BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: The 1975 Mars-Venus Ballistic Dual-Planet Flyby - Case 720

DATE: December 19, 1967

FROM: A. A. VanderVeen

ABSTRACT

The 1975 Mars-Venus ballistic dual-planet flyby mission is characterized by relatively high injection velocities and narrow launch window.

Some comparisons are made between this mission and the 1975 Mars twilight flyby.

Increased computer capability is illustrated by the graphical data presented. These graphs were machine plotted from stored trajectory data.

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MEMORANDUM FOR FILE

INTRODUCTION

The 1975 Mars-Venus dual-planet ballistic flyby opportunity was known to exist since mid-1966 when it was discussed by H. F. Michielsen of Lockheed during a presentation to NASA Headquarters and Bellcomm. It was subsequently investigated as a possible alternative to the 1975 Mars twilight flyby mission, although at the time of this writing any 1975 mission appears to be largely of academic interest.

The planetary encounter dates for this mission do not occur as predicted on the basis of converting an inbound Venus swingby Mars stopover mission to a dual-planet ballistic flyby. That conversion requires more turning during the Mars encounter than is possible with the existing high approach velocity there. The encounter dates for this mission subject the outbound leg to transfer angles of a little more than 180°, producing a "ridge effect" that is evidenced by relatively high earth departure velocities. It has been shown, however, (Reference 1) that this mission is reasonable to consider if high performance cryogenic injection stages are available. Furthermore, improvements can be expected in mission characteristics by employing a small impulse at Mars in order to furnish some of the required turning angle and to "move away" from the 180° transfer ridge.

MISSION CHARACTERISTICS

The mission profile is shown in Figure 1, on which are also tabulated the planetary encounter dates, the relative velocities of the spacecraft with respect to the planets at these dates, the radius of passage, and the maximum and minimum excursions from the sun. The mission illustrated requires 620 days. A type #3 inbound Venus swingby trajectory with its characteristically close approach to the sun can be recognized in the mission profile after the Mars encounter.

Figure 2 presents the earth departure characteristics superimposed on which are the 1.0 passage radius contours at Mars and Venus. Only the unshaded region of the graph represents ballistic flyby trajectories that do not impact either planet. This figure shows that such flybys are possible only during a 14-day earth launch window and that the minimum earth departure V_∞ is greater than .30 emos.

Figures 3 and 4 give the flyby data at Mars and Venus, respectively, and it is noted that the passage velocities are moderately high at Mars and very high at Venus. These high velocities result from the manner in which the spacecraft's trajectory cuts across the planetary orbits at the time of encounter. (See Figure 1)

Figure 5 reveals that the earth entry velocities are moderately low.

CONCLUSIONS

The 1975 Mars-Venus ballistic dual-planet flyby does not represent an attractive mission opportunity. However, it does add to the small accumulation of knowledge and understanding of multi-planet flyby missions in general.

The mission opportunity uses outbound legs that "lie" near the 180° earth-Mars transfer ridge. The unfavorable earth departure characteristics support the contention that the ridge region will not "produce" attractive mission opportunities from the standpoint of injection velocities and launch delay sensitivities.

In comparison with the 1975 Mars twilight flyby mission, the slower passage velocity at Mars is very important from the standpoint of easing the design requirements of a surface sample retrieving probe (Reference 1). The higher injection velocity characteristic of this mission implies a requirement for more launch vehicles. Solar flare protection may be required due to the close approach to the sun. This mission is two months shorter than the 1975 Mars twilight flyby, and the earth entry requirements are not as severe.

ACKNOWLEDGMENT

The graphical data presented in Figures 2-5 were machine plotted using stored trajectory data. Acknowledgment is made to P. F. Long for overall computer program development and to Mrs. J. N. Friend for the contour plotting program.

A. A. VanderVeen

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Attachments
Figures 1-5
Reference

REFERENCE

1. London, H. S. - Other Mission Applications for a Cryogenic Planetary Injection Module, Bellcomm Memorandum for File, November 23, 1967.

