Errata

Effect of Mass Asymmetry on Ballistic Match of Projectiles

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[JSR 13, 757-760 (1976)]

IN the above Engineering Note, the author has discovered an error which concerns the effect of lateral cg-offset-induced trim angle on the magnitude of the first maximum yaw. Lateral cg offset does contribute to the trim angle K_3 as indicated in the note; however, it also produces an initial rate of change of total angle of attack ($\dot{\xi}_0$) which acts to cancel much of the effect that the cg-offset-induced trim has on first maximum yaw. As indicated below, this makes cg-offset-induced trim much less effective in inducing initial yawing motion than an equivalent principal-axis misalignment-induced trim.

For the following development, it is assumed that within the gun tube the projectile is constrained to rotate about its axis of geometric symmetry and not about an axis through its cg. Therefore, assuming the total lateral rate and $\xi_0 = 0$ when the projectile exits the tube and negligible effects of gravity,

$$\dot{\xi}_0 \approx (p^2 y_{cg}/U) + i(p^2 z_{cg}/U)$$

Substituting this result and the expression for K_3 into Eqs. (3) and (4) of the above note, and ignoring the effects of damping and the contributions of K_4, the corrected forms of Eqs. (5) and (6) become

$$K_1 \approx \frac{-(\delta_\beta + i\delta_\alpha)(I/I_X) + (K_3/2)[1-\sqrt{1-1/S_g}]}{\sqrt{1-1/S_g}}$$

$$\approx \frac{-(\delta_\beta + i\delta_\alpha)(I/I_X)}{\sqrt{1-1/S_g}}$$

$$K_2 \approx \frac{(\delta_\beta + i\delta_\alpha)(I/I_X) - (K_3/2)[1+\sqrt{1-1/S_g}]}{\sqrt{1-1/S_g}}$$

$$\approx \frac{(\delta_\beta + i\delta_\alpha)(I/I_X)}{\sqrt{1-1/S_g}}$$

where

$$K_3 = (\delta_\beta + pz_{cg}/U) + i(\delta_\alpha - py_{cg}/U)$$

As indicated above, the principal-axis misalignment angles δ_α and δ_β experience large magnification in K_1 and K_2 even for large S_g. The approximate magnification factor given above and in Fig. 1 of the note is never smaller than I/I_X. The magnification of cg-offset-induced trim in K_1 and K_2 can become large only for $S_g \rightarrow 1$; i.e., lateral cg-offset contributions to first maximum yaw are only important for marginal gyroscopic stability conditions. For equivalent levels of cg-offset-induced and principal-axis misalignment-induced trim angle, the contribution of cg-offset-induced trim to first maximum yaw is negligible in comparison to that of principal-axis misalignment.

Therefore, the discussion in the note under the sub-heading "6-DOF Simulations" is concerned with the effects of principal axis misalignment and not with the total K_3 as indicated. Since the initial condition $\xi_0 = \dot{\xi}_0 = 0$ was used, the results of the 6-DOF simulations presented in Figs. 2 and 3 likewise are for principal-axis misalignment and not for total K_3 as indicated. The summation under the subheading "Conclusions" is basically correct except that it should be noted that contributions to first maximum yaw resulting from cg-offset-induced trim angle are large only for a marginal gyroscopic stability condition.

Received Jan. 5, 1977.
Index categories: LV/M Dynamics, Uncontrolled; LV/M Trajectories.

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