sources prior to lift-off... [and] has no less than one verified tracking source at all times from lift-off to orbit insertion for an orbital launch, to the end of powered flight for a suborbital launch	✓			**AFSPCMAN 91-710 (2004)**, **Vol 2, 1.6.9.1; Vol 6, Atch 7, A7.2.1.1.3.1.** Ref Text in: Range Docs - Item E04	Range second update to Launch Area Tracking Requirements: ER reverts back to previous launch area tracking requirements. Comes after engineering evaluation of historical GPS metric tracking performance off CCAFS pads, shows acceptable coverage, and MFCOs determining MTE-3 seconds does not provide sufficient reaction time. Previous Practice: Range Safety allowed for two tracking sources mandatory by 3 sec's prior to Minimum Time to Endanger (MTE). This change was necessary for GPS/TMIG (Global Positioning System/ Telemetry Inertial Guidance) equipped vehicles since GPS Metric Tracking was new and the Range did not have performance history necessary to commit GPS at T-0. Once GPS had demonstrated availabilty at T-0, the Range began to commit GPS at T-0 and the requirements were reverted back to 1 source at T-0 and a second NLT 3 seconds prior to MTE. Current Practice: One tracking source mandatory at T-0; two tracking sources mandatory by 3 seconds prior to MTE.	**ELS**	Equivalent Level of Safety for Launch Area Tracking: The FAA's previously evaluated and accepted one tracking source from T-0 through 3 seconds prior to MTE and two sources from 3 seconds prior to MTE to the end of Range Safety Responsibility as an equivalent level of safety. With flight history supporting GPS MT off of the pad, the Range now commits GPS at T-0 and can achieve one tracking source from T-0 through 3 seconds prior to MTE and two sources from 3 seconds prior to MTE to the end of Range Safety Responsibility for all FAA licensed launch vehicles. Ref. FAA Review of Changes in Federal Range Practices for Determination of ELS: E-04, Launch Area Tracking
E 05	2010	$100x10^{-6}$	**§ 417.107 (b) Flight safety, public risk criteria,** **(1)** ...total risk associated with the launch to all members of the public, excluding persons in water-borne vessels and aircraft, does not exceed an expected number of 1×10^{-4} casualties. The total risk consists of risk posed by impacting inert and explosive debris, toxic release, and far field blast overpressure.	✓	✓		**AFI 91-217, (18 Feb 2010):** **4.6.5** Launch Safety, Public & Launch Personnel Risk: **4.6.5.1.1.** Public. **AFSPCMAN 91-710 (2004):** **Vol 1, A4.3.5**: Acceptable Risk Criteria **AFSPCMAN 91-711 (2007)** **Ch 3, Sec. 3.6**. Risk to General Public. **3.6.1, 3.6.1.2** Ref Text in: Range Docs - Item E05	**Air Force Instruction (AFI) 91-217, (18 Feb 2010)** modified the requirements for public risk on Air Force launch ranges for government launches to now be 0.0001 (100×10^{-6}). **AFSPCMAN 91-710 (current version 2004)** having thus been amended, finds its revised requirements are not in sync with current FAA requirements.	**ELS**	Equivalent Level of Safety for Flight Safety, Public Risk (Expected Casualties, E_C) Part 417 was revised on 20 July 2016, whereby FAA requirements for risk no longer lags behind AF ranges. This final rule also revises the acceptable risk threshold for launch from an Ec of 30×10^{-6} for each hazard to an Ec of 1×10^{-4} for *all three hazards combined*. Furthermore, this final rule expresses the revised Ec *limit using the correct number of significant digits* to properly represent the uncertainty in Ec calculations. This final rule changes the FAA's collective risk limits for launch and reentry to more closely match the Ec standard currently used by the US Air Force and NASA for government missions, and to account for the level of uncertainty that exists in the Ec calculations. Ref. FAA Review of Changes in Federal Range Practices for Determination of ELS: E-05, Public Risk Criteria (Expected Casualty)

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W 01	2015	Ship Protection	**§ 417.107 (b) Flight Safety - Public risk criteria**. A launch operator may initiate the flight of a launch vehicle only if flight safety analysis performed under paragraph (f) of this section demonstrates that any risk to the public satisfies the following public risk criteria: ... **(3)** A launch operator must implement water borne vessel hazard areas that provide an equivalent level of safety to that provided by water borne vessel hazard areas implemented for launch from a Federal launch range. **Apx B (B417.5(a)):** Launch site hazard area. **(a)** General. A launch operator must perform a launch site hazard area analysis that protects the public, aircraft, and ships from the hazardous activities in the vicinity of the launch site. The launch operator must evacuate and monitor each launch site hazard area to ensure compliance with §§ 417.107(b)(2) — (b)(3).	✓	✓		**AFSPCMAN 91-710 (2004),** **Vol 1, Atch 4: A4.3.5, A4.3.7.** **Vol 6, Atch 7: A7.2.7.2.3.3., A7.2.8.1, A7.2.8.3.1.1** **AFSPCMAN 91-711:** **Ch 3, sec. 3.6.1, 3.7.4** **Ch 5, sec. 5.4.3.2** Ref Text in: Range Docs - Item W01	Individual and Collective Aggregated Risk for Personnel in Waterborne Vessels (Concerning ship protection on day of launch.) Requirements establish launch commit criteria for waterborne vessels that are based on cumulative hit probabilities. Implementation of the newer requirements prior to release of the updated regulation will result in non-compliance with the FAA's current requirements	WVR	A *waiver* will be required for transition from Hit Probabilities to Ec for waterborne vessels, for each licensed launch from ER or WR. Until a regulatory change is made in the future, a *waiver* must be issued for the affected mission to meet current FAA requirements [§§ 417.107 (b)(3) and B417.5(a)] . Ref. Fed Register 81 FR 28930 (May 10, 2016)
W 02	2016	Construct Impact Limit Lines	**417.213(d) [Constructing Impact Limit Lines]** Designated debris impact limits. The analysis must establish designated impact limit lines to bound the area where debris with a ballistic coefficient of three or more is allowed to impact if the flight safety system functions properly.	✓	✓		**AFSPCMAN 91-710 (2004):** **Vol.2, Atch 3, A3.3.6.** **AFSPCMAN 91-711 (2007):** **Ch 3, Sec 3.8.7.2.** Ref Text in: Range Docs - Item W02	The Range Safety practices follow an internal range safety requirements document, AFSPCM 91-711 *(Launch Safety Requirements for AFSPC Organizations, Feb 2007*), directing that methodology for calculating ILLs on the ER and WR sets the boundary solution using a *mean* ballistic coefficient (beta) value for determining ILLs. Criteria are set for debris with a beta of 3 psf, but since it is a mean value, some debris with a beta greater than 3 psf can achieve range beyond the ILLs. Thus, the definition of "Flight Safety Limit" in 14 CFR 417.3 as well the 417.213(d) regulation cannot technically be met on either Range.	WVR	The FAA coordinated with the USAF range safety teams, reviewed the recently identified limitations in the current process, and determined that while the practice is not in technical compliance with the FAA Rule, there is continued protection of the public through a risk analysis and meeting established AF and FAA risk criteria. Formalizing changes to the FAA's flight safety limits/impact limit line determinations will require the FAA to initiate a rulemaking activity. The *waiver* process will suffice for these and future changes until a rulemaking activity is completed. Ref. Fed Register 81 FR 1470 (Jan. 12, 2016)

★—**Regulatory text has been paraphrased for the sake of brevity. The full text regulations can be found at AST's website (http://ast.faa.gov).**

★★—**Some Range Practices have been operating under the 1997 EWR 127-1 "Range Safety Requirements" (last updated 1999), and have been "grandfathered" by 14 CFR Part 417, when the Rule was first published on 25 Aug 2007. The LSSAs that assessed those grandfathered practices as having met current FAA requirements, remain valid. As such, those range practices that are still grandfathered under EWR 127-1, are not included in this matrix.**

LEGEND of DETERMINATIONS	
ELS	Practice is Equivalent Level of Safety to FAA Regulation
WVR	Operator must submit a Request for a Waiver to Regulation
N / I	No Impact. Does not violate, or is not applicable to, Regulation

Requirements Documents for Range Current Practices, as assessed under 14 CFR §417.111(b)(6) & (j)

AFSPCMAN 91-710 (2004), Vol 6, Atch 7

Vol 6, Atch 7: Range Safety Launch Commit Criteria

A7.2.8. Launch Area Air And Sea Surveillance:

A7.2.8.1, General Description. Areas to be cleared of boats and ships are defined by Flight Analysis and based on probability contours and/or Toxic Hazard Zones, including known impact areas of jettisoned stages/bodies and destruct debris resulting from malfunction scenarios plus the areas and altitudes in which Toxic Hazards will exist. Areas defined by Notice to Airmen (NOTAM) and Notice to Mariners (NTM) are surveyed on launch day.

A7.2.8.3.1.1 At the ER, if the sum total of the individual hit probabilities of all targets plotted within, or predicted to be within, the established probability contours exceed 10^{-5}, a launch hold or scrub may be initiated.

AFSPCMAN 91-711 (2007)

5.4. Launch Area Air and Sea Surveillance.

5.4.2. Hazardous Area Surveillance and Control.

5.4.2.1. Surveillance Aircraft. Aircraft support for surveillance control is required for all launches at the ER and all pad launches at the WR.

5.4.2.2. Radar Surveillance. Where available, land-based range radars or other assets from assisting government agencies are required to perform air and sea surveillance of the hazardous launch area.5.4.2. Hazardous Area Surveillance and Control.

Sec. 4.6.6 : **Requirements Documents for Range Current Practices, as assessed under 14 CFR §417.107(e)**

Air Force Instruction (AFI) 91-217, Space Safety and Mishap Prevention Program (18 Feb 2010): Ch 4, Launch & Range Safety

4.6. Launch Safety.

4.6.6. Safe Separation – CA and COLA [Conjunction Assessments and Collision Avoidance]**.** The appropriate wing commander is responsible for precluding any activity that would adversely affect active or manned spacecraft, based on a pre-launch COLA process identified by the MAJCOM.

4.6.6.1. The COLA process will be developed based on assessments that account for launch vehicle flight from launch through orbit insertion plus the required number of revolutions of the launched objects. The COLA process will account for:

4.6.6.1.1. The type of orbit the vehicle or component is injected into, operating in or passing through, and;

4.6.6.1.2. Its altitude exceeding the manned spacecraft or space asset altitude by the appropriate miss distance, and;

4.6.6.1.3. Sufficient time for the launched objects to be cataloged in the Satellite Catalog. Launch objects include the launch vehicle, payload, jettisoned components and planned debris.

