

## Appendix A. Failure Response Modes in Program DAMP

In program DAMP, no attempt is made to model vehicle behavior for failure of specific systems and components. A list of such failures and possible behaviors for any vehicle would be extensive, and variations from vehicle to vehicle would complicate the modeling process, or make it almost impossible. Instead, failure *responses* are modeled in DAMP without regard to the specific failure that causes the response. There are only six possible response modes in DAMP, five for failures, and one to model the behavior of a normal vehicle. The six vehicle-response modes are described in layman's language as follows; technical descriptions are provided in Ref. [1].

**Mode 1:** Vehicle topples over or falls back on the launch point after a rise of, at most, a few feet. Propellants deflagrate or explode with some assumed TNT equivalency.

**Mode 2:** Vehicle loses control at or shortly after liftoff, with all flight directions equally likely. Destruct is transmitted as soon as erratic flight is confirmed, usually no later than six to twelve seconds after launch. For each vehicle, a latest destruct time is established that is used in computing the maximum impact distance for pieces, given that a Mode-2 response has occurred.

**Mode 3:** Vehicle fails to pitch-program normally, producing near-vertical flight while thrusting at normal levels. Vehicle may tumble rapidly out of control at any point during vertical flight resulting in spontaneous breakup, or may be destroyed when destruct criteria are violated. The mode is terminated by destruct action if the vehicle reaches the so-called "straight-up" time without programming. This time varies with launch vehicle and with mission, but usually occurs (at Cape Canaveral Air Station) between 30 and 70 seconds after launch.

**Mode 4:** Vehicle flies within normal limits until some malfunction terminates thrust, causes spontaneous breakup, or results in destruct by flight-control personnel. Breakup may or may not be preceded by a rapid tumble while the vehicle is still thrusting but, in any event, vehicle debris and components impact near the intended flight line.

**Mode 5:** Vehicle may impact in any direction from the launch point within its range capability. At any range, impacts are most likely to occur along the flight line, becoming less likely as the angular deviation from the flight line increases. As the impact range increases, weighting is progressively increased to favor the downrange direction. In any fixed direction, the impact probability decreases as the impact range increases. Flight may terminate spontaneously due to complete loss of vehicle stability or because of destruct action. Outside the launch area, any malfunction with the potential to cause a substantial deviation from the intended flight direction is classified as a Mode-5 failure response. By definition, Mode-5