

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Sum No.	GMT Day 32	EI sec	OEX data	Milestone	Entry Event	Remarks	MSID
1	13:10:39	EI+2010		TIG-5	APU 2 Start		
2	13:15:30	EI-1719		TIG	OMS TIG		
3	13:18:08	EI-1561			OMS End of Burn		
4	13:31:25	EI-794		EI-13	APU 1 Start		
5	13:31:29	EI-790			APU 3 Start		
5.5	13:39:29.559	EI-286.4	X		Start of OEX PCM Data Block		
6	13:44:09	EI#0		EI	Entry Interface (400,000 ft)	Mach 24.57	
6.1	13:45:39 / 48:59	EI+90 / EI+290	X		16 Temperature Sensors on the lower surface to the left of or at the centerline experience off-nominal early temperature trends (warmer temperature rise rate compared to previous flights of OV-102 at the same inclination)		V00T9849A V07T9784A V07T9666A V07T9786A V07T9468A V07T9787A V07T9470A V07T9788A V07T9711A V07T9475A V07T9713A V07T9480A V07T9785A V09T9845A V09T9231A V07T9489A
6.15	13:48:39	EI+270	X		Left Wing Front Spar at RCC Panel 9 - initiation of off-nominal trend in strain (small increase) followed by a more significant off-nominal signature to failure at EI+495 secs	The measurement began to fail at approximately EI+495 sec	V12G9921A E1105.0 Y-239.0 Z800
6.2	13:48:59	EI+290	X		Left Wing RCC Panel 9 Lower Attach Clevis (between RCC 9 and 10) - initiation of an off-nominal temperature trend (early temperature increase compared to previous flights of same inclination)	The measurement began to fail at approximately EI+492 sec	V00T9910A E1112.0 Y-239.0 Z280.0
6.3	13:49:32	EI+323			Start of initial roll		
6.4	-13:49:39*	-EI+330*	X		Left Wing Front Spar Caps Strain Gage shows early off nominal downward trend	*Note: PCM3 entry data is in snapshot format (not continuous). Time indicated is at start of data segment where off-nominal signature is first observed, therefore event may have started earlier than noted.	V12G9169A E1107 Y330 Z7
6.45	13:49:49 / 49:50	EI+340 / EI+350	X		4 Left OMS Pod Surface Temps - Start of off-nominal temperature trend - cooler rise rate when compared to previous flights of same inclination	Followed by the start of a warmer-than-expected temperature trend beginning in the EI+510 to EI+540 sec range	V07T9976A V07T9978A V07T9220A V07T9972A
QBAR = -15 psf (-0.10 psi), Mach 24.4				----- 32:13:50:00 -----		EI + 351 sec: WLE Stagnation Temp: ~2520 F	(STS-107 Nom EOM Design Press)
6.5	13:50:00 / 43	EI+351 / EI+394			Five events of unexpected return link comm drop-out (Comm events 1-5)	On upper left aft antenna (TDRS 171W). Appears off-nominal based on previous fit data. Comm loss not continuous thru period indicated.	
6.7	13:50:09	EI+380	X		Left PLBD Surface TC BP3703T - Start of off-nominal temperature trend - cooler rise rate when compared to previous flights of same inclination	Followed by large increase in temperature at EI + 570 seconds	V07T9925A E1126.5 Y-114 Z441.4
6.9	13:50:19	EI+370	X		Left Wing Lower Surface Thermocouple BP2510T begins off-nominal temp increase from -2000 deg F to ~2200 deg F over approx 50 seconds followed by a momentary 100 deg F temperature spike	The measurement subsequently fails at approximately EI+496 sec	V07T9666A E1121.1 Y-235.5 Z1WR
7	13:50:53	EI+404			Start of Peak Heating	Determined by analysis	
QBAR = -19 psf (-0.13 psi), Mach 24.1				----- 32:13:51:00 -----		EI + 411 sec: WLE Stagnation Temp: ~2650 F	
7.2	13:51:14	EI+425	X		Left Wing Front Spar at RCC Panel 9 - start of off-nominal increasing temperature trend	Increasing trend continues until the measurement starts to fail at approximately EI+520 sec	V00T9895A E1192.2 Y-239.0 Z-239.0
7.25	13:51:14	EI+425	X		Left Wing RCC Panel 9 Lower Attach Clevis (between RCC 9 and 10) - start of a more rapid off-nominal increasing temperature trend	Increases until the measurement starts to fail at approximately EI + 492 secs	V00T9910A E1112.0 Y-239.0 Z280.0
7.3	deleted					Rationale for deletion: Upon further evaluation of the data, it was determined that the remote sensor signature had been seen in previous flights and could be explained by known events.	
7.35	deleted					Rationale for deletion: Moved to seq # 11.37 after further analysis.	
7.37	13:51:49	EI+480	X		OMS-L Pod HRS1 Surf T13-AFT - Start of off-nominal higher-than-expected temperature trend when compared to previous flights of same inclination	Sensor sees a sharp temp increase at EI+910 and goes erratic at EI+940	V07T9223A E1437.2 Y-126 Z422

Appendix A.1 - STS-107 Mishap Investigation - Summary Time Line

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Sum No.	GMT GMT Day 32	EI sec	OEX data	Milestone	Entry Event	Remarks	MSID
START = 22 Jul (0:15 pm) March 23.7		----- 32:13:52.00 -----				EI + 471 sec; WLE Stratigraion Temp: ~2100 F	
7.4	13:52:09 / 52:55	EI+480 / EI+486			Four events of unexpected return link comm drop-out (Comm events 6-9)	Rationale for deletion: Moved to seq # 6.75 after further analysis. On upper left aft antenna (TDRS 171M). Appears off-nominal based on previous fit data. Comm loss not continuous thru period indicated.	V079889A X262.0 Y-23.0 ZRR
7.46	13:52:09 / 52:49	EI+480 / EI+520	X		Nose Cap RCC Attach OutBoard Clevis (Chin Panel) - Temporary change in slope, then returns to "nominal" Note: Adjacent sensor V0799888 (on centerline) does not show this signature		V07P8038A V07P8086A V07P8151A
7.47	13:52:16	EI+487	X		Two Left Wing and 1 Right Wing Surface Pressure measurements show signs of failure	First OEX data that show signs of failure	V07P8151A 18 of 18 measurements
7.48	13:52:16 / 53:17	EI+487 / EI+522	X		All of the active measurements (does not include PCM 3 data in snapshot mode) running in the wire bundles along the left wing leading edge show signs of failure - 16 measurements		Multiple measurements
7.49	13:52:16 / 56:24	EI+487 / EI+735	X		The vast majority of left wing OEX measurements show signs of failure during this time period - this includes all left wing temperature and pressure measurements and all strain measurements aft of Xo 1040 with the exception of three strain measurements on the upper surface of the LMLG compartment Additionally, 30 right wing pressure measurements show signs of failure		
7.5	13:52:17	EI+488		Approx Vehicle Ground Location: 39.0 N / -129.2 W	Altitude 236,800 ft / Mach 23.6 - Over the Pacific Ocean, approx 300 miles West of California Coastline	Approx vehicle position when first off-nominal data was seen; Data source: STS-107 GPS Trajectory Data	
7.7	13:52:17	EI+488			LMG Brake Line Temps (D) - small increase in temperature ("bit flip up")	Initiation of temp rise ("bit flip up") - may be nominal based on rise rate comparison w/ flight experience	V58T1703A
7.75	13:52:18	EI+489	X		Left Wing Spar Cap Lwr L103 (Xo 1040 Spar - Lower Cap) - off-nominal increase in strain indication followed by gradual decrease over approx 330 seconds interval until measurement failure at -EI+935		V12G9048A
7.77	13:52:24	EI+495	X		Left Wing Front Spar at RCC Panel 9 - strain gage goes erratic for approximately 20 second - measurement appears to be failing	Subsequent data is suspect	V12G9921A X1196.0 Y-229.0 ZACC
7.8	13:52:25	EI+496	X		Left Outboard Elevon Wide Band Accelerometers - off-nominal vibration response (approximately 2G peak-to-peak) V08D9729A - L OB Elevon Z-Vib (MUX1B Ch 2)		V08D9729A
7.85	13:52:29	EI+500	X		DMS-L Pod HRS1 Surf T1-AFT - Start of slightly off-nominal erratic trend when compared to previous flights of same inclination	Followed by drop in temperature at EI + 570 seconds and subsequent erratic temperature changes	V0779219A X1507.1 Y-126.0 ZAG2.0
7.9	13:52:31	EI+502	X		Left Outboard Elevon Wide Band Accelerometers - off-nominal vibration response (approximately 3G peak-to-peak) V08D9729A - L OB Elevon Z-Vib (MUX1B Ch 2)		V08D9729A
8	deleted					Rationale for deletion: moved to seq #6.7	
8.5	13:52:32/55	EI+503			Supply H2O Dump Nozzle Temps (A, B) (2) and Vacuum Vent Temp (1) - transient (15 and 23 seconds, respectively) increase in typical rise rates.	GMT shown indicates initial rise duration. Supply H2O Dump Nozzle temps took additional 48 secs to return to nominal temp rise vacuum vent temps took additional 40 secs to return to nominal rise	V62T0440A V62T0551A
8.6	13:52:34	EI+505	X		DMS-L Pod HRS1 Surf T2-AFT - Start of off-nominal lower-than-expected temperature trend (compared to previous flights of same inclination) until sensor sees a sharp temp increase at EI+910 and goes erratic at EI+940		V0779222A X1485.9 Y-126 ZAG2.0
8.65	13:52:39 / 53:09	EI+510 / EI+940	X		4 Left OMS Pod Surface temps - Change in existing off-nominal temperature trend (following a cooler rise rate than expected, the temperature trend that is significantly warmer when compared to previous flights of same inclination)		V0779976A V0779220A V0779978A V0779972A
8.7	13:52:41	EI+512			LMG Brake Line Temps (A, C) (2) - start of off nominal trend	Unusual Temperature Increase	V58T1700A V58T1702A
8.75	13:52:44 / 52:50	EI+515 / EI+521			First clear indication of off-nominal aero increments	Delta yawing and rolling moment coefficients indicate off-nominal trends. Derived by analysis.	nila

