PJRR
3-7-72
G&CD
C. FINCH

LUMINARY POSTFLIGHT ANALYSIS

- NO SIGNIFICANT ANOMALIES OR PROBLEMS WERE OBSERVED
- PROBLEMS OF INTEREST WERE
  - PGNCS/AGS ALTITUDE RATE DIVERGENCE DURING DESCENT
  - PGNCS/MSFN VELOCITY DIFFERENCE AT INSERTION
  - DAP PERFORMANCE DURING DESCENT WITH THE HEAVY LM

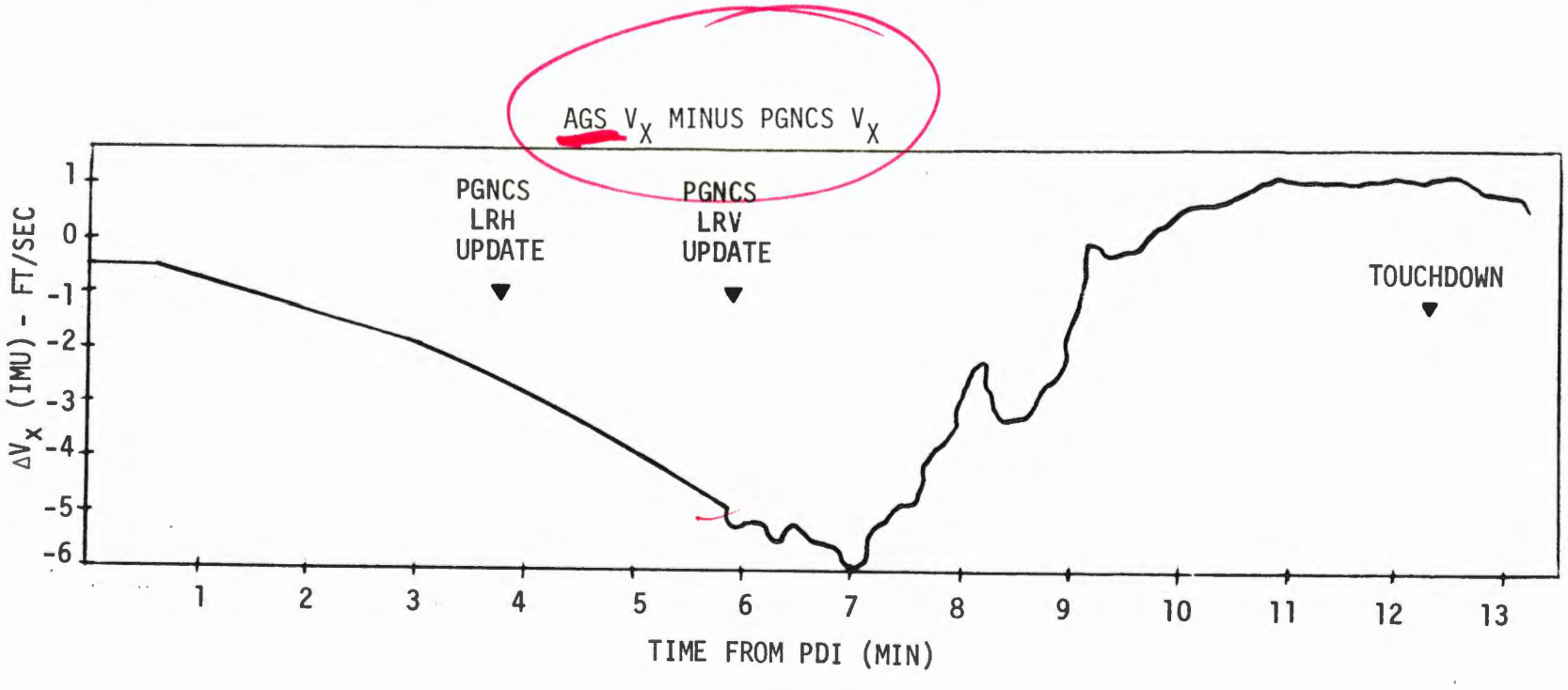
Doug RUE

LUMINARY SOFTWARE REVIEW

POSTFLIGHT INVESTIGATIONS

- PGNCS ONBOARD ALTITUDE RATE DURING DESCENT
- PGNCS ASCENT VELOCITY ERROR
- DAP DESCENT PERFORMANCE WITH HEAVY LM

PGNCS ONBOARD ALTITUDE RATE DIVERGENCE DURING EARLY PART OF DESCENT



LUMINARY SOFTWARE REVIEW

ANALYSIS RESULTS:

