Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	MET:	Problem	FIAR	IFA STS-73-V-01	EPD&C - EMEC, G
	GMT:		SPR 73RF01	UA	Manager:
			IPR 73V-0236	PR OEL-2-18-1761	
					Engineer:

Title: MEC 1 Pre-Flight BITE Word Indicated Failure ()

Summary: INVESTIGATION/DISCUSSION: During the STS-73 countdown for a launch attempt on October 7, 1995, the master events controller (MEC) 1 pre-flight built-in test equipment (BITE) read revealed that bit 9 of word 5 (core B), the power-on enable command steady state, was set in the incorrect state on MEC 1. Subsequent troubleshooting demonstrated that the core B critical drivers were not enabled. As a result, the launch was scrubbed. The MEC was removed and replaced, and no subsequent MEC problems occurred on the vehicle.

The failed MEC, serial number (s/n) 11, was sent to the NASA Shuttle Logistics Depot (NSLD), where it underwent teardown, test, and evaluation (TT&E). Six complete functional test runs were performed. During these runs, the failure of the core B functional circuit was confirmed, with an intermittent fail-to- turn-on occurring in the critical outputs from core B. Additionally, there were incorrect indications of the pyrotechnic initiator capacitor (PIC) capacitance voltage measurement (CVM) BITE. This indicates a CVM-BITE-related circuit failure. Seven loop-test runs confirmed the intermittent loss of the capability of core B to process critical commands. However, the word 5 bit 9 failure indication was not duplicated during the TT&E at NSLD. The exact failure mode is not currently understood based on testing performed. Further troubleshooting, including a test on the suspected core B power-turn-on (PTO) circuit is planned. A CAR is open and the work and results will be tracked by the CAR. At this time, the failure is not believed to be generic, based on failure history of the MECs across the fleet. This particular MEC has no relevant failure history. However, a similar failure occurred on core A of MEC s/n 4 in November of 1994. This one- time failure was not duplicated and was closed as an unexplained anomaly. Due to the transient nature of the failure, no determination could be made on whether the failure was a functional circuit failure or a BITE circuit failure. That MEC is currently awaiting shipment to SAIL for confidence testing. CAUSE(s)/PROBABLE Cause(s): The most likely cause of this failure can be isolated to module 3B within the MEC. There are two PTO circuits on module 3B. Either of these circuits could have triggered, and this would have caused the failure indication observed. There are approximately 60 components in each circuit. Due to the intermittent nature of the failure, a bad solder joint is a more likely cause than a faulty component. CORRECTIVE_ACTION: The MEC in question has been removed and replaced. The core B failure was confirmed at NSLD, but the original signature observed has not been duplicated. Further troubleshooting is planned. RATIONALE FOR FLIGHT: The failure is not believed to be generic. The most likely

cause is a bad solder joint. However, this will be verified when the unit is further tested.

Tracking No	**Time**	**Classification**	**Documentation**		**Subsystem**
MER - 0	**MET:**	Problem	**FIAR**	**IFA** STS-73-V-02	Hydraulics
MMACS-01	**GMT:**		**SPR** 73RF02	**UA**	**Manager:**
			IPR 75V-0012	**PR**	
					Engineer:

Title: WSB 3 Failed to Cool ()

Summary: INVESTIGATION/DISCUSSION:During ascent, water spray boiler (WSB) 3 failed to provide cooling to auxiliary power unit (APU) 3 as evidenced by the lubrication oil return temperature increasing above the normal spray start temperature of 250? F. When the temperature reached 260? F, the crew was requested to switch from controller A to controller B. After switching controllers, the temperature continued to rise at the same rate. When the temperature reached 326? F, the crew was directed to shut down APU 3 early.   Approximately one minute later, WSB 3, on controller B, began spraying. The APU system 3 was run during flight control system (FCS) check-out resulting in a near-out-of specification APU lubrication oil temperature of 273? F at spray start (275? F maximum). The cause(s) of this failure could not be readily identified due to the limited instrumentation of the WSB parameters. Possible causes of this ascent anomaly are suspected to be one or a combination of the following: controller electronics intermittent failure, water valve mechanical hesitance, water valve electrical intermittent failure, water leakage past the water valve in ascent reducing the electric heater modifications capabilities, temperature sensor intermittent failure, temperature sensor anomalous transient response, and water feedline electric heater non-performance.

