APPENDIX F TO PART 417 [RESERVED]

APPENDIX G TO PART 417—NATURAL AND TRIGGERED LIGHTNING FLIGHT COMMIT CRITERIA

G417.1 GENERAL

For purposes of this section, the requirement for any weather monitoring and measuring equipment needed to satisfy the lightning flight commit criteria limits the equipment to only that which is needed. Accordingly, the equipment could include a ground-based, or airborne field mill, or a weather radar, but may or may not be limited to those items. Certain equipment, such as a field mill, when utilized with the lightning flight commit criteria, may increase launch opportunities because of the ability to verify the electric field in any cloud within 5 nautical miles of the flight path. However, a field mill is not required in order to satisfy the lightning flight commit criteria.

(a) This appendix 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.

(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.

G417.3 DEFINITIONS, EXPLANATIONS AND EXAMPLES

For the purpose of appendix G417:

Anvil cloud means a stratiform or fibrous cloud produced by the upper level outflow or blow-off from thunderstorms or convective clouds.

Associated means that two or more clouds are causally related to the same weather disturbance or are physically connected. Associated does not have to mean occurring at the same time. A cumulus cloud formed locally and a cirrus layer that is physically separated from that cumulus cloud and that is generated by a distant source are not associated, even if they occur over or near the launch point at the same time.

Bright band means an enhancement of radar reflectivity caused by frozen hydrometeors falling and beginning to melt at any altitude where the temperature is 0 degrees Celsius or warmer.

Cloud means a visible mass of water droplets or ice crystals produced by condensation of water vapor in the atmosphere.

Cloud edge means the visible boundary, including the sides, base, and top, of a cloud as seen by an observer. In the absence of a visible boundary as seen by an observer, the 0 dBZ radar reflectivity boundary defines a cloud edge.

Cloud layer means a vertically continuous array of clouds, not necessarily of the same type, whose bases are approximately at the same level.

Cumulonimbus cloud means any convective cloud with any part at an altitude where the temperature is colder than -20 degrees Celsius.

Debris cloud means any cloud, except an anvil cloud, that has become detached from a parent cumulonimbus cloud or thunderstorm, or that results from the decay of a parent cumulonimbus cloud or thunderstorm.

Disturbed Weather means a weather system where dynamical processes destabilize the air on a scale larger than the individual clouds or cells. Examples of disturbed weather include fronts and troughs.

Electric field measurement aloft means the magnitude of the instantaneous vector electric field (E) at a known position in the atmosphere, such as measured by a suitably instrumented, calibrated, and located airborne-field-mill aircraft.

Electric field measurement at the surface of Earth means the 1-minute arithmetic average of the vertical electric field (Ez) at the ground measured by a ground-based field mill. The polarity of the electric field is the same as that of the potential gradient; that is, the polarity of the field at Earth's surface is the same as the dominant charge overhead. An interpolation based on electric field contours is not a measurement for purposes of this appendix.

Field mill is a specific class of electric-field sensor that uses a moving, grounded conductor to induce a time-varying electric charge on one or more sensing elements in proportion to the ambient electrostatic field.

Flight path means the planned normal flight trajectory, including its vertical and horizontal uncertainties to include the sum of the wind effects and the three-sigma guidance and performance deviations.

Moderate precipitation means a precipitation rate of 0.1 inches/hr or a radar reflectivity factor of 30 dBZ.

Nontransparent means cloud cover is nontransparent if (1) forms seen through it are blurred, indistinct, or obscured; or (2) forms are seen distinctly only through breaks in the cloud cover. Clouds with a radar reflectivity factor of 0 dBZ or greater are also nontransparent.

Ohms/Square means the surface resistance in ohms when a measurement is made from

an electrode on one surface extending the length of one side of a square of any size to an electrode on the same surface extending the length of the opposite side of the square. The resistance measured in this way is independent of the area of a square.