1. SENSOR ERROR CONTRIBUTIONS TO THE TOTAL ERROR WAS -2.3 FT/SEC.
2. DIFFERENT μ_M FOR PGNCS AND AGS CONTRIBUTED -0.5 FT/SEC ERROR AT START OF LRV UPDATE.
3. DIVERGENCE BETWEEN AGS AND PGNCS R_X AT START OF LRH UPDATING CAUSED ADDITIONAL -1.0 FT/SEC.

DESCENT ΔV_X ERROR FIT TABLE

TIME FROM PDI (MIN) \ VELOCITY ERRORS FT/SEC	INITIAL OFFSET	SENSOR ERRORS	GRAVITY MODEL DIFFERENCE DUE TO $\Delta\mu$	GRAVITY MODEL DIFFERENCE DUE TO Δh	$\sum \frac{\partial \Delta V_X}{\partial \varepsilon i}(\varepsilon i)$	$\Delta V_X - \sum \frac{\partial \Delta V_X}{\partial \varepsilon i}(\varepsilon i)$
1	-0.6	-0.2	-0.1	0	-0.9	-0.1
2	-0.6	-0.6	-0.1	0	-1.3	0.1
3	-0.6	-1.0	-0.3	0	-1.9	0
4	-0.6	-1.4	-0.3	-0.1	-2.4	-0.2
5	-0.6	-1.8	-0.5	-0.6	-3.5	-0.2
6	-0.6	-2.3	-0.5	-1.0	-4.4	-0.6

CONCLUSIONS:

1. OF THE 5 FT/SEC DIVERGENCE OBSERVED AT START OF LRV UPDATE, 1.5 FT/SEC WAS THE RESULT OF DIFFERENCES IN COMPUTATION OF GRAVITY EFFECTS.
2. THE 2.3 FT/SEC SENSED VELOCITY ERROR CAN BE SATISFIED WITH REASONABLY SIZED COMBINATIONS OF PIPA BIAS ERROR, AGS ACCELEROMETER AND PGNCS/AGS ATTITUDE DIFFERENCE ERROR.

LUMINARY SOFTWARE REVIEW

PGNCS ASCENT VELOCITY ERROR

	$\Delta\dot{X}$ (RADIAL)	$\Delta\dot{Y}$ (CROSSRANGE)	$\Delta\dot{Z}$ (DOWNRANGE)
PGNCS-MSFN (PGNCS CORRECTED FOR BEST RLS)	10.8 ft/sec	-7.33 ft/sec	-3.02 ft/sec

MOST PROBABLE ERROR SET

ERROR SOURCE	VALUE	RATIO FLIGHT/PREFLIGHT	CONTRIBUTION (FT/SEC) ΔV_X	ΔV_Y	ΔV_Z
BX (PIPA BIAS)	163 μg	0.8 σ	2.30		
BY	71 μg	0.3 σ		0.98	
BZ	-163 μg	0.8 σ			-2.30
XSF (PIPA SCALE FACTOR)	116 ppm	1 σ	0.13		
YGCDR (GYRO CONSTANT DRIFT)	-0.03°/HR	1 σ	0.20		
YADSR (G SENSITIVE DRIFT)	-0.075°/HR/G	1 σ	0.14		
ϕY (PLATFORM MISALIGNMENT)	-295 $\widehat{\text{SEC}}$	5 σ	8.0		-1.60
ϕX	-305 $\widehat{\text{SEC}}$	2 σ		-8.31	
			Σ10.77	-7.33	-3.90

QUALITY OF FIT:

- PGNCS FORCED TO AGREE WITH MSFN $\dot{X}$ BECAUSE RADIAL DIRECTION IS MOST ACCURATE FOR MSFN. $\dot{Z}$ VELOCITY FIT IS WITHIN 1 FT/SEC AND THE MSFN UNCERTAINTY FOR DOWNRANGE IS ≈1 FT/SEC.

