

Technical Comment

Comment on “Guidance for an Aerocapture Maneuver”

Michael E. Tauber*

NASA Ames Research Center,
Moffett Field, California 94035

IN Ref. 1, it is stated that the aerodynamic forces on the vehicle being aerocaptured are controlled by “altering the angle of attack” and thereby controlling the lift coefficient. Furthermore, the resulting variation of drag coefficient with angle of attack was ignored in Ref. 1. The purpose of this Comment is to point out that an aerodynamic control method that is much more effective than the pitch modulation considered in Ref. 1 has been studied and utilized during entries for many years.

During aerocapture, it is desirable to have a large range of lift coefficients available, while keeping the vehicle’s ballistic coefficients constant. This is accomplished by modulating the vehicle’s bank angle, i.e., by rolling the vehicle about its velocity

vector. By this method, the angle of attack can be held constant (at the trim angle, if desired), and the C_D and the ballistic coefficient remain constant. Furthermore, the vertical component of the normal force vector (essentially the lift) can be varied over its entire range, from maximum positive to maximum negative values. Reaction controls, rather than aerodynamic ones, are usually utilized to change the bank angle of the vehicle, thus requiring the use of fuel. However, the fuel expenditure that is required to change the bank angle is far less than the amount that would have to be used to continuously hold the vehicle at pitch angles that differ significantly from its trim angle of attack. Also, it has been shown² that bank angle modulation to vary the lift can enlarge the entry corridor by increasing the entry angle for the undershoot boundary, where both the heating rate and deceleration reach a maximum. Finally, the crew’s deceleration tolerance can be increased somewhat when the bank angle is varied, as opposed to the pitch angle.² For bank modulation, the deceleration force vector can be kept at a constant angle with respect to the occupants whose tolerance to g loads is highest when the force is applied in a direction normal to the upper torso. The advantages of bank angle variation to modulate the lift vector were recognized long ago, and this method of control was used successfully on the Apollo command module during lunar return³ and, more recently, for the Space Shuttle Orbiter.

References

- ¹Gurley, J. G., “Guidance for an Aerocapture Maneuver,” *Journal of Guidance, Control, and Dynamics*, Vol. 16, No. 3, 1993, pp. 505–510.
- ²Lyne, J. E., “Physiologically Constrained Aerocapture for Manned Mars Missions,” NASA TM 103954, Aug. 1992.
- ³Graves, C. A., and Harpold, J. C., “Re-Entry Targeting Philosophy and Flight Results from Apollo 10 and 11,” AIAA Paper 70-28, Jan. 1970.

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*Research Scientist. Associate Fellow AIAA.