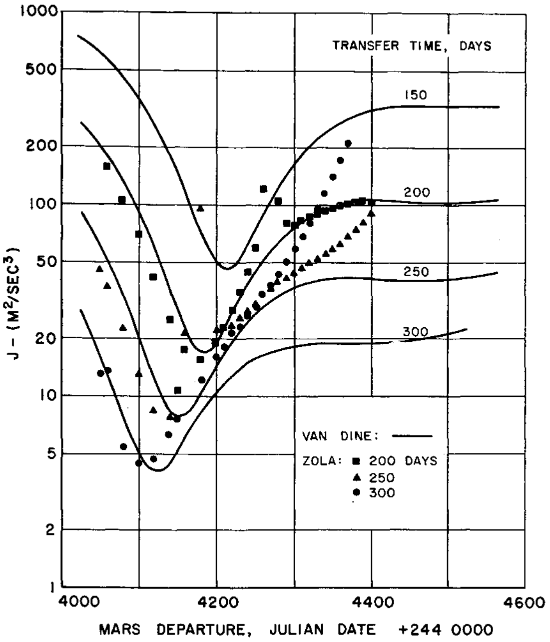

Fig. 2 Zola's results (data points) compared to Van Dine's for 1980 Mars to Earth trips.

This ridge effect was encountered in other trajectories when the same comparisons were made. Figure 2 compares the length method against Van Dine's results for Mars to Earth trips in 1980. At a trip time of 200 days, and neglecting the ridge effect, Zola's data agree rather well with Van Dine's results. The agreement, however, breaks down at the 250-day trip time, especially for trips departing from Mars after the minimum-J departure date.

The discrepancy between the results in Zola's comment and that presented here is the fact that Zola's data are based on circular, coplanar, planetary orbits. Under these conditions Zola's data agree with Melbourne's corresponding results up to about the Hohmann transfer time. It is of interest to note that by comparing three-dimensional J's against those from circular, coplanar assumptions, the values differ by about a factor of 2. This gives rise to the question of the factor $\frac{1}{2}$ in the definitions for J.

Furthermore, these differences point up the problem of using circular, coplanar-based impulsive-thrust data to estimate low-thrust trajectory requirements which, consequently, do not necessarily represent any particular opposition year. This problem is indicated in Fig. 3 wherein the circular, coplanar curve is bracketed by the three-dimensional data from

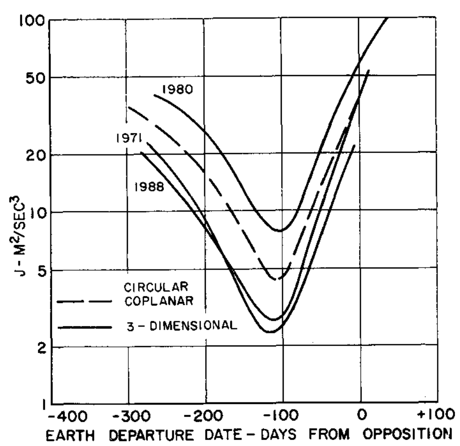

Fig. 3 Comparison of J requirements resulting from circular, coplanar orbits and three-dimensional planetary orbits; 250-day Earth-Mars trips.

the 1971, 1980, and 1988 oppositions. For analyses in which the opposition year effects are not important, the circular, coplanar data are quite useful. Obviously, if the year of launch is important, the reference-mode data should reflect this. Between 1971 and 1980, the J requirements can change by about a factor of 3.

As Zola indicates, the primary purpose of the length method is to aid in the evaluation of constant-specific impulse, low-thrust systems. For these evaluations, high-thrust data, whether from circular, coplanar trajectories or from SP-35, are not desirable reference-mode solutions for the reasons shown here and in Ref. 3. This is particularly true for round-trip missions if one leg has a launch date and a trip time much different from that permitted by the accuracy of the characteristic-length technique (e.g., see Fig. 2).