LUMINARY SOFTWARE REVIEW

REASONS FOR SELECTION OF LARGE ϕY

- INSTRUMENT ERROR (BX, XSF, GYRO DRIFT) REQUIRED TO ACCOUNT FOR ΔV_X WOULD SUGGEST FAILED INSTRUMENT. NO INDICATION OF INSTRUMENT PROBLEM FROM FREE-FALL, DESCENT, SURFACE OR POST-ASCENT DATA.

- PRE-LIFTOFF ALIGNMENT WAS AT-3 (STAR-GRAVITY). INDEPENDENT POSTFLIGHT STUDIES HAVE GIVEN INDICATION THAT GRAVITY ANOMALY EXISTED AT LANDING SITE WHICH DEFLECTED IMU MEASURE OF GRAVITY AWAY FROM THE LANDING SITE RADIUS.

- PGNCS/AGS SENSED VELOCITY DIFFERENCES CAN BE SATISFIED WITH REASONABLY SIZED AND BELIEVABLE SENSOR ERRORS.

CONCLUSIONS:

1. PGNCS IMU PERFORMANCE WAS SATISFACTORY.
2. PGNCS INSERTION ERROR WAS MOST PROBABLY THE RESULT OF PLATFORM PRE-LIFTOFF MISALIGNMENT AND WAS CAUSED BY A GRAVITY ANOMALY AT THE LANDING SITE.

LUMINARY SOFTWARE REVIEW

DAP DESCENT PERFORMANCE WITH HEAVY LM

RCS PROPELLANT CONSUMPTION - LBS

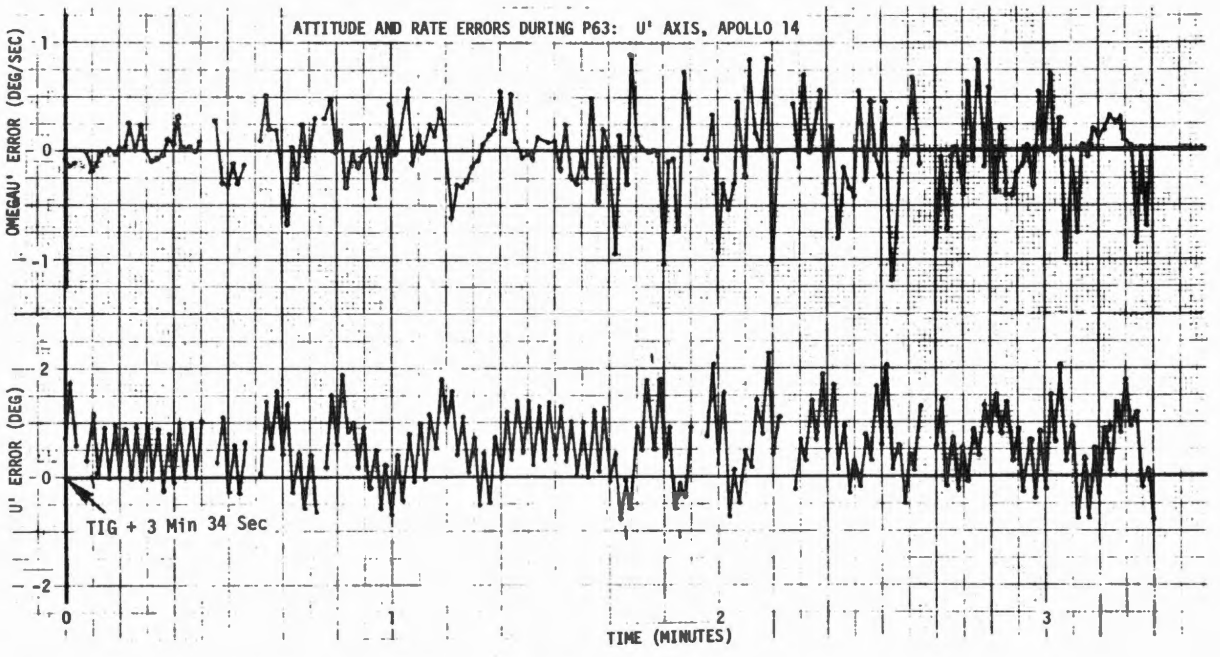
	A-15	A-14	A-12
P63	8.87	7.06	15.66
P64	10.99	7.83	16.35
P66	22.20	64.97	60.25
TOTAL	42.06	79.86	92.26