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Sum No.	GMT - GMT Day 32	EI SEC	QEX data	Milestone	Entry Event	Remarks	MSID
8.8	deleted					Rationale for deletion: inadvertently added to summary timeline	
9	deleted						
10	13:52:59	EI+530			Left INBD Elevon Lower Skin Temp (1) - OSL	Began trending down 3 secs earlier	V09T1006A
QBAR = -29.9 psf (-0.18 psi) Mach 23.2		----- 32:13:53:00 -----				EI + 531 sec: WLE Stagnation Temp: ~2800 F	
10.5	deleted					Rationale for deletion: Merged with seq # 8.75 after further analysis.	
10.6	13:53:03	EI+534	X		Left Outboard Elevon Wide Band Accelerometers - onset of signal saturation indicating likely measurement failure (approximately 100 peak-to-peak - off-scale)		V08D9729A
11	13:53:10 / 36	EI+541 / EI+567			Hydraulic System Left Outbd / Inbd Elevon Return Line Temps (4) - OSL	OSL was preceded by Nominal Temp rise.	V58T0394A V58T0193A V58T0157A V58T0257A
11.1	deleted					Rationale for deletion: alpha modulation time tag updated - moved to seq #11.25	
11.2	13:53:26	EI+557		Approx Veh Grid Location: 38.7 N / -123.5 W	Altitude 231600 ft / Mach 23.0 - Crossing the California Coastline	Data source: STS-107 GPS Trajectory Data	
11.21	13:53:29	EI+560	X		Left Fuselage Side Surface Temp BP3605T - start of off-nominal increasing temperature trend from -180 deg F to 400 deg F	Trend followed by temperature drop and rise	V0779253A X1000.7 Y-105 Z354.5
11.22	13:53:29	EI+560	X		Left PLBD Surface TC BP3603T - Start of slightly off-nominal erratic temperature trend when compared to previous flights of same inclination		V0779913A X1003.8 YLH Z441.3
11.23	13:53:29	EI+560	X		Left PLBD Surface TC BP3703T - start of off-nominal temperature rise, peaking at EI+625, followed by temperature drop and subsequent off-nominal higher-than-expected temperature signature		V0779925A X1138.5 YLH Z441.4
11.24	13:53:29	EI+560	X		Left Fuselage Side Surface TC BP3604T - Start of slightly off-nominal erratic temperature trend when compared to previous flights of same inclination		V0779903A X1005 Y-105 Z386.4
11.25	13:53:31	EI+562		Alpha Modulation	Angle of attack (alpha) modulation active		V90H0803C
11.3	13:53:32 / 54:22	EI+563 / EI+565			Two events of unexpected return link comm drop-out (Comm events 10-11)	On upper left aft antenna (TDRS 171W). Appears off-nominal based on previous fit data. Comm loss not continuous thru period indicated.	
11.35	13:53:37	EI+568	X		Xo 1040 Spar (M/G Forward Wall Spar) Strain Gage - Upper Cap - start of off-nominal increase in strain indication (over an approximate 115 second interval) followed by sudden decrease		V12G9049A X1040 Y-135 Z19PR
11.37	13:53:38	EI+569			Inertial sideslip angle (Beta) exceeds flight history.	The steady state navigation derived sideslip angle becomes out-of-family as compared to previous flight data at this point in the trajectory.	V90H2249C
11.4	13:53:44	EI+575	X		OMS-L Pod HRSI Surf T1-AFT - Start of off-nominal lower-than-expected temperature trend when compared to previous flights of same inclination	Sensor goes erratic at EI+940	V0779219A X1507.1 Y-128.0 Z422.0
11.5	13:53:45 / 54:11	EI+576 / EI+602			1st reported debris (5) observed leaving the Orbiter just aft of Orbiter envelope (Debris # 1 thru 5)	EOC video # EOC2-4-0055, 0056, 0064, 00136 & 0201. No evidence of jet firings near events.	N/A
QBAR = -29 psf (-0.20 psi) Mach 22.7		----- 32:13:54:00 -----				EI + 591 sec: WLE Stagnation Temp: ~2850 F	
12	deleted						
13	13:54:10 / 55:12	EI+601 / EI+663			Left Main Gear Brake Line Temp B (1) / Strut Actuator Temp (1) / Sys 3 LMG Brake Bw Viv Ret Line Temp (FWD) (1) - start of off nominal trend	Unusual Temperature Increase	V58T1701A V58T0842A V58T0405A
13.5	13:54:11	EI+602			Reversal in growth trend of derived roll moment coefficient	Observed roll moment changed from a negative to positive slope (derived by analysis).	N/A

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14	13:54:20	EI#611			Start of slow aileron trim change	The aileron trim setting observed in flight first deviates from the predicted trim setting at this pt in trajectory (GMT is approximate (+/- 10 sec) for aileron).	V90H1500C (aileron trim)
15	13:54:22	EI#613			Mid Fuselage LT BondLine Temp at x1215 (1) & LH Aft Fus Sidewall Temp at x1410 (1) - start of off nominal trend	Unusual increase in temperature rise rate	V34T1106A V09T1724A
15.2	13:54:29	EI#620	X		Left Fuselage Side Surface Temp BP3605T peaks and starts downward trend		V07T9253A x1328.7 Y-195 Z204.5
15.3	13:54:33.3 / 54.37	EI#624.3 / EI#628			Flash #1 - Orbiter envelope suddenly brightened (duration 0.3 sec), leaving noticeable luminous signature in plasma trail; plus Debris # 6 - report of very bright debris observed leaving the Orbiter just aft of the Orbiter envelope.	EOC video # EOC2-4-0026, 0034, & 0009B. R3R and R2R jet firings occurred near events. Debris events 6 & 14 are visually the biggest, brightest events & therefore may indicate the most significant changes to the Orbiter of the western debris events.	n/a
15.32	13:54:34	EI#625	X		Left Fuselage Side Surface Temp BP3703T peaks and starts downward trend		V07T9925A x1328.5 YLH Z041.5
13.33	13:54:39	-EI#630	X		Strain Gages Centered on the Upper Surface of the Left MLG Wheel Wheel - Higher than-expected strain indications observed in these gages	Note: PCMS entry data is in snapshot format (not continuous), therefore event may have occurred earlier than noted	V12G9156A, V12G9157A, V12G9158A
13.34	13:54:39	-EI#630	X		Left Wing X1040 Spar Web - shows increase in strain	Note: Adjacent sensor V12G9165A did not show similar "off-nominal" signature at this time, also, PCMS entry data is in snapshot format (not continuous), therefore event may have occurred earlier than noted	V12G9166A V12G9167A (V12G9165A-nominal)
QBAR = -34.5 psi (-0.24 psi); Mach 22.1				----- 32-13:55:00 -----		EI = 651 sec; WLE Stagnation Temp: ~2900 F	
15.35	13:55:04 / 55:29	EI#655 / EI#680			Debris # 7, 7A, & 8 thru 10 observed leaving the Orbiter just aft of Orbiter envelope. Debris 8, 9, & 10 were seen aft of the Orbiter envelope inside Debris Shower A (near event listed).	EOC video # EOC2-4-0005, 0017, 0021, 0028, 0030, 0098 & 0161 No evidence of jet firings near events.	n/a
15.37	13:55:22 / 55:28	EI#673 / EI#679			Debris Shower A - Report of debris shower seen just aft of Orbiter envelope.	Seen just aft of Orbiter envelope. Over the course of these four seconds a luminous section of plasma trail is observed which appears to contain a shower of indefinite particles and multiple, larger discrete debris that includes Debris 8, 9, and 10.	Saw debris: EOC2-4-0098, 0161, 0005, 0030 Saw shower: EOC2-4-0017, 0021, 0028
15.4	deleted					Rationale for deletion: Upon further evaluation of the data, it was determined that the remote sensor signatures had been seen in previous flights and/or could be explained by known events.	
15.43	13:55:33 / 56:03	EI#684 / EI#714			Two events of return link comm drop-outs (Comm events 12 & 13)	On upper right aft antenna (TDRS 171/W). Uncertain if off-nominal based on previous flight data. Comm loss not continuous thru period indicated.	
15.44	deleted					Rationale for deletion: Moved to 15.46 after further review of the data	
15.45	13:55:35 / 56:12	EI#686 / EI#723			Debris # 11, 11A, 11B, 11C & 12 thru 15 observed leaving the Orbiter just aft of Orbiter envelope. Debris #11B & #11C events were both seen at the head of a parallel plasma trail aft of the Orbiter envelope. Debris #12 event was preceded and followed by secondary plasma trails. Debris #13 event was followed by momentary brightening of plasma trail adjacent to debris. Debris #14 event consisted of very bright debris observed leaving the Orbiter.	EOC video # EOC2-4-0005, 0017, 0021, 0028, 0030, 0050, & 0098 No evidence of jet firings near events. (Nearest jet firings occur at 56:17.) Debris events 8 & 14 are visually the biggest, brightest events & therefore may indicate the most significant changes to the Orbiter of the western debris events.	n/a
15.46	13:55:36	EI#687	X		Xo 1040 Spar (MLG Forward Wall Spar) Strain Gage - Upper Cap - sudden drop in strain followed by gradual increase until erratic signature at approximately EI#930		V12G9049A X1040 Y-135 ZUPR

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15.5	13:55:41	EI+692			Mid Fuselage Port (Left) Bill Longeron Temp at X1215 - start of off nominal trend	Unusual Temperature Increase	V94T1118A
QBAR = +40 psf (~0.28 psi); Mach 21.4				----- 32:13:56:00 -----		EI + 711 sec; WLE Stagnation Temp. ~2900 F	
16	13:56:03 / 56:24	EI+714 / EI+735			Left Lower/Upper Wing Skin Temps - Trending down (2)	Indication of potential measurement failures	V09T1002A V09T1024A
16.5	13:56:16 / 56:53	EI+727 / EI+764			Hyd Sys 1 LMG Uplock Actuator Unlock Line Temp; Sys 3 LMG Brake Sw Vlv Ret Line Temp (FWD); LMG Brake Line Temp C; LMG Brake Line Temp B; Sys 3 Left Main Gear Strut Actuator Temp - all show a temp rise rate change.	Significant increase in temp rise rate on all four lines	V58T0125A V58T1701A V58T0842A V58T0405A V58T1702A
16.55	13:56:30 / 56:55	EI+741 / EI+766			First Roll Reversal initiation / completion		V90H1044C
16.6	deleted					Rationale for deletion: Cabin dropout (event 14) is deleted since probably nominal due to completion of roll reversal resulting in elevation angle nearing 60 deg's (vertical tail interference warning).	
QBAR = +42 psf (~0.29 psi); Mach 20.7				----- 32:13:57:00 -----		EI + 771 sec; WLE Stagnation Temp. ~2900 F	
16.65	13:57:09	EI+780	X		Fuselage Side Surf Thermocpi BP3976T - start of off-nominal trend (temp increase followed by temp drop / rise)		N0719270A #1482.1 Y-124.8 Z307.1
16.67	13:57:09	EI+780	X		Fuselage Lower Surface BF Thermocpi BP220T - start of off-nominal trend (shallow temp drop)		N0719508A #1592 Y-111.1 Z LWR
16.7	13:57:19 / 24	EI+790 / EI+795			MLG LH Outbd Tire Pressures 1 & 2 - start of small increase in pressures	Not seen in previous flights	V51P0570A V51P0572A
16.8	13:57:19 / 58:01.5	EI+790 / EI+832.5			Debris # 16 (very faint debris) observed leaving just aft of Orbiter followed by two events of asymmetrical brightening of the Orbiter shape (Flares 1 and 2). (Occurred over eastern AZ and NM.)	Debris #16: EOC video # EOC2-4-00148-2. Flares #1 & 2: EOC2-4-00148-4. Observations by personnel from the Starfire Optical Range (Kirtland Air Force Base, NM).	n/a
17	13:57:28 / 57:43	EI+790 / EI+814			Left Lower/Upper Wing Skin Temps (2) - OSL		V09T1002A V09T1024A
18	deleted						
19	13:57:54				Sys 2 LH Brake Sw Vlv Return Temp (1)	Unusual Temperature Increase	V58T0841A
QBAR = +52.5 psf (~0.36 psi); Mach 19.8				----- 32:13:58:00 -----		EI + 831 sec; WLE Stagnation Temp. ~2880 F	
20	13:58:03				Start of sharp aileron trim increase	GMT is approximate (+/- 10 sec)	V90H1500C
20.3	13:58:04	EI+835	X		Left fuselage side surface temp BP3605T starts off-nominal temperature increase		N0719253A #1000.7 Y-105 Z354.5
20.5	13:58:04 / 58:19	EI+835 / EI+850			Increase in off-nominal aero increments.	Substantial increase in rate of change of rolling and yawing moment increments and initial indication of off-nominal pitching moment increment. Derived by analysis.	n/a
21	deleted						
22	deleted						
22.5	13:58:16	EI+847			LMG Brake Line Temp D - Temp rise rate change	Significant increase in temp rise rate.	V58T1703A
23	13:58:32 / 58:54	EI+863 / EI+865			MLG LH Inbd / Outbd Tire Pressures (4) - Decay to OSL		V51P0570A V51P0573A V51P0571A V51P0572A
24	deleted						
25	13:58:39 / 58:46	EI+870 / EI+879			MLG LH Inbd/Outbd Wheel Temps (2) - OSL		V51T0574A V51T0575A
25.5	13:58:40	EI+871			BFS Fault Msg (4) - Tire Pressures - 1st Message		
26	13:58:56	EI+867			BFS Fault Msg (4) - Tire Pressures - Last Message		

