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LUMINARY MEMO # 239

TO: Distribution  
FROM: D. Eyles  
DATE: February 22, 1972  
SUBJECT: EMPs to display H and H on the DSKY.

EMP 107 designates an erasable memory program to display landing radar altitude and altitude-rate on the DSKY in the event that the tape meters are broken. It all started when the glass broke on Apollo 15. There are two uses for this data: (1) to update the AGS, and (2) to compare to the PGNCS calculated values, especially during P66.

Two different erasable programs have been concocted and tested for this purpose. They have in common that they are executed between the end of Servicer and the landing guidance, and are initiated by loading the starting address of the erasable program into the upper order half of AVGEXIT, after ignition, when AVGEXIT is loaded with the double-precision address of LUNLAND. (Thus when the DXCH Z at the end of Servicer transfers control to the erasable program, EBANK is set to 7.). They both use noun 99 for display.

They differ in philosophy. The first presented here assumes that the PGNCS state vectors are valid. The second assumes only that the program sequencing is healthy. The second is preferable, and it is the second version which is documented as EMP 107.

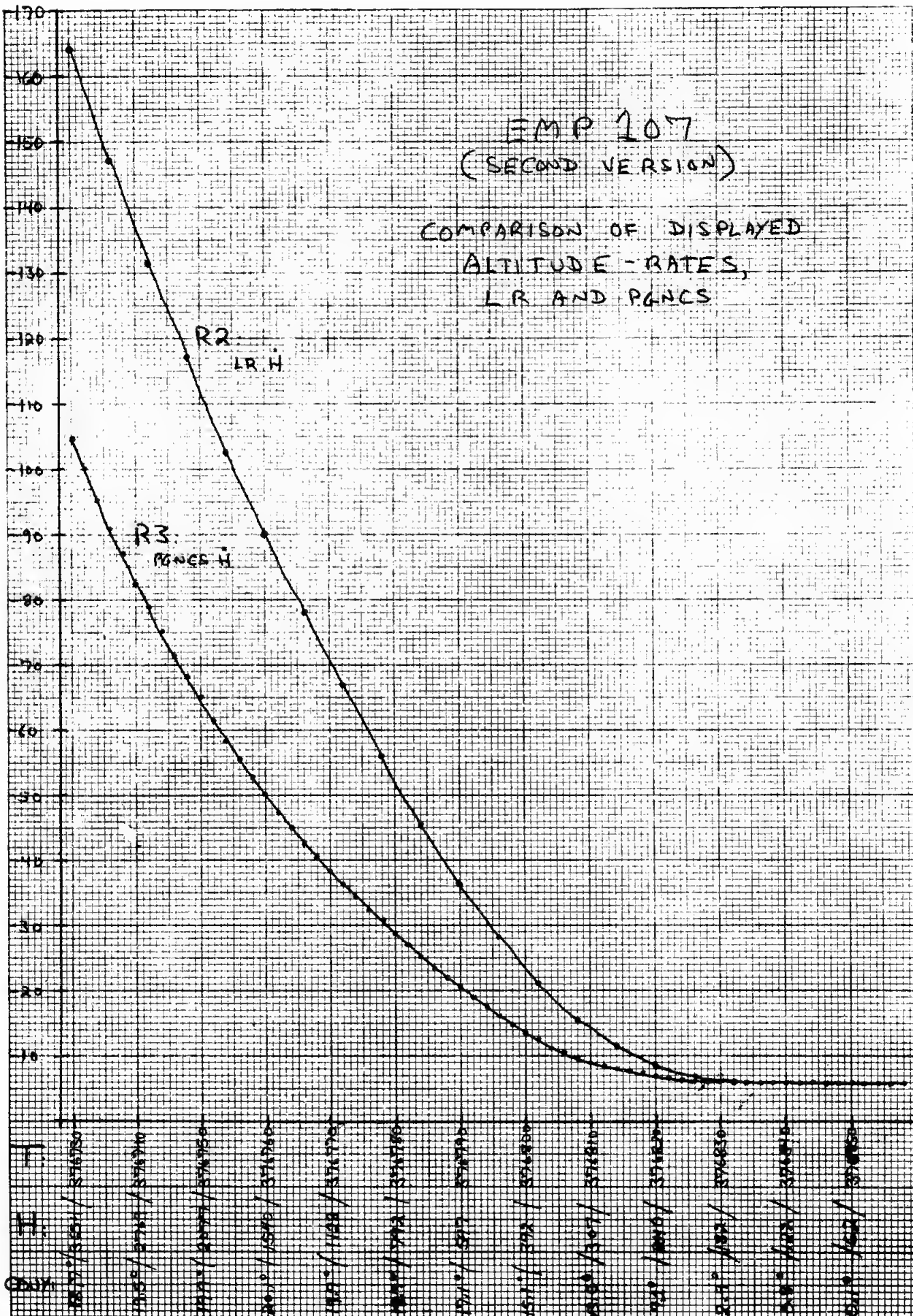
The first of the two versions extracts "raw" radar data in just the same way the radar update routine extracts  $\Delta H$  and  $\dot{\Delta H}$  for use in updating the position and velocity vectors. For  $H$ , this consists of multiplying the scalar radar reading HMEAS, by the projection of the range beam vector on the unit position vector. For  $\dot{H}$ , the process is somewhat more complicated because the direction of the radar x-beam and the sensed velocity alone do not provide enough information to separate the velocity due to altitude-rate from that due to horizontal motion across the surface. This requires use of the PGNCS velocity vector. (Note that the three beam velocities would allow this separation to be made, but this would require a more complex erasable program than there is room for.) The unit position vector is also used in the  $\dot{H}$  extraction. Implicit in this discussion is that the vehicle attitude, described by the XNBPIP vector, is also required for both extractions. Thus in this version of the EMP, a working IMU and valid PGNCS state vectors are assumed -- in calculating values for comparison to PGNCS values. There would seem to be an inconsistency there. On the other hand, the  $H$  and  $\dot{H}$  displayed, in R1 and R2 of N99 respectively, are true altitude and altitude-rate, independent of the LM's horizontal velocity and attitude. This version is attached as Appendix A.

