Weight Advantages of Use of Parking Orbit

for Lunar Soft Landing Mission

The results of a feasibility study investigating the advantages of using a lunar parking orbit for the soft landing mission are summarized here. The weight advantage due to use of a parking orbit, as compared with a direct landing, is a result of the fact that some of the weight in the parking orbit need not be taken to the lunar surface and returned to the parking orbit. That portion of the weight in the parking orbit which is not essential for the lunar landing part of the mission (i.e., the fuel for return from parking orbit to earth, re-entry heat shield, etc.) is considered to be left in orbit for later rendezvous with the landing portion of the vehicle. As can be anticipated, a considerable savings in fuel weight results from not carrying this non-essential weight to the lunar surface and back.

The procedure used in this study is as follows:

(a) Starting from a 300-mile earth orbit, apply a velocity impulse to obtain parabolic velocity.

(b) Apply a velocity impulse on approaching moon to establish a circular orbit around the moon at low altitude (50-mile altitude used here).

(c) Apply velocity impulses to get from circular lunar orbit to surface of moon, one impulse to establish elliptical grazing orbit, another to reduce velocity to zero at surface. Similarly, two impulses are used to return to circular orbit.

(d) From lunar parking orbit, apply velocity impulse for return to earth at parabolic (earth referenced) velocity.

(e) Compare results of useful weight taken to lunar surface and useful weight returned to earth on basis of leaving part of vehicle weight in the lunar parking orbit vs. leaving nothing in the parking orbit.

In connection with part (c), it should be noted that if the circular parking orbit were established at zero altitude (i.e., at the lunar surface) the process of establishing the circular orbit, and then applying an impulse for slowing to zero velocity at the surface would correspond to a direct approach as far as velocity requirements are concerned. With a 50-mile altitude orbit, instead of zero altitude, a small but practically negligible penalty (approx. 150 ft/sec velocity difference in a total of 5600 ft/sec) is associated with the establishment of the circular orbit as compared with the direct approach.

All propellant weight estimates were made on the basis of a simple impulsive velocity (ideal velocity) relation. Fuel tanks were considered to be staged after each velocity impulse, assuming the tank weight equal to 5 percent of the propellant weight.

The results are summarized in the three figures. Figures 1 and 2 show the useful weight taken to the surface of the moon, and the useful weight returned to the earth, both based on the weight in the original 300-mile earth orbit, as a function of the portion of the return vehicle weight which could be left in orbit. "Useful weight" includes payload, structure, equipment, and engines, but does not include fuel or tankage. The bottom part of Figures 1 and 2 shows the increase in useful weight returned to earth or useful weight taken to the moon, as a result of leaving fuel and fuel tankage for return from parking orbit to earth plus a portion of the return vehicle in the parking orbit, as compared with leaving nothing in the parking orbit. (The curve is actually two curves which are essentially the same.) Figure 1 gives results with specific impulse of 300 sec. in the mass ratio calculations, Figure 2 with 400 sec.

Figure 3 shows the percent of the total weight in the circular lunar orbit which should be left in the parking orbit for later rendezvous, as a function of the same abscissa used in the other figures.

The abscissa of the figures is a design parameter which is primarily a function of the weight of the earth reentry heat shield, but can include other equipment and structure not used in the landing portion of the mission. It is expected that the latter will be small compared to the heat shield weight. An estimate for the heat shield weight for reentry with parabolic velocity is of the order of 20 to 40 percent of the total return vehicle weight. Using a mean value of 30 percent for the heat shield weight, Figures 1 and 2 show that an increase in useful weight of some 60 percent for $I_{sp} = 300$ and 45 percent for $I_{sp} = 400$ can be effected by leaving the non-essential items in the parking orbit.

This saving, however, must be compared with the additional complications involved in requiring a rendezvous with the components left in the parking orbit.

