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COLOSSUS Memo #77

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DATE: August 6, 1968  
SUBJECT: COLOSSUS Program Notes at Time of FACI (8/8/68)

The attached Notes are the official Colossus Program Notes at the FACI. These notes were reviewed at the MIT/NASA Pre-FACI Review held at the MIT Instrumentation Laboratory on August 2, 1968.



## COLOSSUS Program Notes

### Section 1. Nouns Verbs, Displays

- 1.1 Some nouns are not manually callable with valid data at any time; e.g., 1, 2, 3, 5, 6, 7, 10, 12, 15, 16, 24, 25, 26, 29, 30, 31, 34, 41, 72, 97, 98.
- 1.2 The following nouns can never be loaded: 40, 44, 45, 50, 63, 80.
- 1.3 There are 3 priority displays in COLOSSUS which will ignore any response for 2 seconds.
  - V06N49 in R22
  - V05N09, R1 = 00404 in R52
  - V50N18 in R60 during P20
- 1.4 The program will ignore any attempt to load Channel 7 via the DSKY. It will not even alarm. Channel 7 is the super-bank indicator and is under exclusive program control.
- 1.5 When loading decimal data into the AGC, the ENTER sometimes changes the last digit of the loaded value since PINBALL roundoff in decimal/octal/decimal conversion occurs when data is keyed in (decimal to octal) and entered and redisplayed (octal to decimal).



## COLOSSUS Program Notes

### Section 2. Selection of New Programs and Extended Verbs

- 2.1 V37 should not be called for 20 seconds after the NO ATT light goes off. If it is, the PIPA FAIL inhibit bit will not be reset and a PIPA FAIL will go undetected.
- 2.2 In ENTRY (P62 - P67), V37's are inhibited after a response to "please perform separation" except a request to perform P00. To get another program up, P00 must be entered first, then the desired program called. Care should be taken, however, that P62 be reselected before entering the atmosphere, since AVEG is terminated by going to P00. Any program which does not require DAP control may be selected from P00.
- 2.3 When a new program selection is made via V37 the key release light will remain on during R00 and will not go off until the new program is started. No further keyboard activity should be attempted until the key release light goes off and the new mode lights are displayed.
- 2.4 At times when program selection is not allowable by astronaut action (V37 XXE), expect for P00, R00 will issue a 1520 alarm and the interrupted activity will resume. Attempts to select non-existent programs will result in an operator error light and return to the interrupted program activity and display.
- 2.5 V96E will interrupt all "P-program" activity and place the computer in P00. P00 integration will not be performed unless P00 is reselected. However, selection of any other program (V37 XXE) will restore normal program activity.
- 2.6 After V82E, meaningful information in N50 (DELRSPASH) is available only during P11 and P00.
- 2.7 V82 should never be selected in P11 within  $\pm 5$  seconds of LIFTOFF time.
- 2.8 Since some extended verbs (notably V82, V83, and V85) use several JOB areas, a software restart may be generated if these verbs are selected in periods of high activity due to VAC or Core Set overflow. In this case the Program Alarm light will be lit and alarm code 1201 or 1202 will be stored. Extended verb activity will be lost and the verb must be reselected. Typical periods of high activity when this might occur are
  - 1) V83 in P3X or P7X with P20 in the background, and
  - 2) V82 in P4X with Lambert.
- 2.9 Extended verbs are not restart protected. If the restart light goes on during an extended verb, the verb should be reselected.



## COLOSSUS Program Notes

### Section 3. Ground Updates and Pad Loads

- 3.1 The lunar-solar ephemeris pad loaded data is only good for  $2^{26}$  cs (approximately 14.5 days). If the flight lasts longer, new data must be loaded.
- 3.2 Any P27 update will destroy the preferred alignment matrix (e.g., that calculated by P40, P41), except an update of the matrix itself. Therefore if a preferred alignment is to be part of an update, it should be the last quantity in the sequence.
- 3.3 Downrupts may be lost at infrequent intervals during high level computer activity.



## COLOSSUS Program Notes

### Section 4. Navigation and W-Matrix

- 4.1 V96 could leave the other state vector and the W-Matrix out of phase if requested during any permanent state vector updates, P00, P20, P22, P23, and P76, and Average G.
- 4.2 Coasting integration of state vectors backwards in time cannot exceed one orbital period. Many programs and routines require coasting integration of state vectors to a desired time; e.g., P40, therefore the time associated with the permanent state vector should not exceed this desired time by more than one orbital period. P00 does not integrate the CM state vector backwards in time but will synchronize the LM state vector to the CM state vector time.
- 4.3 The W-matrix should not be initialized to magnitudes greater than 325 ft/sec and the following limits in position:
  - a) for rendezvous navigation - 8.5 N.M.
  - b) for orbital navigation - 8.5 N.M.
  - c) for cislunar navigation - 275 N.M.
- 4.4 During a sequence of marks in P22, the first mark should not be identified as the "offset" landing site. (Identification is made either by N71 or exercising V52E.)
- 4.5 The range and range rate displays (in R31 and R34) may degrade considerably at ranges below  $\sim .3 - .5$  N.M. depending on marking schedules and resultant AGC navigation accuracy.