If quantities of variable-thrust data are available as reference-mode solutions, Zola's technique is quite helpful in estimating constant-thrust performance (Mars and Venus missions). Under these circumstances, it is a most efficient means of generating approximate trajectory data and of performing mission studies.

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[4] *Planetary Flight Handbook,* NASA SP-35 (August 1963).

Comment on "A Method for Calculating Parachute Opening Forces for General Deployment Conditions"

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FIVE comments are offered here on Jamison's recent article[1] (equation numbers and nomenclature the same as Jamison's):

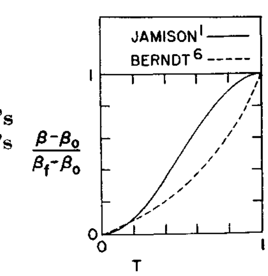
1) Jamison does not appear to be acquainted with Pounder's work,[2] which remains the most thorough and rational treatment yet available on the problems of parachute inflation and opening shock.

2) Jamison assumes that the diameter vs time relationship is

$$\beta = a + bT + cT^2 + dT^3 \tag{13}$$

with boundary conditions $\beta(0) = \beta_0$, $\beta(1) = \beta_f$, $\dot{\beta}(0) =$

Fig. 1 Comparison of Jamison's opening function with Berndt's experimental data.



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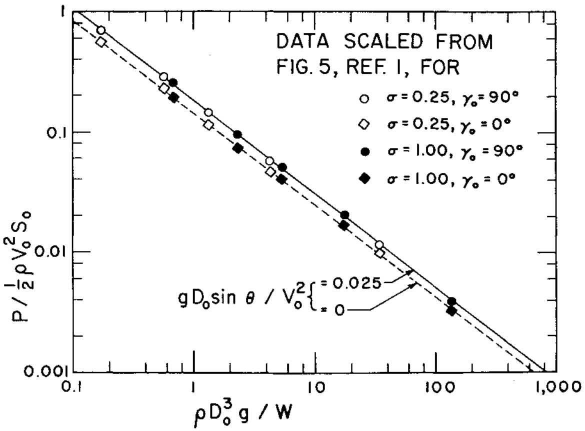

Fig. 2 Jamison's opening force data presented in terms of Euler number, effective Froude number, and mass ratio.

$\dot{\beta}(1) = 0$. These assumptions result in the opening function

$$(\beta - \beta_0)/(\beta_f - \beta_0) = 3T^2 - 2T^3$$

which is shown in Fig. 1 of this comment.

The aforementioned opening function appears satisfactory for a 3-ft-diam chute tested in a wind tunnel.[3] However, it does not agree with other scale-model-chute wind-tunnel test data[2] nor with full-scale flight-test data.[4–6] Berndt's flight-test data for 28-ft-diam chutes are shown in Fig. 1 for comparison.

3) He also assumes that "system velocity at the end of inflation is approximately 30% higher than the system steady-state velocity." This assumption does not appear valid for the wide range of deployment conditions to which the analysis is supposed to apply.

4) Jamison presents opening force data in terms of four variables: canopy loading (W/S_0), earth g's (P/W), initial flightpath angle (γ_0), and atmosphere density ratio (σ). However, the data can better be presented in terms of three dimensionless parameters: Euler number ($P/0.5\rho V_0^2S_0$), "effective" Froude number ($gD_0 \sin\gamma_0/V_0^2$), and "mass ratio" ($\rho D_0^3g/W$).[7] That such is the case is demonstrated in Fig. 2 of this comment, which replots Jamison's data in terms of these parameters. The reader may wish to compare Jamison's Fig. 5 and this comment's Fig. 2 (which both contain the same data) with the experimental data in Fig. 2 of Ref. 7.

5) Jamison also presents filling time (t_f) as a function of (W/S_0), γ_0, and σ, i.e., again a total of four variables. Filling time data can better be presented in terms of three dimensionless parameters: "distance ratio" (V_0t_f/D_0), effective Froude number, and mass ratio.

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