§ 417.207   Trajectory analysis.

(a) *General.* A flight safety analysis must include a trajectory analysis that establishes:

(1) For any time after lift-off, the limits of a launch vehicle's normal flight, as defined by the nominal trajectory and potential three-sigma trajectory dispersions about the nominal trajectory.

(2) A fuel exhaustion trajectory that produces instantaneous impact points with the greatest range for any given time after liftoff for any stage that has the potential to impact the Earth and does not burn to propellant depletion before a programmed thrust termination.

(3) For launch vehicles flown with a flight safety system, a straight-up trajectory for any time after lift-off until the straight-up time that would result if the launch vehicle malfunctioned and flew in a vertical or near vertical direction above the launch point.

(b) *Trajectory model.* A final trajectory analysis must use a six-degree of freedom trajectory model to satisfy the requirements of paragraph (a) of this section.

(c) *Wind effects.* A trajectory analysis must account for all wind effects, including profiles of winds that are no less severe than the worst wind conditions under which flight might be attempted, and must account for uncertainty in the wind conditions.

§ 417.209   Malfunction turn analysis.

(a) *General.* A flight safety analysis must include a malfunction turn analysis that establishes the launch vehicle's turning capability in the event of a malfunction during flight. A malfunction turn analysis must account for each cause of a malfunction turn, such as thrust vector offsets or nozzle burn-through. For each cause of a malfunction turn, the analysis must establish the launch vehicle's turning capability using a set of turn curves. The analysis must account for:

(1) All trajectory times during the thrusting phases of flight.

(2) When a malfunction begins to cause each turn throughout the thrusting phases of flight. The analysis must account for trajectory time intervals between malfunction turn start times

that are sufficient to establish flight safety limits and hazard areas that are smooth and continuous.

(3) The relative probability of occurrence of each malfunction turn of which the launch vehicle is capable.

(4) The time, as a single value or a probability time distribution, when each malfunction turn will terminate due to vehicle breakup.

(5) What terminates each malfunction turn, such as, aerodynamic breakup or inertial breakup.

(6) The launch vehicle's turning behavior from the time when a malfunction begins to cause a turn until aerodynamic breakup, inertial breakup, or ground impact. The analysis must account for trajectory time intervals during the malfunction turn that are sufficient to establish turn curves that are smooth and continuous.

(7) For each malfunction turn, the launch vehicle velocity vector turn angle from the nominal launch vehicle velocity vector.

(8) For each malfunction turn, the launch vehicle velocity turn magnitude from the nominal velocity magnitude that corresponds to the velocity vector turn angle.

(9) For each malfunction turn, the orientation of the launch vehicle longitudinal axis measured relative to the nominal launch vehicle longitudinal axis or Earth relative velocity vector at the start of the turn.

(b) *Set of turn curves for each malfunction turn cause.* For each cause of a malfunction turn, the analysis must establish a set of turn curves that satisfies paragraph (a) of this section and must establish the associated envelope of the set of turn curves. Each set of turn curves must describe the variation in the malfunction turn characteristics for each cause of a turn. The envelope of each set of curves must define the limits of the launch vehicle's malfunction turn behavior for each cause of a malfunction turn. For each malfunction turn envelope, the analysis must establish the launch vehicle velocity vector turn angle from the nominal launch vehicle velocity vector. For each malfunction turn envelope, the analysis must establish the vehicle velocity turn magnitude from the nominal velocity magnitude that