F-2 KK
3-7-72
G+C D

- POSTFLIGHT ANALYSIS FOCUSES ON PROBLEMS NOTED DURING FLIGHT, CREW COMMENTS, AND REVIEW OF DATA
  - NOT A SOFTWARE VERIFICATION
  - MORE HARDWARE/SOFTWARE COMPATIBILITY

COLOSSUS POSTFLIGHT ANALYSIS

- NO SIGNIFICANT ANOMALIES OR PROBLEMS WERE OBSERVED
- PROBLEMS OF INTEREST DURING P20 OPTION 5 WERE
  - LONGER-THAN-NORMAL JET FIRINGS
  - POINTING ACCURACY NOT GOOD AS EXPERIMENTERS EXPECTED
- TESTING DONE TO OPTIMIZE DEADBAND SELECTION TO REDUCE NUMBER OF JET FIRINGS

COLOSSUS SOFTWARE REVIEW

POSTFLIGHT INVESTIGATIONS

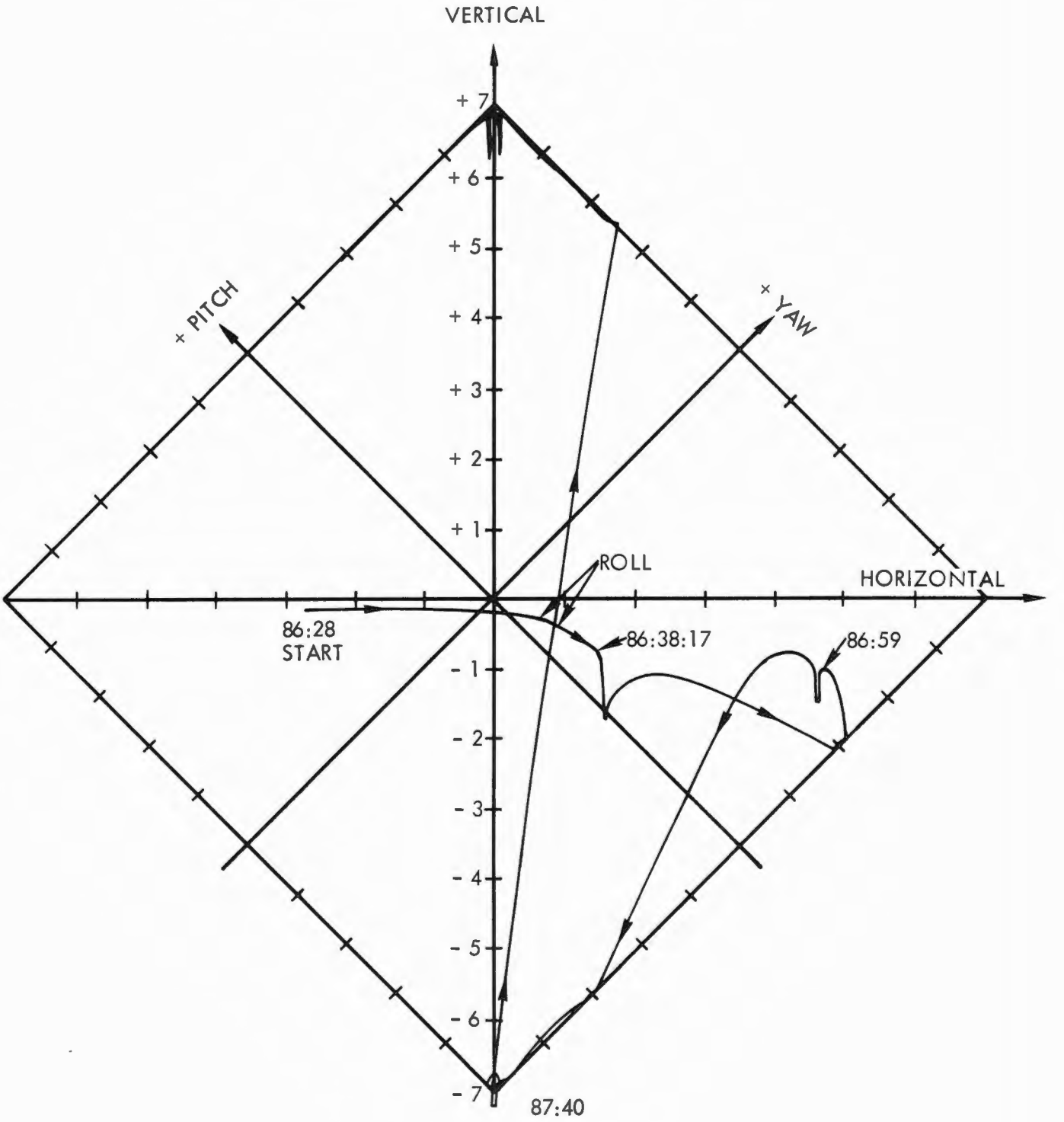
- LARGE RCS JET FIRINGS DURING P20
- EVALUATION OF P20 ATTITUDE ERROR DEADBANDS

COLOSSUS SOFTWARE REVIEW

LARGE RCS JET FIRINGS DURING P20

- PREFLIGHT STUDIES INDICATED THE INTERRUPTION OF P20 RATE MANEUVER BY CERTAIN NAVIGATION ROUTINES.
- POSTFLIGHT EVALUATION OF APOLLO 15 P20 OPERATIONS REVEALED PITCH AND YAW DAP ATTITUDE ERROR TRANSIENTS OF 0.7° FOR CSM/LM CONFIGURATION, OCCURRING EVERY 30-40 MINUTES DUE TO P20 INTERRUPTIONS.