What sets this anomaly apart from WSB ascent anomalies observed in the past is that all three WSB systems have an electric heater modification on the water supply feedline to preclude hard freeze-ups of the WSB spray-bar. During STS- 74 ascent, a high lubrication oil return temperature (289? F) was observed on system 3 with the heater modification installed, but was not high enough to require switching to the alternate WSB controller or early APU shutdown. FCS checkout and entry performance of this WSB was nominal. Other flights with the electric heater modification on STS-69 (heater modification installed only on system 3) and STS-72 exhibited good ascent performance. CAUSE(s)/PROBABLE Cause(s): Determining the cause(s) of the STS-73 ascent anomaly as well as the numerous WSB ascent anomalies observed in the past is complicated by nominal ground test results and ambiguous flight data. Ground testing per the OMRSD requirements verified all WSB systems to be operating nominally prior to STS- 73. The STS-73 performance in ascent and FCS checkout seemed to indicate a problem on the

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Tracking No	**Time**	**Classification**	**Documentation**		**Subsystem**
MER - 0	**MET:**	Problem	**FIAR**	**IFA** STS-73-V-03	OMS/RCS
PROP-01	**GMT:**		**SPR** 73RF03	**UA**	**Manager:**

IPR IPR 75V-0006 **PR**

Engineer:

Title: Primary Thruster F1F Failed Off ()

Summary: INVESTIGATION/DISCUSSION: Primary reaction control system (RCS) thruster F1F (s/n 402) failed-off when it was fired during the RCS trim maneuver at 293:16:54:40 (000:03:01:40 MET). The indicated thruster chamber pressure (Pc) reached only 17 psia prior to the thruster being deselected by redundancy management. The thruster fire command appeared nominal and post fail-off temperature drops of the fuel and oxidizer injector tubes indicate that both of the thruster propellant valves achieved at least pilot-stage flow. The fail- off signature of this thruster was unusual in that following the fail-off, the thruster Pc required approximately 15 minutes to return to zero psia. As a result of this response, a blockage of the Pc tube that ports pressure to the pressure transducer was identified during flight as the likely cause of failure, rather than the typical oxidizer-valve failure caused by metallic- nitrate contamination. The blockage theory was further supported by the pressure response of thruster F1F in comparison to other thrusters during entry. Also, in the several minutes following the fail-off, the F1F thruster injector tube temperatures rose to a value 4 to 5 ?F higher than their pre- fire temperatures, which is indicative of a good firing at the time of deselection. Failure of the Pc tube was not considered likely because this tube was flushed prior to the STS-73 mission. The thruster F1F remained deselected for the remainder of the flight.

Pc tube blockage has been experienced twice prior to STS-73. On STS-51I and STS-33, thrusters F1F and F1U, respectively, had blocked Pc tubes. Both instances resulted in a fail-off condition with a slowly decaying Pc very similar to the STS-73 response. The F1F Pc tube blockage (STS-51I) was attributed to room-temperature vulcanizing (RTV) material contamination, most likely from the RTV used to secure the thruster paper covers in place prior to launch. Blockage of the F1U Pc tube (STS-33) was confirmed by borescope; however, in attempting to remove the blockage with an aspirator, the blockage material was lost. Following the STS-73 mission, a Pc response test confirmed the pressure response seen in flight. However, an attempt to unblock the thruster Pc tube on the vehicle was unsuccessful. As a result, the thruster was removed and replaced and sent to the White Sands Test Facility (WSTF) for repair. This repair is expected to performed in February 1996. CAUSE(s)/PROBABLE Cause(s): The fail-off was most probably caused by a blockage of the thruster F1F Pc tube. CORRECTIVE_ACTION: Thruster F1F was removed and replaced and sent to the WSTF for repair. This repair is scheduled for February, 1996. Once repaired, the appropriate retesting will be performed and the thruster will be returned to spares at KSC. RATIONALE FOR FLIGHT: Blockage of a thruster Pc tube is not a generic problem. Primary RCS thrusters have multiple redundancy (criticality 1R3) for all nominal mission phases.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:**	Problem	**FIAR**	**IFA** STS-73-V-05	OMS/RCS
PROP-02	**GMT:**		**SPR** 73RF05	**UA**	**Manager:**
			IPR 75V-00013	**PR**	
					Engineer:

