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LUMINARY Memo #154

To: Distribution
From: L. Berman
Date: 1 June 1970
Subject: Luminary Development Memo #141 - Replacement of LOGSUB

In the above-referenced memo, a scheme for replacing LOGSUB by a direct call to POLY, using a 3rd order polynomial instead of the 7th order used by LOGSUB, was proposed. A polynomial was selected which represented the logarithm with an error of less than 0.1% for $Tgo/T_{BUP} < .4$.

However, the arithmetic of the guidance is such that this error is magnified by differencing operations during the computation, leading to significant errors in the guidance parameters.

In a typical launch simulation, it was found that near injection, the computation of the pitchrate or jerk term becomes unstable. Stable guidance is preserved only by the limitations imposed on the jerk. Despite the preservation of stability, there is a cost of 6.4 fps ΔV incurred by the use of the 3rd order polynomial.

The use of a fourth order polynomial would still leave a saving of 28 registers. A 4th order polynomial was selected:

$$L = - Tgo/Tbup - 1/2(\frac{Tgo}{Tbup})^2 - .32793766\ (\frac{Tgo}{Tbup})^3 - .36834864\ (\frac{Tgo}{Tbup})^4$$

A simulation run with this approximation yielded guidance profiles essentially indistinguishable from the original program. The ΔV loss was approximately 0.4 fps.

old		new	
DLOAD	DSU	DLOAD	DDV
	TBUP		TGO
	TGO		TBUP
DDV	CALL	EXIT	
	TBUP	TC	POLY
	LOGSUB	DEC	3
SL	PUSH	2DEC	0
	5	2DEC	+.5
	(8 reg)	2DEC	+.25
	+		
	LOGSUB(38 reg)	2DEC	+.16396883
	= 46 reg.	2DEC	+.18417432
		TC	INTPRET
		SL1	PUSH
			18 reg

The simulation indicates a time saving of approximately 3 msec.