Precipitation means detectable rain, snow, hail, graupel, or sleet at the ground; virga, or a radar reflectivity factor greater than 18 dBZ at altitude.

Specified Volume means the volume bounded in the horizontal by vertical plane, perpendicular sides located 5.5 km (3 NM) north, east, south, and west of the point on the flight track, on the bottom by the 0 degree C level, and on the top by the upper extent of all clouds.

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

Thunderstorm means any convective cloud that produces lightning.

Transparent Cloud cover is transparent if objects above, including higher clouds, blue sky, and stars can be distinctly seen from below; or objects, including terrain, buildings, and lights on the ground, can be distinctly seen from above. Transparency is only defined for the visible wavelengths.

Triboelectrification means the transfer of electrical charge from ice particles to the launch vehicle when the ice particles rub the vehicle during impact.

Volume-Averaged, Height-Integrated Radar Reflectivity (units of dBZ-kilometers) means the product of the volume-averaged radar reflectivity and the average cloud thickness within a specified volume relative to a point along the flight track.

Within is a function word used to specify a distance in all directions (horizontal, vertical, and slant separation) between a cloud edge and a flight path. For example, ''within 10 nautical miles of a thunderstorm cloud'' means that there must be a 10 nautical mile margin between every part of a thunderstorm cloud and the flight path.

G417.5 LIGHTNING

(a) A launch operator must not initiate flight for 30 minutes after any type of lightning occurs in a thunderstorm if the flight path will carry the launch vehicle within 10 nautical miles of that thunderstorm.

(b) A launch operator must not initiate flight for 30 minutes after any type of lightning occurs within 10 nautical miles of the flight path unless:

(1) The cloud that produced the lightning is not within 10 nautical miles of the flight path;

(2) There is at least one working field mill within 5 nautical miles of each such lightning flash; and

(3) The absolute values of all electric field measurements made at the Earth's surface within 5 nautical miles of the flight path and at each field mill specified in paragraph (b)(2) of this section have been less than 1000 volts/meter for 15 minutes or longer.

(c) If a cumulus cloud remains 30 minutes after the last lightning occurs in a thunderstorm, section G417.7 applies. Sections G417.9 and G417.11 apply to any anvil or detached anvil clouds. Section G417.13 applies to debris clouds.

G417.7 CUMULUS CLOUDS

For the purposes of this section, ''cumulus clouds'' do not include altocumulus, cirrocumulus, or stratocumulus clouds.

(a) A launch operator must not initiate flight if the flight path will carry the launch vehicle within 10 nautical miles of any cumulus cloud that has a cloud top at an altitude where the temperature is colder than −20 degrees Celsius.

(b) A launch operator must not initiate flight if the flight path will carry the launch vehicle within 5 nautical miles of any cumulus cloud that has a cloud top at an altitude where the temperature is colder than −10 degrees Celsius.

(c) A launch operator must not initiate flight if the flight path will carry the launch vehicle through any cumulus cloud with its cloud top at an altitude where the temperature is colder than −5 degrees Celsius.

(d) A launch operator must not initiate flight if the flight path will carry the launch vehicle through any cumulus cloud that has a cloud top at an altitude where the temperature is between +5 degrees Celsius and −5 degrees Celsius unless:

(1) The cloud is not producing precipitation;

(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

(3) All electric field measurements made at the Earth's surface within 5 nautical miles of the flight path and at each field mill used as required by paragraph (d)(2) of this section have been between −100 volts/meter and +500 volts/meter for 15 minutes or longer.

G417.9 ATTACHED ANVIL CLOUDS

(a) A launch operator must not initiate flight if the flight path will carry the launch vehicle through, or within 10 nautical miles of, a nontransparent part of any attached anvil cloud for the first 30 minutes after the last lightning discharge in or from the parent cloud or anvil cloud.

