relative probabilities of occurrence for all failure-response modes for these vehicles, LLV1, and other new launch systems.

Although it may be reasonable to establish the relative probability of occurrence of a Mode-5 failure response by empirical means, the number of Mode-5 failures is too small to have any hope of establishing accurate values for the shaping constants from this sample alone. Inadequate descriptions of vehicle behavior in the available historical records and uncertainty in impact location following a malfunction add to the difficulty of classifying failure responses. In view of the limited data available for vehicles that have experienced Mode-5 failures, the values chosen for the Mode-5 constants must depend on simulations of vehicle behavior following failure.

2. Examples Showing Need for Mode 5

The need for a Mode-5 response or some similar response mode (or a multiplicity of other response modes) can be seen from the following vehicle performance descriptions extracted from Appendix D:

(1) Atlas 8E, 24 Jan 61. Missile stability was lost at about 161 seconds, some 30 seconds after BECO, probably due to failure of the servo-amplifier power supply. The sustainer engine shut down at 248 seconds, and the vernier engines about 10 seconds later. Impact occurred 1316 miles downrange and 215 miles crossrange.

(2) Titan M-4, 6 Oct 61. A one-bit error in the W velocity accumulation caused impact 86 miles short and 14 miles right of target.

(3) Atlas 145D (Mariner R-1), 22 July 62. Booster stage and flight appeared normal until after booster staging at guidance enable at about 157 seconds. Operation of guidance rate beacon was intermittent. Due to this and faulty guidance equations, erroneous guidance commands were given based on invalid rate data. Vehicle deviations became evident at 172 seconds and continued throughout flight with a maximum yaw deviation of 60° and pitch deviation of 28° occurring at 270 seconds. The vehicle deviated grossly from the planned trajectory in azimuth and velocity, and executed abnormal maneuvers in pitch and yaw. The missile was destroyed by the RSO at 293.5 seconds, some 12 seconds after SECO.

(4) Atlas SLV-3 (GTA-9), 17 May 66. Vehicle became unstable when B2 pitch control was lost at 121 seconds. Loss of pitch control resulted in a pitch-down maneuver much greater than 90°. Guidance control was lost at 132 seconds. After BECO, the vehicle stabilized in an abnormal attitude. Although the vehicle did not follow the planned trajectory, SECO (at 280 seconds), VECO (at 298 seconds), and Agena separation occurred normally from programmer commands.

(5) Atlas 95F (ABRES/AFSC), 3 May 68. Immediately after liftoff the telemetered roll and yaw rates indicated that the missile was erratic. During the first 10 seconds of flight the missile yawed hard to the left. It then began a hard yaw to the right,