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LUMINARY Memo #178

TO: Distribution
 FROM: Peter S. Weissman
 DATE: 20 October 1970
 SUBJECT: Inputs to LM DAP During Descent and Ascent

The following guide is intended to make clear for the crew and other autopilot "users" when the various inputs to the LM autopilot are modified during descent and ascent.

DESCENT

	<u>"Event"</u>	<u>Actions following "event"</u>	
P63	Selection of program	Ullage request turned off Use of GTS disallowed Manual X-axis override in AUTO allowed Commanded rate set to zero Use of angular acceleration estimate inhibited Deadband restored to crew-selected value	} (generally redundant)
	IMU fine align (or bypass)	Reference attitude ← present attitude Deadband ← 1 Select Mode 2 FDAI error display (effective V62)	
	E to V50N18	If not PGNCS AUTO mode and Auto Throttle, flash V50N25 R1-203	

	TIG-30	SERVICER (AVERAGE G) started on a 2 second cycle: decrements the mass estimate as a function of ΔV and updates the DAP control authority estimates (which are functions of mass)
	TIG-7.5	Ullage requested
	PRO to V99 and TIG	DPS turned on Not Minimum Impulse mode when in ATT HOLD (effective V77) Allow use of angular acceleration estimate
	TIG + 0.5	Ullage request turned off
	TIG + 3	Allow use of GTS so long as it is not disabled by the crew and the measured acceleration is above the threshold
	TIG + ZOOMTIME (26 sec)	Throttle-up to full thrust Guidance started
	H \leq 30K ft	Manual X-axis override inhibited and the guidance starts controlling yaw as well as pitch and roll when in AUTO
P64	Major mode change	Deadband \leftarrow 0.3° Guidance commands pitch-over for landing site visibility
P66	Major mode change	(Deadband left at its current value) Manual X-axis override in AUTO allowed
	PRO to V6N60 and engine disarmed	Steering discontinued and DAP forced to be completely reinitialized every 2 sec until P66 is exited; includes nulling the commanded rate and setting the reference attitude equal to the present attitude. ROD switch and the throttle continue to be serviced.
P68	Selection of program	Guidance and navigation discontinued; commanded rate zeroed Engine turned off by LGC Ullage request turned off (redundant) Manual X-axis override in AUTO allowed (redundant) Use of GTS disallowed Deadband restored to crew-selected value Use of angular acceleration estimate inhibited

Reference attitude ← present attitude
 Minimum Impulse mode when in ATT
 HOLD (effective V76)
 Flag set to indicate LM staged

ASCENT

P12

Selection of program

Ullage request turned off
 Use of GTS disallowed
 Manual X-axis override in AUTO
 allowed
 Commanded rate set to zero
 Use of angular acceleration estimate
 inhibited
 Deadband restored to crew-selected
 value

} redundant

PRO to V6N33

X-axis translation to use 4 jets
 Vertical rise flag set

PRO to V6N76

Reference attitude ← present attitude
 Commanded rate set to zero (redundant)
 Deadband ← 1
 Use of GTS disallowed (redundant)
 If not in PGNCS AUTO, check code 203
 displayed

TIG-30

SERVICER (AVERAGE G) started on a
 2 second cycle: decrements the mass
 estimate as a function of ΔV after lift-
 off and updates the DAP control authority
 estimates (which are functions of mass)

PRO to V99 and
 TIG

APS turned on
 Not Minimum Impulse mode when in ATT
 HOLD (effective V77)
 Use of angular acceleration estimate
 allowed
 Angular acceleration estimate set to pad-
 loaded value
 Ascent guidance started; manual X-axis
 override in AUTO inhibited until 12 sec
 after the vertical rise phase

TIG + 0.5

Ullage request turned off (redundant)

$\dot{R} > 40 \text{ ft/sec}$
 (or $R > 25 \text{ K ft}$)

Vertical rise ended

P70,
P71

TGO = 0
(Flashing V16N63)

PRO to V16N63
(optional)

V34 to V16N63, or
PRO or V34 to V16N85

Program selection
(pushbutton or V37)

APS turned off
Commanded rate set zero
Use of angular acceleration estimate inhibited
Deadband restored to crew-selected value
Use of GTS disallowed (redundant)

Reference attitude ← present attitude
Commanded rate set zero (redundant)
Deadband ← 0.3°

Deadband restored to crew-selected value
Manual X-axis override in AUTO allowed
(redundant)
Ullage request turned off (redundant)

If P71, flag set to indicate LM staged
Ullage request turned off
Use of angular acceleration estimate allowed
Manual X-axis override in AUTO allowed
Not Minimum Impulse mode when in ATT
HOLD (effective V77)
Deadband ← 1°
DAP forced to idle for 0.2 - 0.3 sec;
RCS jets and GTS drives turned off;
DAP re-initialized, which includes
zeroing the commanded rate and setting
the reference attitude equal to the present
attitude
X-axis translation to use 4 jets
If not in PGNCS AUTO or, if P70, if throttle
not in AUTO check code 203 displayed;
guidance not connected until there is a
response to the display
If $R < 25$ K ft the vertical rise phase is
entered and manual X-axis override in
AUTO is inhibited until 12 seconds
after this phase is ended. Vertical rise
ended when $\dot{R} > 40$ ft/sec or $R > 25$ K ft

CONTINUED AS IN P12

NOTES

1. This memo is applicable to LUMINARY ID.
2. Certain actions which are included above are unnecessary in the nominal sequence of events because they do not make any change to the existing conditions. Such actions are denoted "redundant".
3. The following alarms which are not of the BAILOUT or POODOO types all have the effect of holding the commanded rate zero until the alarm condition disappears.
 - 402 — any time in powered flight
 - 1410 — any time in powered flight
 - 1406 — P63, P64
 - 1466 — P66
4. The 401 alarm, which can occur any time in powered flight, causes the desired middle gimble angle to be limited so as to avoid gimbal lock, but does not otherwise affect the steering or control.
5. If, during any powered flight program other than P66 the measured acceleration falls below the appropriate threshold, the commanded rate will be held zero and use of GTS will be disallowed. If the condition persists for 4 seconds (10 seconds if the thrust monitor has just been enabled) V97 is flashed on the DSKY. After that, in P63 and P64 there will be no more steering until the V97 is responded to; in ascent the steering will resume as soon as the low thrust condition disappears even if the V97 is still on the DSKY. The guidance algorithm of P66 is an exception: it does not recognize thrust failures (although use of GTS is disallowed and V97 is displayed).
6. Alarms 2001, 2002, 2003 and 2004 occur when the autopilot is unable to perform a particular rotation or translation because too many RCS jets have been disabled. They do not have any effect on the guidance or steering except, of course, for the fact that the desired rotation or translation is not carried out.
7. The IMU fine alignment option at the beginning of P63 is to be deleted from future programs. The actions which are shown following this "event" are not related to the alignment and they will continue to be performed at the same time (prior to the V50N18 display).