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LUMINARY Memo #225

To: Distribution  
From: P. Volante  
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Subject: Failure Protection of the PGNCS/AGS RR Data Transfer

In LUMINARY 1E (Rev 209), for Apollo 15 and subsequent flights, Rendezvous Radar mark data is transferred to the AGS via the Rendezvous/Prethrust Downlist when P20 is operating and reading the radar. When this change was implemented, both radar and computer failures were considered in order to provide protection to the AGS from invalid data caused by a PGNCS failure.

Only radar readings which could be used to update the state vector in P20 are transmitted to the AGS. The AGS code word which indicates that good RR data is available on the Downlist is not set if any of the following conditions occurred during the RR read sequence:

1. Loss of RR data good discrete.
2. RR CDU fail.
3. RR range scale change.

Once a good RR reading has been obtained in R22, the AGS code word is set, and the mark data is written into the downlink registers in a copy cycle. Subsequent activity in P20 will not affect the transmission of this data to the AGS. However no reasonability checks have been made on the data transmitted. Further processing of the mark data in R22 may yield a 525 alarm (RR LOS not within  $3^{\circ}$  of state vector LOS) or a Noun 49 display (state vector update exceeds prescribed limits). These conditions may be due to large state vector errors, or to a radar problem, such as side-lobe lockon or simply a bad reading which did not cause the data good discrete to be lost. If the problem is in the radar data, it will still be transmitted to the AGS, and used to update the AGS state.

Any restart, hardware or software, causes the AGS code word to be reset. A software restart is caused by Verb 37 selection of a new program, or a BAILOUT alarm (3xxxx code). A hardware restart is caused by the following conditions:

1. Scalar double frequency
2. Scalar fail
3. Counter fail
4. Voltage fail
5. Night Watchman (NEWJOB register not tested within a specified interval)
6. RUPTLOCK (Interrupt or INHINT in effect for an excessive time period or else too much time between interrupts)
7. TC TRAP (only TC instructions are being executed, i. e. a TC SELF).
8. Erasable or fixed memory parity fail.

Although restarts reset the AGS code word so that the AGS will not accept the RR Mark data, one problem might occur during a hardware restart (which was pointed out by Clint Tillman of GAEC). A hardware restart retransmits the current downlist from the beginning. However the AGS is unaware that a restart has occurred in the PGNCS, and will read in the 9th to 16th words from the downlist after it recognizes the Rendezvous/Prethrust list ID. If the hardware restart occurs during the transmission of words 2-16, the PGNCS downlist is started over at word 1, but the AGS continues to read in the data as though it were words 9-16. Hence some portion of the AGS mark data will be garbage. Now if the word which the AGS thinks is the AGS code word (which could be anywhere from word 1 to word 15 of the PGNCS list) has a valid setting, i. e.  $17776_8$  or  $57776_8$ , the AGS will accept the data and try to update with partly invalid information. The words which the AGS could receive as the AGS code word are (ignoring the list ID):

1. CSM Position X
2. CSM Position Y
3. CSM Position Z

4. CSM Velocity X
5. CSM Velocity Y
6. CSM Velocity Z
7. CSM State Vector Time
8. Marktime
9. CDU Y
10. CDU Z
11. RR Trunnion CDU
12. RR Shaft CDU
13. RR Range
14. RR Range-Rate

For the AGS to receive and update with incorrect data two conditions must be satisfied:

- a. A hardware restart must occur while transmitting words 2-15 of the downlist
- b. The word which the AGS thinks is the AGS code word must have a valid setting.