Table 3 Effect of various terms (transonic flights, shots 81 and 82)

	Cases		
	1	2	3
$C_{\ell_{p+}}$	-30.41	-10.39	-18.29
$C_{\ell_{p-}}$	-30.41	-10.39	-18.29
$C_{\ell_{0V}}$	0	-0.31×10^{-3}	-0.41×10^{-3}
$C_{\ell_{0V^2}}$	0	0	-0.21×10^{-5}
$C_{\ell_{pV}}$	0	0	0
$C_{\ell_{\gamma\bar{\alpha}^2}}$	-0.200	-0.002	-0.810
PE-ϕ	132	4.40	1.27

N.B. C_{ℓ_0} term was allowed to be unique for each flight (see below): shot 81 = -0.045; shot 82 = 0.016.

highest roll damping derivative, $C_{\ell_{p+}} = -20.39$, exists when the fins are cupped into the directon of roll. Also, note that the quality of fit (note PE-ϕ for case 2) is excellent and the listed probable errors are equivalent to the expected measurement precision. The remaining cases (3 and 4) demonstrate the effect of $C_{\ell_{0V}}$ and $C_{\ell_{pV}}$, respectively, on the theoretical fit. Neither of these terms significantly improved or altered the quality of fit.

The two transonic flights (shots 81 and 82) that were reanalyzed during the present investigation were at Mach numbers of 1.028 and 1.092, and both were rolling in the counterclockwise direction. These flights were also fitted using the modified moment expansion, Eq. (2), and the results are shown in Table 3. Case 1 of this table is similar to the original expansion used in Ref. 1, and the quality of fit (PE-ϕ = 132) is very poor, demonstrating that additional terms in the moment expansion are required. Case 2 is similar to case 1 with the addition of the $C_{\ell_{0V}}$ term. This term significantly improved the quality of fit (PE-ϕ = 4.40); however, the probable error is still three times larger than the measuring accuracy associated with these models. The fit represented by case 3 included the quadratic velocity term $C_{\ell_{0V^2}}$ in addition to the other terms, and the associated probable error is consistent with the expected measurement precision (PE-ϕ = 1.27). Also note that C_{ℓ_p} for this case ($C_{\ell_p} = -18.29$) falls between $C_{\ell_{p+}}$ and $C_{\ell_{p-}}$, as determined from the subsonic flights. Since both models were rolling in the counterclockwise direction, the unique values for $C_{\ell_{p+}}$ and $C_{\ell_{p-}}$ could not be determined.

All attempts to reanalyze the measured roll profiles of the two supersonic flights (shots 87 and 88) were unsuccessful. As noted previously, both these flights were near the classic pitch-roll resonant condition ($P/\omega_N \approx 1.0$), and for this condition the angular and rolling motions are strongly coupled. Since the analysis technique used herein assumed that the motions could be decoupled and fitted separately, this may be the cause of the failure to fit the two supersonic flights adequately.

Concluding Remarks

A modified expansion for the rolling moment coefficient has been developed and was used successfully in fitting experimental flight data for a wraparound fin configuration. It is believed that the results obtained at the subsonic and transonic conditions add significantly to the understanding of the rolling motions associated with these configurations. These results indicate that different values of the roll damping derivative C_{ℓ_p} exist, depending on the direction of spin and also that the roll driving moment C_{ℓ_0} is a strong function of velocity throughout the transonic regime.

References

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• "Optimal Multiple-Impulse Time-Fixed Rendezvous Between Circular Orbits," Vol. 9, No. 1, 1986, pp. 17-22. In Fig. 4 on p. 19 the number of impulses for the $\beta = 0$ and TIME = 0.4 case should be labelled as 2 rather than 3. The case of $\beta = 270$ does require 3 impulses as indicated.