4.6.6.2. The Space Wings, in conjunction with the JSpOC, will protect on-orbit manned spacecraft and active satellites from collision with launched objects IAW DoDD 3100.10 and MAJCOM requirements. Space wings will obtain CAs from the JSpOC to establish COLA holds in the launch windows to ensure safe separation criteria from manned and active orbital objects based on the risk criteria specified in the following paragraphs.

4.6.6.2.1. This CA/COLA process will be used for all launch vehicles, ballistic missions and propagated debris with an altitude capability equal to or greater than 150 km.

4.6.6.2.2. A CA/COLA process will also be used for each launch vehicle component that does not immediately reenter after separation from the launch vehicle and/or spacecraft.

4.6.6.2.3. The CA/COLA process will be used prior to the planned launch to protect cataloged manned and active orbiting objects from collision with launched objects. This process includes the computation of launch times that would result in violating either the appropriate miss distance or probability of collision IAW RCC 321.

4.6.6.2.4. Safe Separation for launch (CA/COLA) will cover the period of time from when the launched objects achieve an altitude greater than 150 km, and until they are catalogued by the JSpOC and become part of the orbital CA process or until surface impact for suborbital launches.

4.6.6.2.5. If there is a deviation beyond the planned three-sigma trajectory, the launch wing is relieved of responsibility for any resulting collision with active or manned orbiting objects.

4.6.6.3. Safe Separation Criteria for Launch.

4.6.6.3.1. Manned Spacecraft. The risk to each on-orbit manned spacecraft from launched objects will not exceed a collision probability of 1×10^{-6} (one in one million).

4.6.6.3.2. Active Satellites. The acceptable risk to active satellites from launched objects will be established by 14 AF, but should not exceed a collision probability of 10×10^{-6} (ten in one million).

4.6.6.3.3. Probability. Since CA and COLA based collision probability determinations require considerably higher fidelity range user data and can be costly, an acceptable alternative to the above criteria is to perform the assessment using more conservative miss distance volumes.

4.6.6.3.3.1. To mitigate the risk to manned spacecraft, either ellipsoidal miss distance volumes of 200 km in-track and 50 km cross-track and radially, or spherical volumes of 200 km may be used.

4.6.6.3.3.2. For active satellites, 14 AF shall provide the appropriate conjunction assessment data to the launch wings to establish launch hold periods. A spherical miss distance volume of 25 km may be used to determine the appropriate launch hold periods.

4.6.6.3.3.3. These criteria may be waived based on national need and operational considerations by a MAJCOM-approved authority.

4.6.6.4. The launching agency is responsible for the protection of manned spacecraft and active satellites from the end of the appropriate wing commander's (or equivalent) responsibility as defined above in paragraph 4.6.6.2 until separation of the last launch component, if there are additional orbital changes during this time.

AFI 91-217 UPDATE (17 April 2014): Ch 4, Launch & Range Safety

4.4 Launch Safety

4.4.3. Launch Collision Avoidance (LCOLA). All launches from Air Force ranges and all Air Force launches from non-Air Force ranges shall accomplish LCOLA procedures accounting for all launched objects (e.g., booster segments, payloads, jettisoned components, and debris) with an altitude capability equal to or greater than 150 km.

4.4.3.1. Responsibilities. Launch operators/range users shall provide the launch wings and the Joint Space Operations Center (JSpOC) with planned flight profile data for all space launch vehicle and jettisoned components (to include upper stages pre-programmed for a controlled reentry, up until atmospheric reentry). Space Wing Commanders shall establish and enforce launch window hold periods, based on the LCOLA conjunction assessments computed by JSpOC against catalogued objects, and on safe separation of launched objects as defined by USSTRATCOM, IAW SD 505-1 V2, *Space Surveillance Operations – Event Processing.* For Air Force launches from non-Air Force ranges, the senior Air Force representative involved with the launch assumes responsibility of LCOLA risk management.

4.4.3.2. Timeframe. LCOLA shall cover the period of time from when launched objects achieve an altitude equal to or greater than 150 km, until location uncertainty makes performing a pre-launch safety COLA infeasible, or until the suborbital or reentry components descend to less than 150 km.

4.4.3.2.1. There is currently a gap between the end of the launch COLA and the time when JSpOC can establish a reliable track of orbital components, plus the time when an active asset can respond to a JSpOC conjunction assessment. This is known as the “COLA gap” and is a recognized deficiency in LCOLA assessments. Programs shall use industry best practices to mitigate the COLA gap risk to manned objects.

4.4.3.3. Launch window hold periods. Determine the launch window hold periods based on one or a combination of the following methodologies and criteria:

4.4.3.3.1. Probability of Collision. The probability of collision between the launch components and manned objects shall not exceed 1 10^{-6} (one in one million). The probability of collision between the launch components and unmanned objects (to include active satellites and orbital debris) shall not exceed 10 x 10^{-6} (ten in one million). Reference RCC 321.

4.4.3.3.2. Safe Separation Distance. The safe separation distance for manned objects shall consist of either ellipsoidal miss distance volumes with semi-axes of 200 km in-track, 50 km cross-track, and 50 km radial; or spherical volumes with a radius of 200 km. The safe separation distance for unmanned objects shall consist of three-sigma ellipsoidal miss distance volumes calculated from the covariance data. Where the covariance data are not available, utilize a spherical miss distance volume with a radius of 25 km for active satellites and 2.5 km for debris.

AFSPCMAN 91-710 (2004, cert'd current 2014)

Vol 6, Atch 7: Range Safety Launch Commit Criteria

A7.2.3. Collision Avoidance:

A7.2.3.1. General Description. A collision avoidance (COLA) analysis is used in the minus count to protect manned/mannable orbiting objects from collision with a launch vehicle or its jettisoned components.

A7.2.3.2. Applicability. All launch vehicles with the potential to collide with manned/mannable orbiting objects shall meet the following criteria:

A7.2.3.3. Collision Avoidance Launch Commit Criteria:

A7.2.3.3.1. The COLA program computes the closest approach between the launch vehicle and an orbiting object based on a miss distance screening criteria of 200 kilometers for manned/mannable objects.

A7.2.3.3.2. A COLA (no launch) closure time period is calculated for the defined miss distance for any object approaching within distances less than the above criteria.

A7.2.3.4. Offices of Primary Responsibility. 30 SW/SEY and 45 SW/SEO are the OPRs for determining COLA launch commit criteria.

A7.2.3.5. Reference Documents. Mission-specific COLA criteria shall be documented in the COLA Requirements letter by 45 SW/SEO and 30 SW/SEY.

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3.8 Flight Safety Analysis (FSA)

3.8.18. Collision Avoidance (COLA) Analysis. A FSA shall include a COLA analysis that establishes each launch wait in a planned launch window during which a Range User shall not initiate flight in order to protect any manned orbiting object. The analysis shall be performed on all components or propagated debris achieving altitudes greater than 150 km. Based on the COLA analysis, the FSA shall identify “launch wait” periods within the launch widow. The launch wait periods are no launch periods. Wing Safety shall ensure that the Range Users account for uncertainties associated with launch vehicle performance and timing and ensure that any calculated launch waits incorporate all additional time periods associated with such uncertainties. A Range User shall implement any launch waits as flight commit criteria.

3.8.18.1. Orbital Launch. For an orbital launch, the COLA analysis shall establish any launch waits needed to ensure that the launch vehicle, any jettisoned components or propagated debris, and payloads do not violate the criteria in 3.6.1.6. for manned orbiting spacecraft during ascent to orbital insertion plus an analyst defined number of revolutions to account for the objects’ orbit type, its altitude exceeding the manned spacecraft altitude by the appropriate miss distance; and sufficient time for the object to be catalogued by the JSpOC (1 SPCS).

3.8.18.2. Suborbital Launch. For a suborbital launch, the COLA analysis shall establish any launch waits needed to ensure that the launch vehicle, any jettisoned components or propagated debris, and any payload do not violate the criteria in 3.6.1.6. for manned orbiting objects throughout the flight.

3.8.18.3. Wing Safety shall document and provide to the SW Operations Group (Range) the mission-specific COLA results. This documentation shall identify mission-specific launch wait periods and mission-specific COLA criteria including items such as the operations number, operation description, spacecraft evaluated, and encounter results.

3.8.18.4. Analysis Not Required. COLA analysis may not be required if the three-sigma maximum altitude capability of the launch vehicle, jettisoned components or planned debris is greater than 50 km below the orbital perigee of a manned object.

Requirements Documents for Range Current Practices, as assessed under 14 CFR §417.203(d)

AFSPCMAN 91-710 (2004), Vol 1

Vol 1, Chap 2. Flight Safety Requirements, Responsibilities and Authorities:

2.3 Space Wing Responsibilities:

2.3.5. Range Safety Offices. Unless otherwise noted, the use of the term Range Safety in this publication refers to 30 SW/SE and 45 SW/SE. The Range Safety Offices provide Systems Safety, Flight Safety Analysis, Pad Safety (45 SW), Mission Flight Control (30 SW), and direct support to the 1st Range Operations Squadron (1 ROPS) and 2nd Range Operations Squadron (2 ROPS) mission flight control function for all missions from the ranges. The Safety Offices also provide traditional Air Force ground safety programs. The responsibilities of the Chiefs of Safety or their designated representatives apply throughout all phases of a launch program (planning, generation, execution, and recovery) and include, but are not limited to, the following:

2.3.5.1. Enforcing safety requirements to ensure that public safety, launch area safety, and launch complex safety are adequately provided by and for all programs using the ranges

2.3.5.2. Evaluating, training, and approving Range Users who wish to assume “control authority” for launch complex safety in accordance with Attachment 7 of this volume

2.3.5.3. Providing oversight, review, approval, and monitoring for all public safety and launch area safety concerns during prelaunch operations at the launch complex and launch vehicle or payload processing facilities

2.3.5.4. Auditing operations at a launch complex and associated support facilities for launch complex safety concerns in accordance with a jointly accepted Launch Complex Safety Training and Certification program (Attachment 7 of this volume). If the Range User control authority decides not to or cannot implement the plan, Range Safety shall assume complete safety responsibility.

2.3.5.5. Reviewing and approving flight plans, design, inspection, procedures, testing, and documentation of all hazardous and safety critical launch vehicles, payloads, and ground support equipment, systems, subsystems, facilities, and material to be used at the ER and WR. Review and approval shall be in accordance with the requirements of volumes 2 through 6 of this publication.

2.3.5.6. Flight Safety Review with the SW/CC. Prior to each launch, Range Safety shall brief the SW/CC of the safety status of the launch vehicle. The briefing shall include vehicle hazards, the status of any applicable waivers and any other issues that contribute to the risk of the flight. The briefing shall be in the format chosen by the SW/CC and may be accomplished at the Launch Readiness Review (LRR) or via a separate safety briefing.