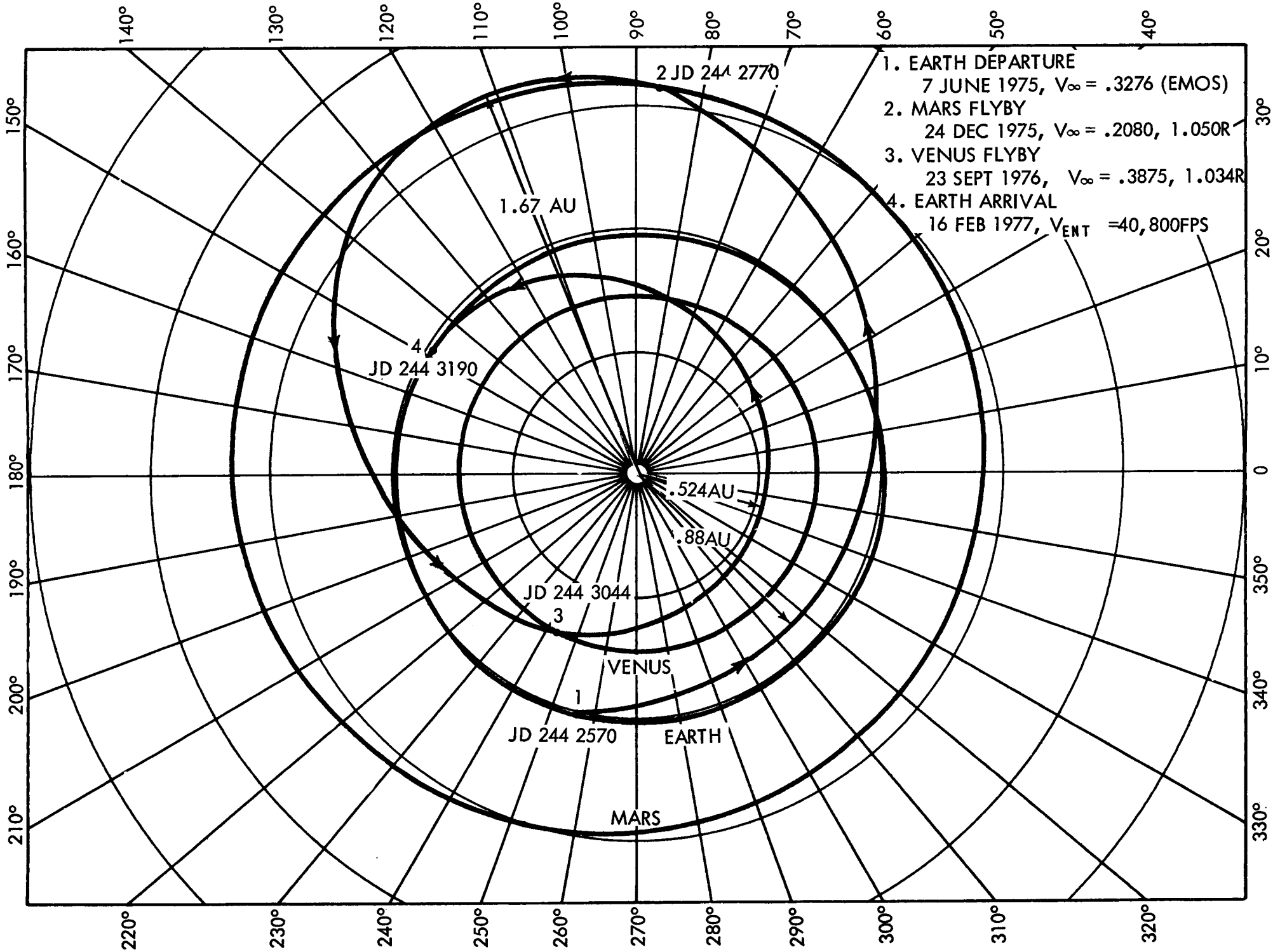
