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LUMINARY Memo #166

To: Distribution
From: D. Moore
Date: 23 July 1970
Subject: DVTOTAL Vs. VGDISP Discrepancy in Powered Flight

Summary:

While monitoring N40 in the LM Powered Flight programs (P40, P41, P42) it was noticed that there was an error between R2 (VGDISP) and R3 (DVTOTAL). It has been discovered that a .34% computational error (encountered in Servicer, due to using only the high order part of a double precision constant (KPIP1) to update the amount of delta-V accumulated in the burn) is the cause for the observed error.

Problem:

GAEC via Clint Tillman notified MIT/DL of an observed discrepancy in N40 while performing a simulated DPS burn. The discrepancy was such that if, in P30, N81 was loaded so that the magnitude of Delta-V was 1000 fps and P40 was performed, then VGDISP was not zero, DVTOTAL was not 1000, and VGDISP + DVTOTAL was not 1000. The error noticed was 3 - 3.5 fps short of 1000 (e. g. 997 fps). The problem was to investigate the coding and perform simulations at MIT/DL using hybrid and all-digital facilities to find the answer to the question of the missing Delta-V.

Investigation:

A hybrid simulation was run with the astronaut sequence as follows:

Select P30 (V37E30E)
Load N33 (TIG)
Load N81 (DV)
Proceed to P30 exit.

Select P40 (V37E30E)

Maneuver to Burn Attitude

Monitor N40 before burn

R1 - TFI (Time from ignition)

R2 - VGDISP (Same as N81 magnitude)

R3 - DVTOTAL (zero until TIG)

Monitor N40 during burn

Monitor N40 after burn

R1 - TFI (Time from ignition)

R2 - VGDISP (nearly zero)

R3 - DVTOTAL (nearly same as R2 before burn)

Before the burn N40 appeared as:

R1 - -01X00 (1 min to TIG)

R2 - +10000

R3 - +00000

During the burn N40 appeared as:

R1 - -01X00 (1 min to engine cutoff)

R2 - +07124

R3 - +02870

After the burn N40 appeared as:

R1 - -00X00

R2 - +00009

R3 - +09963

It is noticed that after the burn began, $DVTOTAL + VGDISP \neq 1000$ fps. In fact, that sum was less than 1000 fps by about 3 fps at the end of the burn. On information supplied by Clint Tillman of GAEC, a suspicious bit of coding was analyzed. In Servicer, just before DVTOTAL is updated for the display, an instruction is done in single precision on a double precision constant; thus, losing the accuracy of the low-order part of that constant. The coding

CA KPIP1

where KPIP1 is a 2DEC constant which transforms ABDELV at 2^{14} cm/sec to ABDELV at 2^7 m/cs. KPIP1 is .0128, or $\frac{2^7}{10000}$. The octal value for

KPIP1 (both words) is 00321, 26706. Losing the lower part of the word results in a .0034 relative error between the total word and the high order word. This then is a .34% error introduced in the update of DVTOTAL by the coding in Servicer. With a VG of 1000 fps to be reached with the burn, an error of 3 fps is easily accounted for by the error caused by losing the low-order part of KPIP1 in the DV update calculation.

It has been seen that the .34% error from Servicer is the cause of the 3 fps discrepancy in the burn performed by Clint Tillman and David Moore on the hybrid facility at MIT/DL. Robert Covelli aided in the analysis of the problem by noting the relative error caused by the loss of the low-order part of the constant, KPIP1.

Conclusion:

The error has been accounted for with the notation of the induced .34% error from the DV update calculation.

Suggestions:

Recode this section of Servicer using DMP instead of the SHORTMP routine to give accuracy to the DVTOTAL update calculation by using both parts of KPIP1.