## COLOSSUS Program Notes

### Section 5. Rendezvous and Targetting

- 5.1 Lambert computation should not be used within approximately  $3^{\circ}$  of target vector.
- 5.2 All uplinked  $\Delta V$ 's and target vectors must be in the same sphere of influence as the AGC determined state at TIG and TIG-30.
- 5.3 To ensure processing of the last mark in P20, wait until the computer activity light goes on before proceeding. The light indicates the previous mark is being processed. If Proceed is done too soon, one of the last 2 marks may be ignored.
- 5.4 V83 and V85 displays will be meaningless at altitudes greater than 425 N.M. for earth and 210 N.M. for moon if these verbs are exercised during periods of precision state vector integration.
- 5.5 The uplinked target vector (P31) must be such that the resultant transfer angle from TIG-30 throughout the powered maneuver will not lie within  $170^{\circ} - 190^{\circ}$ . Target vectors within this cone will be rotated into the CM current plane of motion..
- 5.6 A computational pole does exist at  $180^{\circ}$  for all targetting, (exactly, or within fractions of a degree) and attempted solutions with this transfer angle will be meaningless.
- 5.7 Provided that the time of ignition, TIG, is defined to occur outside the lunar sphere of influence, P37 will always produce a conic solution although no precision solution may be possible.
- 5.8 For pre-apogee, long transit time aborts, the conic solutions in P37 may be grossly inaccurate yielding erroneous landing site coordinate displays. In addition, long integration periods of perhaps 10 - 30 minutes may be experienced.
- 5.9 The assumption is made in the rendezvous targetting routines (i. e., not P30 or P31) that the resultant perigee altitude will be less than 9999.9 N.M. If it is greater, then this display (N58) will become meaningless.
- 5.10 The  $v_G$  or  $\Delta v$  displays in control coordinates, N85 or N83, are based on reading the accelerometers every 2 seconds. The displays, however, are asynchronous one second monitors. The result is a possible  $1/2 - 1\ 1/2$  second delay between the application of  $\Delta V$  and the visible result.



## COLOSSUS Program Notes

### Section 6. Optics and IMU

- 6.1 Optics CDU fail during TVC sets the tracker light which will stay on even if fail is removed.
- 6.2 During auto optics, the computational lag between sampling the IMU CDU's and driving the optics causes the optics to lag behind the target. The amount of offset is proportional to the S/C angular rate. At the usual rate of  $4^\circ/\text{min.}$ , the maximum offset would be 0.133 deg. This will not cause an error during manual tracking and marking.
- 6.3 After a fresh start, optics must be taken out of zero and returned to perform an optics zero since it is not the position of the switch but the change to the zero position that triggers the zeroing program.
- 6.4 Backward IMU alarm (1427) will always be displayed in P61 & P62 following a P40 or P41 deorbit maneuver unless the ground uplinks a preferred alignment.
- 6.5 If mode switch is in attitude hold during R55 (gyro torquing routine) the DAP will maneuver the vehicle to follow the platform as it moves.



## COLOSSUS Program Notes

### Section 7. Powered Flight, Boost and Entry

- 7.1 TGO display is discontinuous immediately after ignition. TGO is computed from the ratio of velocity to be gained over  $\Delta V$ , where  $\Delta V$  is the velocity change over the last time period. At ignition  $\Delta V$  will be small. As thrust develops  $\Delta V$  will increase until it becomes fairly constant. Until this time, the ratio will behave erratically. The computation settles down in 4 to 5 seconds.
- 7.2 If a roll jet fails "on" during SPS thrust, an appreciable roll excursion  $30^\circ$  may occur. The PITCH-YAW DAP will continue to function properly.
- 7.3 Once the stroke test is started it cannot be stopped except by completion, selection of another P-program or changeover to SCS.
- 7.4 The engine gimbal trim angles (astronaut input to N48) should not exceed  $9^\circ$ .
- 7.5 The RCS DAP will not hold attitude adequately when translating in Y or Z with LM attached or at very small propellant loading (10%), CSM alone.
- 7.6 The display of range to go (N64) in P63 is either zero or the last P62 value on the first two second pass.
- 7.7 The Down Range Error display (N66) in P67 will be set to 9999.9 N.M. when the vehicle state "goes past" the target. That is, under these conditions this display will not exhibit negative down range error.
- 7.8 Because of the .01 second time granularity in the AGC, the calculation of small Lambert maneuvers may differ considerably from ground computations. The immediate effect, e.g., in P41, will be a different set of desired gimbal angles from those expected on the ground. The angular difference between the ground and AGC  $v_G$ 's is a function of earth or moon environment, the magnitude of  $v_G$ , and the active vehicle transfer angle. For 1 ft/sec maneuvers, this angular "error" could vary from  $\sim 5^\circ$  (at  $140^\circ$  transfer) to  $\sim 20^\circ$  (at  $60^\circ$  transfer) to  $\sim 30^\circ$  (at  $30^\circ$  transfer) for the earth. For the moon these angles are  $\sim 1^\circ$ ,  $\sim 3^\circ$ , and  $\sim 5^\circ$  respectively. For greater  $v_G$  the angular error is inversely proportional to the magnitude (approximately). Since the maximum error is  $30^\circ$ , the cross axis velocity introduced by performing the maneuver is  $< \pi/6$  ft/sec.



## COLOSSUS Program Notes

### Section 7. Powered Flight, Boost and Entry (continued)

- 7.9 Due to the lower roll acceleration of the CM during entry (based on previous flight test data) the entry steering system may fall short by 30 - 40 N. M. as a result of single ring operation under the following set of improbable conditions:

A roll rate will be established responding to a lateral switch, then the roll command changes causing the shortest path to be in the opposite direction. The vehicle will then kill off the original roll rate and roll in this new direction. But by this time the response has been so delayed that proper ranging is no longer possible.

- 7.10 During the trimming of Lambert derived  $v_G$ , the  $v_G$  display may jump in earth environment, .1 - .2 ft/sec at transfer of  $140^\circ$ , .3 - .5 ft/sec at transfer of  $60^\circ$  and .5 - 1 ft/sec at transfer of  $30^\circ$ . For moon environment these jump numbers are .02, .05 and .1 respectively.