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	Day	32						
QBAR = -83.5 psf (-0.44 psi); Mach 18.7								
----- 32-13:59:00 -----								
EI + 891 sec; WLE Stagnation Temp: ~2850 F								
27		13:59:06				Left Main Gear Downlocked Indication - Transferred ON		V51X0125E
27.3		13:59:09 / 59:39	EI+900 / EI+930	X		Several left side temperature measurements show a rapid increase in temperature followed by erratic behavior and subsequent loss of the measurements at approximately EI+940		V07T9925A V07T9976A V07T9972A V07T9978A V07T9976A V07T9222A V07T9903A V07T9223A
27.5		13:59:23	EI+914			Loss of MCC real-time data to the workstations in the FCR and MER		
27.7		13:59:26 / 59:28	EI+917 / EI+919			Abrupt increase in off-nominal aero increments.	Abrupt increase in rate of change of pitching, rolling, and yawing increments. Magnitude of aero increments starting to exceed ability of aileron to laterally trim the vehicle. Derived by analysis.	n/a
28		13:59:30.66 / 59:30.68	EI+921.66 / EI+921.68			Start of two yaw jets firing (R2R and R3R)	Fired continuously until end of data at 13:59:37.4	V79X2634X V79X2638X
29		13:59:31	EI+922			Observed elevon deflections at LOS	Left: -8.11 deg (up) Right: -1.15 deg (up)	
29.3		13:59:31.4 / 59:34.5	EI+922.4 / EI+925.5			Several events and PASS and BFS FSM messages during this time period all indicate the failure signature of ASA 4	ASAs responded appropriately. However, signature is indicative of failure of ASA 4.	V57H0253A (5 Hz)
29.5		13:59:32	EI+923			Observed aileron trim at LOS	-2.3 degrees	
30		deleted				deleted		
31		deleted				deleted		
32		deleted				deleted		
32.5		13:59:32	EI+923		Approx Veth Grid Location: 32.9 N / -99.0 W	Altitude ~200700 ft / Mach ~18.1 - Near Dallas TX	Approximate Vehicle Ground Location at Loss of Signal based on GMT. Data source: STS-107 GPS Trajectory Data	n/a
33		13:59:32.136	EI+923.136		LOS	Last valid downlink frame accepted by ODRC - OI / BFS / PASS. Start of reconstructed data.	Nominal loss of comm at this GMT (for ~15 sec max based on previous ft data)	
34		deleted				deleted		
35		13:59:35/36	EI+926 / EI+927			Sideslip on vehicle changes sign.	The event occurred between the two times listed. Aerodynamic forces due to sideslip are now reinforcing aerodynamic asymmetry.	n/a
36		13:59:36	EI+927			Growth in Bank attitude error	Up until this time the flight control had been able to maintain the Bank error around 5 deg.	
37		13:59:36.8	EI+927.5			Aerojet DAP Requests Third Right Yaw RCS Jet (R4R)	This additional jet is required to counteract the increasing aerodynamic moments on the vehicle. Fired continuously until end of data at 13:59:37.4	
38		13:59:37.3	EI+928.3			Aerojet DAP Requests Fourth Right Yaw RCS Jet (R1R)	This additional jet is required to counteract the increasing aerodynamic moments on the vehicle. Fired continuously until end of data at 13:59:37.4	
39		13:59:37.n	EI+928.n			Last aileron data	The aileron position is now approx -5.2 deg with approx -2.5 deg of aileron trim. The rate of change of aileron trim had reached the maximum allowed by the flight control system.	
40		13:59:37.396	EI+928.396		End of 5-second period of reconstructed data	End of first 5-seconds of the 32-second period of post-LOS data. Start of approximately 25 seconds of no data available	GMT derived by MER data personnel	n/a
40.5		13:59:39 / 14:00:19	EI+930 / EI+970	X		Beginning at EI+930 and continuing until the loss of sync on OEX data (EI+964.4 for PCM and EI+970.4 for FDM), essentially all of the OEX data for the entire vehicle becomes erratic and fails		
40.7		13:59:46 / 48	EI+937 / EI+939			Debris A observed leaving the Orbiter - Large debris seen falling away from the Orbiter envelope.	EOC videos # EOC2-4-0018, -0024, -0209-B, -0221-3 and -0221-4	
41		13:59:46.347 / 14:00:01.900*	EI+937.347 / EI+952.900			PASS Fault Message annunciation - ROLL REF PASS Fault Message annunciation - L RCS LEAK BFS Fault Message annunciations - L RCS LEAK (2)	*Time info computed on some of the events.	
41.5		14:00:01 / 04	EI+952 / EI+955			Debris B and C observed leaving the Orbiter	EOC video EOC2-4-0024 (for both B and C)	

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Sum No.	GMT GMT Day 32	EI SEC	OEX data	Milestone	Entry Event	Remarks	MSID
OSAR - in pdf. Mach on ----- 32:14:00:00 ----- EI + 951 sec; WLE Stagnation Temp: ~2800 F							
42	deleted					Rationale for deletion: moved to 40.7 after further review of the videos	n/a
43	14:00:02.654	EI+953.854			PASS Fault Message annunciation - L RCS LIET		
44	14:00:02.660	EI+953.860		Beginning of 2-second period of reconstructed data	Start of last 2-seconds of the 32 second period of post-LOS data.		
					During this final 2 second period of reconstructed data, the data indicates the following systems were <u>nominal</u> . APUs were running and WSE cooling was evident. MPS integrity was still evident. Fuel cells were generating power and the PRSD tank/lines were intact. Comm and navids systems in the forward fuselage were performing nominally. RSB, Body Flap, main engine, and right wing temps appeared active. ECLSS performance was nominal.		
					During this final 2 second period of reconstructed data, the data indicates the following systems were <u>not nominal</u> . All three Hyd systems were lost. The left inboard elevon actuator temps were either OSL, or no data exists. Majority of left OMS pod sensors were either OSH or OSL, or no data exists. Elevated temps at bottom bondline centerline skin forward and aft of the wheel wells and at the port side structure over left wing were observed. EPDC shows general upward shift in Main Bus amps and downward shift in Main Bus volts. AC3 phase A inverter appeared disconnected from the AC Bus.		
					GNC data suggests vehicle was in an uncommanded attitude and was exhibiting uncontrolled rates. Yaw rate was at the sensor maximum of 20 degrees. The flight control mode was in AUTO. (Note that all Nav-derived parameters (e.g., alpha) are suspect due to high rates computing the IMU state.)		
45	14:00:03.470 / 14:00:03.637*	EI+954.470 / EI+954.637			BFS Fault Message annunciation - L OMS TK P BFS Fault Message annunciation - Indeterminant BFS Fault Message annunciation - SM1 AC VOLTS PASS Fault Message annunciation - L RCS PVT	Time info compiled on some of the events.	
46	14:00:03.637	EI+954.637			PASS Fault Message annunciation - DAP DOWNMODE RHC	The s/w process which logs the PASS message runs every 1.92 seconds, so this event could have occurred as early as 14:00:01.717 GMT. However, during the 2 sec period, available vehicle data indicates RHC was in detent and DAP was in AUTO.	
47	14:00:04.826	EI+955.826		End of 2-second period of reconstructed data	Last identifiable OI Downlink frame		n/a
47.5	14:00:13.439	EI+964.439	X		OEX PCM loss of sync		
48	deleted					Rationale for deletion: moved to 41.5 after further review of the videos	n/a
48.3	14:00:17.918.8	EI+968.8 / EI+969.8			Catastrophic Event of an unknown nature (formally referred to as "Main Body Breakup) consisting of a sudden brightening of the Orbiter envelope followed by a definitive change in the character of the trail and disintegration of the main orbiter envelope into multiple pieces	EOC videos MIT-DVCAM-0001, EOC2-4-018, -0024, -0209-B, -0221-3 and -0221-4	
48.5	14:00:19.44	EI+970.44	X		FDM1 A end of data		
49	deleted					Rationale for deletion: moved to 48.3 after further review of the videos	n/a
50	14:00:53	EI+1004		End of Peak Heating		Determined by analysis	

* Nominal/Expected Event or Performance

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	DEX Data	GMT		EI secs	Milestone	Entry Event	Remarks	MSID / ID	
			GMT Day 32							
1	1	-	13:10:39		EI-2010	TIG-5	APU 2 Start - Low Press			
2	2	-	13:15:30		EI-1719	TIG	OMS TIG			
3	3	-	13:18:08		EI-1561		OMS End of Burn			
4	-	-	13:26:09		EI-1080		FRCS Dump Start			
5	-	-	13:27:12		EI-1017		FRCS Dump Complete			
6	4	-	13:31:25		EI-764	EI-13	APU 1 Start - Low Press			
7	5	-	13:31:29		EI-760		APU 3 Start - Low Press			
8	-	-	13:31:57		EI-732		APU 1 Norm Press			
9	-	-	13:31:59		EI-730		APU 2 Norm Press			
10	-	-	13:32:01		EI-728		APU 3 Norm Press			
11	-	-	13:32:29		EI-700		SSME Engine Slow sequence start	Sequence was completed with closure of TVC Iso Vlv 1 at 13:33:30 GMT.		
12	-	-	13:39:09		EI-300	EI-5	Entry interface minus 5 minutes (304 PRO)	Aerocject DAP (entry FCS) and Entry Guidance are activated upon transition to OPS 304. Entry Guidance provides open-loop attitude commands (angle of attach = 40 deg, roll = 0 deg) to the entry FCS until sufficient drag is available to begin closed-loop guidance operations.	V90Q8001C	
13	-	-	13:39:11		EI-298		Speedbrake close & Rudder cmd'd to zero	The speedbrake is not used until below Mach 10.0, and the rudder until below Mach 5.0.		
13.5	5.5	X	13:39:28.559		EI-280.4		Start of OEX PCM Data Block			
14	6	-	13:44:09		EI+0	EI	Entry Interface (400,000 Ft)	Historical reference point to reflect initiation of atmospheric flight (Mach 24.6)		
15	-	-	deleted					Rationale for deletion: currently there is no relevant zero event at qbar<0.5 psf so not required for this timeline.		
15.5	6.1	X	13:45:39 / 48.59		EI+90 / EI+290		16 Temperature Sensors on the lower surface to the left of or at the centerline experience off-nominal early temperature trends (warmer temperature rise rate compared to previous flights of OV-102 at the same inclination)		V09T9849A V07T9666A V07T9468A V07T9470A V07T9711A V07T9478A V07T9713A	V07T9784A V07T9786A V07T9787A V07T9788A V07T9478A V07T9480A
							V09T9849A-OB Elevon Gap LWR Surface Edge Temp V07T9666A-Wing Lower Surface TC BP2510T V07T9468A-Fuselage Lower Surface TC BP1300T V07T9470A-Fuselage Lower Surface TC BP1301T V07T9711A-Wing Lower Surface TC BP2867T V07T9713A-Wing Lower Surface TC BP2878T V07T9785A-LH Outboard Lwr Elevon Fwd Surface V09T9231A-Outboard Elevon, Mid Gap, Fwd Temp V07T9784A-LH LWR AFT Fuselage Surface Temp V07T9786A-Fuselage Pen Region TC BP3074-1F V07T9787A-Aft Fuselage Lower Aft Surface Temp V07T9788A-Body Flap LH Lwr Outboard Fwd Temp V07T9478A-Fuselage Lower Surface TC BP1600T V07T9480A-Fuselage Lower Surface TC BP1602TR V09T9845A-Outboard Elevon, Mid Gap, FWD Temp V07T9489A-Fuselage LWR Surface TC BP1900T	X1429.1 Y-315.3 ZLWR X1121.1 Y-235.5 ZLWR X618 Y0 ZLWR X620 Y-51 ZLWR X1262.0 Y-369.3 ZLWR X1402.0 Y-375.3 ZLWR X1396.1 Y-372.2 ZLWR X1430.1 Y-316 ZLWR X1442.0 Y-117.0 ZLWR X1387.0 Y-229.0 ZLWR X1513 Y-113 ZLWR X1530.0 Y-119.4 ZLWR X1003.8 Y0.0 ZLWR X1004.1 Y-99.8 ZLWR X1430.4 Y-316 ZLWR X1391.5 Y0.0 ZLWR	V09T9845A V07T9489A	

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Integ Time Line Team - REV 19 BASELINE