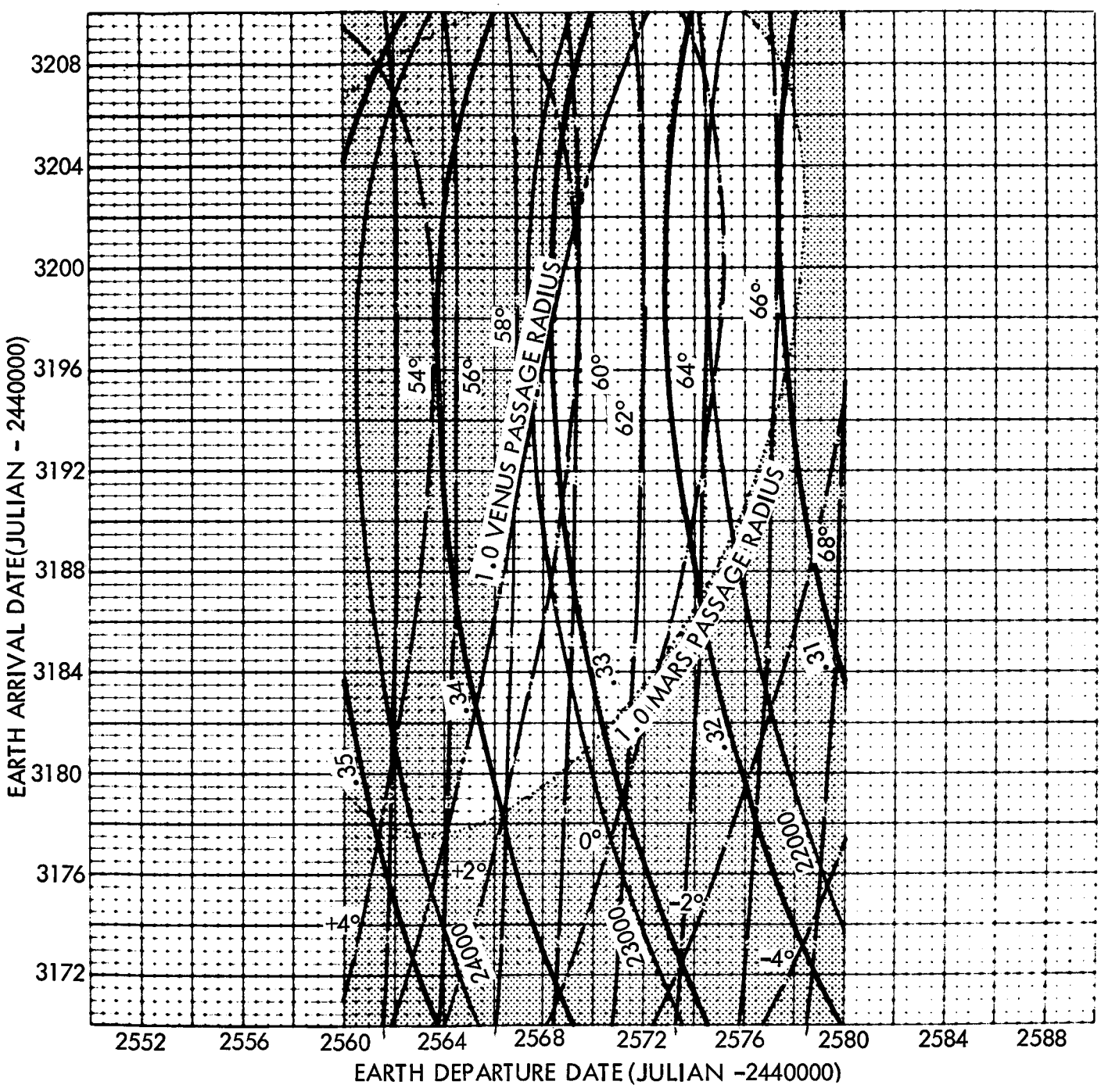