- LIMIT CYCLES DEVELOP AT MAXIMUM VERTICAL ERROR BECAUSE OF GRAVITY-GRADIENT TORQUES AND LIMIT CYCLES ARE OF LOW AMPLITUDE BECAUSE OF LOW JET ACCELERATION.
- DEADBANDS ARE QUICKLY EXCEEDED IF INTERRUPTION OCCURS DURING A LIMIT CYCLE AT NEGATIVE DEADBANDS, RESULTING IN LARGE RCS JET FIRINGS.
- PROBLEM ALLEVIATED ON APOLLO 16 BY FOLLOWING PROCEDURES:
    - SETTING SURFFLAG TO PREVENT LM STATE VECTOR INTEGRATION
    - LIMIT TIME TAG ON STATE VECTOR UPLINKS TO BE WITHIN 30 MINUTES OF UPLINK TIME
    - LIMIT USE OF EXTENDED VERBS THAT REQUIRE INTEGRATION
    - LIMIT USE OF PROGRAMS THAT ALLOW P20 TO RUN IN BACKGROUND BUT PREVENT PERIODIC INTEGRATION

ERROR CROSSPLOT



APOLLO 16 P20 PARAMETER SELECTION

FOR IMPROVED LUNAR ORBIT LIMIT CYCLE PERFORMANCE

INTRODUCTION

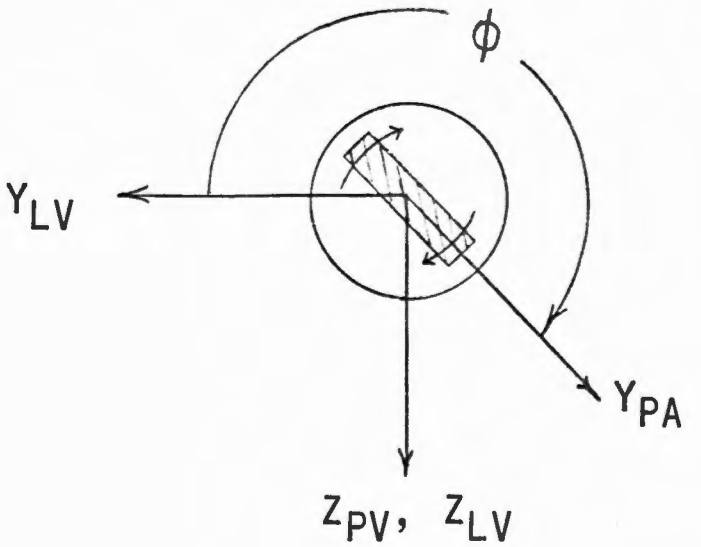
APOLLO 15 POSTFLIGHT DATA SHOWED THAT GRAVITY GRADIENT TORQUES CAUSED POOR LUNAR ORBIT LIMIT CYCLE PERFORMANCE