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID
16	--	--	13:47:52	EI+223	Qbar 2.0 psf	Elevon, BF active	The elevons (elevator and aileron) and body flap are first used for vehicle attitude control. Although the body flap is active at this time, actual motion does not occur until 4-seconds later due to time delays and hysteresis in the forward command path.	
16.3	6.15	X	13:48:39	EI+270		Left Wing Front Spar at RCC Panel 9 - initiation of off-nominal trend in strain (small increase) followed by a more significant off-nominal signature to failure at EI+495 secs	The measurement began to fail at approximately EI+495 sec	V12G9921A X1106.0 Y-239.0 ZMD
16.6	6.2	X	13:48:59	EI+290		Left Wing RCC Panel 9 Lower Attach Clevis (between RCC 9 and 10) - initiation of an off-nominal temperature trend (early temperature increase compared to previous flights of same inclination)	The measurement began to fail at approximately EI+492 sec	V09T9910A X1112.0 Y-239.0 Z38.0
17	--	--	deleted					
17.5	--	--	13:49:07	EI+298	ISLECT = 2	Closed-Loop Guidance	Entry guidance initiates closed-loop roll commands to converge drag to the reference drag profile.	
17.7	--	--	deleted				Rationale for deletion: After further review of the data, it was concluded that this event was not off-nominal	
18	--	--	13:49:16	EI+307	Qbar 10 psf	Roll Jets Deactivated	Roll control is achieved solely through aileron and yaw jet commands from this point forward.	
19			deleted					
20	6.3	--	13:49:32	EI+323		Initial Roll	Entry guidance determines that a non-zero roll is required to achieve the targeted drag level. (Mach 24.5)	V90H1044C
20.1	6.4	X	-13:49:39*	-EI+330*		Left Wing Front Spar Caps Strain Gage shows early off nominal downward trend	*Note: PCM3 entry data is in snapshot format (not continuous). Time indicated is at start of data segment where off-nominal signature is first observed, therefore event may have started earlier than noted.	V12G9169A X1107 Y232 Z3
20.2	6.45	X	13:49:49 / 59	EI+340 / EI+350		4 Left OMS Pod Surface temps - Start of off-nominal temperature trend - cooler rise rate when compared to previous flights of same inclination V07T9976A-Left OMS Pod TC BP0731T V07T9220A-OMS-L Pod LRSI Surface Temp-FWD V07T9978A-OMS-L Pod Thermocouple BP0732T V07T9972A-Left OMS Pod TC BP0749T	Followed by the start of a warmer-than-expected temperature trend beginning in the EI+510 to EI+540 sec range (seq 24.96) X1342.5 Y-128.5 Z462.6 X1321.0 YLH Z464.0 X1359.6 Y-135.1 Z463.1 X1324 Y-98 Z488	V07T9976A V07T9220A V07T9978A V07T9972A

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Seq No.	Sum No.	OEX Data	GMT		EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32	GMT Day 32					
QBAR = -15 psf (-0.10 psi); Mach 24.4			----- 32: 13:50:00 -----				EI + 351 sec; WLE Stagnation Temp: -2520 F (STS-107 Norm EDM Design Pred)		
20.3	6.5	--	13:50:00 / 43		EI+351 / EI+394	Five events of unexpected Return link comm drop-out. Event 1 - 13:50:00 (1 sec); Event 2 - 13:50:04 / 06; Event 3 - 13:50:16/22; Event 4 - 13:50:25/28; Event 5 - 13:50:42 (1 sec)	On upper left aft antenna (TDRS 171/W) 9 Band comm drop-outs considered out-of-family based on comparison with previous 102 flight data at 39 degrees, into KSC, descending node and similar look angles to TDRS. Note: Observed Forward link (cmd link) dropout associated with events 3 and 4 (normal response due to switch to/from auxiliary oscillator instead of Fwd link frequency).		
20.35	6.7	X	13:50:09		EI+360	Left PLBD Surface TC BP37037 - Start of off-nominal temperature trend - cooler rise rate when compared to previous flights of same inclination	Followed by large increase in temperature at EI + 570 seconds	V07T9925A X1138.5 YLH 2441.4	
20.4	6.9	X	13:50:19		EI+370	Left Wing Lower Surface Thermocouple BP2510T begins off-nominal temp increase from ~2000 deg F to ~2200 deg F over approx 50 seconds followed by a momentary 100 deg F temperature spike	The measurement subsequently fails at approximately EI+496 sec	V07T9666A X1121.1 Y-235.5 ZLWR	
20.5	--	--	13:50:30		EI+381	1st Entry Heating Indication Noted OI Telemetry	Nominal Rise in Center Line Bond Temp (1) due to Entry Heating	Aft fuselage center bottom bond line	V09T1702A
21	7	--	13:50:53		EI+404	Start of Peak Heating	Determined by analysis. The peak heating period represents the approximate time period during which the heating rate has flattened out at or near its maximum value.		
21.5			deleted				Rationale for deletion: The signatures of the STS-107 remote sensor events were very subtle. Upon further evaluation of the data, it was determined that the remote sensor signatures had been seen in previous flights and/or could be explained by known events. The events are therefore not considered to be anomalous.		
QBAR = -19 psf (-0.13 psi); Mach 24.1			----- 32: 13:51:00 -----				EI + 411 sec; WLE Stagnation Temp: -2650 F		
21.7	7.2	X	13:51:14		EI+425	Left Wing Front Spar at RCC Panel 9 - start of off-nominal increasing temperature trend	Increasing trend continues until the measurement starts to fail at approximately EI+520 sec	V09T9895A X1102.2 Y-239.0 Z-239.0	
21.9	7.25	X	13:51:14		EI+425	Left Wing RCC Panel 9 Lower Attach Clevis (between RCC 9 and 10) - start of a more rapid off-nominal increasing temperature trend	Increases until the measurement starts to fail at approximately at EI + 492 secs (ref seq 16.6 for 1st off-nominal event and seq 24.12 for failure)	V09T9910A X1112.0 Y-239.0 Z288.0	
22	--		delete				Rationale for deletion: Moved to seq 31.3 (Due to wing effects, it is more appropriate to compare this parameter against previous flights for identification of off-nominal performance instead of simply referencing the point at which Beta goes and stays negative.)		

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Seq No.	Sum No.	OEX Data	GMT GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID	
22.2	7.37	X	13:51:49	EI+460		OMS-L Pod HRSI Surf T3-AFT - Start of off-nominal higher-than-expected temperature trend when compared to previous flights of same inclination	Sensor sees a sharp temp increase at EI+910 and goes erratic at EI+940	V07T9223A X1437.2 Y-126.2422	
DBAR - -22 psf (-3.15 psi); Mach 23.7						----- 32:13:52:00 -----	EI + 471 sec; WLE Stagnation Temp. -2700 F		
22.5		-	deleted				Notation for Deletion: Moved to seq 426.3 (Accounted for wind effects in the aero increment derivation process)		
22.6	7.45	--	13:52:09 / 15	EI+480 / EI+486		Unexpected Return link comm drop-out (Event 6)	On upper left aft antenna (TDRS 171/W). S Band comm drop-out considered out-of-family based on previous fit data (same remarks as seq # 20.3 above).		
22.8	7.46	X	13:52:09 / 49	EI+480 / EI+520		Nose Cap RCC Attach OutBoard Clevis (Chin Panel) - Temporary change in slope, then returns to "nominal" Note: Adjacent sensor V09T9888 (on centerline) does not show this signature	V09T9888A X262.0 Y-23.0 LWR		
23		-	deleted						
23.3	--	--	13:52:15	EI+486	2nd Entry Heating Indication Noted in OI Telemetry	Nominal Rise in Center Line Bond Temps (2) due to Entry Heating	Mid Fus Lower "Mid" Skin Temp. Mid Fus Bottom Center Bond Line Temp X1214	V34T1110A V34T1112A	
23.35	7.47	X	13:52:16	EI+487		Two Left Wing and 1 Right Wing Surface Pressure measurements show signs of failure V07P8038A - L Wing Upper Surface Press (WB 3 to LE) V07P8086A - L Wing Lower Surface Press (WB 3) V07P8151A - R Wing Lower Surface Press	First OEX data to show signs of failure	V07P8038A V07P8086A V07P8151A	
23.4	7.48	X	13:52:16 / 53:17	EI+487 / EI+522		All of the active measurements (does not include PCM 3 data in snapshot mode) running in the wire bundles along the left wing leading edge show signs of failure - 18 measurements	Note: Pressure measurement V07P8038A noted in seq 23.35 is included in this grouping	V07P8010A V07P8022A V07P8023A V07P8024A V07P8025A V07P8026A V09T9895A V07P8037A V07P8038A V07P8044A	V07P8058A V07P8071A V07P8072A V07P8073A V07P8074A V09T9895A V09T9910A V07T9666A V12G9921A
23.45	7.49	X	13:52:16 / 56:24	EI+487 / EI+735		The vast majority of left wing OEX measurements show signs of failure during this time period - this includes all left wing temperature and pressure measurements and all strain measurements aft of Xo 1040 with the exception of three strain measurements on the upper surface of the LMLG compartment Additionally, 30 right wing pressure measurements show signs of failure	Note: The pressure measurements noted in seq 23.35 are included in this grouping	Multiple measurements	
23.5	7.5	--	13:52:17	EI+488	Approx Vehicle Ground Location: 39.0 N / -129.2 W	Altitude 236,800 ft / Mach 23.6 - Over the Pacific Ocean, approx 300 miles West of California Coastline	Approx vehicle position when first off-nominal data was seen; Data source: STS-107 GPS Trajectory Data		

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Seq No.	Sum No.	OEX Data	GMT GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID
24	7.7	--	13:52:17	EI+488		LMG Brake Line Temp D - On wheel well inbd sidewall (aft of sw vlv) - Small increase in temperature ("bit flip up")	Initiation of temp rise ("bit flip up") - may be nominal based on rise rate comparison with flight experience (similar temp response has been observed at this time frame on a small percentage of flights). Reference seq # 54.5 for next V58T1703A event.	V58T1703A
24.1	7.75	X	13:52:18	EI+489		Left Wing Spar Cap Lwr L103 (Xo 1040 Spar - Lower Cap) - off-nominal increase in strain indication followed by gradual decrease over approx 330 seconds interval until measurement failure at approximately EI+935		V12G9048A
24.12	--	X	13:52:21 / 24.8	EI+492 / EI+495.8		2 Left Wing temperature sensors begin an off-nominal response that appears to be an indication of the measurements (sensors/wiring) failing: V09T9910A - Wing LE 55 LWR attach clevis RCC10 V07T9666A - Wing LWR SURF TC	These measurements are included in the grouping of the event noted in seq 23.45 - all left wing temperature sensor failures are shown on the timeline X1112.0 Y-239.0 Z289.0 WB-Run 1 X1121.1 Y-235.5 ZLWR WB-Run 1	
24.14	--	X	13:52:22	EI+493		Unusual Upward Shift (in one sample) of 3 Thermocouples and Downward Shift (in one sample) of 2 Thermocouples Upward Shift: V07T9480A - Fusig LWR Surf TC BP1602TR V07T9489A - Fusig LWR Surf TC BP1900T V07T9492A - Fusig LWR Surf TC BP1602TR Downward Shift: V07T9522A - Fusig Air Penetration Area TC BP3325T V07T9636A - Left Wing upper surface TC BP4860T	All sensors receive a common 5 V power excitation via Channel 89 of PCM MUX 1	V07T9480A X1004.1 Y-89.8 ZLWR X649.3 Y-105.0 V07T9489A X1391.5 Y0.0 ZLWR Z354.8 V07T9492A X1357.8 Y-358.0 X1511.1 Y1.3 ZLWR ZLWR
24.16	7.77	X	13:52:24	EI+495		Left Wing Front Spar at RCC Panel 9 - strain gage goes erratic for approximately 20 second - measurement appears to be failing	Subsequent data is suspect	V12G9521A X1106.0 Y-239.0 ZMID
24.18	7.8	X	13:52:25	EI+496		Left Outboard Elevon Wide Band Accelerometer - off-nominal vibration response (approximately 2G peak-to-peak) V08D9729A - L OB Elevon Z-Vib (MUX1B Ch 2)		V08D9729A
24.2	--	X	13:52:29	EI+500		Approx 10% of right wing strain gages shows small off-nominal data trend (flattening of signal followed by normal data increase or a increase in strain alone)		Multiple measurements
24.22	--	X	13:52:29	EI+500		Left Wing Lower Surface Thermocouple BP2570T - Start of approx 80 deg F drop in temperature over 20 seconds		V07T9674A X1353.1 Y-236.4 ZLWR
24.24	7.85	X	13:52:29	EI+500		GMS-L Pod HRSI Surf T1-AFT - Start of slightly off-nominal erratic trend when compared to previous flights of same inclination	Followed by drop in temperature at EI + 570 seconds and subsequent erratic temperature changes	V07T9219A X1507.1 Y-126.0 Z422.0