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ISP = 300

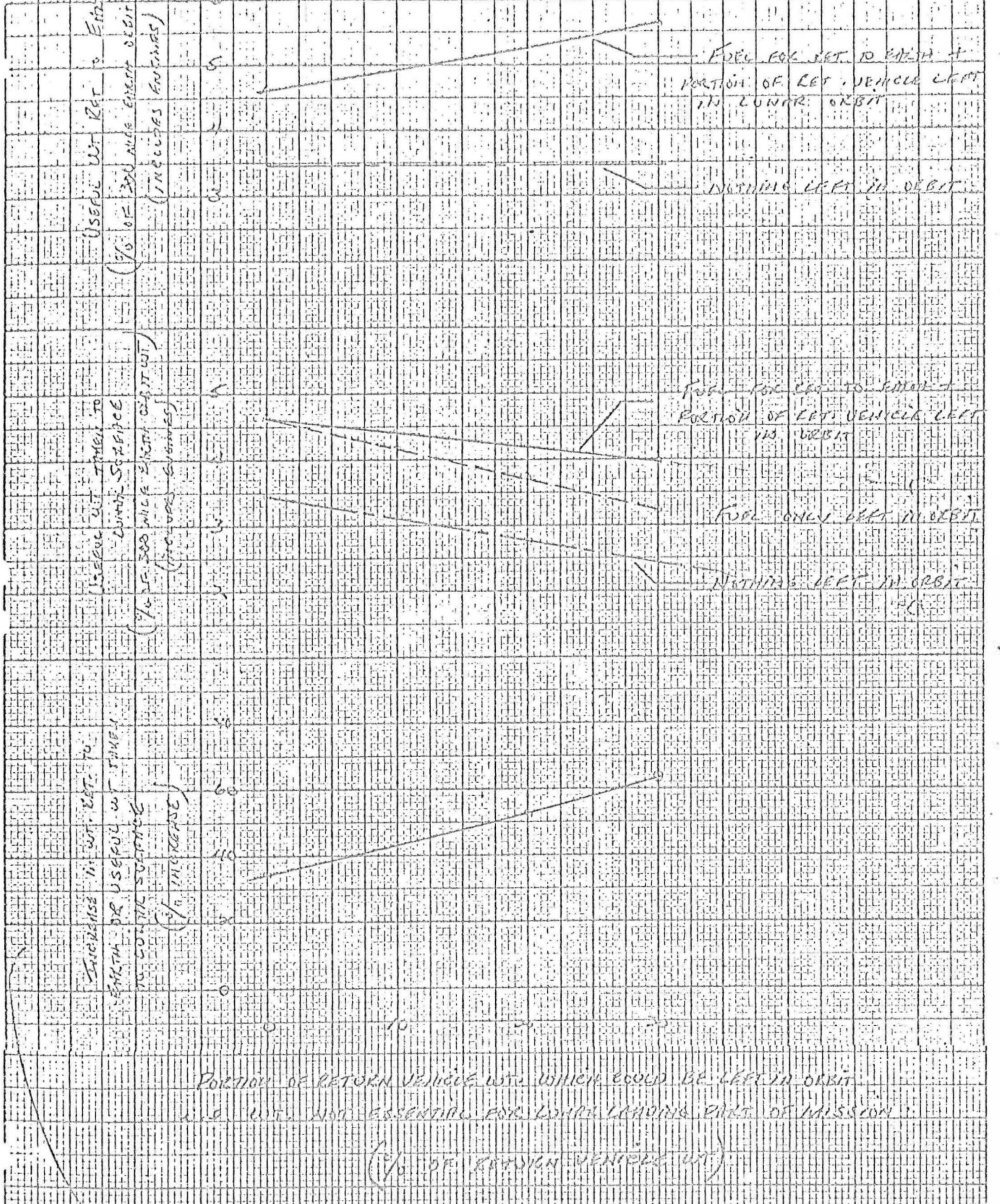

FIGURE 1: SUMMARY OF RESULTS FOR ISP = 300 SEC.