Title: Transient Thruster Command Path Failure ()

Summary: INVESTIGATION/DISCUSSION: During STS-73 on-orbit operations at 300:18:04 G.m.t. (007:04:11 MET), vernier reaction control subsystem (RCS) thrusters R5R and R5D failed to fire when commanded for attitude control. The chamber pressure (Pc) for each thruster remained at zero and as a result, redundancy management software deselected the thrusters as failed off. Both thrusters were hot-fired successfully and reselected for use. This failure recurred eight times, during which time the thrusters had more than 3000 successful firings. Additionally, primary RCS thrusters L3D and R3D failed off once.

A similar failure of thruster R5D occurred during STS-65, which was the previous flight of this vehicle (reference IFA STS-65-V-05). During STS-65, thruster R5D fired successfully approximately 2500 times before and 1613 times after a single failure. The most likely cause of the failure was determined to be a transient loss of command B logic. The RCS thrusters were not suspect. Troubleshooting performed after that flight failed to duplicate the anomaly. After STS-65, the right OMS pod was removed for use on OV-105, and has flown several flights without a recurrence of this failure. The multiplexer/demultiplexer (MDM) FA2, serial number (s/n) 121, and reaction jet driver aft (RJDA) 2, s/n 20, that make up the command path to the thrusters are the same units that were flown on STS-65. The signature observed during STS-73 indicated that the command path to the thrusters was failing intermittently. During two of the failures on STS-73, a slight increase in Pc was noted for a very short duration, followed by the indicated Pc returning to zero. For the remaining occurrences, no Pc was noted. The RJD requires two commands (A and B) to fire a thruster. Command A is a toggle, and command B is an enable. When no thruster firing is commanded, command A is logic 1 (5-volt MDM discrete on) and command B is logic zero (5- volt MDM discrete off). When a thruster firing is initiated, command A transitions to logic zero and is thereafter toggled every 40 ms for the duration of the firing, and command B is set to logic 1 for the duration of the firing. Once the thruster is on, if command A stops toggling, the thruster will be on for approximately 130 ms from the last transition to zero and then stop firing. However, if command B goes to zero, the thruster driver goes off in less than 5.3 ms. The A commands for thrusters R5R, R5D, L3D, and R3D share a hybrid on card 2, channel 0 in MDM FA2, and the B commands for each of these thrusters share a hybrid on card 10, channel 0 in MDM FA2. Either card failing would prevent thruster firing. The two components in the RJDA common to all of the thrusters in question is the power supply and the clock card. The only single- point failure in the wiring between the MDM and the RJDA that could cause the signature observed is the low side of the command; however, thorough ground checkout results were nominal. Logic power loss could also have caused the failure. Logic-power inputs to the RJDA were hi-potted, wiggle tested, and visually inspected with no anomalous conditions noted. Postflight, command A (MDM FA2 card 2) was toggled at the 40 ms rate while command B (MDM FA2 card 10) was cycled for 10,000 on-commands of the thruster. Breakthrough boxes were installed to monitor MDM data transfer and RJDA 2 trickle current. The failure was not duplicated on the vehicle. The MDM and RJDA were then removed and sent to the NASA Shuttle Logistics Depot (NSLD) for further testing. The RJDA was cycled approximately 150,000 times and the failure was duplicated once, with more cycles exhibiting off-nominal output. The test setup was altered to monitor the 5V power supply via a Pc output of a thruster. A drop in this output voltage occurred, indicating an intermittent 5V power supply. The RJDA will undergo extensive invasive testing and this will be documented under the CAR. As a result of the RJD findings, the MDM is no longer suspect and will be returned to flight spares after undergoing acceptance test procedures. A review of the RJDA failure history revealed no previous relevant failures. CAUSE(s)/PROBABLE Cause(s): The cause of the intermittent fail-off of the thrusters is the RJDA. NSLD troubleshooting indicates momentary drops in the 5V power supply. CORRECTIVE_ACTION: The MDM and RJDA have been removed and replaced. Troubleshooting duplicated the failure in the RJDA, and is continuing under CAR KB3493. The MDM will be returned to flight