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Seq No.	Sum No.	OEX Data	GMT	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
24.26	7.9	X	13:52:31	EI+502		Left Outboard Elevation Wide Band Accelerometer - off-nominal vibration response (approximately 3G peak-to-peak) V08D9729A - L OB Elevation Z-Vib (MUX18 Ch 2)		V08D9729A
24.28	--	X	13:52:31.3 / 38.4	EI+502.3 / EI+509.4		5 Left Wing temperature sensors begin an off-nominal response that appears to be an indication of the measurements (sensors/wiring) failing: V07T9786A - LH INBD LWR Elevation Fwd Surf V09T9893A - Wing Elevation Cove LWR Surf Temp V09T9894A - Wing Elevation Cove UPR Surf Temp V09T9860A - Elevation Cove Insul Surf 90 V09T9231A - Elevation LWR PLUG TEMP 1 (Surface)	These measurements are included in the grouping of the event noted in seq 23.45	V07T9786A V09T9893A V09T9894A V09T9860A V09T9231A
24.3	7.45	--	13:52:25 / 31	EI+496 / EI+502		Two events of unexpected Return link comm drop-out Event 7 - 13:52:25/26; Event 8 - 13:52:29/31	On upper left aft antenna (TDRS 171/W). S Band comm drop-out considered out-of-family based on previous fit data (same remarks as seq # 20.3 above).	
24.5			deleted					
24.7			deleted					
24.8	8.5	--	13:52:32	EI+503		Supply H2O dump Nozzle temps A/B show temporary increase in temp rise rate (15 second duration of high rise rate).	High rise rate is bounded by data loss. Increase in rise rate not observed on previous flights. GMT shown indicates start of initial rise duration. Reference event seq no. 26.6 for termination of event.	V62T0440A V62T0439A
24.9	8.5	--	13:52:32	EI+503		Vacuum vent temp shows temporary increase in temp rise rate (23 second duration of high rise rate).	High rise rate is bounded by data loss. Increase in rise rate not observed on previous flights. GMT shown indicates start of initial rise duration. Reference event seq no. 26.65 for termination of event.	V62T0551A
24.93	8.6	X	13:52:34	EI+505		OMS-L Pod HRS1 Surf T2-AFT - Start of off-nominal lower-than-expected temperature trend (compared to previous flights of same inclination) until sensor sees a sharp temp increase at EI+910 and goes erratic at EI+940		V07T9222A X1486.9 Y-126.2422.0
24.96	8.65	X	13:52:39 / 53.09	EI+510 / EI+540		4 Left OMS Pod Surface temps - Change in existing off-nominal temperature trend (following a cooler rise rate than expected, the temperature trend that is significantly warmer when compared to previous flights of same inclination) V07T9976A-Left OMS Pod TC BP0731T V07T9220A-OMS-L Pod LRSl Surface Temp-FWD V07T9978A-OMS-L Pod Thermocouple BP0732T V07T9972A-Left OMS Pod TC BP0749T	Previous event seq 20.2	V07T9976A V07T9220A V07T9978A V07T9972A

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Integ Time Line Team - REV 19 BASELINE

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID
25	8.7	--	13:52:41	EI+512		MLG Brake Line Temp A - On strut facing MLG door - start of off nominal trend	Initiation of temp rise - off nominal based on rise rate comparison with flight experience.	V58T1700A
25.5			deleted					
26	8.7	--	13:52:41	EI+512		Left Main Gear Brake Line Temp C - Start of off nominal trend	Unusual Temp Rise	V58T1702A
26.3	8.75	--	13:52:44 / 52:50	EI+515 / EI+521		First clear indication of off-nominal aero increments	Delta yawing moment coefficient indicates off-nominal trend at 13:52:44; delta rolling moment coefficient at 13:52:50. Derived by analysis.	n/a
26.5			deleted					
26.6	8.5	--	13:52:47	EI+518		Supply H2O dump Nozzle temps A/B return to typical rise rates.	High rise rate is bounded by data loss. GMT shown indicates end of initial rise duration. Temp took additional 48 seconds to return to nominal temp rise (53:35 GMT).	V62T0440A V62T0439A
26.63	7.45	--	13:52:49 / 55	EI+520 / EI+526		Unexpected Return link comm drop-out (Comm event 9)	On upper left aft antennae (TDRS 171/W). S-Band comm drop-out considered out-of-family based on previous fit data (same remarks as seq # 20.3 above).	
26.64	--	X	13:52:49.5 / 52:51.4	EI+520.5 / EI+522.4		2 Left Wing temperature sensors begin an off-nominal-response that appears to be an indication of the measurements (sensors/wiring) failing: V09T9895A - Wing Front Spar Panel 9 Temp V09T9849A - Outboard ELEVON, Lower Surface Edge	These measurements are included in the grouping of the event noted in seq 23.45 X1102.2 Y-239.0 Z-239.0 WB-Run 3 X1429.1 Y-315.3 ZLWR WB-Run 1	V09T9895A V09T9849A
26.65	8.5	--	13:52:55	EI+526		Vacuum vent temp returns to typical rise rate.	High rise rate is bounded by data loss. GMT shown indicates end of initial rise duration. Temp took additional 40 seconds to return to nominal temp rise (53:35 GMT).	V62T0551A
26.7	--	--	13:52:56	EI+527		Left INBD Elevon Lower Skin Temp - Start of off nominal trend	Temp trending down	V09T1006A
27	10		13:52:59	EI+530		Left INBD Elevon Lower Skin Temp - OSL		V09T1006A
27.1	--	X	13:52:59.4 / 53:07.4	EI+530.4 / EI+538.4		5 Left Wing temperature sensors begin an off-nominal-response that appears to be an indication of the measurements (sensors/wiring) failing: * V07T9785A - LH OTBD LWR Elevon Fwd Surf V07T9711A - Wing LWR SURF TC V07T9636A - Wing L Upper Surf Thermocouple V09T9845A - Outboard ELEVON, MID GAP, Fwd * V07T9713A - Wing LWR SURF TC	These measurements are included in the grouping of the event noted in seq 23.45 X1396.1 Y-372.2 ZLWR WB-Run 1 X1362.0 Y-369.3 ZLWR WB-Run 1 X1357.8 Y-358.0 ZUPR WB-Run 4 X1440.4 Y-316 ZLWR WB-Run 1 X1402.0 Y-375.3 ZLWR WB-Run 1	V09T9845A V07T9711A V07T9636A
*Note: These measurements were observed off-nominal in the EI+485 / 488 period but it was inconclusive if the measurements were falling at that time								

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Seq No.	Sum No.	OEX Data	GMT GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			QBAR = -25.5 psi (-0.18 psi); Mach 23.2			----- 32:13:53.00 -----		EI + 531 sec; WLE Stagnation Temp: ~2800 F
27.2	--	--	deleted				Rationale for deletion: This event merged with new sequence # 26.3 (Accounted for wind effects in zero increment derivation process).	
27.5	--	--	13:53:02	EI+533		Hyd Syst 1 LH INBD Elevon Actr Ret Ln Temp - start of off nominal trend Hyd Syst 3 LOE Ret LN Temp - start of off nominal trend	Temp trending down	V58T0157A
27.7	10.6	X	13:53:03	EI+534		Left Outboard Elevon Wide Band Accelerometer - onset of signal saturation indicating likely measurement failure (approximately 10G peak-to-peak - off-scale) V08D9729A - L OB Elevon Z-Vib (MUX1B Ch 2)	Temp trending down	V58T0394A V08D9729A
28	11	--	13:53:10	EI+541		Hyd Syst 3 LOE Ret LN Temp - OSL	OSL was preceded by Nominal Temp rise	V58T0394A
29	11	--	13:53:11	EI+542		Hyd Syst 1LH INBD Elevon Actr Ret Ln Temp - OSL	OSL was preceded by Nominal Temp rise	V58T0157A
29.3			deleted				Rationale for deletion: alpha modulation time lag updated - moved to seq #29.7	
29.5	11.2	--	13:53:26	EI+557	Approx Veh Gnd Location: 38.7 N / -123.5 W	Altitude 231600 ft / Mach 23.0 - Crossing the California Coastline	Data source: STS-107 GPS Trajectory Data	
29.55	11.21	X	13:53:29	EI+560		Left Fuselage Side Surface Temp BP3605T - start of off-nominal increasing temperature trend from -180 deg F to 400 deg F	Trend followed by temperature drop and rise (ref seq 36.2 for next event of this sensor)	V07T9253A X1000.7 Y-105 Z354.5
29.6	11.22	X	13:53:29	EI+560		Left PLBD Surface TC BP3603T - Start of slightly off-nominal erratic temperature trend when compared to previous flights of same inclination		V07T9913A X1003.8 YLH 2441.3
29.63	11.23	X	13:53:29	EI+560		Left PLBD Surface TC BP3703T - start of off-nominal temperature rise, peaking at EI+625, followed by temperature drop and subsequent off-nominal higher-than-expected temperature rise		V07T9925A X1138.5 YLH 2441.4
29.66	11.24	X	13:53:29	EI+560		Left Fuselage Side Surface TC BP3604T - Start of slightly off-nominal erratic temperature trend when compared to previous flights of same inclination		V07T9903A X1006 Y-105 Z398.4
29.7	11.25	--	13:53:31	EI+562	Alpha Modulation	Angle of attack (alpha) modulation active	Entry Guidance enables limited delta angle of attack commands from the reference angle of attack to promote improved convergence to the reference drag profile.	V90H0803C
30	11	--	13:53:31 / 53-34	EI+562 / EI+565		Hyd Syst 1 LOE Return Line Temp - OSL	OSL was preceded by Nom Temp rise plus data loss 3 sec's prior to event	V58T0193A
30.2	11.3	--	13:53:32 / 34	EI+563 / EI+565		Unexpected Return link comm drop-out (Comm event 10)	On upper left alt antennae (TDRS 171/W). S-Band comm drop-out considered out-of-family based on previous fit data (same remarks as seq # 20.3 above).	

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Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID
30.3	--	--	13:53:34 / 55:57	EI+565 / EI+668	2nd Entry Heating Indication Noted in OI Telemetry	Nominal Rise in Center Line Bond Temps (3) due to Entry Heating	13:53:34 - V09T1016A (Mid Fus Bot Port BL T X 620); 13:54:00 - V09T1022A (Mid Fus Bot Port BL T X 777); 13:55:57 - V09T1624A (Fwd Fus Lwr Skin Bot CL T)	V09T1016A V09T1022A V09T1624A
30.5	--	--	13:53:34	EI+565		Hyd Sys 2 LIE Return Ln Temp - Start of Off Nominal Trend	Temp trending down	V58T0257A
31	11	--	13:53:36	EI+567		Hyd Sys 2 LIE Return Ln Temp - OSL		V58T0257A
31.25	11.35	X	13:53:37	EI+568		Xo 1040 Spar (MLG Forward Wall Spar) Strain Gage - Upper Cap start of off-nominal increase in strain indication (over an approximate 115 second interval) followed by sudden decrease	Reference seq 41.2 for next event of this sensor	V12G9049A X1040 Y-135 ZLWR
31.3	11.37	--	13:53:38	EI+569		Inertial sideslip angle (Beta) exceeds flight history.	The steady state navigation derived sideslip angle becomes out-of-family as compared to previous flight data at this point in the trajectory.	V90H2249C
31.5			deleted					
31.7			deleted					
32			deleted					
32.05	11.4	X	13:53:44	EI+575		OMS-L Pod HRSI Surf T1-AFT - Start of off-nominal lower-than-expected temperature trend when compared to previous flights of same inclination	Sensor goes erratic at EI+940	V07T9219A X1507.1 Y-126.0 Z422.0
32.1	11.5	--	13:53:45 / 47	EI+576 / EI+578		Debris #1 - First report of debris observed leaving the Orbiter	Seen just aft of Orbiter envelope one second after a plasma anomaly which consisted of a noticeably luminescent section of the plasma trail. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0064 EOC2-4-0056 EOC2-4-0201 Plasma anomaly: EOC2-4-0136
32.3	11.5	--	13:53:46 / 50	EI+577 / EI+581		Debris #2 - Second report of debris observed leaving the Orbiter	Seen just aft of Orbiter envelope. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0064 EOC2-4-0056 EOC2-4-0201
32.5	--	--	13:53:46	EI+577		LMG Brake Line Temp A - On strut facing MLG door - Start of off nominal trend (temp rise rate change)	Temp rise rate change from 1.4 F/min to 5.5 F/min and increasing to LOS	V58T1700A
32.6	--	X	13:53:47.6	EI+578.6		1 temperature sensor begins an off-nominal response that appears to be an indication of the measurement (sensor/wiring) falling	This measurement is included in the grouping of the event noted in seq 23.45	V07T9674A
						V07T9674A - Wing LWR SURF TC	X1353.1 Y-236.4 ZLWR WB-Run 4	