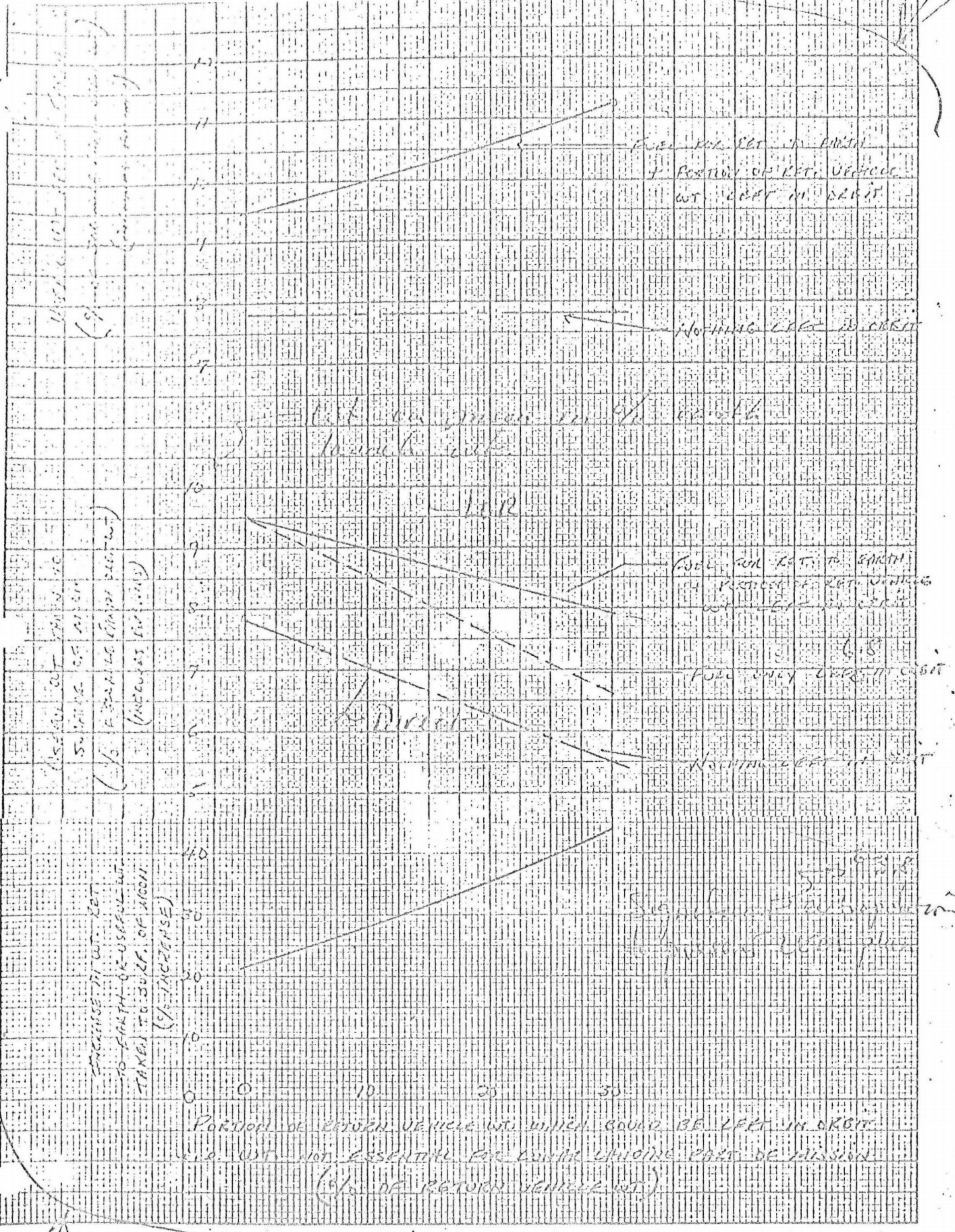

FIGURE 2. - SUMMARY OF RESULTS FOR I_{sp} = 400 SEC.