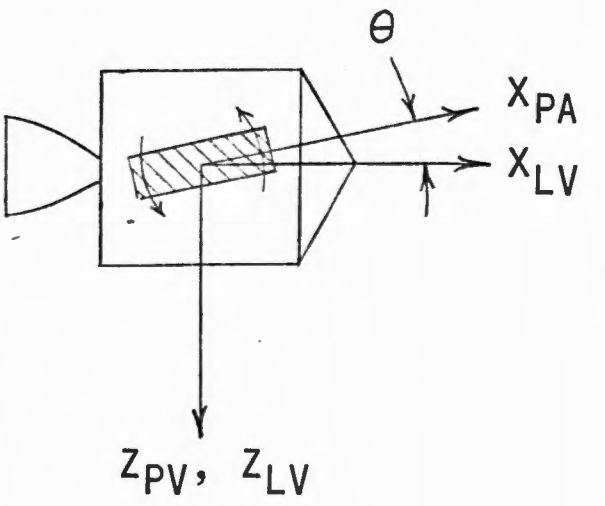
- CSM ALONE
  - ATTITUDE ERROR FOR ALL AXES BIASED TOWARD NEGATIVE DEADBAND (AVG. $\sim -4^{o}$/AXIS)
  - HIGH FREQUENCY OF JET FIRINGS, 26/ORBIT
- CSM/LM
  - ATTITUDE ERRORS
    - ROLL - BIASED TOWARD NEGATIVE DEADBAND (AVG. $\sim -4^{o}$)
    - PITCH AND YAW - ALTERNATELY HUNG UP ON BOTH SIDES OF DEADBAND
  - VERY HIGH JET FIRING FREQUENCY (100-200/ORBIT)

BACKGROUND

- THERE ARE SIGNIFICANT PRINCIPAL AXES OFFSETS FROM THE REFERENCE LOCAL VERTICAL COORDINATE SYSTEM

	CSM	CSM/LM
ROLL	234.5°	233°
PITCH	4.5°	1°





BACKGROUND (CONTINUED)

- PRINCIPAL AXIS OFFSETS PRODUCE GRAVITY GRADIENT TORQUES IN CONTROL AXES AS FOLLOWS
  - ROLL - BOTH CONFIGURATIONS, NEARLY CONSTANT AND NEGATIVE
  - PITCH AND YAW
    - CSM - ALWAYS NEGATIVE
    - CSM/LM - MOST LIKELY ALWAYS NEGATIVE, BUT DEPENDS ON I.C.

- FOR CSM/LM, CORRECTIVE ROLL FIRINGS CAUSE A LARGE NEGATIVE PITCH TORQUE, 1100 FT. LBS., DUE TO 11 FT. SEPARATION OF CENTER OF GRAVITY AND THRUSTER PLANE

P20 CHANGES WHICH IMPROVE PERFORMANCE

- DECREASE DEADBAND
  - REDUCES AVERAGE PITCH AND YAW GRAVITY GRADIENT TORQUES, AND THEREFORE, FREQUENCY OF JET FIRINGS
  - REDUCES BIAS IN POINTING
- FOR THE CSM/LM, BIAS POINTING VECTOR IN PITCH
  - ASSURE POSITIVE PITCH AND YAW GRAVITY GRADIENT TORQUES. HENCE, NEGATIVE PITCH TORQUE FROM ROLL FIRINGS WILL REDUCE REQUIRED PITCH AND YAW CORRECTIVE JET FIRINGS

SPECIFIC RECOMMENDATIONS

- CSM - REDUCE DEADBAND TO 2.5° - 3.0°
- CSM/LM
  - REDUCE DEADBAND TO 2°
  - BIAS PITCH POINTING BY 2°

flt plan says 3° and no biasing

S Shaffer to initiate change for CSM/LM CASE

G&C FUNCTIONAL SIMULATOR TEST RESULTS

P20 PARAMETERS	CSM ALONE			CSM/LM		
	FIRINGS PER ORBIT	AVERAGE POINTING ERROR		FIRINGS PER ORBIT	AVERAGE POINTING ERROR	
		ROLL	PITCH*		ROLL	PITCH*
APOLLO 15 VALUES	26	-3.5^{o}	5.5^{o}	100+	-4^{o}	7.0^{o}
APOLLO 16 SIMULATIONS	22	-1.5^{o}	3.0^{o}	~50	-1.25^{o}	-4.5^{o}

* WRT LOCAL HORIZONTAL