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Seq No.	Sum No.	OEX Data	GMT	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
32.7	11.5	--	13:53:54 / 58	EI+585 / EI+589		Debris #3 - Third report of debris observed leaving the Orbiter. Event followed by momentary brightening of plasma trail.	Seen just aft of Orbiter envelope followed one second later by a plasma anomaly which consisted of a noticeably luminous section of the plasma trail. No evidence of RCS jet firings (ref Atlas data and plots).	Debris: EOC2-4-0055, 0056 Plasma Anomaly: EOC2-4-0064, 0136
GBAR = -29 psi (-0.20 psi), Mach 22.7			----- 32-13:54:00 -----			EI + 591 sec; WLE Stagnation Temp: -2850 F		
32.8	11.5	--	13:54:00 / 04	EI+591 / EI+595		Debris #4 - Fourth report of debris observed leaving the Orbiter	Seen just aft of Orbiter envelope. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0056 EOC2-4-0055
32.9	11.5	--	13:54:07 / 11	EI+598 / EI+602		Debris #5 - Fifth report of debris observed leaving the Orbiter	Seen just aft of Orbiter envelope at the head of a plasma anomaly. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0056 EOC2-4-0055
33	13	--	13:54:10	EI+601		LMG Brake Line Temp B - Start of off nominal trend	Temp Increase	V58T1701A
33.3	13.5	--	13:54:11	EI+602		Reversal in growth trend of derived roll moment coefficient	Observed moment changed from a negative slope to positive slope. Derived by analysis	n/a
33.5	11.3	--	13:54:14 / 22	EI+605 / EI+613		Unexpected Return link comm drop-out (Comm event 11)	On upper left aft antennae (TDRS 171/W). S-Band comm drop-out considered out-of-family based on previous fit data (same remarks as seq # 20.3 above).	
34	14	--	13:54:20	EI+611		Start of slow aileron trim change	The aileron trim setting observed in flight first deviates from the predicted trim setting at this point in the trajectory, indicating that flight control is reacting to asymmetric aerodynamic conditions that are varying over time. (GMT is approximate (13:54:20 +/- 10 seconds))	V90H1500C
34.5			deleted				Rationale for deletion: Moved to seq #33.3, time lag updated	
35	15	--	13:54:22	EI+613		M-FUS LT BL Temp at x1215 - start of off nominal trend (increased rise rate)	Unusual Temp Rise (Rise rate higher than STS-109 & 87). Rise rate increased from 1 F/min (typical) to 7.5 F/min.	V34T1106A
35.2	15	--	13:54:22	EI+613		LH Aft Fus Sidewall Temp at x1410 - start of off nominal trend (increased rise rate)	Unusual Temp Rise (Rise rate higher than STS-109 & 87). Rise rate increased from 2.7 F/min (typical) to 5.4 F/min.	V09T1724A
35.5	13	--	13:54:24	EI+615		Sys 3 Left Main Gear Strut Actuator Temp - start of off nominal trend	Unusual Temp Rise	V58T0405A
35.7	--	--	13:54:25	EI+616	Approx Veh Grd Location: 38.3 N / -119.0 W	Altitude 227400 ft / Mach 22.5 - Crossing the California / Nevada State Line	Data source: STS-107 GPS Trajectory Data	
35.8	--	--	13:54:26	EI+617		S-Band switched from upper left aft antennae to upper right aft antenna.	TDRS 171/W	

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Seq No.	Sum No.	OEX Data	GMT		EI secs	Milestone	Entry Event	Remarks	MSID / ID	
			GMT Day 32							
36			deleted							
36.2	15.2	X	13:54:29		EI+620		Left Fuselage Side Surface temp BP3605T peaks and starts downward trend	Ref seq 29.55 for previous event of this sensor and seq 54.1 for next event of this sensor	V07T9253A X1000.7 Y-105 Z354.5	
36.5	15.3	--	13:54:33.3 / 33.9		EI+624.3 / EI+624.9		Flash #1 - Orbiter envelope suddenly brightened (duration 0.3 sec) leaving noticeably luminiscent signature in plasma trail	Note: R3R and R2R 0.24 sec jet firings occurred at 13:54:33.52 / 33.76 and 13:54:33.54 / 33.78 respectively (ref: RCS Atlas analysis and plots).	EOC2-4-0055 EOC2-4-0034 EOC2-4-0009B EOC2-4-0056 EOC2-4-0070	
36.55	15.32	X	13:54:34		EI+625		Left Fuselage Side Surface temp BP3703T peaks and starts downward trend	Ref seq 29.63 for previous event of this sensor and seq 70.1 for next event of this sensor	V07T9925A X1138.5 YLH Z441.5	
36.6	15.3	--	13:54:35 / 37		EI+626 / EI+628		Debris #6 - Very bright debris seen leaving the Orbiter	Seen just aft of Orbiter envelope. Also, reference RCS jet firing note in item # 36.5 above. Debris events 6 and 14 are visually the biggest, brightest events and therefore may indicate the most significant changes to the Orbiter of the western debris events.	EOC2-4-0055 EOC2-4-0034 EOC2-4-0009B EOC2-4-0066 EOC2-4-0070	
36.7	15.33	X	13:54:39		-EI+630		Strain Gages Centered on the Upper Surface of the Left MLG Wheel Wheel - Higher-than-expected strain indications observed in these gages	Note: PCM3 entry data is in snapshot format (not continuous), therefore event may have occurred earlier than noted	V12G9156A, V12G9157A, V12G9158A	
36.8	15.34	X	13:54:39		-EI+630		Left Wheel X1040 Spar Web - shows increase in strain	Note: Adjacent sensor V12G9165A did not show similar "off-nominal" signature at this time, also, PCM3 entry data is in snapshot format (not continuous), therefore event may have occurred earlier than noted	V12G9165A V12G9167A (V12G9165A-nominal)	
37			deleted							
37.5			deleted							
37.7	--	--	13:54:53		EI+644		MLG LH Outbd Wheel Temp - start of off nominal trend	2 bit flips up (ref #56.5 when temp starts to trend down)	V51T0574A	
QBAR = -34.5 psf (-0.24 psi) Mach 22.1			----- 32:13:55:00 -----				EI + 651 sec; WLE Stagnation Temp: ~2900 F			
37.75	15.35	--	13:55:04 / 06		EI+655 / EI+657		Debris #7 - Seventh report of debris observed leaving the Orbiter	Seen just aft of Orbiter envelope. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0030	
37.8	13	--	13:55:12		EI+663		Sys 3 LMG Brake Sw Viv Ret Line Temp (FWD) - start of off nominal trend	Temp Increase	V58T0842A	
37.9	15.35	--	13:55:17 / 19		EI+668 / EI+670		Debris #7A - Report of debris observed leaving the Orbiter	Seen just aft of Orbiter envelope	EOC2-4-0161	
38			deleted							
39			deleted							
40	--	--	13:55:21		EI+672	Drag 11 ft/sec ²	Drag Measurement Incorporation	Incorporation of drag-derived altitude into the vehicle navigation state.		

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Seq No.	Sum No.	OEX Data	GMT GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID
40.02	15.35	--	13:55:21 / 25	EI+672 / EI+676		Debris #8 - Report of debris observed leaving the Orbiter.	Seen just aft of Orbiter envelope inside the aforementioned Debris Shower A. No evidence of RCS jet firings (ref Atlas data and plots).	Debris: EOC2-4-0030, 0098, & 0161
40.05	15.37	--	13:55:22 / 28	EI+673 / EI+679		Debris Shower A - Report of debris shower seen just aft of Orbiter envelope.	Seen just aft of Orbiter envelope. Over the course of these four seconds a luminescent section of plasma trail is observed which appears to contain a shower of indefinite particles and multiple, larger discrete debris that includes Debris 8, 9, and 10.	Saw debris: EOC2-4-0098, 0161, 0005, 0030 Saw shower: EOC2-4-0017, 0021, 0028
40.1			deleted				Rationale for deletion: moved to 40.02 after further review of the videos	
40.2	15.35	--	13:55:24 / 28	EI+675 / EI+679		Debris #9 - Report of debris observed leaving the Orbiter.	Seen just aft of Orbiter envelope inside the aforementioned Debris Shower A. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0005, 0098
40.3	15.35	--	13:55:25 / 29	EI+676 / EI+680		Debris #10 - Report of debris observed leaving the Orbiter	Seen well aft of Orbiter envelope inside the aforementioned Debris Shower A. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0005
40.4			deleted				Rationale for deletion: The signatures of the STS-107 remote sensor events were very subtle. Upon further evaluation of the data, it was determined that the remote sensor signatures had been seen in previous flights and/or could be explained by known events. The events are therefore not considered to be anomalous.	
40.5	--	--	13:55:32	EI+683	Approx Veh Grd Location: 37.4 N / -114.1 W	Altitude 223400 ft / Mach 21.8 - Crossing the Nevada / Utah State Line	Data source: STS-107 GPS Trajectory Data	
40.6	15.43	--	13:55:33 / 35	EI+684 / EI+686		Return link comm drop-out (Comm event 12)	First comm drop out after switched to upper right aft antennae (TDRS 17 I/W). While uncommon to have a drop out at this point, inconclusive if drop-out is off-nominal based on previous flt data.	
41			deleted					
41.2			deleted				Rationale for deletion: Moved to 41.25 after further review of the data	

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Seq No.	Sum No.	DEX Data	GMT		EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day	GMT 32					
41.5	15.45	--	13:55:35 / 39		EI+686 / EI+690		Debris #11 - Report of debris observed leaving the Orbiter	Appears at the head of a secondary parallel plasma trail well aft of Orbiter envelope. A second piece of debris is also seen in the secondary plasma trail. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0050, EOC2-4-0098
41.55	15.46	X	13:55:36		EI+687		Xo 1040 Spar (MLG Forward Wall Spar) Strain Gage - Upper Cap sudden drop in strain followed by gradual increase until erratic signature at approximately EI+930	Reference seq 31.25 for previous event of this sensor	V12G9049A X1040 V-135 ZUVR
41.6	15.45	--	13:55:38 / 40		EI+689 / EI+691		Debris #11A - Report of debris observed leaving the Orbiter	Seen just aft of Orbiter envelope.	EOC2-4-0098
41.7	15.45	--	13:55:38 / 42		EI+689 / EI+693		Debris #11B - Report of debris observed leaving the Orbiter	Seen at head of a parallel plasma trail aft of the Orbiter envelope.	EOC2-4-0098
42	15.5	--	13:55:41		EI+692		Mld Fus Port (Left) Still Longn Temp at x1215 - start of off nominal trend	Unusually high temp rise with respect to STS-87 & 109. Went to 2.9 F/min from 0 F/min.	V34T1118A
42.2	15.45	--	13:55:42 / 46		EI+693 / EI+697		Debris #11C - Report of debris observed leaving the Orbiter	Seen at head of a parallel plasma trail well aft of the Orbiter envelope.	See debris & parallel trail: EOC-4-0098 See parallel plasma trail only: EOC2-4-nn28 nn28 EOC2-4-0028, 0050, 0098
42.3	15.45	--	13:55:44 / 46		EI+695 / EI+697		Debris #12 - Report of debris observed leaving the Orbiter. Event was preceded and followed by secondary plasma trails.	Seen aft of Orbiter envelope. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0028, 0050, 0098
42.5			deleted					Rationale for deletion: Moved to seq # 42.75 (mislocated in timeline based on GMT associated with event)	
42.7	15.45	--	13:55:54 / 58		EI+705 / EI+708		Debris #13 - Report of debris observed leaving the Orbiter. Event was followed by momentary brightening of plasma trail adjacent to debris.	Seen well aft of Orbiter envelope. No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0005, 0017, 0021, 0161
42.75	--	--	13:55:55		EI+706	Approx Veh Grd Location: 37.0 N / -112.4 W	Altitude 222100 ft / Mach 21.5 - Crossing the Utah / Arizona State Line	Data source: STS-107 GPS Trajectory Data	
42.8	15.45	--	13:55:57 / 59		EI+708 / EI+710		Debris #14 - Very bright debris observed leaving the Orbiter.	Seen just aft of Orbiter envelope. Debris events 6 and 14 are visually the biggest, brightest events and therefore may indicate the most significant changes to the Orbiter of the western debris events.- No evidence of RCS jet firings (ref Atlas data and plots).	EOC2-4-0005, 0017, 0021, 0028, 0030