(b) A launch operator must not initiate flight if the flight path will carry the launch vehicle through, or within 5 nautical miles of, a nontransparent part of any attached anvil cloud between 30 minutes and three hours after the last lightning discharge in or from the parent cloud or anvil cloud unless:

(1) The portion of the attached anvil cloud within 5 nautical miles of the flight path is located entirely at altitudes where the temperature is colder than 0 degrees Celsius; and

(2) The volume-averaged, height-integrated radar reflectivity is less than +33 dBZ-kft everywhere along the portion of the flight path where any part of the attached anvil cloud is within the volume.

(c) A launch operator must not initiate flight if the flight path will carry the launch vehicle through a nontransparent part of any attached anvil cloud more than 3 hours after the last lightning discharge in or from the parent cloud or anvil cloud unless:

(1) The portion of the attached anvil cloud within 5 nautical miles of the flight path is located entirely at altitudes where the temperature is colder than 0 degrees Celsius; and

(2) The volume-averaged, height-integrated radar reflectivity is less than +33 dBZ-kft everywhere along the portion of the flight path where any part of the attached anvil cloud is within the specified volume.

G417.11 Detached Anvil Clouds

For the purposes of this section, detached anvil clouds are never considered debris clouds.

(a) A launch operator must not initiate flight if the flight path will carry the launch vehicle through or within 10 nautical miles of a nontransparent part of a detached anvil cloud for the first 30 minutes after the last lightning discharge in or from the parent cloud or anvil cloud before detachment or after the last lightning discharge in or from the detached anvil cloud after detachment.

(b) A launch operator must not initiate flight if the flight path will carry the launch vehicle within 5 nautical miles of a nontransparent part of a detached anvil cloud between 30 minutes and 3 hours after the time of the last lightning discharge in or from the parent cloud or anvil cloud before detachment or after the last lightning discharge in or from the detached anvil cloud after detachment unless section (1) or (2) is satisfied:

(1) This section is satisfied if all three of the following conditions are met:

(i) There is at least one working field mill within 5 nautical miles of the detached anvil cloud; and

(ii) The absolute values of all electric field measurements at the surface within 5 nautical miles of the flight path and at each field mill specified in (1) above have been less than 1000 V/m for 15 minutes; and

(iii) 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.

(2) This section is satisfied if both of the following conditions are met:

(i) The portion of the detached anvil cloud within 5 nautical miles of the flight path is located entirely at altitudes where the temperature is colder than 0 degrees Celsius; and

(ii) The volume-averaged, height-integrated radar reflectivity is less than +33 dBZ-kft everywhere along the portion of the flight path where any part of the detached anvil cloud is within the specified volume.

(c) A launch operator must not initiate flight if the flight path will carry the launch vehicle through a nontransparent part of a detached anvil cloud unless Section (1) or (2) is satisfied.

(1) This section is satisfied if both of the following conditions are met:

(i) At least 4 hours have passed since the last lightning discharge in or from the detached anvil cloud; and

(ii) At least 3 hours have passed since the time that the anvil cloud is observed to be detached from the parent cloud.

(2) This section is satisfied if both of the following conditions are met.

(i) The portion of the detached anvil cloud within 5 nautical miles of the flight path is located entirely at altitudes where the temperature is colder than 0 degrees Celsius; and

(ii) The volume-averaged, height-integrated radar reflectivity is less than +33 dBZ-kft everywhere along the portion of the flight path where any part of the detached anvil cloud is within the specified volume.

G417.13 Debris Clouds

(a) A launch operator must not initiate flight if the flight path will carry the launch vehicle through any nontransparent part of a debris cloud for 3 hours after the debris cloud is observed to be detached from the parent cloud or after the debris cloud is observed to have formed from the decay of the parent cloud top to an altitude where the temperature is warmer than −10 degrees Celsius. The 3-hour period must begin again at the time of any lightning discharge in or from the debris cloud.

