Table 6. Failure Probabilities for Atlas, Delta, and Titan

	Predicted Failure Probability *	
Vehicle	Flight Phase 0 - 1	Flight Phase 0 - 2
Atlas	0.022	0.031
Delta	0.010	0.013
Titan	0.040	0.064

* Exponential filter with F = 0.98

For Delta, the predicted failure probabilities shown in Table 2 for flight-phases 0 - 1 and 0 - 2 are the same, since no second-stage failure has occurred in the 125 flights included in the representative sample. Obviously, this does not mean that the probability of a Delta second-stage failure is zero. As stated earlier, the choice of F is a judgment matter with the most reasonable range for F considered to be $0.97 \leq F \leq 0.99$. To show a difference in failure probabilities between Delta flight phases, a value of F = 0.98 has been used for flight phases 0 - 1, and 0.99 for flight phases 0 - 2. It is an interesting coincidence that the same value of 0.013 is obtained using F = 0.98 and all Delta configurations (see Table 3). Another way to estimate the Delta second-stage failure probability is to calculate an upper confidence limit at some suitable level for an event that has occurred zero times in 125 trials. At the 80% confidence level, the reliability is at least 0.987, so the failure probability during second-stage burn (flight phases 1.5 - 2) is no bigger than 0.013.

5.2 Relative and Absolute Probabilities for Response Modes

For Atlas, Delta, and Titan vehicles, failure-response Modes 1, 2, and 3 are much less likely to occur than Modes 4 and 5. Since the probabilities of occurrence for the less-likely modes may be only one in a thousand or less, such responses may not have occurred at all in the flight tests of representative configurations. In fact, in the combined samples for Atlas, Delta, and Titan, only 16 failures have occurred during flights phases 0 - 2. None of the 16 resulted in response-modes 1, 2, or 3. Because of the small number of failures in the representative configuration samples, the relative probabilities of occurrence for Modes 1 through 5 have been estimated using results from all vehicle configurations and launches shown in Appendix D. The rationale for this approach is that, except for obvious problems that have been corrected, other changes made through the years to improve vehicle reliability have reduced the probabilities of occurrence of all response modes more or less proportionally. The greater significance of more recent vehicle modifications and test results is accounted for by using an exponential filter to estimate overall failure probabilities. Thus, if Mode-1 failures occurred more frequently in the distant past than in recent years, the weighting process reduces the significance of the earlier Mode-1 responses in the relative probability-of-occurrence calculations. As tabulated from Appendix D, the number (count) of failures by response mode and flight phase for Atlas, Delta, Titan, and Eastern-Range Thor launches are given in Table 7 through Table 10. Thor launches