2.3.5.7. Determining the need for and approving the airborne Flight Safety System (FSS); reviewing and approving the design, test, and documentation for airborne FSSs; monitoring and verifying the installation, checkout, and status of the flight termination system (FTS) in accordance with Range Safety instructions at locations designated by Range Safety

2.3.5.8. Determining criteria for flight termination action; assessing risks to protect the general public, launch area, and launch complex personnel and property; developing and using mathematical models to increase the effectiveness of errant vehicle control while minimizing restrictions on launch vehicle flight; establishing mission rules and criteria for flight termination action in conjunction with the Range User

2.3.5.9. Determining collision avoidance (COLA) launch hold requirements for mannable orbiting objects and providing the COLA requirements letter documenting mission specific criteria. AFI 91-202 provides additional requirements for minimizing risk of collision with other objects and for on-orbit collision avoidance; however, neither of these issues is the responsibility of the ranges. At present, the Safety Office is only interested in COLAs to mannable vehicle such as the International Space Station and the Space Transportation System from launch to orbital insertion.

2.3.5.10. Providing applicable Range Safety Operations Requirement (RSOR) and Operations Supplement (Ops Sup) documents; providing a Range Safety Launch Operations Approval Letter no later than the Launch Readiness Review (LRR) (45 SW/SE may provide a verbal GO instead); evaluating and issuing safety approval for personnel authorized to remain in hazardous launch areas; and providing the final Range Safety approval to launch
2.3.5.11. Providing certified Mission Flight Control Officers (MFCOs) and associated Range Safety support personnel for launch operations and, together with qualified personnel from 1 ROPS and 2 ROPS, exercise safety operations waiver authority as delegated by the SW Commander, monitor real-time launch vehicle progress, and act as the sole authority for the real-time determination and execution of flight termination
2.3.5.12. Supporting the Launch Disaster Control Group (LDCG ER)/Launch Support Team (LST WR) and advising the onsite commander regarding disaster preparedness and response and, as necessary or as requested, providing technical assistance in the event of failures and mishaps
2.3.5.13. Assessing Range Safety Critical Launch Commit Criteria for launch operations
2.3.5.14. Establishing a configuration control process for maintaining Range Safety documentation in a timely, technically correct, easily understood manner that is accessible to Range Users, including tailored Range Safety Requirements and standards developed jointly with other agencies
2.3.5.15. Ensuring safety is consistent with operational requirements, including the prevention of test objects from violating established limits through impact for vehicles with suborbital trajectories and through orbital injection/insertion or escape velocity for space vehicles (DoDD 3200.11, paragraph 4.2.9.8.)
2.3.5.16. Ensuring public safety up until the time of flight at which the launch vehicle/spacecraft achieves a sustainable orbit or escape velocity for space vehicles, or through final impact for vehicles with suborbital trajectories and can be shown to pose no statistically significant additional safety risk
2.3.5.17. Approving or disapproving equivalent level of safety (ELS) requests.

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Ch 3, FSA Policy and Processes

3.1. AFSPC Launch Safety Program.

AFSPC operates two USAF-owned national ranges established under DoDD 3200.11, Major Range and Test Facility Base, for all users having a valid need for launch and test range capabilities. Operation of AFSPC ranges carries with it specific responsibilities for public and Launch Safety. The objective of this chapter is to codify the policy and requirements for the AFSPC ranges to ensure completion of the necessary flight safety analyses and associated approvals as a prerequisite for the launch of any vehicle or the conduct of any test from the ER or the WR.

Requirements Documents for Range Current Practices, as assessed under Apx G to 14 CFR part

AFSPCMAN 91-710 (2004)

Vol 6, Atch 7: Range Safety Launch Commit Criteria

A7.2.5. Natural and Triggered Lightning:

A7.2.5.1 General Description. Both natural and triggered lightning can cause launch vehicle malfunction and/or destruction. Triggered lightning is the phenomena associated with launch vehicles affecting the atmosphere during flight so that, under certain meteorological conditions, lightning is triggered and attracted to the launch vehicle.

. . .

A7.2.5.4. Natural and Triggered Lightning Launch Commit Criteria:

A7.2.5.4.1. Lightning:

A7.2.5.4.1.1. Do not launch for 30 minutes after any type of lightning occurs in a thunderstorm if the flight path will carry the vehicle within 10 nautical miles of that thunderstorm.

A7.2.5.4.1.2. Do not launch for 30 minutes after any type of lightning occurs within 10 nautical miles of the flight path. Unless:

A7.2.5.4.1.2.1. The cloud that produced the lightning is not within 10 nautical miles of the flight path; and

A7.2.5.4.1.2.2. There is at least one working field mill within 5 nautical miles of each such lightning flash; and

A7.2.5.4.1.2.3. The absolute values of all electric field measurements at the surface within 5 nautical miles of the flight path and at the mills(s) specified in A7.2.5.4.1.2.2 above have been less than 1,000 V/m (volts per meter) for 15 minutes.

A7.2.5.4.1.3. Anvil clouds are covered in A7.2.5.4.3 below.

A7.2.5.4.1.4. If a cumulus cloud remains 30 minutes after the last lightning occurs in a thunderstorm, then the criteria in A7.2.5.4.2 apply.

A7.2.5.4.2. Cumulus Clouds. Cumulus clouds discussed below do not include altocumulus, cirrocumulus, or stratocumulus.

A7.2.5.4.2.1. Do not launch if the flight path will carry the vehicle within 10 nautical miles of any cumulus cloud with its cloud top higher than the –20^{o}C level.

A7.2.5.4.2.2. Do not launch if the flight path will carry the vehicle within 5 nautical miles of any cumulus cloud with its cloud top higher than the –10^{o}C level.

A7.2.5.4.2.3. Do not launch if the flight path will carry the vehicle through any cumulus cloud with its cloud top higher than the –5^{o}C level.

A7.2.5.4.2.4. Do not launch if the flight path will carry the vehicle through any cumulus cloud with its cloud top between the +5^{o}C and –5^{o}C levels. *Unless:*

A7.2.5.4.2.4.1. The cloud top is not producing precipitation; and

A7.2.5.4.2.4.2. The horizontal distance from the center of the cloud top to at least one working field mill is less than 2 nautical miles; and

A7.2.5.4.2.4.3. All electric field measurements at the surface within 5 nautical miles of the flight path and at the mills(s) specified in A7.2.5.4.2.4.2 above have been between –100 V/m and +500 V/m for 15 minutes.

A7.2.5.4.3. Anvil Clouds:

A7.2.5.4.3.1. Attached Anvils:

A7.2.5.4.3.1.1. Do not launch if the flight path will carry the vehicle through nontransparent parts of attached anvil clouds.

A7.2.5.4.3.1.2. Do not launch if the flight path will carry the vehicle within 5 nautical miles of nontransparent parts of attached anvil clouds for the first 3 hours after the time of the last lightning discharge that occurs in the parent cloud or anvil cloud.

A7.2.5.4.3.1.3. Do not launch if the flight path will carry the vehicle within 10 nautical miles of nontransparent parts of attached anvil clouds for the first 30 minutes after the time of the last lightning discharge that occurs in the parent cloud or anvil cloud.

A7.2.5.4.3.2. Detached Anvils. Detached anvil clouds are never considered *debris clouds* , nor are they covered by the criteria in A7.2.5.4.4.

A7.2.5.4.3.2.1. Do not launch if the flight path will carry the vehicle through nontransparent parts of a detached anvil cloud for the first 3 hours after the time that the anvil cloud is observed to have detached from the parent cloud.

A7.2.5.4.3.2.2. Do not launch if the flight path will carry the vehicle through nontransparent parts of a detached anvil cloud for the first 4 hours after the time of the last lightning discharge that occurs in the detached anvil cloud.

A7.2.5.4.3.2.3. Do not launch if the flight path will carry the vehicle within 5 nautical miles of nontransparent parts of a detached anvil cloud for the first 3 hours after the time of the last lightning discharge that occurs in the parent cloud or anvil cloud before detachment or in the detached anvil cloud after detachment. *Unless:*

A7.2.5.4.3.2.3.1. There is at least one working field mill within 5 nautical miles of the detached anvil cloud; and

A7.2.5.4.3.2.3.2. The absolute values of all electric field measurements at the surface within 5 nautical miles of the flight path and at the mill(s) specified in A72.5.4.3.2.3.1. above have been less that 1,000 V/m for 15 minutes; and

A7.2.5.4.3.2.3.3. The maximum radar return from any part of the detached anvil cloud within 5 nautical miles of the flight path has been less than 10 dBZ for 15 minutes.

A7.2.5.4.3.2.4. Do not launch if the flight path will carry the vehicle within 10 nautical miles of nontransparent parts of a detached anvil cloud for the first 30 minutes after the time of the last lightning discharge that occurs in the parent cloud or anvil cloud before detachment or in the detached anvil cloud after detachment.

A7.2.5.4.4. Debris Cloud:

A7.2.5.4.4.1. Do not launch if the flight path will carry the vehicle through any nontransparent parts of a debris cloud during the 3-hour period defined in the A7.2.5.4.4.3 below.

A7.2.5.4.4.2. Do not launch if the flight path will carry the vehicle within 5 nautical miles of any nontransparent parts of a debris cloud during the 3-hour period defined in the A7.2.5.4.4.3 below. *Unless:*

A7.2.5.4.4.2.1. There is at least one working field mill within 5 nautical miles of the debris cloud; and

A7.2.5.4.4.2.2. The absolute values of all electric field measurements at the surface within 5 nautical miles of the flight path and at the mill(s) specified in a. above have been less that 1,000 V/m for 15 minutes; and

A7.2.5.4.4.2.3. The maximum radar return from any part of the debris cloud within 5 nautical miles of the flight path has been less than 10 dBZ for 15 minutes.

A7.2.5.4.4.3. The 3-hour period cited in A7.2.5.4.4.1 and A7.2.5.4.4.2 above begins at the time when the debris cloud is observed to have detached from the parent cloud or when the debris cloud is observed to have formed from the decay of the parent cloud top below the altitude of the –100C level. The 3-hour period begins anew at the time of any lightning discharge that occurs in the debris cloud.

A7.2.5.4.5. Disturbed Weather. Do not launch if the flight path will carry the vehicle through any nontransparent clouds that are associated with a weather disturbance having clouds that extend to altitudes at or above the 0^{o}C level and contain moderate or greater precipitation or a radar bright band or other evidence of melting precipitation within 5 nautical miles of the flight path.

A7.2.5.4.6. Thick Cloud Layers:

A7.2.5.4.6.1. Do not launch if the flight path will carry the vehicle through nontransparent parts of a cloud layer that is:

A7.2.5.4.6.1.1. Greater than 4,500 feet thick and any part of the cloud layer along the flight path is located between the 0oC and the –20^{o}C levels or

A7.2.5.4.6.1.2. Connected to a cloud layer that, within 5 nautical miles of the flightpath, is greater than 4,500 feet thick and has any part located between the 0^{o}C and the –20^{o}C levels.