(b) A launch operator must not initiate flight if the flight path will carry the launch vehicle within 5 nautical miles of a nontransparent part of a debris cloud during the 3-hour period defined in paragraph (a) of this section, unless:

(1) There is at least one working field mill within 5 nautical miles of the debris cloud;

(2) The absolute values of all electric field measurements at the Earth's surface within 5 nautical miles of the flight path and measurements at each field mill employed required by paragraph (b)(1) of this section

have been less than 1000 volts/meter for 15 minutes or longer; and

(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 or longer.

G417.15 Disturbed Weather

(a) A launch operator must not initiate flight if the flight path will carry the launch vehicle through a nontransparent cloud associated with disturbed weather that has clouds with cloud tops at altitudes where the temperature is colder than 0 degrees Celsius and that contains, within 5 nautical miles of the flight path:

(1) Moderate or greater precipitation; or

(2) Evidence of melting precipitation such as a radar bright band.

G417.17 Thick Cloud Layers

(a) A launch operator must not initiate flight if the flight path will carry the launch vehicle through a nontransparent part of a cloud layer that is:

(1) Greater than 4,500 feet thick and any part of the cloud layer along the flight path is located at an altitude where the temperature is between 0 degrees Celsius and −20 degrees Celsius; or

(2) Connected to a thick cloud layer that, within 5 nautical miles of the flight path, is greater than 4,500 feet thick and has any part located at any altitude where the temperature is between 0 degrees Celsius and −20 degrees Celsius.

(b) A launch operator need not apply the lightning commit criteria in paragraphs (a)(1) and (a)(2) of this section if the thick cloud layer is a cirriform cloud layer that has never been associated with convective clouds, is located only at temperatures of −15 degrees Celsius or colder, and shows no evidence of containing liquid water.

G417.19 Smoke Plumes

(a) A launch operator must not initiate flight if the flight path will carry the launch 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 be detached from the smoke plume.

(b) Section G417.7 applies to cumulus clouds that have formed above a fire but have been detached from the smoke plume for more than 60 minutes.

G417.21 Surface Electric Fields

(a) A launch operator must not initiate flight for 15 minutes after the absolute value of any electric field measurement at the Earth's surface within 5 nautical miles of the flight path has been greater than 1500 volts/meter.

(b) A launch operator must not initiate flight for 15 minutes after the absolute value of any electric field measurement at the Earth's surface within 5 nautical miles of the flight path has been greater than 1000 volts/meter unless:

(1) All clouds within 10 nautical miles of the flight path are transparent; or

(2) All nontransparent clouds within 10 nautical miles of the flight path have cloud tops at altitudes where the temperature is warmer than +5 degrees Celsius and have not been part of convective clouds that have cloud tops at altitudes where the temperature is colder than −10 degrees Celsius within the last 3 hours.

G417.23 Triboelectrification

(a) A launch operator must not initiate flight if the flight path will go through any part of a cloud at an altitude where the temperature is colder than −10 degrees Celsius up to the altitude at which the launch vehicle's velocity exceeds 3000 feet/second; unless

(1) The launch vehicle is ''treated'' for surface electrification; or

(2) A launch operator demonstrates by test or analysis that electrostatic discharges on the surface of the launch vehicle caused by triboelectrification will not be hazardous to the launch vehicle or the spacecraft.

(b) A launch vehicle is treated for surface electrification if

(1) All surfaces of the launch vehicle susceptible to ice particle impact are such that the surface resistivity is less than 10^9 ohms/square; and

(2) All conductors on surfaces (including dielectric surfaces that have been treated with conductive coatings) are bonded to the launch vehicle by a resistance that is less than 10^5 ohms.

Appendix H to Part 417 [Reserved]

Appendix I to Part 417—Methodologies for Toxic Release Hazard Analysis and Operational Procedures

I417.1 General

This appendix provides methodologies for performing toxic release hazard analysis for the flight of a launch vehicle as required by §417.229 and for launch processing at a launch site in the United States as required by §417.407(f). The requirements of this appendix apply to a launch operator and the launch operator's toxic release hazard analysis unless the launch operator clearly and convincingly demonstrates that an alternative approach provides an equivalent level of safety.