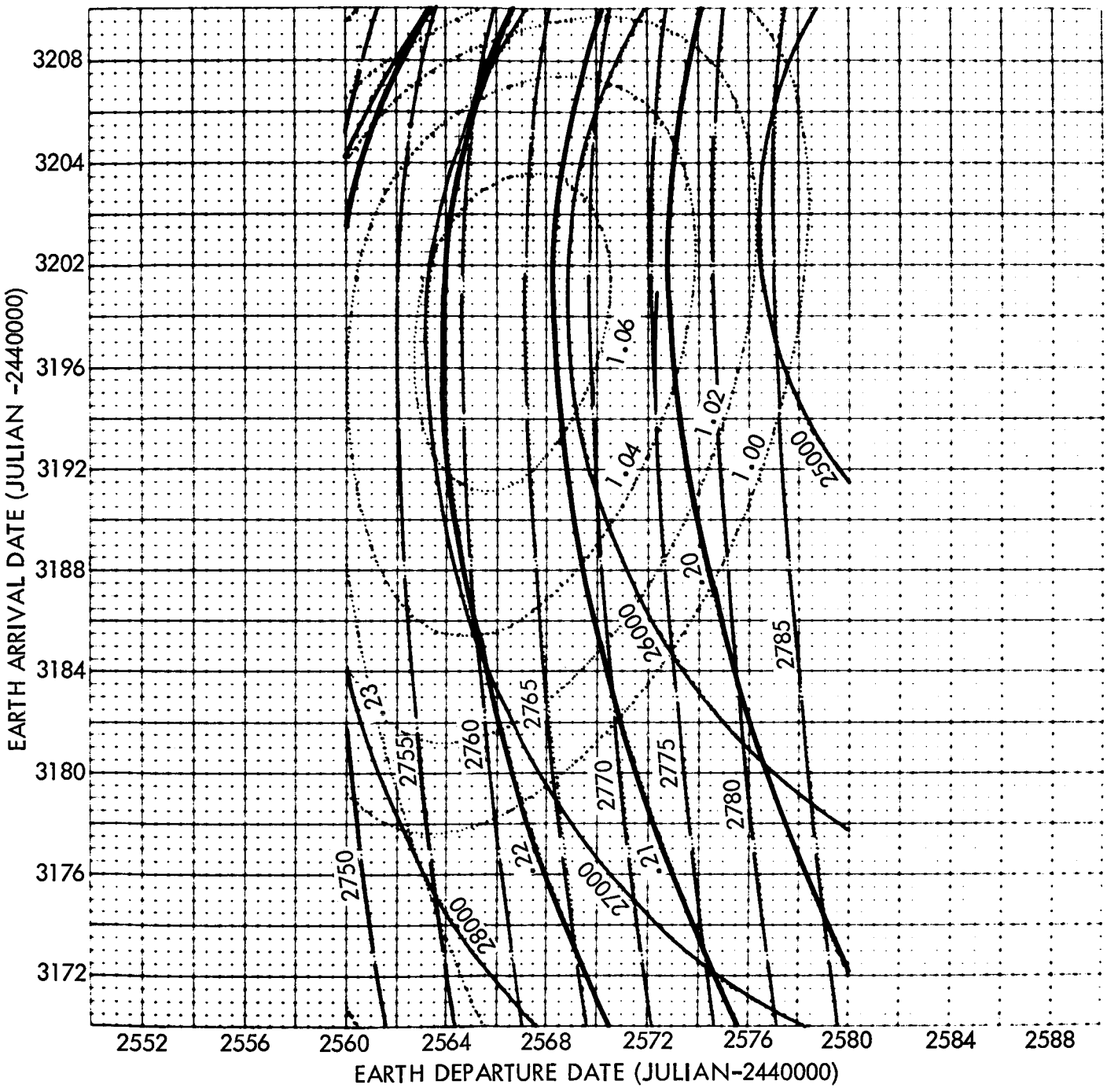