Exception: *The following exception applies to both A7.2.5.4.6.1.1 and A7.2.5.4.61.2 above: The cloud is a cirriform cloud that has never been associated with convective clouds,* and *is located entirely at temperatures of –15oC or colder,* and *shows no evidence of containing liquid water (e.g., aircraft icing).*

A7.2.5.4.7. Smoke Plumes. Do not launch if the flight path will carry the vehicle through any cumulus cloud that has developed from a smoke plume while the cloud is attached to the smoke plume, or for the first 60 minutes after the cumulus cloud is observed to have detached from the smoke plume. Cumulus clouds that have formed above a fire but have been detached from the smoke plume for more than 60 minutes are considered cumulus clouds and are covered in A7.2.5.4.2.

A7.2.5.4.8. Surface Electric Fields (ER Only):

A7.2.5.4.8.1. Do not launch for 15 minutes after the absolute value of any electric field measurement at the surface within 5 nautical miles of the flight path has been greater that 1,500 V/m.

A7.2.5.4.8.2. Do not launch for 15 minutes after the absolute value of any electric field measurement at the surface within 5 nautical miles of the flight path has been greater that 1,000 V/m. *Unless:*

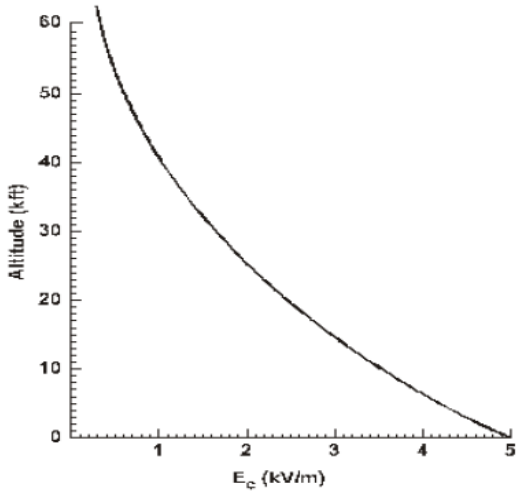
A7.2.5.4.8.2.1. All clouds within 10 nautical miles of the flight path are transparent; or

A7.2.5.4.8.2.2. All nontransparent clouds within 10 nautical miles of the flight path have cloud tops below the +5oC level and have not been part of convective clouds with cloud tops above the –10oC level within the last 3 hours.

A7.2.5.4.8.3. Electric field measurements at the surface are used to increase safety by detecting electric fields caused by unforeseen or unrecognized hazards. For confirmed failure of one or more field mill sensors, the countdown and launch may continue.

A7.2.5.4.9. Electric Fields Aloft (ER Only). The criteria cited in A7.2.5.4.3, A7.2.5.4.4, A7.2.5.4.5, A7.2.5.4.6, A7.2.5.4.7, and A7.2.5.4.8.2 need not be applied if, during the 15 minutes prior to launch time, the instantaneous electric field aloft throughout the volume of air expected to be along the flight path, does not exceed EC where EC is shown as a function of altitude in Figure A7.1. The thresholds on electric field measurements at the surface in A7.2.5.4.8 and elsewhere in these LCC are lower than 5 kV/m (kilovolts per meter) to allow for the effect of the surface screening layer.

Figure A7.1. Instantaneous Critical Electric Field (E_c) Versus Altitude.



Legend: kft = thousand feet

A7.2.5.4.10. Triboelectrification. Do not launch if a vehicle has not been treated for surface electrification and the flight path will go through any clouds above the –10oC level up to the altitude at which the vehicle's velocity exceeds 3,000ft/sec. A vehicle is considered "treated" for surface electrification if:

A7.2.5.4.10.1. All surfaces of the vehicle susceptible to precipitation particle impact have been treated to assure

A7.2.5.4.10.1.1. That the surface resistivity is less than 109 ohms/square; and

A7.2.5.4.10.1.2. That all conductors on surface (including dielectric surfaces that have been treated with conductive coatings) are bonded to the vehicle by a resistance that is less than 105 ohms; or

A7.2.5.4.10.2. It has been shown by test or analysis that electrostatic discharges (ESDs) on the surface of the vehicle caused by triboelectrification by ice particle impact will not be hazardous to the launch vehicle or the mission. In A7.2.5.4.10.1.1 above, the correct unit for surface resistivity is ohms/square. This means that any square area of any size measured in any units has the same resistance in ohms when the measurement is made from an electrode extending the length of one side of the square to an electrode extending the length of the opposite side of the square. The area-independence is literally valid only for squares; it is not true for other shapes such as rectangles and circles.

A7.2.5.5. Offices of Primary Responsibility. 30 SW/SEY and 45 SW/SESE along with 30 WS and 45 WS are the OPRs for natural and triggered lightning launch commit criteria. 30 SW/SE and 45 SW/SE are the OCRs.

A7.2.5.6. Reference Documents. Additional or different mission specific lightning launch commit criteria shall be documented in the RSOR.

45 Weather Squadron (45 WS) Lightning Launch Commit Criteria

6.7. Range Safety Natural and Triggered Lightning Launch Commit Criteria (LCC). The Lightning Flight Commit Criteria are a set of rules developed by the Lightning Advisory Panel consisting of leading scientists in atmospheric electricity. These rules were accepted by Range Safety to ensure the avoidance of natural and/or triggered lightning during space/ballistic launch operations. See **Attachment 14** and/or **AFSPCMAN 91-710, Attachment 7**. [shown above]

Attachment 14 LIGHTNING LAUNCH COMMIT CRITERIA, LAP RECOMMENDATION 08/20/14

A14.1. PREAMBLE

A14.1.1. The launch safety rules include launch-commit criteria that identify each condition that must be met in order to launch. These include criteria for trained weather personnel to monitor the meteorological conditions and implement each launch constraint developed using the following Natural and Triggered Lightning Launch-Commit Criteria. The launch operator must have clear and convincing evidence that none of these criteria is violated at the time of launch. Whenever there is ambiguity about which of several LLCC applies to a particular situation, all potentially applicable LLCC must be applied. If any other hazardous conditions exist, other than those identified below, the launch weather team will report the hazardous condition to the final approval authority for launch, who will determine whether launching would expose the launch vehicle to a lightning hazard and not launch in the presence of the hazard.

A14.1.1.1. NATURAL AND TRIGGERED LIGHTNING LAUNCH-COMMIT CRITERIA

A14.1.1.2. GENERAL. These are the launch-commit criteria for mitigating against natural lightning strikes and lightning triggered by the flight of a launch vehicle through or near an electrified environment. A launch operator may not launch unless the weather conditions satisfy all of these Natural and Triggered Lightning Launch-Commit Criteria (LLCC).

A14.1.1.3. In order to meet the LLCC, a launch operator must employ any:

A14.1.1.4. Weather monitoring and measuring equipment needed, and

A14.1.1.5. Procedures needed to verify compliance.

A14.1.2. When equipment or procedures, such as a field mill or calculation of the maximum radar reflectivity (MRR) of clouds, are used with the lightning launch-commit criteria to increase launch opportunities, a launch operator must evaluate all applicable measurements to determine whether the measurements satisfy the criteria. A launch operator may not turn off available instrumentation to create the appearance of meeting a requirement and must use all radar reflectivity measurements within a specified volume for a MRR calculation.

A14.1.3. If a launch operator proposes any alternative lightning launch-commit criteria, the launch operator must clearly and convincingly demonstrate that the alternative provides an equivalent level of safety to that required here.

A14.2. DEFINITIONS. [Listing only the added/edited definitions]

Maximum radar reflectivity (MRR) means the largest radar reflectivity within a specified volume that is associated with an evaluation point. [Note: Section 25(b) provides full details on how to calculate MRR.] [Note 2: This term shows up in the Anvil Cloud (attached & detached) and Debris cloud rule.]

Thick cloud layer means one or more cloud layers whose combined vertical extent from the base of the bottom cloud layer to the top of the uppermost cloud layer exceeds 1.4 km (4,500 feet). Cloud layers are combined with neighboring layers for determining total thickness only when they are physically connected by vertically continuous clouds.

A14.10. THICK CLOUD LAYERS.

A14.10.1. This section does not apply to either attached or detached anvil clouds. Two or more cloud layers must be combined if they are physically connected by towering cumuliform clouds, but a cumulus cloud is never combined with cloud layers to increase the total thickness beyond the combined thickness of the layered clouds.

A14.10.2. A launch operator may not launch if the flight path will carry the launch vehicle through a non-transparent cloud layer that is:

A14.10.2.1. Greater than or equal to 1.4 km (4,500 feet) thick and any part of the cloud layer within the flight path is located at an altitude where the temperature is between 0 degrees Celsius and -20 degrees Celsius, inclusive; or

A14.10.2.2. Connected to a thick cloud layer that, at a slant distance of less than or equal to 5 nautical miles from the flight path, is greater than or equal to 1.4 km (4,500 feet) thick and has any part located at any altitude where the temperature is between 0 degrees Celsius and -20 degrees Celsius, inclusive.

A14.10.3. A launch operator may launch despite paragraphs A14.10.2.1 and A14.10.2.2 if the thick cloud layer:

A14.10.3.1. Is a cirriform cloud layer that has never been associated with convective clouds,

A14.10.3.2. Is located entirely at altitudes where the temperature is colder than or equal to -15 degrees Celsius, and

A14.10.3.3. Shows no evidence of containing liquid water.

A14.10.4. A launch operator need not apply the lightning launch-commit criteria in paragraphs A14.10.2.1 and A14.10.2.2 if the cloud layer does not contain a radar reflectivity of 0 dBZ or greater at any location that is less than or equal to 5 nautical miles from the flight path.

Requirements Documents for Range Current Practices, as assessed under 14 CFR §417.113(c)(2)(iii)

AFSPCMAN 91-710 (2004):

Vol 2 Flight Safety Requirements (certified current 17 June 2013), Chapter 1: Ground Rules

1.6. Ground Rules, Range User Responsibilities

1.6.9 Range User Range Tracking System Performance Requirements.

The following requirements apply to Range Users who use other than AFSPC range assets for range tracking. The range tracking system (RTS) consists of the hardware, software, and personnel required to transmit, receive, process, and display launch vehicle data for Range Safety purposes.

1.6.9.1 General. An RTS, including at least two adequate and independent instrumentation data sources shall be provided and shall be maintained from T-0 through each phase of powered flight up to the end of Range Safety responsibility.

Vol. 6 (certified current 3 April 2014), Attachment 7: Range Safety Launch Commit Criteria:

A7.2.1. Flight Safety Systems.

