Technical Comments

Comment on "Development of the Iterative Guidance Mode with Its Application to Various Vehicles and Missions"

DONALD J. DOBNER*
Auburn University, Auburn, Ala.

IN the recent paper by Chandler and Smith[1,2] the Iterative Guidance Mode equations are derived for the flat-earth case. The thrust direction control angle χ is considered to be of the form

$$\chi = \tilde{\chi} - (K_1 - K_2 t) \tag{1}$$

In order to obtain a solution for the control parameters $\tilde{\chi}$, K_1, and K_2 it is necessary to assume that $(K_1 - K_2 t)$ is a small angle so that

$$\sin\chi = \sin\tilde{\chi} - (K_1 - K_2 t)\cos\tilde{\chi} \tag{2}$$

and

$$\cos\chi = \cos\tilde{\chi} + (K_1 - K_2 t)\sin\tilde{\chi} \tag{3}$$

and also to add the constraint

$$-K_1 V_{ex} L\cos\tilde{\chi} + K_2 J\cos\tilde{\chi} = 0 \tag{4}$$

As an alternate form of the Iterative Guidance Mode equations it is proposed that χ be of the form

$$\chi = \tilde{\chi} + K_2 t \tag{5}$$

Now it is only necessary to assume that $K_2 t$ is a small angle so that

$$\sin\chi = \sin\tilde{\chi} + K_2 t\cos\tilde{\chi} \tag{6}$$

and

$$\cos\chi = \cos\tilde{\chi} - K_2 t\sin\tilde{\chi} \tag{7}$$

After substituting (6) and (7) into the acceleration expressions and performing the integration over the time T the results are

$$\dot{y}_T = \dot{y}_1 + gT + V_{ex} L\sin\tilde{\chi} + K_2 J\cos\tilde{\chi} \tag{8}$$

and

$$y_T = y_1 + \dot{y}_1 T + \tfrac{1}{2}gT^2 - S\sin\tilde{\chi} - K_2 Q\cos\tilde{\chi} \tag{9}$$

The solution to (8) and (9) is obtained without using any additional constraint. The control parameters are thus given by

$$\tilde{\chi} = \sin^{-1}[(QA + JB)/(JS - V_{ex}QL)] \tag{10}$$

and

$$K_2 = (B - S\sin\tilde{\chi})/Q\cos\tilde{\chi} \tag{11}$$

where

$$A = -\dot{y}_T + \dot{y}_1 + gT \tag{12}$$

and

$$B = -y_T + y_1 + \dot{y}_1 T + \tfrac{1}{2}gT^2 \tag{13}$$

Since cutoff usually occurs when the desired V_T is reached, the $\dot{x}_T$ requirement is achieved simultaneously with reaching the desired $\dot{y}_T$.

The methods illustrated are extendable to three dimensions and multistage vehicles. The derivation of the control parameter expressions is greatly simplified for the more complicated cases. In addition to the simplification of the derivation, flight simulations of the Saturn V vehicle have shown improvement in fuel consumption of about 25% with respect to the optimum for injection into a 100-naut-mile circular parking orbit. Modifications can be made to the Iterative Guidance Mode equations to obtain performance more nearly like the optimum. The extension to three dimensions and multistage vehicles, the improved fuel consumption, and the modification to obtain performance more nearly like the optimum are all discussed, at length, in Ref. 3.

References

[1] Chandler, D. C. and Smith, I. E., "Development of the iterative guidance mode with its application to various vehicles and missions," *AIAA/JACC Guidance and Control Conference* (American Institute of Aeronautics and Astronautics, New York, 1966), pp. 688–696.

[2] Chandler, D. C. and Smith, I. E., "Development of the iterative guidance mode with its application to various vehicles and missions," J. Spacecraft Rockets **4**, 898–903 (1967).

[3] Dobner, D. J., "An alternate form of the iterative guidance mode with performance improvement techniques," Ph.D. dissertation, Auburn University, Auburn, Ala. (August 23, 1967); also Auburn Research Foundation TR 13, Contract NAS8 20104 (June 30 1967).

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* Graduate Assistant, Electrical Engineering Department.