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RTCC REQUIREMENTS FOR MISSION G: LANDING SITE DETERMINATION USING A LUNAR GRAVITY VECTOR

Mathematical Physics Branch

MISSION PLANNING AND ANALYSIS DIVISION

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PROJECT APOLLO

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By Paul F. Flanagan
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RTCC REQUIREMENTS FOR MISSION G:

LANDING SITE DETERMINATION USING A LUNAR GRAVITY VECTOR

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SUMMARY AND INTRODUCTION

Equations are presented for use in the Real-Time Computer Complex (RTCC) program to compute the selenographic latitude and longitude of the LM on the lunar surface using a gravity vector determined by LM accelerometer readings. The determination is independent of MSFN radar, rendezvous radar, and the CSM trajectory. It is consistent with an optically determined platform alignment.

A currently defined RTCC processor can use rendezvous radar or CSM optical sightings of the LM to determine position relative to the CSM orbit. Since the method presented here is independent of rendezvous radar, the results can be compared with that of rendezvous radar to measure the difference in selenographic and relative position. This method provides backup capability in case of rendezvous radar failure.

METHOD

During the lunar stay phase of the mission, the RTCC will process telemetered or voice-linked data from the landed LM. The RTCC processor requires as input a gravity vector in spacecraft body coordinates, an optically determined platform alignment, and gimbal angle data.

The LM guidance computer (LGC) filters the noise in accelerometer data and measures the gravity vector twice to minimize the bias. The gravity vector is then transformed from stable member (platform) to body coordinates and is available to the RTCC from telemetry. The gravity vector computed in the LGC is directed away from the moon's center. After the gravity vector determination, REFSMMAT will be determined using the alignment optical telescope. REFSMMAT provides the transformation from the basic reference system, i.e., mean nearest Besselian year (MNBY), to the platform system. Both the observational data and the LGC determination of REFSMMAT are available from telemetry. Knowledge of the time interval in which this orientation is valid is essential for selecting telemetered gimbal angles which provide the transformation from the spacecraft body system to the platform system.

The libration matrix, the transformation from the basic reference system to the moon-fixed selenographic system, is required for the time associated with the gimbal angles.

COMPUTATIONAL PROCEDURE

Onboard data processing is a manual procedure. The gravity vector, REFSMMAT, gimbals and associated time are specified by the controller by a manual entry device (MED).

The procedure uses the following inputs:

1. A unit gravity vector, $\hat{g}$, obtained in body coordinates.

2. A REFSMMAT. An AOT alignment is performed (preferably using the multiple mark capability) to compute a REFSMMAT.

3. Gimbal angles and the associated time. The platform orientation for which these gimbals are valid must be the same as the orientation defined by the REFSMMAT used. This can be accomplished as long as there is no torquing of the platform between the time of gimbal readout and the time of alignment.

The procedure is as follows:

Transform the unit gravity vector in body coordinates to platform coordinates.

$$\hat{g}_P = \begin{pmatrix} \cos IGA & 0 & \sin IGA \\ 0 & 1 & 0 \\ -\sin IGA & 0 & \cos IGA \end{pmatrix} \begin{pmatrix} \cos MGA & -\sin MGA & 0 \\ \sin MGA & \cos MGA & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos OGA & -\sin OGA \\ 0 & \sin OGA & \cos OGA \end{pmatrix} \hat{g}_B$$

where $\hat{g}_B$ is the unit gravity vector in body coordinates and IGA, MGA, and OGA are the inner, middle and outer gimbals.

Transform the gravity vector in platform coordinates to MNBY coordinates.

$$\hat{g}_{MNBY} = [REFSMMAT]^T \hat{g}_P$$

where REFSMMAT is the telemetered or ground computed transformation matrix.

Transform the gravity vector in MNBY to selenographic coordinates.

$$\hat{g}_{SG} = L\ \hat{g}_{MNBY}$$

where L is the interpolated libration matrix at the time associated with the gimbal angles.

Then

$$\hat{g}_{SG} = (X,\ Y,\ Z)$$

where X, Y, and Z are the selenographic Cartesian unit coordinates of the LM position since the gravity vector determined onboard is directed away from the moon's center.

Compute selenographic longitude and latitude.

$$\lambda = \tan^{-1} \frac{Y}{X}$$

$$\phi = \sin^{-1} Z$$