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Technical Comment

Comment on "Optimum Vehicle Acceleration Profile for Minimum Human Injury" by C. P. Hatsell

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IN this well-written and interesting paper Hatsell considers the problem of determining optimal thrust profile for an ejection seat that will minimize human injury by keeping the dynamic response index (DRI) below a safe level.[1] The thrust delivery time and the terminal velocity are specified. Using a linear dynamic spinal injury model and a quadratic criterion (modified Gadd index), it is shown that the injury rate can be reduced to less than 0.2%.

The purpose of this Technical Comment is to bring an Engineering Note[2] on a closely related topic to the author's attention and to compare the results given in Ref. 1 with that given in Ref. 2.

Reference 2 analyzed the problem of delivering a specified thrust impulse to an ejection seat while maintaining the dynamic response index at a safe level in a specified time interval. Just as in Ref. 1, a second-order spinal injury model was employed. The performance index was quadratic in the difference between maximum permissible spinal displacement and the actual displacement. The thrust impulse specification was included as an isoperimetric constraint. Note that the fixed thrust impulse specification is equivalent to the specification of the ejection seat terminal velocity. The resulting optimal control problem was shown to have a bang-bang control solution, with the optimal thrust history being a pulse train. Using the spinal injury rate curve given in Ref. 3, a comparison between the optimal thrust history and a nominal catapult acceleration history was made. This comparison showed that the spinal injury rate for the optimal thrust history was less than 0.2% against 90% for the nominal thrust history. The thrust impulses were nearly equal in both cases. Since the spinal injury rates corresponding to optimum thrust profiles in Refs. 1 and 2 were similar under dramatically different thrust-time histories, one must conclude that this problem has additional design degrees of freedom. A more detailed spinal injury model should perhaps be employed to absorb these degrees of freedom.

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References

[1]Hatsell, C. P., "Acceleration Profile for Minimum Human Injury," *Journal of Guidance, Control, and Dynamics*, Vol. 15, No. 1, 1992, pp. 215–221.

[2]Menon, P. K. A., and Walker, R. A., "Optimal Catapult Impulse Shaping for Ejection Seats," *Journal of Guidance, Control, and Dynamics*, Vol. 8, No. 5, 1985, pp. 658–660.

[3]Brinkley, J. W., and Shaffer, J. T., "Dynamic Simulation Techniques for the Design of Escape Systems: Current Applications and Future Air Force Requirements," Symposium on Biodynamic Models and Their Applications, AMRL-TR-71-29, Wright-Patterson Air Force Base, OH, Dec. 1971.

Errata

Refinements in Determining Satellite Drag Coefficients: Method for Resolving Density Discrepancies

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IN Fig. 3 of this paper some of the numbers along the left-hand side were cut off. The AIAA Editorial Staff regrets this error and any inconvenience it has caused our readers. The correct figure is presented here.

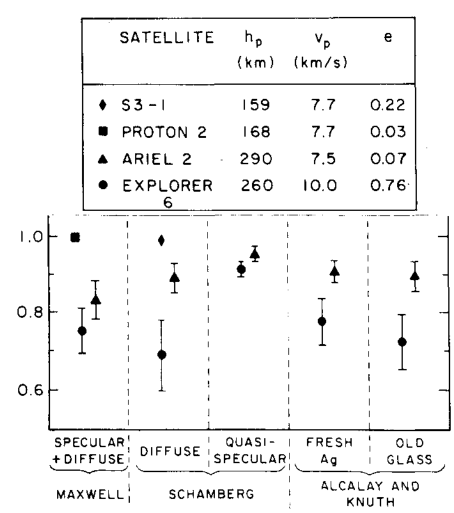

Fig. 3 Accommodation coefficients measured by four satellites. Each vertical column contains accommodation coefficients calculated from satellite data corresponding to one of the five angular distributions in Fig. 2. The perigee heights, velocities at perigee, and orbital eccentricities of the four satellites are shown in the box. This figure suggests that below 20 km, the angular distribution of reemitted molecules is very close to the Lambert cosine law.