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Seq No.	Sum No.	OEX Data	GMT	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
QBAR = -40 psf (-0.28 psi); Mach 21.4			----- 32:13:56.00 -----			EI = 711 sec: WLE Stagnation Temp: -2900 F		
42.9	15.43	--	13:56:00 / 03	EI+711 / EI+714		Return link comm drop-out (Comm event 13)	On upper right aft antennae (TDRS 171/W). While uncommon to have a drop out at this point, inconclusive if drop-out is off-nominal based on previous fit data. Note: No further comm drop-out events are listed in the timeline thru LOS, since are not considered out-of-family at this time.	
43	--	--	13:56:02	EI+713	Qbar 40 psf	Aft RCS Pitch Jets Deactivated	Pitch control is solely achieved through elevator and body flap commands from this point forward.	
44	16	--	13:56:03	EI+714		Left Lower Wing Skin Temp - start of off nominal trend	Temp reading trending down (potential sensor/wire damage)	V09T1002A
44.2	15.45	--	13:56:08 / 12	EI+719 / EI+723		Debris #15 - Report of debris observed leaving the Orbiter.	Seen just aft of Orbiter envelope. Nearest jet firings: R2R jet firing at 032:13:56:17.30 56:17.54 for 0.24 seconds, & R3R jet firing at 032:13:56:17.28 / 56:17.52 for 0.24 seconds. (Ref: RCS Atlas data analysis and plots).	EOC2-4-0017
44.5	16.5	--	13:56:16	EI+727		Hyd Sys 1 LMG UpLK Actr Unlk Ln Temp - Temp rise rate change	Temp rise rate change from 0.7 F/min (nominal) to 3.9F/min and increasing to LOS	V58T0125A
44.6	16.5	--	13:56:17	EI+728		Sys 3 LMG Brake Sw Vlv Ret Line Temp (FWD) - Temp rise rate change	Temp rise rate change from 1.5 F/min to 8.9 F/min (stayed at this rate to LOS)	V58T0842A
44.7	16.5	--	13:56:20	EI+731		LMG Brake Line Temp C - Temp rise rate change	Temp rise rate change from 1.3 F/min to 9.9 F/min (stayed at this rate to LOS)	V58T1702A
44.8	16.5	--	13:56:22	EI+733		LMG Brake Line Temp B - Temp rise rate change	Temp rise rate change from 2.1 F/min to 9.1 F/min increasing to LOS	V58T1701A
45	16	--	13:56:24	EI+735		Left Upper Wing Skin Temp - start of off nominal trend	Temp reading trending down (potential sensor/wire damage)	V09T1024A
46	16.55	--	13:56:30	EI+741		1st Roll Reversal Initiation	Entry guidance changes the sign of the roll command to redirect the vehicle back towards the center of the delta azimuth (heading error) corridor.	V90H1044C
46.5	--	--	13:56:45	EI+756	Approx Veh Grd Location: 36.1 N / -109.0 W	Altitude 219000 ft / Mach 20.9 - Crossing the Arizona / New Mexico State Line	Data source: STS-107 GPS Trajectory Data	
46.7	16.5	--	13:56:53	EI+764		Sys 3 Left Main Gear Strut Actuator Temp - Temp rise rate change	Temp rise rate change from 1.7 F/min to 12.9 F/min (stayed at this rate to LOS)	V58T0405A
47	16.55	--	13:56:55	EI+766	Roll Reversal #1	1st Roll Reversal Complete	Actual roll achieves desired roll command.	V90H1044C

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT	EI	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
47.5			deleted				Rationale for deletion: Comm dropout (event 14) is deleted since probably nominal due to completion of roll reversal resulting in elevation angle nearing 80 degrees.	
48			deleted				Rationale for deletion: IMU Velocity increase reflects accelerations imparted during roll reversal. Same signature observed on STS-109. Nominal event.	
GBAR = -42 psf (-0.29 psi) Mach 20.7			----- 32:13:57:00 -----			EI + 771 sec: WLE Stagnation Temp: -2900 F		
49	--	--	13:57:00 deleted			Bodyflap deflection up 3 degrees	Matches nominal aero simulation	V90H6410C
49.51	16.65	X	13:57:09	EI+780		Fuselage Side Surf Thermocpl BP9976T - start of off-nominal trend (temp increase followed by temp drop / rise)		V07T9270A X1486.1 Y-124.8 Z327.1
49.53	16.67	X	13:57:09	EI+780		Fuselage Lower Surface BF Thermocpl BP220T - start of off-nominal trend (shallow temp drop)		V07T9508A X1560 Y-111.1 Z LWR
49.55	16.8	--	13:57:19 / 29	EI+790 / EI+800		Debris # 16 - Very faint debris observed leaving just aft of Orbiter. (Occurred over eastern AZ and NM.)	Observations by personnel from the Starfire Optical Range (Kirtland Air Force Base, NM). Note: nearest jet firings: L2L jet firing at 032:13:56:54.71 / 57:01.12 & 032:13:57:46.35 / 57:53.12 & L3L jet firing at 032:13:56:54.66 / 57:01.07 & 032:13:57:46.33 / 57:53.10 (cell 4 occurred during data dropouts & were determined based on injector temps alone). Also, R2R at 032:13:57:43.94 / 57:44.42 & R3R at 032:13:57:43.92 / 57:44.40 for 0.48 secs ea (Ref Atlas data analysis and plots.)	EOC2-4-0148-2
49.6	16.9	--	13:57:19	EI+790		MLG LH Outbd Tire Pressure 1 - start of off nominal trend	Bit flip up - off nominal thru comparison with previous flights	V51P0570A
49.7	16.9	--	13:57:24	EI+795		MLG LH Outbd Tire Pressure 2 - start of off nominal trend	Bit flip up - off nominal thru comparison with previous flights	V51P0572A
50	17	--	13:57:28	EI+799		Left Lower Wing Skin Temp - OSL		V09T1002A
51	--	--	deleted				Rationale for deletion: Originally indicated as "Start of Roll trim in elevators". Inserted independently early in the investigation, but is better defined by sequence no. 54. "Roll trim" is better indicated with alleron trim.	
52	17	--	13:57:43	EI+814		Left Upper Wing Skin Temp - OSL		V09T1024A
53	19	--	13:57:54	EI+825		Sys 2 LH Brake Switching Vlv Return Temp (AFT) - start of off nominal trend	Temp increase	V58T0841A

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	DEX Data	GMT GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID
53.5	16.8	--	13:57:53.5 / 55.5	EI+824.5 / EI+826.5		Flare 1: Asymmetrical brightening of Orbiter shape observed. (Occurred over eastern AZ and NM.)	Observations by personnel from the Starfire Optical Range (Kirtland Air Force Base, NM). Note: nearest jet firings: Same as seq no. 49.55 plus L2L at 032:13:58:00.50 / 01.46 & L3L at 032:13:58:00.48 / 01.44 (in both cases there was no start up data, but good tail off/shutdown) - 0.96 sec pulse each. Also, R2R at 032:13:58:03.18 / 09.16 & R3R at 032:13:58:03.18 / 09.16 - (in both cases firings occurred during data dropouts and were determined by injector temps). (Ref Atlas analysis and plots.)	EOC2-4-0148-4
53.7	16.8	--	13:57:59.5 / 58.01.5	EI+830.5 / EI+832.5		Flare 2: Asymmetrical brightening of Orbiter shape observed. (Occurred over eastern AZ and NM.)	Observations by personnel from the Starfire Optical Range (Kirtland Air Force Base, NM). Note: same jet firing information as for event seq no.s 49.55 & 53.5. (Ref Atlas analysis and plots.)	EOC2-4-0148-4
OBAR = -52.5 psf (-0.36 psi); Mach 19.8			----- 32:13:58:00 -----			EI + 831 sec; WLE Stagnation Temp: ~2880 F		
54	20	--	13:58:03	EI+834		Start of "sharp" aileron trim increase	An abrupt increase in the rate of change in the aileron trim occurs near this time, indicating flight control is now compensating for increasingly asymmetric aerodynamics. (This trend continues to LOS. (GMT is approximate (13:58:03+/-10 seconds).)	V90H1500C
54.1	20.3	X	13:58:04	EI+835		Left fuselage side surface temp BP3605T starts off-nominal temperature increase	Ref seq 36.2 for previous event of this sensor	V07T9253A X1000.7Y-105 Z34.5
54.3	20.5	--	13:58:04 / 58:19	EI+835 / EI+850		Increase in off-nominal aero increments.	Substantial increase in rate of change of rolling (13:58:04) and yawing (13:58:19) moment increments and initial indication of off-nominal pitching moment increment (13:58:05). Derived by analysis.	n/a
54.5	22.5	--	13:58:16	EI+847		LMG Brake Line Temp D - Temp rise rate change	Temp rise rate change from 0.9 F/min to 11.7 F/min (stayed at this rate to LOS)	V58T1703A
55			deleted					
55.5			13:58:20	EI+851	Approx Veh Grd Location: 34.2 N / -103.1 W	Altitude 209800 ft / Mach 19.5 - Crossing the New Mexico / Texas State Line	Data source: STS-107 GPS Trajectory Data	
56			deleted					
57	23	--	13:58:32	EI+863		MLG LH Outbd Tire Pressure 1 - pressure trending down (to OSL)	Trending to OSL following 7 sec LOS (initiation time not exact) - ref #60	V51P0570A
58	23	--	13:58:32	EI+863		MLG LH Inbd Tire Pressure 1 - pressure trending down (to OSL)	Trending to OSL following 7 sec LOS (initiation time not exact) - ref #64	V51P0571A
58.5	--	--	13:58:32	EI+863		MLG LH Outbd Wheel Temp - temperature trending down (to OSL)	Trending to OSL following 7 sec LOS (initiation time not exact) - ref #62	V51T0574A