Flight safety systems are those ground and airborne systems required to monitor, track, aid decision making, and, if necessary, destroy errant launch vehicles in flight.

A7.2.1.1. Ground Range Safety Systems:

A7.2.1.1.3. Ground Range Safety System Launch Commit Criteria:

A7.2.1.1.3.1. Range tracking systems include radars, optics, and telemetered inertial guidance downlinks.

A7.2.1.1.3.1.1. Two adequate and independent tracking sources shall be available throughout powered flight.

A7.2.1.1.3.1.1.1. *Adequate* is defined by error statistics for each source.

A7.2.1.1.3.1.1.2. *Independent* is defined as having no common components or systems between the vehicle and the front-end computers in the Range Operations Control Center (ROCC) such as to create a common failure mode.

Requirements Documents for Range Current Practices, as assessed under 14 CFR §417.107(b)(1)

Air Force Instruction (AFI) 91-217 (18 Feb 2010):

4.6.5 Launch Safety, Public and Launch Personnel Risk:

4.6.5.1. The risk to the public will not exceed the criteria listed below for mission operations (to include launch processing, space and suborbital launches, and subsequent controlled reentry);

4.6.5.1.1. Public. The general public will not be exposed to a collective Expectation of Casualty (Ec) greater than 100 10-6 (one-hundred in one million) for all hazards associated with a mission (ref. RCC 321 for guidance on assigning mission risk).

AFI 91-217 update (17 Apr 2014):

4.4 Launch Safety

4.4.1. The following outlines acceptable risk levels for hazards associated with launches. Launch operations risk management shall apply risk analysis consistent with DOD, RCC, Air Force, and industry standards and practices. . . .

4.4.2. Personnel Risk The risk criteria listed below applies to all launches. For FAA-licensed launches from Air Force ranges, the Air Force shall enforce FAA public risk criteria.

4.4.2.1. Public. The risk to the general public shall not exceed an individual Probability of Casualty (Pc) of 1 x 10^{-6} (one in one million), and the collective risk to the general public shall not exceed a casualty expectation (Ec) of 100 x 10^{-6} (one hundred in one million). These risk levels shall apply for all hazards from lift-off to orbital insertion, including planned debris impacts, and from lift-off to final impact for a suborbital mission. Reference RCC 321, *Common Risk Criteria Standards for National Test Range*s.

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Vol 1, Atch 4: Acceptable Risk Criteria

A4.3.5. The risk associated with the total flight to all members of the general public, excluding persons in waterborne vessels and aircraft, shall not exceed an expected average number of 0.00003 casualties (Ec < 30 x 10^{-6}) from impacting inert and explosive debris, Ec < 30 x 10^{-6} for toxic release (exposure to rocket propellant effluent), and Ec < 30 x 10^{-6} for far field blast overpressure. The Ec criterion for each hazard applies to each launch from liftoff through orbital insertion, including planned impact for an orbital launch, and through final impact for a suborbital launch. Range Safety shall determine the public risk due to other hazards associated with the proposed flight of a launch vehicle on a case-by-case basis.

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Chap 3 Flight Safety Analysis Policy and Processes

3.6. Risk to General Public.

No hazardous condition is acceptable (acceptable hazard) if mission objectives can be reasonably obtained from a safer approach, methodology, or position. Containment of the hazard shall be accomplished when possible. When containment of the hazard is not possible, a risk analysis shall be performed. When the decision maker has agreed that the risk is within acceptable levels acceptable launch risk), and cannot be further reduced by reasonable methods, the hazardous operation may proceed. Launch area and downrange overflight shall be evaluated and the total risk accumulated. Individual hazardous activities may only exceed guidance levels based on national need.

3.6.1. **Launch Vehicles.** Initiation of launch vehicle flight may be accomplished if the FSA satisfies all of the following public risk criteria

. . .

3.6.1.2. Risk associated with the flight to all members of the general public (collective risk), excluding persons in waterborne vessels and aircraft, does not exceed a casualty expectation of 30×10^{-6} for each hazard per launch.

Requirements Documents for Range Current Practices, as assessed under 14 CFR §417.107(b)

AFSPCMAN 91-710 (2004)

Vol 1, Atch 4: Acceptable Risk Criteria

A4.3.5. The risk associated with the total flight to all members of the general public, excluding persons in waterborne vessels and aircraft, shall not exceed an expected average number of 0.00003 casualties (Ec < 30 x 10^{-6}) from impacting inert and explosive debris, Ec < 30 x 10^{-6} for toxic release (exposure to rocket propellant effluent), and Ec < 30 x 10^{-6} for far field blast overpressure. The Ec criterion for each hazard applies to each launch from liftoff through orbital insertion, including planned impact for an orbital launch, and through final impact for a suborbital launch. Range Safety shall determine the public risk due to other hazards associated with the proposed flight of a launch vehicle on a case-by-case basis.

A4.3.7. The probability of debris impact to all waterborne vessels (Piv) shall not exceed 0.00001 (Piv < x 10^{-5}) in each debris impact hazard area identified by Range Safety.

Vol 6, Atch 7: Range Safety Launch Commit Criteria

A7.2.2.: Blast

A7.2.2.1. General Description. The BLAST model addresses intermediate hazardous range effects of a shock wave from an inadvertent detonation, such as from a launch vehicle malfunction, impact, or destruction. Near-in areas of overpressure above one pound per square inch (psi) are evacuated of personnel and are not considered in the assessment. At far-out distances, with overpressures of less than 0.1 psi, there are relatively small hazards. It is the intermediate distance with overpressures of 0.1 to 0.5 psi that are of concern. The area encompassing overpressures in this range varies considerably with local meteorological conditions.

A7.2.2.2. Applicability. This launch commit criteria is generally applicable to large launch vehicles with large amounts of propellants, solid rocket motor launch vehicles with high energy propellants, and launch vehicles using launch complexes near the borders of general population.

A7.2.2.3. Blast Launch Commit Criteria. If the expected casualties of a potential blast overpressure exceed those limits defined in Volume 1 of this publication, Range Safety recommends the range go “red” until another BLAST model run can be made with updated meteorological data.

A7.2.2.4. Offices of Primary Responsibility. 30 SW/SEY is the OPR for launch commit criteria associated with the Blast C model; 45 SW/SESE is the OPR for launch commit criteria associated with the Blast X (tailored version of Blast C) model.

A7.2.2.5. Reference Documents. Mission-specific blast launch commit criteria shall be addressed in the RSOR.

A7.2.7. Safety Clearance Zones.

A7.2.7.2. Hazardous Launch Areas:

A7.2.7.2.3. Hazardous Launch Area Launch Commit Criteria:

A7.2.7.2.3.3. VEA/BEA. Ships and aircraft shall remain outside this area during launch. Ships/boats are protected to a Pi level of 1 x 10^{-5}. Aircraft are protected to a Pi level of 1 x 10^{-8}. (See Volume 7 for definitions of vessel exclusion area and boat exclusion area.)

A7.2.8. Launch Area Air And Sea Surveillance:

A7.2.8.1, General Description. Areas to be cleared of boats and ships are defined by Flight Analysis and based on probability contours and/or Toxic Hazard Zones, including known impact areas of jettisoned stages/bodies and destruct debris resulting from malfunction scenarios plus the areas and altitudes in which Toxic Hazards will exist. Areas defined by Notice to Airmen (NOTAM) and Notice to Mariners (NTM) are surveyed on launch day.

A7.2.8.3.1.1 At the ER, if the sum total of the individual hit probabilities of all targets plotted within, or predicted to be within, the established probability contours exceed 10^{-5}, a launch hold or scrub may be initiated.

AFSPCMAN 91-711 (2007)

3.6. Risk to General Public No hazardous condition is acceptable (acceptable hazard) if mission objectives can be reasonably obtained from a safer approach, methodology, or position. Containment of the hazard shall be accomplished when possible. When containment of the hazard is not possible, a risk analysis shall be performed. When the decision maker has agreed that the risk is within acceptable levels (acceptable launch risk), and cannot be further reduced by reasonable methods, the hazardous operation may proceed. Launch area and downrange overflight shall be evaluated and the total risk accumulated. Individual hazardous activities may only exceed guidance levels based on national need.

3.6.1. Launch Vehicles. Initiation of launch vehicle flight may be accomplished if the FSA satisfies all of the following public risk criteria:

3.6.1.1. Risk to any individual member (individual risk) of the general public does not exceed a casualty expectation of 1×10^{-6} for each hazard per launch.

3.6.1.2. Risk associated with the flight to all members of the general public (collective risk), excluding persons in waterborne vessels and aircraft, does not exceed a casualty expectation of 30 x 10-6 for each hazard per launch.

3.6.1.3. The cumulative hit probability of inert and explosive debris impact for each group of public and mission support waterborne vessels in all impact areas identified by Wing Safety does not exceed 1×10^{-5}.

3.6.1.4. Aircraft shall not be exposed above 1 x 10-6 collective probability of impact. A more conservative criterion of a 1 x 10-8 collective probability of impact (that is also used for ships) may be used for aircraft to account for risk uncertainty caused by variability in aircraft type, position, altitude, and speed.

3.6.1.5. Trains shall not be exposed above 1 x 10-6 probability of impact.

3.6.1.6. For all launch vehicles, jettisoned components, propagated debris, and payloads with the potential to collide with manned orbiting objects, the level of protection provided to the spacecraft shall be: (1) ensuring a spherical miss distance of 200 km or (2) ensuring an ellipsoidal miss distance of 200 km in-track and 50 km perpendicular to the in-track axis or (3) not exceeding a probability of impact greater than 1 x 10-6 per spacecraft. COLA analysis is used in the minus count to protect orbiting objects from collision with a launch vehicle or its jettisoned components. A COLA closure time period (no launch) is calculated for any object violating the criteria described below. A COLA closure time period shall result in a launch hold for that time period. A mission/launch scrub occurs only if the closure time period conflicts with any remaining time for the mission launch window. At present, Wing Safety only requires COLAs for manned objects such as the International Space Station, Space Transportation System, and critical supply vehicles to manned objects.

3.7. Risk to LEP and NOP. Initiation of the flight of a launch vehicle may only be approved if the FSA satisfies the following risk criteria for LEP and NOP for the following hazards:

3.7.4. The cumulative hit probability criteria to waterborne vessels and aircraft as stated in paragraphs 3.6.1.3. and 3.6.1.4. apply to LEP, NOP, and mission support vessels in all impact areas identified by Wing Safety.