spares after undergoing standard acceptance test procedures. RATIONALE FOR FLIGHT: The RJDA has been removed from the vehicle. Should the failure recur, recovery of the thrusters is probable. A hard failure of the thrusters results in loss of vernier control and reduced thruster redundancy. The failure history of the RJDA indicates that this failure is not generic.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:**	Problem	**FIAR**	**IFA** STS-73-V-06	C&T - S-Band
INCO-04	**GMT:**		**SPR** 73RF08	**UA**	**Manager:**
			IPR IPR 75V-0011	**PR**	x36054
					Engineer:

Title: S-band Lower Right Antenna Forward Link Dropouts ()

Summary: INVESTIGATION/DISCUSSION: Beginning on Orbit 29, the S-band forward link became intermittent when the lower right (LR) antenna was in use in the Tracking and Data Relay Satellite (TDRS) low-frequency mode. Review of the data from several different operating configurations eliminated the TDRS as a cause of this problem. The problem was also independent of frequency and power amplifier selection. The problem continued throughout the mission.

On-orbit troubleshooting showed that the forward link recovered immediately with the removal of the high-power radio frequency (RF) signal. This was achieved by turning off the power amplifier (PA) and going to the receive-only mode. The problem would usually recur 2 to 18 minutes after selection of the LR antenna, although some passes using the LR antenna experienced no drop- outs. Data analysis also revealed that a gradual ramp-up of reflected power was occurring whenever the LR antenna was selected. Taken as a whole, the in- flight troubleshooting and analysis indicated a possible problem somewhere in the antenna path. The Ku-band system was used to supplement two-way communications for the remainder of the flight. Postflight troubleshooting in the Orbiter Processing Facility (OPF) duplicated the anomaly. The failure was subsequently isolated to the S-band antenna switch assembly. CAUSE(s)/PROBABLE Cause(s): During postflight troubleshooting, the anomaly was isolated to the S-band antenna switch assembly by physically interchanging the lower antenna path cables at the switch assembly. Failure analysis will be conducted to determine the exact cause of the failure. CORRECTIVE_ACTION: The S-band antenna switch assembly was removed and replaced. Further troubleshooting of the switch will be conducted at the Electronic Systems Test Laboratory (ESTL) per CAR 73RF08. RATIONALE FOR FLIGHT: The faulty S-band antenna switch assembly has been removed and the replacement assembly has successfully completed retest. For loss of the S-band forward link due to any cause, the Ku-band and UHF systems provide communications redundancy. For this specific condition, three other antennas are available to allow continued S-band system use, depending on the attitude restrictions of the mission.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:**	Problem	**FIAR**	**IFA** STS-73-V-08	FC/PRSD
EGIL-03	**GMT:**		**SPR** 73RF07	**UA**	**Manager:**

IPR IPR 75V-0023 **PR**

Engineer:

Title: H2 Manifold 1 Isolation Valve Failed Open ()

Summary: INVESTIGATION/DISCUSSION: At 308:13:42 G.m.t. (014:23:49 MET), the power reactant storage and distribution (PRSD) manifold 1 isolation valve failed to close when commanded for in-flight checkout. Four minutes later, the crew held the switch to the “Open” position for 10 seconds, then to the “Closed” position for 10 seconds; however, the valve again failed to close. Manifold pressure data confirmed that the valve remained open. No further in-flight attempts to close the valve were made.