FIGURE 1 - MISSION PROFILE



EARTH DEPARTURE V_∞ (EMOS)
INJECTION VELOCITY (FT/SEC)
RIGHT ASCENSION (DEG)
DECLINATION (DEG)
MARS PASSAGE RADIUS (P. RAD.)
VENUS PASSAGE RADIUS (P. RAD.)

FIGURE 2 - EARTH DEPARTURE CHARACTERISTICS



MARS ARRIVE - DEPART V_∞ (EMOS)
PERIAPSIS VELOCITY (FT/SEC)
PASSAGE RADIUS (P. RAD.)
PASSAGE DATE (JULIAN- 2440000)

FIGURE 3 - MARS PASSAGE CHARACTERISTICS2750

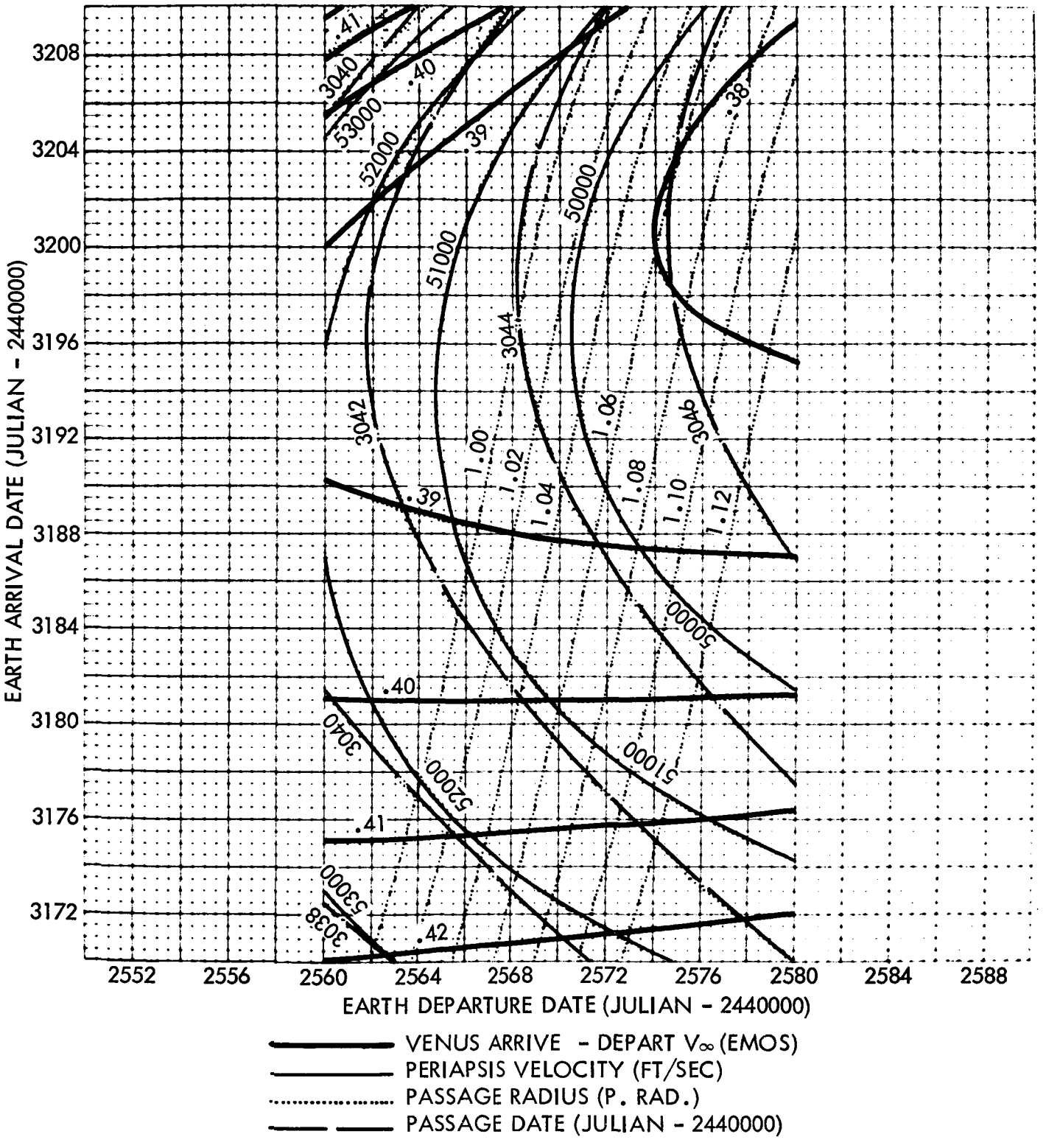


FIGURE 4 - VENUS PASSAGE CHARACTERISTICS

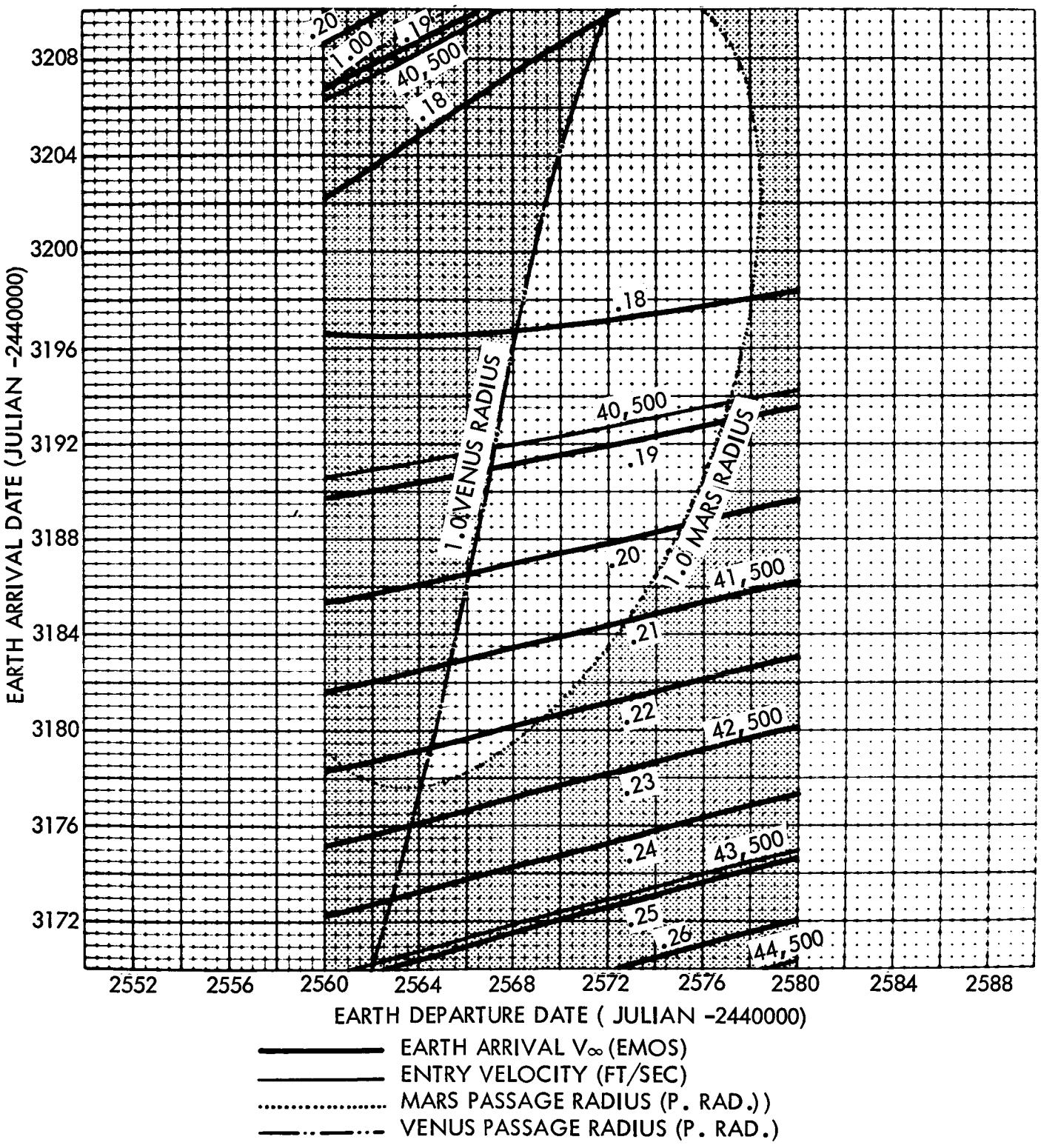


FIGURE 5 - EARTH ARRIVAL CHARACTERISTICS

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