JOURNAL OF GUIDANCE, CONTROL, AND DYNAMICS
Vol. 31, No. 6, November–December 2008

Erratum

Flight Dynamics and Hybrid Adaptive Control of Damaged Aircraft

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[*J. Guidance*, 31(3), pp. 751–764 (2008)]

DOI: 10.2514/1.39924

Some equations in this article, first printed in the May–June 2008 issue of the *Journal of Guidance, Control, and Dynamics*, are incorrect. The derivation of Eq. (11) is incorrect, and the effect of gravity was not included in Eqs. (12), (13), (14), (31), and (36). This error was realized after the article was printed.

The corrected equations are printed below.

IN THE article titled "Flight Dynamics and Hybrid Adaptive Control of Damaged Aircraft" in *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 31, No. 3, pp. 751–764 [1], the derivation of the moment equation, Eq. (11), is incorrect. The equation as written applies to a fixed point in an inertial reference frame, whereas the reference point O is stationary in the body-fixed reference frame, which is not fixed in Earth's inertial coordinate system [2]. Thus, the effect of the velocity at point O needs to be accounted for. Furthermore, the effect of gravity was not included. As a result, Eqs. (12–14) and Eqs. (31–36) are also affected.

The correct moment equations that replace Eqs. (11–14) are

$$\begin{aligned}\mathbf{M} &= \frac{\mathrm{d}\mathbf{H}_B}{\mathrm{d}t} + \omega \times \mathbf{H}_B + m\mathbf{v} \times (\omega \times \Delta\mathbf{r}) - \Delta\mathbf{r} \times \mathbf{W} \\ &= \mathbf{I}\dot{\omega} + \Delta\dot{\mathbf{I}}\omega + m\Delta\mathbf{r} \times \dot{\mathbf{v}} + m\Delta\dot{\mathbf{r}} \times \mathbf{v} + \Delta\dot{m}\Delta\mathbf{r} \times \mathbf{v} + \omega \\ &\quad \times \mathbf{I}\omega + m\omega \times (\Delta\mathbf{r} \times \mathbf{v}) + m\mathbf{v} \times (\omega \times \Delta\mathbf{r}) - \Delta\mathbf{r} \times \mathbf{W} \qquad (11)\end{aligned}$$

$$\begin{aligned}L &= I_{xx}\dot{p} - I_{xy}\dot{q} - I_{xz}\dot{r} + I_{xy}pr - I_{xz}pq + (I_{zz} - I_{yy})qr \\ &\quad + I_{yz}(r^2 - q^2) + m(\dot{w} - qu + pv - g\cos\theta\cos\phi)\Delta y \\ &\quad - m(\dot{v} + ru - pw - g\cos\theta\sin\phi)\Delta z \qquad (12)\end{aligned}$$

$$\begin{aligned}M &= -I_{xy}\dot{p} + I_{yy}\dot{q} - I_{yz}\dot{r} + I_{yz}pq - I_{xy}qr + (I_{xx} - I_{zz})pr \\ &\quad + I_{xz}(p^2 - r^2) - m(\dot{w} - qu + pv - g\cos\theta\cos\phi)\Delta x \\ &\quad + m(\dot{u} - rv + qw + g\sin\theta)\Delta z \qquad (13)\end{aligned}$$

$$\begin{aligned}N &= -I_{xz}\dot{p} - I_{yz}\dot{q} + I_{zz}\dot{r} + I_{xz}qr - I_{yz}pr + (I_{yy} - I_{xx})pq \\ &\quad + I_{xy}(q^2 - p^2) + m(\dot{v} + ru - pw - g\cos\theta\sin\phi)\Delta x \\ &\quad - m(\dot{u} - rv + qw + g\sin\theta)\Delta y \qquad (14)\end{aligned}$$

where $\Delta\mathbf{r} = [\,\Delta x \quad \Delta y \quad \Delta z\,]^T$ is defined as a vector from point O to the c.g.