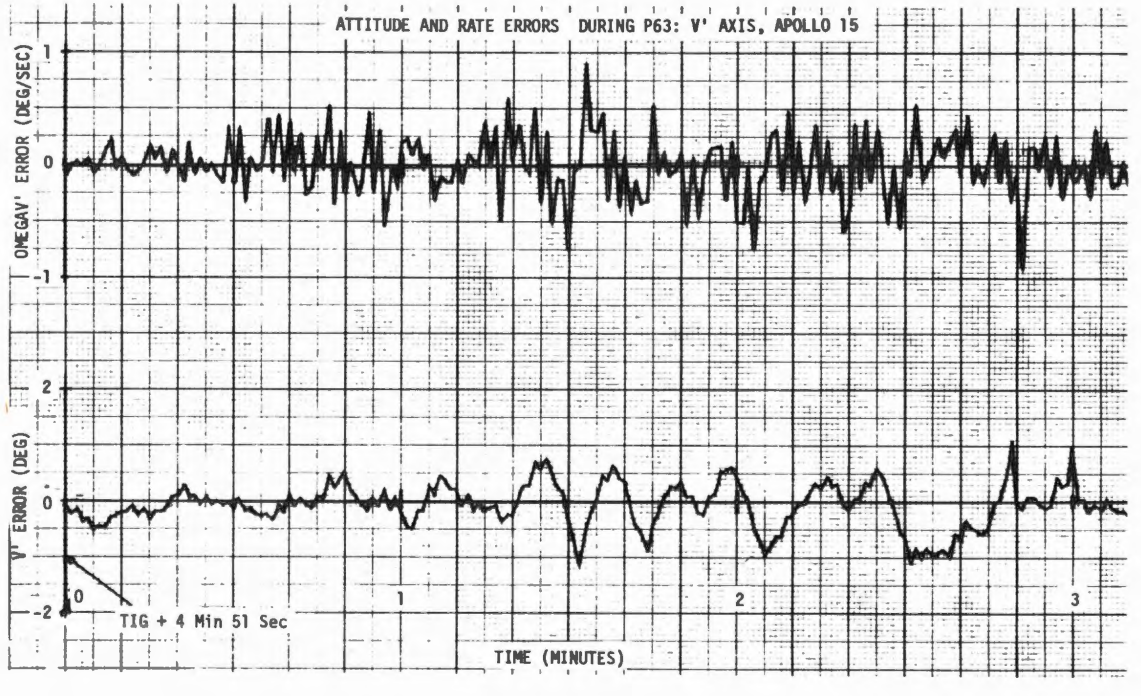
- ONLY P63 AND P64 PHASES ARE SUITABLE FOR COMPARISON. OBSERVED CONSUMPTION FOR THOSE TWO PHASES WAS WITHIN EXPECTED RANGE OF PREVIOUS MISSIONS.

SLOSH INTERACTION

- A-15 SLOSH ACTIVITY INITIATED 120 SECONDS LATER THAN A-14 SLOSH AND WAS NOT SUSTAINED. ON PREVIOUS LUNAR LANDINGS, SLOSH WAS INITIATED AT APPROXIMATELY SAME TIME AND WAS SUSTAINED THROUGHOUT DESCENT UNTIL P66 MANUAL ACTIVITY OBSCURED SLOSH CHARACTERISTICS.

- DURING SHORT PERIOD OF A-15 SLOSH ACTIVITY, SLOSH AMPLITUDE WAS MUCH REDUCED FROM A-14, A-12, AND A-11, AND RAPIDLY DAMPED.


ATTITUDE AND RATE ERRORS DURING P63: U' AXIS, APOLLO 14
OMEGAU' ERROR (DEG/SEC)
U' ERROR (DEG)
TIG + 3 Min 34 Sec
TIME (MINUTES)


ATTITUDE AND RATE ERRORS DURING P63: V' AXIS, APOLLO 15
OMEGAV' ERROR (DEG/SEC)
V' ERROR (DEG)
TIG + 4 Min 51 Sec
TIME (MINUTES)