5.4. Launch Area Air and Sea Surveillance.

5.4.3. Launch Area Air, Land, and Sea Surveillance Launch Commit Criteria (LCC). Areas to be cleared of boats, ships, and trains are defined by Flight Analysis and based on hit probability contours and/or THZs, including known impact areas of jettisoned stages/bodies and destruct debris resulting from malfunction scenarios plus the areas and altitudes in which toxic hazards will exist. Hazardous Launch Areas are defined by NOTAM and those areas within the coverage capabilities of local land based radars or support aircraft are surveyed on launch day for intruder aircraft and are analyzed as a potential for risk to the launch vehicle or the aircraft.

5.4.3.2. Boat and Ship Traffic LCC. If the sum total of the individual hit probabilities of all targets plotted within, or predicted to be within, the established probability contours exceeds acceptable risk criteria as stated in AFSPCMAN 91-710 Volume 1, a launch hold or mission/launch scrub may be initiated.

Requirements Documents for Range Current Practices, as assessed under 14 CFR §417.213(d)

AFSPCMAN 91-710 (2004, cert'd 17 Jun 2013), Vol 2 Flight Safety Requirements

Vol 2, Atch 3: Fragment Data

A3.3. Fragment Data Items.

These requirements provide a description of the data items required for each fragment or fragment group for each potential mode of vehicle breakup. The variation of the fragment characteristics with flight time shall be defined. Normally this is accomplished by specifying multiple fragment lists, each of which is applicable over a specified period of flight.

A3.3.6. Ballistic Coefficient (beta). Nominal, plus three-sigma, and minus three-sigma values (psf) for each fragment or group; including graphs of the coefficient of drag (Cd) versus Mach number for the nominal and three-sigma beta variations for each fragment or group. Each graph shall be labeled with the shape represented by the curve and reference area used to develop the curve. A Cd versus Mach curve for axial, transverse, and tumble orientations (when applicable) shall be provided for fragments not expected to stabilize during free-fall conditions. For fragments that may stabilize during free-fall, Cd versus Mach curves should be provided for the stability angle of attack. If the angle of attack where the fragment stabilizes is other than 0 degrees, both the coefficient of lift (CL) versus Mach number and the Cd versus Mach number curves should be provided. If available, equations for Cd versus Mach curves should be provided. The difficulty of estimating drag coefficient curves and weights for vehicle pieces is fully realized. If this cannot be done satisfactorily, an estimate of the subsonic and supersonic W/ Cd A for each major piece may be provided instead. In either case, three-sigma tolerance limits

AFSPCMAN 91-711 (2007, cert'd 24 Jan 2013)

Ch 3. Flight Safety Analysis Policy and Processes

Sec 3.8. Flight Safety Analysis (FSA)

A FSA assessment shall demonstrate that an AFSPC range will, for each launch, control the risk to the public from hazards associated with normal and malfunctioning launch vehicle flight. The analysis shall employ hazard isolation, risk assessment, or a combination of risk assessment and partial isolation of the hazards, to demonstrate control of risk to the public.

Sec 3.8.7. Flight Safety Limits Analysis. A FSA shall identify the location of populated or other protected areas, and establish flight safety limits (destruct lines) that define when an FSS shall terminate a launch vehicle's flight to prevent the hazardous effects of the resulting inert and explosive debris impacts from reaching any populated or other protected area and ensure that the launch satisfies the public risk criteria. The population used for analysis shall take variations due to growth in the local populous and temporary changes due to seasonal or special circumstances.
Sec 3.8.7.2. Designated Inert and Explosive Debris Impact Limits. The analysis shall establish designated impact limit lines (ILLs) to bound the area where debris with a ballistic coefficient of three or more is allowed to impact if the FSS functions properly.

Technical Document

REVIEW OF CHANGES TO FEDERAL RANGE CURRENT PRACTICES FOR DETERMINATIONS OF EQUIVALENT LEVEL OF SAFETY

(Revision 0)

Prepared by the

LICENSING AND EVALUATION DIVISION
of the
OFFICE OF
COMMERCIAL SPACE TRANSPORTATION

September 27, 2016

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CHANGES TO FEDERAL RANGE CURRENT PRACTICES FOR
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E-01: Regarding Changes to Collision Avoidance Criteria

As applied to Launch Site Safety Assessment Matrix Item E-01.

Intent

This report assesses the approach by both the Eastern and Western Range (EWR) for determining Collision Avoidance parameters, and documents the FAA's resulting determination of an *equivalent level of safety* (ELS) in its usage.

Introduction

The Air Force ranges have increased the stringency of its calculation for Collision Avoidance (COLA) to protect on-orbit manned spacecraft and *active satellites* from collision with launched objects with an altitude capability equal to or greater than 150 km. This change moves beyond the AF ranges' previous practice, which had been parallel to FAA requirements for COLA, under 14 CFR part 417. The possible impact would be the narrowing of available launch windows.

Background

Current FAA regulations require that a licensed launch operator obtain a collision avoidance analysis from the US Air Force, in order to assure inhabited or habitable spacecraft are not jeopardized during the licensed launch operations.

From 14 CFR § 417.107(e) Flight safety, Collision avoidance:

"(1) A launch operator must ensure that a launch vehicle, any jettisoned components, and its payload do not pass closer than 200 kilometers to a manned or mannable orbital object —

(i) Throughout a sub-orbital launch; or

(ii) For an orbital launch:

(A) During ascent to initial orbital insertion and through at least one complete orbit; and

(B) During each subsequent orbital maneuver or burn from initial park orbit, or direct ascent to a higher or interplanetary orbit or until clear of all manned or mannable objects, whichever occurs first.

(2) A launch operator must obtain a collision avoidance analysis for each launch from United States Strategic Command or from a Federal range having an approved launch site safety assessment. United States Strategic Command calls this analysis a conjunction on launch assessment. Sections 417.231 and A417.31 of appendix A of this part contain the requirements for obtaining a collision avoidance analysis. A launch operator must use the results of the collision avoidance analysis to develop flight commit criteria for collision avoidance as required by § 417.113(b)."

Also, from § 417.231 Collision avoidance analysis:

"(a) General. A flight safety analysis must include a collision avoidance analysis that establishes each launch wait in a planned launch window during which a launch operator must not initiate flight, in order to protect any manned or mannable orbiting object. A launch operator must account for uncertainties associated with launch vehicle performance and timing and ensure that any calculated launch waits incorporate all additional time periods associated with such uncertainties. A launch operator must implement any launch waits as flight commit criteria according to § 417.113(b).

(b) Orbital launch. For an orbital launch, the analysis must establish any launch waits needed to ensure that the launch vehicle, any jettisoned components, and its payload do not pass closer than 200 kilometers to a manned or mannable orbiting object during ascent to initial orbital insertion through at least one complete orbit.

(c) Suborbital launch. For a suborbital launch, the analysis must establish any launch waits needed to ensure that the launch vehicle, any jettisoned components, and any payload do not pass closer than 200 kilometers to a manned or mannable orbital object throughout the flight.

(d) Analysis not required. A collision avoidance analysis is not required if the maximum altitude attainable by a launch operator's unguided suborbital launch vehicle is less than the altitude of the lowest manned or mannable orbiting object. The maximum altitude attainable must be obtained using an optimized trajectory, assuming 3-sigma maximum performance."

Finally, from 14 CFR 417, Appendix A (A417.31) Collision:

"(a) General. A flight safety analysis must include a collision avoidance analysis that satisfies the requirements of § 417.231. This section applies to a launch operator obtaining a collision avoidance assessment from United States Strategic Command as required by § 417.231 and to the analysis products that the launch operator must file with the FAA as required by § 417.203(e). United States Strategic Command refers to a collision avoidance analysis for a space launch as a conjunction on launch assessment."

[The rest of the reference § A417.31 is a descriptive guidance on an acceptable method of acquiring a COLA analysis and is not included here, for brevity]

The FAA assessment of the Range practices at the time of the part 417 Rule's publishing in 2007, was that they satisfied the FAA requirements. On 18 February 2010, the U.S. Air Force published AF Instruction 91-217, *Space Safety and Mishap Prevention Program* (later updated, 17 April 2014). This document implements space safety, mishap prevention and mission effectiveness guidance for AF space systems, and is applicable to all AF organizations and personnel that develop, test, or operate any space system or who provide launch/range services for space systems.

Herein, the AF tightened its COLA criteria; for instance, under Section 6.6.4 Safe Separation – CA and COLA:

"The appropriate wing commander is responsible for precluding any activity that would adversely affect active or manned spacecraft, based on a pre-launch COLA process identified by the MAJCOM"

Thus, in accordance with the 2014 AFI 91-217, the Air Force's Space wings, in conjunction with the Joint Space Operations Center (JSpOC, USSTRATCOM) were instructed to protect on-orbit manned spacecraft and *active satellites* from collision with launched objects. Later, on 22 July 2016, the responsibility for the COLA function was reassigned from the JSpOC to the 18th Space Control Squadron (18 SPCS, AFSPC). Space wings were to obtain Conjunction Assessments (CAs) from the 18 SPCS to establish COLA holds in the launch windows to ensure safe separation criteria from manned and active orbital objects.

The 2014 update to AFI 91-712 further clarified the stringent criteria for COLA. Under Section 4.4.3 Launch Collision Avoidance:

> *"All launches from Air Force ranges and all Air Force launches from non-Air Force ranges shall accomplish LCOLA procedures accounting for all launched objects (e.g., booster segments, payloads, jettisoned components, and debris) with an altitude capability equal to or greater than 150 km. ..."*

While both the Eastern and Western Ranges still follow their original AFSPCMAN 91-710 (Range Safety User Requirements Manual, 2004) and 91-711 (Launch Safety Requirements for AF Space Command Organizations, 2007), their higher headquarters requirements do not allow for a less restrictive COLA, therefore the ranges now abide by the more stringent criteria laid out in AFI 91-217.

Discussion

By the new AF direction, the current practice now is for both ER and WR to comply with AFI 91-217 for launch COLA requirements. The commercial launch operator launching from the federal ranges (ER & WR) will have a required minimum COLA analysis that is consistent with FAA regulation § 417.107 (e). The commercial launch operator may request more stringent analysis at its discretion.

The analysis of Launch Collision Avoidance is consolidated at the 18 SPCS, which works with both ER & WR. The ER and WR requirements meet or exceed FAA regulation § 417.107 (e), because they also protect for active satellites in addition to manned spacecraft. Each federal range also enforces COLA closures, as a launch commit criteria. In addition, it should be noted that the AF COLA process also includes screening for orbital debris, as well as manned/mannable and active satellites; this is current practice as levied by AFI 91-217 (2014). As a result of this, the newer practice is an equivalent level of safety with the FAA's requirement.

Conclusion

The changes made by both Air Force ranges (ER and WR) do not impact FAA requirements and provide an equivalent level of safety.

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E-02: Regarding Flight Safety Analysis as Conducted by USAF and NASA Launch Ranges

As applied to Launch Site Safety Assessment Matrix Item E-02.