The second version of EMP 107 takes a different approach. To begin with, it recognizes another contradiction: if the tape meters are broken and the DSKY is displaying radar data, no direct, simultaneous comparison of PGNCS and radar data is possible. Consequently, PGNCS altitude-rate is rescaled and displayed in R3 of N99, to the nearest tenth of a foot per second. (The same thing cannot be done in the earlier version without using an additional block of erasable memory.) However, the main difference between the two versions is that the second displays exactly the values that would be seen on the meters if they were working. HMEAS and

VMEAS (for the x-beam only) are simply scaled and displayed, in R1 and R2 of N99 respectively. Thus the PGNCS state vectors need not be valid and the IMU need not even be working. Only the radar read routine (and Servicer which calls it) need to be functioning. The disadvantage is that the displayed values are not true altitude and altitude-rate. R1 is a slant range. R2 is a velocity which contains a contribution due to horizontal motion. Indeed this velocity overflows the display scaling, and is set to zero, until (roughly) the re-acquisition of radar data after high-gate. And it does not represent true  $\dot{H}$  until the vehicle's attitude is erect. A plot on the next page, taken from a simulation of a fully automatic landing, shows how the  $\dot{H}$  displayed in R2 converges on the true (PGNCS) altitude-rate .

# EMP 107 (SECOND VERSION)

COMPARISON OF DISPLAYED  
ALTITUDE - RATES,  
LR AND PGNC



Appendix A

Initiation:

After Ignition: V 21 N 1 E 1251 E 605 E

Display:

V 16 N 99 E (R1: H<sub>LR</sub>; R2: H<sub>LR</sub>; R3: garbage)

Validity:

R1 is valid when the ALT light is out. R2 is valid when the VEL light is out.

604	00000	reserves	VAC4	631	06060	TC	INTPRET
605	34746	CA	ZERO	632	54345	DLOAD	SL
606	54604	TS	VAC4USE	633	03653		VMEAS
607	06060	TC	INTPRET	634	20215		12D
610	76634	RTB	VLOAD*	635	62605	DMP	PDVL*
611	67501		POSINDEX	636	26071		VXSCAL
612	26003		HBEAMNB, 1	637	26025		VXBEAMNB, 1
613	50305	VXM	DOT	640	63305	VXM	PDVL
614	02137		XNBPIP	641	02137		XNBPIP
615	03537		UNIT/R/	642	03527		V
616	54205	DMP	SL	643	52352	VSL2	VSU
617	03655		HMEAS	644	03702		VSURFACE
620	20214		11D	645	44241	DOT	BDSU
621	77605	DMP		646	53361	VXSC	VAD
622	26063		HSCAL	647	00003		2
623	02172	STORE	WWPOS	650	03527		V
624	77776	EXIT		651	54241	DOT	SL
625	44744	CS	ONE	652	03537		UNIT/R/
626	61462	AD	VSELECT	653	20211		8D
627	00006	EXTEND		654	02174	STORE	WWVEL
630	62425	BZMF	LUNLAND	655	77404	BOVB	EXIT
				656	62425	CADR	LUNLAND
				657	12425	TCF	LUNLAND

Appendix B

Initiation:

After Ignition: V 21 N 1 E 1251 E 661 E

Display:

V 16 N 99 E (R1: H<sub>LR</sub>; R2: H<sub>LR</sub>; R3: H<sub>PGNCS</sub>)

Validity:

R3 is always valid. R2 is valid when the VEL light is out and R2 is non-zero. R1 is valid when the ALT light is out.

660	00000	reserves	VAC5	710	54154	TS	MPAC	
661	34746	CA	ZERO	711	54155	TS	MPAC +1	
662	54660	TS	VAC5USE	712	06060	TC	INTPRET	
663	31462	CA	VSELECT	713	02174	STORE	WWVEL	
664	67752	AD	OCT37776	714	77776	EXIT		
665	54000	TS	A	715	06060	TC	INTPRET	
666	00715	TC	715	716	57545	DLOAD	DCOMP	
667	06060	TC	INTPRET	717	03655		HMEAS	
670	41345	DLOAD	DMP	720	54205	DMP	SL	
671	03653		VMEAS	721	26063		HSCAL	
672	26071		VXSCAL	722	20212		9D	
673	77461	SL	EXIT	723	16172	STODL	WWPOS	
674	20223		18D	724	03474		HDOTDISP	
675	10121	CCS	OVFIND	725	42405	DMP	SL4	
676	00710	TC	710	726	00703		702	
677	00712	TC	712	727	02176	STORE	WWBIAS	
700	00710	TC	710	730	77776	EXIT		
701	00712	TC	712	731	34746	CA	ZERO	
702	32176	}	2DEC	732	54121	TS	OVFIND	
703	12173		+ .820209962	733	12425	TC	LUNLAND	
704	}	unused						
705								
706								
707								