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Glen Finneman, et. al.

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GPC 4 Fail on FD07

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Agenda

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- Problem Description
- Potential Contributing Factors
- Software Analysis
- GPC Orbit and Entry Operations
- Flight History Experience
- Conclusions / Recommendations

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Problem Description

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- GPC 4 (SM) failed during crew sleep
- GPC 2 was brought online and configured for SM
- GPC 4 was powered OFF
- GPC 1 dump was performed following crew wakeup
- GPC 4 HISAM was performed
- Data Dump analysis was started
- GPC 4 was IPL'ed and added to Redundant Set in G2
- GPC 4 was freeze dried in G2 and put in HALT

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Potential Contributing Factors

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- South Atlantic Anomaly (SAA)
 - Position verified over Indian Ocean at time of event (no SAA)
- Coronal Mass Ejection (CME)
 - Verified no elevated radiation environment at time of event
- Stored Program Command (SPC)
 - Verified no SPC traffic at time of event
- Power buses nominal during event

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GPC 4 Failure on FD07 Dump Analysis Status

John Magley

FSW

July 17, 2011

Pre-Decisional Internal Use Only



GPC Dump Analysis Status

- **Data dump analysis identified three serious off-nominal signatures**
 - First/Primary Failure Indication
 - System Software CPU Store Protect Error
 - Resultant/Secondary Failure Indications
 - Fail-to-Sync due to GPC 4 failure to arrive at the common set sync point
 - PC 1 Timer Interrupts
- **Observations based on dump analysis**
 - Standard SM processes were executing as expected prior to the failure
 - Store protect error appears to have occurred due to an incorrect store address
 - Address is composed of a base address plus an offset
 - Base address register bits were all zeros (not possible during normal operations)
 - Computed store address resulted in an attempt to write into store protected memory, generating the Store Protect Error
 - System Software responded by terminating the routine requesting the memory write (FIO SVCP) and waiting for the next scheduled task to run (per design)
 - Prematurely terminating system software set up the conditions that led to the Fail-to-Sync and PC 1 Timer Interrupts

GPC Dump Analysis Status (cont'd)

- **The type of sync point where the failure occurred rules out several hardware failure types**
 - Power failure, power transient, hard fail from RUN to HALT or failures that would cause unexpected External 0 or External 1 Interrupts, for example
- **No evidence from analysis that this is a software problem**
 - FIOSVCP is a System Software I/O Support routine that normally executes continuously (at least once every 40 ms) in all running PASS GPCs
 - Analysis of key parameters reflect normal operation prior to the store protect error
 - Given the anomalous base address, the resulting effects leading to the Fail-to-Sync are expected operation of the PASS
- **Data is inadequate to definitively prove what happened**
 - The snapshot of data in this dump does not appear to provide the history required to identify a root cause in this case
 - Data is consistent with an SEU occurrence
 - Investigation is continuing but is unlikely to identify a root cause prior to the point at which a program decision for entry is required



GPC Orbit and Entry Operations

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- GPC4 was made a G2 freeze dry today (FD 9) after getting run-time as a redundant GNC during the crew day.
- The SM function will be moved from GPC2 to GPC4 shortly after the crew post-sleep activities (currently planned for around MET 8/14:00).
- GPC2 will be made a G2 Freeze when the SM is moved to GPC4.
- GPC4 will remain configured as an SM until deorbit prep where it will be configured for a nominal entry config.

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Flight History Experience

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- PRACA items
 - No like CARs for this GPC 4 (s/n 505) or any GPC on this mission
 - One CAR for elapsed time meter changeout and scratches cleanup
 - 3 CARs taken for similar signature failures
 - All single occurrence failures which did not repeat in flight
 - STS-51, 92, & 103 (see backup for details)
 - All three were UA but two attributed to SEU
- Other
 - Some flight experience with no CAR taken
 - STS-71
 - GPC 4 fail to synch, similar signature but not exactly the same
 - After dump analysis, SEU was determined
 - SM successfully reloaded and run for remainder of mission
 - Research still in work

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Conclusions

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- MER-06 Anomaly Investigation Team recommends continuing to use GPC-4 and considers it viable hardware
 - No indications of specific hardware or software issues
 - Historical behavior of these fail to synch events being isolated (non-recurring)
 - Consistent with SEU event but not definitive
 - Local store memory is not error corrected
 - Failure mode in redundant set would be to fall out of RS
- Any second occurrence of failure would require re-assessment