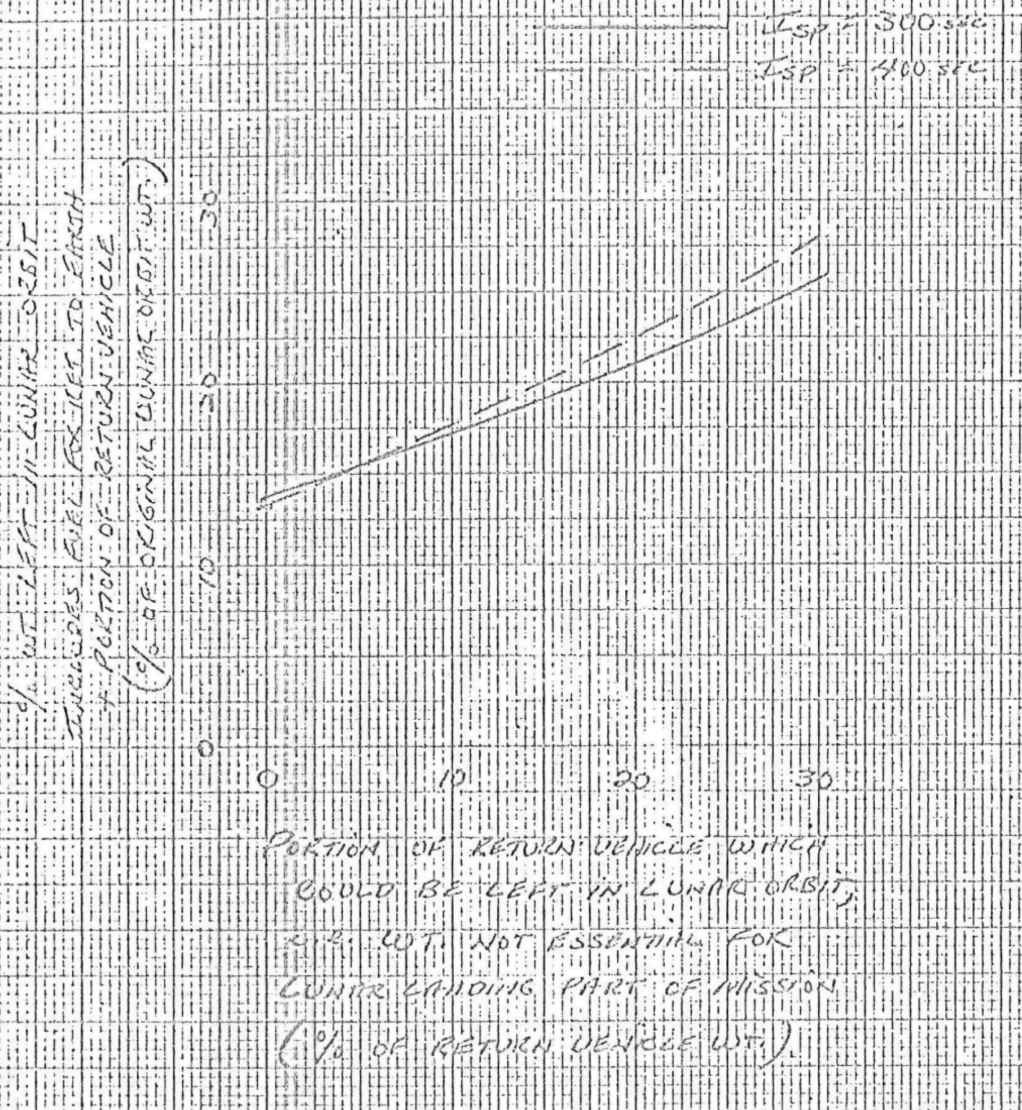

FIGURE 3 – PERCENT WEIGHT LEFT IN PARKING ORBIT