Intent

This report assesses the current practices by federal (Air Force and NASA) launch ranges on how they conduct their respective Flight Safety Analysis (FSA) calculations, and documents the FAA's resulting determination of an *equivalent level of safety* (ELS) for each respective range.

Introduction

Since the publishing of the FAA's Launch Rule, 14 CFR part 417, on 25 August 2006, the Federal ranges have continued to refine and improve on their method of calculating the Flight Safety Analysis. Likewise, the FAA has also worked to improve its method of determining better quality FSA's. This report reviews the ranges' FSA practices to determine whether in the drive to continually improve the process, still meets the FAA requirements.

Background

The development of the FAA's Launch Rule, 14 CFR part 417 was done in near-parallel to the requirements of the developing US Air Force's AFSPCMAN 91-710, and with an understanding of the then current NASA Range Safety Manual (in particular for the Wallops Flight Facility). From that period, the analytical practice by the ranges and the FAA were similar if not identical, with regards to the calculations that would go into the Flight Safety Analysis for each mission.

From 14 CFR Part 417, Subpart C – Flight Safety Analysis

> *"§ 417.203 Compliance,(d) Analyses performed by a Federal launch range. FAA will accept a flight safety analysis used by a Federal launch range without need for further demonstration of compliance to the FAA, if:*
>
> *(1) Launch operator contracted with Federal launch range for provision of flight safety analysis; and*
>
> *(2) the FAA assessed the Federal launch range [via LSSA], and found range's analysis methods satisfy requirements ...*
>
> *In this case, FAA will treat Fed range's analysis as that of a launch operator."*

The focus on the FAA in this particular case is more on the quality of methods and tools the ranges use that may have changes notably in the last 10 years, and whether these changes may have inadvertently deviated from FAA requirements.

Discussion

The FAA Flight Safety Analysts and representatives from FAA Offices at both ER and WR, performed a brief investigation on what the Air Force ranges of Cape Canaveral Air Force Station, Vandenberg Air Force Base, and also NASA's Wallops Flight Facility, currently use in their respective FSA processes. The results from the FAA group's quick look are as follows:

The 45th Space Wing at CCAFS now uses the Trajectory Toolkit (TTK) to pre-process the trajectories received from the launch operators and creates the input files for their Range Risk Analysis Tool (RRAT). With regard to the FAA requirements, 45 SW's newer practice to pre-process the trajectories is also used by the FAA. The practice is an *equivalent level of safety.* With regard to RRAT, the FAA has been using the same program as well.

The 30th Space Wing at VAFB is now performing the Flight Safety Analysis in-house, as opposed to it being done previously by a contractor. The 30 SW incorporation of previously contracted tasks onto the Government side is transparent to how it conduct trajectory analysis. The 30 SW conducts its FSA in accordance with its most current FSA Handbook, and its approach is consistent with those of the 45 SW, WFF and the FAA. The practice is an *equivalent level of safety.*

WFF uses the following analysis tools: Joint Advanced Range Safety System (JARSS), BlastDFO (for Distance Focus Overpressure), and Launch Area Toxic Risk Assessment (LATRA). Here too, WFF's processes are consistent with that used by FAA. Whereas JARSS might be considered medium fidelity when compared to RRAT, the FAA has accepted that for ELV launches from WFF, the JARSS analysis is acceptable and meets the regulations. The practice is an *equivalent level of safety*.

Conclusion

The current practices used by all three federal launch ranges listed here, using their most up-to-date approaches, were found to be an equivalent level of safety for each respective range. Both FAA and the ranges have adopted like, if not identical, analysis practices, at around the same time.

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E-03: Regarding Changes to Lightning Flight Commit Criteria at CCAFS

As applied to Launch Site Safety Assessment Matrix Item E-03.

Intent
This report assesses changes to lightning flight commit criteria and documents the FAA's resulting determination of an *equivalent level of safety* (ELS) in its usage.

Purpose and Background
On December 2, 2013, the Federal Aviation Administration's Office of Commercial Space Transportation (AST) was notified of the Lightning Advisory Panel (LAP) recommended updates to the Lightning Launch Commit Criteria (LLCC).

This change replaced the Volume Averaged Height Integrated Radar Reflectivity (VAHIRR) with the Maximum Radar Reflectivity (MRR), easing calculation of radar reflectivity from existing radar imagery. A second update involved a change to the Thick Cloud Layer rule that will allow launch within 5 nm of a thick cloud layer if it is determined that the radar reflectivity is below 0 dBZ.

The FAA coordinated with the USAF and NASA weather teams, reviewed the changes in the LLCC, and determined that these changes provide an equivalent level of safety to 14 CFR part 417, Appendix G (Lightning Flight Commit Criteria). Therefore, FAA licensed launches from the Federal Ranges (Eastern, Western, Wallops Flight Facility, or Reagan Test Site), that utilize the approaches described above do not impact FAA requirements and do provide an equivalent level of safety.

Discussion
The federal ranges develop AF Safety launch commit criteria (LCC), based on operations requirements whose intent is to protect the public from hazards associated with launching missiles or space launch vehicles.

What the range describes as "Lightning Launch Commit Criteria" (LLCC, shortened to LCC), the FAA uses "Lightning Flight Commit Criteria" (LFCC), for Natural and Triggered Lightning Flight Commit Criteria. Both LCC and LFCCs are natural and triggered lightning avoidance rules, and the range's LCCs have recently been updated. As such, these changes to range practices must be assessed to see if they provide an equivalent level of safety in meeting with the FAA's requirements. These labels sometimes become interchanged, but to avoid confusion, this report will use the FAA's designation for Lightning FCC (LFCC.).

The LFCC launch safety rules are natural and triggered lightning avoidance rules that identify each condition that must be met in order to initiate safe flight. These include criteria for trained weather personnel to monitor the meteorological conditions and implement each flight constraint developed using the following Natural and Triggered Lightning Flight Commit Criteria (LFCC). The launch operator must have clear and convincing evidence that none of these criteria is violated at the time of launch. Whenever there is ambiguity about which of several LFCC applies to a particular situation, all potentially applicable LFCC must be applied.

From part 417, Apx G, G417.1 General:

> *(a) This ... provides flight commit criteria to protect against natural lightning and lightning triggered by the flight of a launch vehicle. A launch operator must apply these criteria under § 417.113 (c) for any launch vehicle that utilizes a flight safety system.*
>
> *(b) The launch operator must employ:*
>
> *(1) Any weather monitoring and measuring equipment needed to satisfy the lightning flight commit criteria; and*
>
> *(2) Any procedures needed to satisfy the lightning flight commit criteria.*
>
> *(c) If a launch operator proposes any alternative lightning flight commit criteria, the launch operator must clearly and convincingly demonstrate that the alternative provides an equivalent level of safety.*

The 45th Weather Squadron (45 WS) updates involve language that nearly parallels the above FAA rule, where the flight commit criteria are for mitigating against natural lightning strikes and lightning triggered by the flight of a launch vehicle through or near an electrified environment. One notable difference of the two is where the range documentation also includes an additional criterion:

> *"When equipment or procedures, such as a field mill or calculation of the maximum radar reflectivity (MRR) of clouds, are used with the lightning flight commit criteria to increase launch opportunities, a launch operator must evaluate all applicable measurements to determine whether the measurements satisfy the criteria. A launch operator may not turn off available instrumentation to create the appearance of meeting a requirement and must use all radar reflectivity measurements within a specified volume for a MRR calculation."*

Likewise, the range documentation has included the definition of the MRR in its list ("the largest radar reflectivity within a specified volume that is associated with an evaluation point"), while replacing the Volume Average Height Integrated Radar Reflectivity (VAHIRR) technique as listed in the current FAA regulations.

In reviewing the description of LLCC changes, it became apparent that these new approaches, if found to be an ELS could likewise be applicable to other federal ranges (e.g., Wallops Flight Facility (NASA), or Reagan Test Site (US Army)), if and when they so choose to adopt these for their respective operations. It should be noted that Vandenberg AFB, as part of the EWR, is already implementing these changes. As such,

any potential finding of ELS for CCAFS operations would be equally applicable to like operations at the other ranges.

Because the updated criteria involves weather, and its potential impact on a launch vehicle's Flight Termination System, a small group of reviewers were included in this reassessment of the range's approach, with regard to the current FAA regulation. The FAA coordinated with USAF and NASA weather teams, reviewed the changes in the LLCC and determined that these changes provide an equivalent level of safety to 14 CFR Part 417, Appendix G (Lightning Flight Commit Criterial):

- The *MRR* is a new technique that can be directly calculated from the radar screen. This technique provides an *equivalent level of safety* as it a radar based technique similar to the VAHIRR technique that allows a launch operator to launch during an anvil cloud or debris cloud is present as long as the calculated value is lower than or equal to the threshold value that was derived for low threat. This method is much simpler to calculate than the VAHIRR and is just as safe.
- The *Thick Cloud layer Rule* change provides additional launch availability, if there is a situation when there is a thick cloud layer but it is showing up as 0dBZ on the radar. The Lightning Advisory Panel has deemed that "a 0 dBZ" reading indicates that it is safe to launch into a thick cloud layer.
- Implementing this change does not result in additional risk but does provide increased launch availability.

Conclusion
The changes made by the 45 WS for the Eastern Range do not impact FAA requirements and provide an equivalent level of safety. As part of the EWR, Vandenberg AFB will update its respective LLCC's to reflect these changes. Also, the updated approaches as described here are easily transferable to any other federal launch range (e.g., Wallops Flight Facility, or Reagan Test Site), if they choose to adopt these approaches for their respective operations. In all instances, the approaches as described by the range do not impact FAA requirements and they do provide an equivalent level of safety.

Formalizing changes to the FAA's Lightning Flight Commit Criteria requires the FAA to initiate a rulemaking activity. The equivalent level of safety evaluation and process will suffice for these and future changes until a rulemaking activity is completed.

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E-04: Regarding Changes to Launch Area Tracking on the Eastern Range

As applied to Launch Site Safety Assessment Matrix Item E-04.

Intent

This report assesses an approach by a federal launch range, for launch vehicle tracking prior to lift-off and up to 3 seconds prior to Minimum Time to Endanger (MTE), and documents the FAA's resulting determination of an *equivalent level of safety* (ELS) in its usage.

Introduction

On 15 January 2015, the Federal Aviation Administration's Office of Commercial Space Transportation (AST) was notified by its Patrick AFB Field Office, of a change in practice on the Eastern Range (ER) located at Cape Canaveral Air Force Station (CCAFS), FL, regarding how it conducts launch area tracking and the effect this change may have on the range being in compliance with FAA requirements concerning flight commit criteria for an expendable launch vehicle that uses a flight safety system.