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Backup

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PRACA Search

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GPC PRACA HISTORY RELATING TO STS-135 ANOMALY

SIMILAR EVENTS:

Vehicle	Flight/Mission	GPC S/N	PRACA Report #	Conclusions
OV-103	STS-51 In-Flight Sep 1993	508	KA0096 060V-0042 UA3180112	UA - THE FTS WAS CAUSED BY SOME TRANSIENT EFFECT AND ITS EFFECTS WERE LIMITED TO A SINGLE GPC DURING RS EXPANSION. THE MOST PROBABLE CAUSE IS THE SOFTWARE SCENARIO IN WHICH GPCS 1,2 AND 4 DID NOT DETECT GPC 3 AT THE I/O COMPLETION POINT FOR DEU POLLING.
OV-103	STS-103 Post-Landing Dec 1999	504	KB4255	UA - THE ERROR EXPERIENCED ON OV103, GPC S/N 504, MAY BE EXPLAINED BY A SINGLE EVENT UPSET (SEU) OF THE CPU LOCAL STORE.
OV-103	STS-92 Immediately Post-Landing Oct 2000	506	KB4394 102V-0018	UA - MOST PROBABLE CAUSE OF THE ANOMALY EXPERIENCED IN GPC S/N 506 WAS A SINGLE EVENT UPSET OF THE GPC LOCAL STORE; SPECIFICALLY AN SEU OF THE RIGHT LOCAL STORE, SECTOR 3, REGISTER 4.

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OTHER EVENTS OF NOTE/INTEREST:

Vehicle	Flight/Mission	GPC S/N	PRACA Report #	Conclusions
OV-103	KSC Jan 1993	526	KB2594 DIG-3-16-0277	UA - THE MOST LIKELY CAUSE OF THIS UNEXPLAINED ANOMALY WAS IDENTIFIED AS THE MIA ASSOCIATED WITH BCE 15; MIA P/N A538R485-20, S/N 458, LOCATED ON MIA PAGE ASSEMBLY P/N 6966025-20, S/N 564.
FSW	JSC Mar 1994		AD9959	DATA ANOMALY OF FTS THAT OCCURRED IN SMS DISCLOSED INCORRECT CODES BEING CLEARED/SET IN THE GPC PSW.
OV-104	STS-66 In-Flight Nov 1994	524	66RF21 STS-66-V-09	THE SUBSEQUENT ANALYSIS ISOLATED THE CAUSE TO A DEFECTIVE MIA PAGE, S/N 568, CONTAINING DEFECTIVE MDMIA, S/N 469. IT WAS DETERMINED THAT TRANSFORMER T2 OF MDMIA S/N 469 HAD AN OPEN AT PINS 1 & 2.
OV-102	STS-78 In-Flight June 1996	533	78RF03 STS-78-V-01	UA - RESULTS OF THE FAILURE ANALYSIS INDICATE THAT THE "MOST PROBABLE" WOULD BE THE ASSOCIATED WIRE HARNESS OR CONNECTOR.
SAIL	JSC Feb 1990	005 Non-flt	AD6739	IBM, AT HOUSTON, VERIFIED THE FAILURE & ISOLATED IT TO A RAM IC, P/N 6135011-2, WHICH WAS REMOVED FROM THE CPU A (CA) PAGE, P/N 6966064. IBM VERIFIED THAT THE GPC WAS SPENDING AN ABNORMALLY LONG PERIOD OF TIME EXECUTING A LOOP OF CODE, THEREBY CAUSING IT TO FAIL TO SYNC.
Vendor	Owego May 2004	519	AE2723	During incoming functional testing, an error occurred while running the room temperature portion of Functional Test Procedure (FTP), the error observed was a failed Memory Test 9, Part 2, with Single Bit ECC errors indicated. The failure was isolated to a discrepant 4-bit counter (IC U44 Pin 11, P/N 102A450-1, lot date code 8622) on the A21 CMOS Page Assembly (Lower memory - P/N 6966070-23, S/N 539).

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OV-104 GPC Installed Serial Numbers

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- OV104 Slot 1 03640000521
- OV104 Slot 2 03640000517
- OV104 Slot 3 03640000514
- OV104 Slot 4 03640000505
- OV104 Slot 5 03640000525

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