After the mission, the valve functioned normally and wire-wiggle tests did not indicate any loss of continuity in the valve actuation circuit. This particular valve (S/N 8) had exhibited similar behavior on STS-43 (OV-104 Flight 9). The valve remained onboard OV-104 for three more flights with no recurrence of the failure. During the OV-104 Orbiter Maintenance Down Period (OMDP), the valve panel was removed and replaced. Cryogenic testing of the removed valve panel could not duplicate the failure to close. The valve panel was then installed on OV-102 for STS-73. This phenomenon has occurred on a number of flights (ref. IFA’s 34-V-12, 37-V- 03, 43-V-09, 49-V-02, 57-V-03, 57-V-06, and 74-V-03). In all of these cases, the failure to close was intermittent. After STS-57, one of the manifold valves that had previously experienced problems was removed and tested under laboratory cold-flow conditions. At temperatures below -75 deg F the anomaly was consistently repeated. The valve failures were attributed to the inability of the closing spring to overcome the excessive magnetic latching forces present under cold-flow conditions. A cold-flow screening test was baselined for each isolation valve to be performed at OMDP to screen out any valves with this problem. Valve S/N 8 had passed this screening test. CAUSE(s)/PROBABLE Cause(s): The cause of failure of valve S/N 8 to close is presently unknown. Failure analysis of S/N 8 will be performed after the cause of this phenomenon is determined through extensive ground testing of the STS-74 O2 manifold valve that experienced a similar failure. If the ground testing fails to find the cause of the problem, instrumentation may be added to one of the Orbiter vehicles in an attempt to understand the failure mode. CORRECTIVE_ACTION: The valve panel containing valve S/N 8 has been removed and replaced. Failure analysis will be performed after further testing of other valves as described previously. RATIONALE FOR FLIGHT: If a manifold isolation valve fails to close on-orbit, crew procedures permit using the other manifold isolation valve. The most severe case would be a failure-to-close should external leak isolation be required during ascent, as this condition would result in depletion of reactants and loss of two fuel cells. No external leak requiring manifold isolation valve use has occurred in the history of the program.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:**	Problem	**FIAR**	**IFA** STS-73-V-09	APU
MMACS-04	**GMT:**		**SPR** KB3473	**UA**	**Manager:**
			IPR	**PR** APU-2-19-0446	
					Engineer:

Title: APU 1 Fuel Pump Inlet Pressure Decay ()

Summary: INVESTIGATION/DISCUSSION: A decay was noted in the auxiliary power unit (APU)- 1 (s/n 402) fuel-pump inlet pressure after APU shutdown following the landing of STS-73. The pressure dropped from 150 to 35 psia over a period of 20 minutes. During the same period, the fuel-pump seal-cavity drain line pressure rose from 20.5 to 22.0 psia. This signature indicated leakage past the fuel pump seal into the seal cavity. A review of data revealed that a much slower decay rate was experienced after the APU hot-fire prior to STS-73 and on-orbit. Postflight checkout of the system at KSC revealed 108 cc of hydrazine in the catch bottle, confirming fuel-pump seal leakage. The APU was removed and returned to Sundstrand for troubleshooting and repair.

CAUSE(s)/PROBABLE Cause(s): Failure analysis was not able to identify a specific cause for the anomaly. During testing, Sundstrand detected out-of- specification helium leakages, but none of the observed conditions were great enough to explain the postlanding leakage. The most probable causes for the leakage are transient contamination of the fuel pump seal, and/or a slight misalignment or defect which allows the seal to leak when rotated to a specific position (thermal effects may also contribute to the condition). CORRECTIVE_ACTION: The APU was removed and replaced. The vendor, Sundstrand, will replace the fuel-pump seal and return the APU to service. RATIONALE FOR FLIGHT: APU-1 on OV-102 has been removed and replaced and the replacement unit has been successfully checked out and hot-fired. This is the first occurrence of significant fuel-pump seal leakage since the improved APU (IAPU) was introduced. This particular APU does not have any unique history, such as age, operating time, exposure time, or acceptance test procedure (ATP) leakage, which would indicate a generic problem. Because of the low frequency of occurrence and the history of this individual APU, the problem is not considered generic, and the APU's are considered to be acceptable for flight.