Current FAA regulations require that an expendable launch vehicle have two tracking sources prior to lift off and no less than one verified tracking source at all times from lift-off to orbital insertion for an orbital launch. A previous modification to this practice by the range was evaluated in October 2012, and had been found to meet the intent of the regulation via an equivalent level of safety.

However, in 2015, the FAA received word that the ER was revising its launch area tracking requirements. This came after an engineering evaluation review of historical GPS metric tracking performance data of the CCAFS pads, which showed acceptable coverage, and the MFCOs determination that with no source at T-0, the Minimum Time to Endanger minus 3-seconds (MTE[1]-3 secs) does not provide sufficient reaction time. Below are the previous and current ER requirements.

Previous: Two tracking sources mandatory by 3 seconds prior to MTE for GPS/TMIG (Global Positioning System/Telemetry Inertial Guidance) equipped vehicles.

[1] **MTE** - *Minimum Time to Endanger* is defined as the first time that a missile has sufficient time to hazard an area outside of the impact limit line. If no sensor has acquired track of the launch vehicle by the MTE, the MFCO is authorized to terminate the flight. MTE is calculated by Range Safety for each launch.

Current: One tracking source mandatory at T-0; two tracking sources mandatory by 3 seconds prior to MTE

The purpose of this review is to document this approach, which was implemented in 2015 by the range, and the resulting determination of an *equivalent level of safety* (ELS) in its usage. Furthermore, this will provide the basis for updating the Launch Site Safety Assessment (LSSA) to reflect this ELS.

Background

Current FAA regulations require that an expendable launch vehicle have two tracking sources prior to lift off and no less than one verified tracking source at all times from lift-off to orbital insertion for an orbital launch.

From 14 CFR § 417.113(c) Flight commit criteria:

"(2) For a launch that uses a flight safety system, the flight-commit criteria must ensure that the flight safety system is ready for flight. This must include criteria for ensuring that:

(iii) The launch vehicle tracking system has no less than two tracking sources prior to lift-off. The launch vehicle tracking system has no less than one verified tracking source at all times from lift-off to orbit insertion for an orbital launch, to the end of powered flight for a suborbital launch; …"

Prior to Air Force Space Command (AFSPC) taking charge of the Eastern Range in 1991, the tracking requirement was for two (2) tracking sources from 3 seconds prior to MTE throughout each phase of powered flight from launch to establishment of the final impact point for launch vehicles with suborbital trajectories or to orbital insertion for space launch vehicles. In 1992, AFSPC changed the standard range tracking requirement to at least two adequate and independent instrumentation data sources is mandatory and shall be maintained from T-0 throughout each phase of powered flight up to the end of Range Safety responsibility

In 2008, Air Force Space Command endorsed the Launch Enterprise Transformation (LET), a way ahead for Evolved Expendable Launch Vehicle (EELV) acquisition and launch range infrastructure. The plan directed transforming launch services acquisition, deploying a range architecture built on GPS Metric Tracking by 2011 and Autonomous Flight Termination by 2018, and finally leveraging Total Force Integration within the Enterprise.

Based on findings from LET, a Fragmentary Order (FRAGO) was implemented in 2010 directing which instrumentation to keep, decommission, mothball or transfer. The result was the loss of a number of radars, all ER metric optics sites and down-range assets at Antigua, Argentia and Ascension. The Ascension radar was not affected by the LET FRAGO due to a support agreement between the US Navy and US Air Force.

In 2012 beacon transponders were removed from Delta IV and Atlas V launch vehicles and replaced with GPS receivers for tracking. Additional tracking was provided via radar

skin track and TMIG as adequate and independent tracking sources. It was at this time the ER transitioned from a two source off the pad to two (2) sources three (3) seconds prior to MTE for GPS/TMIG equipped vehicles. This policy provided greater launch availability with no increase to public safety risk.

Then in Jan 2015, the ER revised its previous policy to allow a launch to proceed with only one tracking source from T-0 through 3 seconds prior to MTE shall be mandatory. Two sources shall be mandatory from 3 seconds prior to MTE to the end of period of Range Safety responsibility. Requiring two tracking sources by 3 seconds prior to the Minimum Time to Endanger (MTE) and one tracking source at T-0 continued to provide acceptable launch availability with no impact to public safety. Additionally, it ensured adequate response time for MFCOs to evaluate late presentation of in-flight data and take appropriate actions to protect public safety and mission assurance.

The Air Force had clarified back to AST then, that the two tracking systems must be 'adequate' and they consider *adequate* to mean that tracking system provides enough support for the Mission Flight Control Officer (MFCO) to make a real-time determination necessary to protect the public, i.e. sufficient information in sufficient time to decide if a mission rule is being violated and to send functions to terminate the vehicle. The Air Force believes that two independent sources of tracking are not required until MTE minus three seconds. There would be no increase to public safety as the MFCO would still have the necessary time and information to contain a vehicle inside the impact limit lines even with a worst case failure scenario. Additional tracking assets would be able to acquire the vehicle by MTE minus three seconds.
An FAA internal meeting took place on 26 September 2012 to discuss the FAA tracking regulation and the ER tracking policy. Attendees included managers from the Office of Commercial Space Transportation (AST), AST safety inspectors, subject matter experts and engineering team members from the Licensing & Evaluation Division and the Safety Inspectors Division. The discussion's focus included tracking adequacy, and independence, radar beacon and skin track, launch vehicle telemetry, precedence and public safety. The conclusion drawn was that the ER tracking policy *met the intent* of §417.113(c)(2)(iii) and posed no increase to public safety. A memorandum was sent on 1 October 2012 to the 45 SW to clarify the FAA's acceptance of the ER tracking policy.

Now, in accordance with 14 CFR §417.1(c), "meets intent" certification:

> *"For a licensed launch from a Federal launch range, a launch operator need not demonstrate to the FAA that an alternative means of satisfying a requirement of this part provides an equivalent level of safety for a launch if written evidence demonstrates that a Federal launch range has, by the effective date of this part [italics added], granted a "meets intent certification," including through "tailoring," that applies to the requirement and that launch. ..."*

The text "*by the effective date of this part*" in the above requirement refers to the "meets intent" evidence being demonstrated to the FAA *no later than the effective date of part 417's publishing* (25 August 2006). So while the term is still used by the Air Force, the use of "meets intent" is, by this text, not in the FAA current parlance. However, the

underlying result is still valid; that is, this practice had demonstrated an *equivalent level of safety* that would satisfy the FAA requirement §417.113(c)(2)(iii).

On 15 January 2016, the Patrick AFB Field Office for AST notified the AST management and subject matter experts in Washington, DC, that the ER is now revising its previous launch area tracking requirements. This comes after an engineering evaluation of historical GPS metric tracking performance off the CCAFS pads, which shows acceptable coverage, and the MFCOs determination that the MTE-3 seconds *does not provide sufficient reaction time.*

Discussion

Whereas the previously determined "meets intent" practice by the range was for two (2) tracking sources to be mandatory by 3 seconds prior to MTE, for GPS/TMIG equipped vehicles; the proposed newer practice is now to have one (1) tracking source mandatory at T-0, and two (2) tracking sources mandatory by 3 seconds prior to MTE. A potential consequence of this change is that at T-0, a loss of one tracking source may mean violation to FAA requirements (the FAA still requires no less than two tracking sources prior to lift-off).

It should be noted that it is not a full reversal to *exactly* the same way as was done prior to the original 2012 range policy, in particular because some of the original range tracking assets used at the time of the original assessment have been retired and some even removed. However, this practice would follow essentially the same tracking requirements as required by the FAA, but with the utilization of different range assets.

The result is that the current practice is actually more conservative than its predecessor that the FAA had previously determined to be an ELS. As such, with a more conservative practice that in the end would result in a safer operation, this proposed change would, like its predecessor be considered a "meets intent", and result in being considered also an *equivalent level of safety*.

Conclusion

The approaches as described by the ER do not impact FAA requirements and provide an *equivalent level of safety*. Formalizing these changes will require the FAA to initiate a rulemaking activity. The equivalent level of safety evaluation and process will suffice for these and future changes until a rulemaking activity is completed.

FAA REVIEW OF
CHANGES TO FEDERAL RANGE CURRENT PRACTICES FOR
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(Revision 0)

E-05: Regarding Flight Safety, Public Risk Criteria (Expected Casualty)

As applied to Launch Site Safety Assessment Matrix Item E-05.

Intent

This report documents the assessment of changes to risk criteria for flight safety, by US Federal Ranges and documents the FAA's rule making leading to a published revision in its launch rules, permitting a determination of an *equivalent level of safety* (ELS) for the range.

Background

In accordance with Air Force Instruction (AFI) 91-217, published 18 February 2010, the Air Force modified its requirements for public risk on Air Force launch ranges for government launches to now be 0.0001 (100×10^{-6}). The direction by that AFI necessitated an amendment to the AFSPCMAN 91-710 (2004), which resulted in its revised requirements no longer being in sync with the then current FAA requirements. The FAA's risk threshold was under 14 CFR § 417.107(b)(1), dated 25 August 2006. The FAA criteria was for the risk associated with the total flight to all members of the public does not exceed an expected average number of 0.00003 casualties ($Ec \leq 30 \times 10^{-6}$) from impacting inert and impacting explosive debris, ($Ec \leq 30 \times 10^{-6}$) for toxic release, and ($Ec \leq 30 \times 10^{-6}$) for far field blast overpressure. Originally, licensed launches with such risks exceeding FAA criteria would require the licensed operator to request a waiver to that requirement.

Discussion

On 20 July 2016, the FAA published a revision to its requirements for risk, where it no longer lags behind AF ranges. The final rule revises the acceptable risk threshold for launch from the previous Ec requirement of 30×10^{-6} for each hazard to an Ec of 1×10^{-4} *for all three hazards combined*. Furthermore, this final rule expresses the revised Ec limit using the correct number of significant digits to properly represent the uncertainty in Ec calculations. This final rule changes the FAA's collective risk limits for launch and reentry to more closely match the Ec standard currently used by the US Air Force and NASA for government missions, and to account for the level of uncertainty that exists in the Ec calculations. The revision with supportive preamble is found in the Federal Register, published on 20 July 2016.
(Link: ***Federal Register/Vol. 81, No. 139/Wednesday, July 20, 2016***).

Conclusion

The Range current practices are now in sync with the FAA's revised requirements, allowing a determination of an Equivalent Level of Safety.

FAA REVIEW OF
CHANGES TO FEDERAL RANGE CURRENT PRACTICES FOR
DETERMINATION OF EQUIVALENT LEVEL OF SAFETY
(Revision 0)

E-##: Future ELS Determinations Will Be Placed Here Over Time

As applied to Launch Site Safety Assessment Matrix Item E-##.

[Placeholder for Additional ELS Determinations of Changes in Federal Range Practices in the Future. This Document will grow along with the LSSA Matrix for which it supports].