Consequently, Eqs. (31–36) are to be revised as

$$\begin{aligned}&\bar{I}_{xx}\dot{p} - \bar{I}_{xy}\dot{q} - \bar{I}_{xz}\dot{r} + \bar{I}_{xy}pr - \bar{I}_{xz}pq + (\bar{I}_{zz} - \bar{I}_{yy})qr \\ &\quad + \bar{I}_{yz}(r^2 - q^2) = (C_l^* + \Delta\bar{C}_l)QSb \qquad (31)\end{aligned}$$

$$\begin{aligned}&-\bar{I}_{xy}\dot{p} + \bar{I}_{yy}\dot{q} - \bar{I}_{yz}\dot{r} + \bar{I}_{yz}pq - \bar{I}_{xy}qr + (\bar{I}_{xx} - \bar{I}_{zz})pr \\ &\quad + \bar{I}_{xz}(p^2 - r^2) = (C_m^* + \Delta\bar{C}_m)QS\bar{c} + \delta_T T_{\max}(z_e - z_0) \qquad (32)\end{aligned}$$

$$\begin{aligned}&-\bar{I}_{xz}\dot{p} - \bar{I}_{yz}\dot{q} + \bar{I}_{zz}\dot{r} + \bar{I}_{xz}qr - \bar{I}_{yz}pr + (\bar{I}_{yy} - \bar{I}_{xx})pq \\ &\quad + \bar{I}_{xy}(q^2 - p^2) = (C_n^* + \Delta\bar{C}_n)QSb + \delta_T T_{\max}y_0 \qquad (33)\end{aligned}$$

$$\Delta\bar{C}_l = \Delta C_l + C_y\frac{\Delta z}{b} - C_z\frac{\Delta y}{b} \qquad (34)$$

$$\Delta\bar{C}_m = \Delta C_m - C_x\frac{\Delta z}{\bar{c}} + C_z\frac{\Delta x}{\bar{c}} \qquad (35)$$

$$\Delta\bar{C}_n = \Delta C_n + C_x\frac{\Delta y}{b} - C_y\frac{\Delta x}{b} \qquad (36)$$

As a result, the vector of the trim parameters is redefined as $\sigma = [\,\Delta\alpha \quad \Delta\beta \quad \Delta\delta_T\,]^T$, which results in the following changes in the system matrices:

$$\mathbf{f}_2^* = QS\begin{bmatrix} C_{l,\alpha}^* b & C_{l,\beta}^* b & 0 \\ C_{m,\alpha}^*\bar{c} + \frac{\delta_T T_{\max,\alpha}(z_e - z_0)}{QS} & C_{m,\beta}^*\bar{c} + \frac{\delta_T T_{\max,\beta}(z_e - z_0)}{QS} & \frac{T_{\max}(z_e - z_0)}{QS} \\ C_{n,\alpha}^* b + \frac{\delta_T T_{\max,\alpha}y_0}{QS} & C_{n,\beta}^* b + \frac{\delta_T T_{\max,\beta}y_0}{QS} & \frac{T_{\max}y_0}{QS} \end{bmatrix}$$

$$\Delta\mathbf{f}_2 = QS\begin{bmatrix} \Delta\bar{C}_{l,\alpha}b & \Delta\bar{C}_{l,\beta}b & \Delta\bar{C}_{l,\delta_T}b \\ \Delta\bar{C}_{m,\alpha}\bar{c} & \Delta\bar{C}_{m,\beta}\bar{c} & \Delta\bar{C}_{m,\delta_T}\bar{c} \\ \Delta\bar{C}_{n,\alpha}b & \Delta\bar{C}_{n,\beta}b & \Delta\bar{C}_{n,\delta_T}b \end{bmatrix}$$

Acknowledgments

The authors wish to thank Barton Bacon and Irene Gregory at NASA Langley Research Center for diligently examining and identifying the errors in the manuscript.

References

[1] Nguyen, N., Krishnakumar, K., Kaneshige, J., and Nespeca, P., "Flight Dynamics and Hybrid Adaptive Control of Damaged Aircraft," *Journal of Guidance, Control, and Dynamics*, Vol. 31, No. 3, 2008, pp. 751–764.
doi:10.2514/1.28142

[2] Bacon, B. J., and Gregory, I. M., "General Equations of Motion for a Damaged Asymmetric Aircraft," *AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2007-6306, 2007.