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GENERAL PARAMETRIC REENTRY STUDY FOR SEVERAL SYNCHRONOUS EARTH ORBITS

By William R. Pruett
Flight Analysis Branch

[redacted]

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
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FIGURES

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SUMMARY AND INTRODUCTION

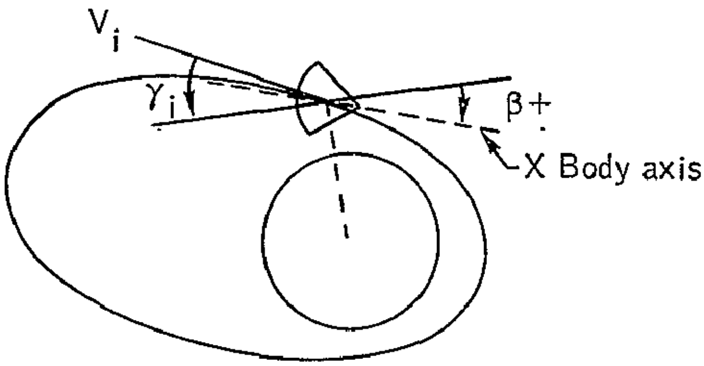
This paper presents the graphic results of a reentry study for five synchronous earth orbits. The orbits considered are:

Perigee	Apogee
100 n. mi.	38 546 n. mi.
1 000 n. mi.	37 646 n. mi.
5 000 n. mi.	33 646 n. mi.
10 000 n. mi.	28 646 n. mi.
19 323 n. mi.	19 323 n. mi.

In keeping with the broad definition of synchronous orbits, each of these orbits has a period of approximately 23.93 hours. The results are presented in figures of inertial velocity and flight-path angle at 400 000 feet. Also presented are the central angle of travel (orbit referenced) and the time from retrofire to 400 000 feet. For the elliptic orbits these parameters are plotted as a function of true anomaly of retrofire, and for the circular orbit they are plotted as a function of retrograde ΔV. Both pitch attitude and ΔV were varied for study.

Mathematical Model

Keplerian equations, a spherical rotating earth, and instantaneous velocity changes were used in this study. The Keplerian solutions were obtained from a general elliptical orbit and reentry program, E042. A reentry altitude of 400 000 feet and a circular earth radius of 20 907 447 feet were used. Beta angles are measured positive clockwise from the local horizontal as indicated in the figure below:



DISCUSSION OF RESULTS

Since reentry may be accomplished by using small ΔV's in the apogee region or large ΔV's near perigee, the 0° to 360° range of true anomalies was split into two sections. The range from 60° to 300° in figures 1(a) through (f), 2(a) through (e), 3(a) through (d), and 4(a) through (d) was used with smaller ΔV's, and the range from -60° to 60° in figures 1(g) through (s), 2(f) through (p), 3(e) through (k), and 4(e) through (j) was used with the large ΔV's. By using this approach, a good picture of the allowable ΔV's at any true anomaly may be obtained without publishing extraneous data.

The retrograde pitch angles were limited to only positive or pitched down attitudes. This was done for two basic reasons. First, the reentry velocity and flight-path angles for negative retrograde pitch angles from any true anomaly can easily be found by simply reading the reentry velocity and flight-path angle for positive pitch angles after retrofire from the explement of the true anomaly desired; i.e., velocity and flight-path angle at 400 000 feet are exactly the same after retrofire from 50° true anomaly at a pitch angle of -20° as from 310° true anomaly and $+20^\circ$ pitch.

However, time from retrofire to 400 000 feet and central angle of travel cannot be found by this method, and, for negative pitch angles, cannot be found from this document. This, then, points up the second reason for not including negative pitch angles. Since positive or pitch-down angles will, in general, give shorter reentry ranges than corresponding negative angles from the same true anomaly in orbit, it would be of minimal value to include them, especially since identical reentry conditions may be achieved by using a positive pitch angle at the explementary true anomaly. The only difference is that much shorter and thus more desirable ranges from retrofire to 400 000 feet would be achieved by using the positive pitch angles.