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT GMT Day 32	EI secs	Milestone	Entry Event	Remarks	MSID / ID
58.7	--	--	13:58:32 / 59:22	EI+863 / EI+913		Sys 2 LH Brake Switching Vlv Return Temp (AFT) - temp rise rate change	Temp rise rate change from 2.5 F/min to 40.0 F/min until 13:59:22 (temp peak) - ref #7n 6	V58T0841A
59	--	--	13:58:36	EI+867		MLG LH Inbd Wheel Temp - start of temperature trending down (to OSL)	Start of trend to OSL - ref #66	V51T0575A
60	23	--	13:58:38	EI+869		MLG LH Outbd Tire Pressure 1 - OSL		V51P0570A
61			Deleted				Rationale for deletion: Moved to seq no. 63.5 after further data review.	
62	25	--	13:58:39	EI+870		MLG LH Outbd Wheel Temp - OSL		V51T0574A
63	23	--	13:58:39	EI+870		MLG LH Outbd Tire Pressure 2 - start of pressure trending down (to OSL)	Start of trend to OSL - ref #68	V51P0572A
63.5	25.5	--	13:58:40	EI+871		BFS Fault Msg (4) - Tire Pressures - First Message	32/13:58:39.94 - SM0 Tire P LOB 32/13:58:41.84 - SM0 Tire P LIB 32/13:58:49.54 - SM0 Tire P LIB 32/13:58:56.26 - SM0 Tire P LOB	
64	23	--	13:58:40	EI+871		MLG LH Inbd Tire Pressure 1 - OSL		V51P0571A
65	--	--	13:58:41	EI+872		MLG LH Inbd Tire Pressure 2 - start of off nominal trend	Press rose -3.5 psia in 2 sec's	V51P0573A
65.5	23	--	13:58:43	EI+874		MLG LH Inbd Tire Pressure 2 - start of pressure trending down		V51P0573A
66	25	--	13:58:48	EI+879		MLG LH Inbd Wheel Temp - OSL		V51T0575A
67	23	--	13:58:48	EI+879		MLG Inbd Tire Pressure 2 - OSL		V51P0573A
68	23	--	13:58:54	EI+885		MLG LH Outbd Tire Pressure 2 - OSL		V51P0572A
69	26	--	13:58:56	EI+887		BFS Fault Msg (4) - Tire Pressures - Last Message		
GBAR = -63.5 psf (-0.44 psi), Mach 18.7 ----- 32:13:59:00 -----								EI + 891 sec; WLE Stagnation Temp. -2850 F
70	27	--	13:59:06	EI+897		Left Main Gear Downlocked Indication - Transferred ON	Uplink indicated no change	V51X0125E
70.1	27.3	X	13:59:09 / 59:39	EI+900 / EI+930		Several left side temperature measurements show a rapid increase in temperature followed by erratic behavior and subsequent loss of the measurements at approximately EI+940		V07T9925A V07T9976A X1138.5 YLH 2441.4 X1342.5 Y-128.5 V07T9972A 2462.6 X1324 Y-98 2488 V07T9978A V07T9976A X1359.6 Y-135.1 X1342.5 Y-128.5 2463.1 2462.6 V07T9222A V07T9903A X1486.9 Y-128.2422D X1008 Y-105.2398.4 V07T9223A V07T9913A X1437.2 Y-126.2422D
						V07T9925A - L Fus Side Surf TC BP7303T (on PLBD) V07T9972A - OMS-L Pod TC BP0749T V07T9976A - OMS-L Pod TC BP0731T V07T9903A - L Fus Side Surf TC BP3604T V07T9913A - L Fus Side Surf TC BP3603T (on PLBD) V07T9976A - OMS-L Pod Thermocouple BP0731T V07T9978A - OMS-L Pod Thermocouple BP0732T V07T9222A - OMS-L Pod HRS1 Surf T2-AFT V07T9223A - OMS-L Pod HRS1 Surf T3-AFT		
70.3	27.5	--	13:59:23	EI+914		Loss of MCC real-time data to the workstations in the FCR and MER		
70.5	--	--	13:59:22	EI+913		Sys 2 LH Brake Switching Vlv Return Temp (AFT) - start of sharp downward temperature trend	Temp trending down until loss of signal - ref #81	V58T0841A
70.7	27.7	--	13:59:26 / 59:28	EI+917 / EI+919		Abrupt increase in off-nominal aero increments.	Abrupt increase in rate of change of pitching (13:59:28), rolling (13:59:28) and yawing (13:59:26) increments. Magnitude of aero increments starting to exceed ability of aileron to laterally trim the vehicle. Derived by analysis.	n/a

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Note: Rev 19 BASELINE updates Rev 13 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
71	28	--	13:59:30.66	EI+921.66		Start of R2R yaw firing	Last pulse before LOS (stayed on to end of first 5-sec period of recon data at 032/13:59:37.4 GMT)	V79X2634X
72	28	--	13:59:30.68	EI+921.68		Start of R3R yaw firing	Last pulse before LOS (stayed on to end of first 5-sec period of recon data at 032/13:59:37.4 GMT)	V79X2638X
73	29	--	13:59:31	EI+922		Observed elevon deflections at LOS	Left: -8.11 deg (up); Right: -1.15 deg (up)	V90H7505C V90H7555C
73.1	29.3	--	13:59:31.400	EI+922.4		FCS Channel 4 Aerosurface position measurements start trending towards their null values	Indicates worsening failure of transducer excitation via a wiring short conditions	V57H0253A (5 Hz)
73.2	29.3	--	13:59:31.478	EI+922.5		All FCS Channel 4 Bypass valves close (indicating bypassed)	Leading indicator of ASA fail (high-rate data)	V58P0915A
73.3	29.3	--	13:59:31.7	EI+922.7		Speedbrake channel 4 Oi position measurement indicated successively 19, 20, 24 degrees over last three samples prior to LOS (should be closed / 0°).	Speedbrake was commanded to "overclose" (-10 degrees), position measurements for Channels 1 thru 3 were 0 degrees. Secondary delta pressure on Ch 4 went to zero, which indicates that the channel was bypassed. This is real data and the ASAs were responding appropriately.	V57H0253A (5 Hz)
73.5	29.5	--	13:59:32	EI+923		Observed aileron trim at LOS	Trim: -2.3 deg (V96H2045C - V90H1500C)	
74	--	--	13:59:32	EI+923		M-FUS LT BL Temp at x1215 - LOS	LOS	V34T1106A
74.5	--	--	13:59:32	EI+923		LH Air Fus Sidewall Temp at x1410 - LOS	LOS	V05F1724A
75	--	--	13:59:32	EI+923		LMG Brake Line Temp A - LOS	LOS at 172.2 F	V58T1700A
76	--	--	13:59:32	EI+923		LMG Brake Line Temp B - LOS	LOS at 154.2 F	V58T1701A
77	--	--	13:59:32	EI+923		LMG Brake Line Temp C - LOS	LOS at 104.8 F	V58T1702A
78	--	--	13:59:32	EI+923		LMG Brake Line Temp D - LOS	LOS at 88.3 F	V58T1703A
79	--	--	13:59:32	EI+923		Left Main Gear Strut Actuator Temp - LOS	LOS at 76.3 F	V58T0405A
80	--	--	13:59:32	EI+923		Hyd Sys 1 LMG Upk Act Unk Ln Temp - LOS	LOS at 52.2 F	V58T0125A
81	--	--	13:59:32	EI+923		Sys 2 LH Brake Sw Viv Return Temp (AFT) - LOS	LOS at 62.8 F	V58T0841A
82	--	--	13:59:32	EI+923		Sys 3 LMG Brake Sw Viv Return Line Temp (FWD) - LOS	LOS at 67.3 F	V58T0842A
82.7	32.5	--	31:59:32	EI+923		Approx Veh Grd Location: 32.9 N / -99.0 W	Approximate Vehicle Ground Location at Loss of Signal based on GMT; Data source: STS-107 GPS Trajectory Data	
82.8	29.3	--	13:59:32.130	EI+923.130		FCS Channel 4 fail flags raised (1 Hz) on all aerosurface actuators	Lagging indicator of ASA position measurement discrepancy	V79X3263X V79X3268X V79X3273X
83	33	--	13:59:32.136	EI+923.136	LOS (Loss of Signal)	Last valid downlink frame accepted by ODR - Oi / BFS / PASS (This time has been referred to as "LOS" throughout the investigation.) Start of reconstructed data	Upper Right Alt (URA) Quad Antenna was selected by BFS Antennae Manage S/W to communicate with TDRS-W. The pointing angle to TDRS-W was off the Orb tail at -65 degs and trending further into blockage. Prev experience / eng calcs predict probable loss of comm at elevation angles greater than -60 degrees. Loss of comm at this GMT is therefore considered nominal.	V79X3278X V79X3334X V79X3339X

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

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Seq No.	Sum No.	OEX Data	GMT	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
84	29.3	--	13:59:32.195	EI+923.195		ASA 4 RPC A&C Trip Indication	Lagging indicator of ASA transducer excitation short condition	V79X4210E V76X4211E
85			deleted				Rationale for deletion: moved to 85.6 after further data review.	
85.5	29.3	--	13:59:32.598	EI+923.598		Left Outboard bypass valve reopens. A force fight between channels 1/2/3 and channel 4 begins, resulting in a difference of up to 0.5 degrees observed between the left outboard and inboard elevons	Indicates a short in bypass valve has grown sufficient to drop below voltage threshold of valve; RPC B is current limiting.	V58P0865A
85.6	29.3	--	13:59:33.680	EI+924.680		BFS Fault Message annunciation (1) - FCS CH 4	TDRS-E Data. Error is detected by ATV/CASA hardware when sensed delta pressure across actuator exceeds a limit indicating the FCS channel is no longer driving the actuator. FCS CH 4 failure will annunciate for any of the following: LIB / LOB / RIB / ROB elevon actuator 4, rudder actuator 4, speedbrake actuator 4, SSME 1/2/3 P/Y Actuator D, & L/R SRB R/T actuator D.	
86	29.3	--	13:59:33.863	EI+924.863		PASS Fault Message annunciation (1) - FCS CH 4	TDRS-E Data	
87			13:59:33.976	EI+924.976		Master Alarm noted		
88	29.3	--	13:59:34.518	EI+925.518		Left Outboard force fight ends, driver currents go to zero. (RPC B trip indication).	Leading indicator of RPC B trip / ASA power down. i.e., indicates opening of all bypass valves (due to RPC B trip removing power) on ASA 4. Force fight goes away since actuators are already at the last commanded position (so channel 4 has no hyd load on the servo asking for position change).	V58P0865A
89	29.3	--	13:59:34.561	EI+925.561		Speedbrake force fight begins (continues to LOS)	Indicates opening of all bypass valves (due to RPC B trip removing power) on ASA 4. Since the speedbrake is at zero but is being commanded to "over-close" position (-10) this results in a force fight between channels 1, 2, 3 and channel 4.	V57P0260A V57P0261A V57P0262A
90	35	--	13:59:35/36	EI+926 / EI+927		Sideslip on vehicle changes sign.	The event occurred between the two times listed. Just prior to initial LOS the magnitude of the negative Sideslip started to decrease and between 59:34 and 59:37 sideslip grew from -.6 to +.8 deg. With this change, the normal roll and yaw moments on the vehicle would change sign. Aerodynamic forces due to sideslip are now reinforcing aerodynamic asymmetry.	

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Integ Time Line Team - REV 19 BASELINE

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT		EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day	GMT 32					
91	36	--	13:59:36		EI+927		Growth in Bank attitude error	Up until this time the flight control had been able to maintain the Bank error around 5 deg. Aerojet DAP drops left wing to compensate for increasing aerodynamic moments, creating a bank attitude error.	
92	37	--	13:59:36.8		EI+927.8		Aerojet DAP Requests Third Right Yaw RCS Jet (R4R)	This additional jet is required to counteract the increasing aerodynamic moments on the vehicle. The RCS jet fired, as expected and stayed on to end of first 5-sec period of recon data at 032/13:59:37.4 GMT.	
93	38	--	13:59:37.3		EI+928.3		Aerojet DAP Requests Fourth Right Yaw RCS Jet (R1R)	This additional jet is required to counteract the increasing aerodynamic moments on the vehicle. The RCS jet fired, as expected and stayed on to end of first 5-sec period of recon data at 032/13:59:37.4 GMT.	
94	39		13:59:37.n		EI+928.n		Last aileron data	The aileron position is now approx -5.2 deg with approx -2.5 deg of aileron trim. The rate of change of aileron trim had reached the maximum allowed by the flight control system.	
95	40	--	13:59:37.396		EI+928.396	End of 5 second period of reconstructed data	End of first 5-seconds of the 32-second period of post-LOS data. Start of approximately 25 seconds of no data available	GMT derived by MER data personnel	
95.5	40.5	X	13:59:39 / 14:00:19		EI+930 / EI+970		Beginning at EI+930 and continuing until the loss of sync on OEX data (EI+964.4 for PCM and EI+970.4 for FDM), essentially all of the OEX data for the entire vehicle becomes erratic and fails		
95.8	40.7	--	13:59:46 / 48		EI+937 / EI+939		Debris A observed leaving the Orbiter - Large debris seen falling away from the Orbiter envelope.		EOC2-4-0018 EOC2-4-0024 EOC2-4-0209-B EOC2-4-0221-3 EOC2-4-0221-4
96	41	--	13:59:46.347		EI+937.347		PASS Fault Message annunciation - ROLL REF	Message retrieved from PASS "fault message buffer" received between 14:00:04 and 14:00:05. Data is potentially error prone. The ROLL REF message is triggered when Roll command req'd to fly reference profile falls below 37 degs. Message generation less than 10 secs (5 guidance cycles) after start of 4 yaw jets firing suggests unexpected reduction in Lift to Drag ratio.	

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

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Seq No.	Sum No.	OEX Data	GMT		EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32						
97	41	--	13:59:52.114		EI+943.114		PASS Fault Message announcement - L RCS LEAK	<p>Note: BFS does not have this message in the Fault message stack. It is likely that BFS announced this message during the 25 second gap of no data, but that if it was announced it was pushed out of the downlist stack by additional fault messages (at least 5) announced during the gap.</p> <p>Data located in PASS fault message buffer. Data is potentially error prone. Generated when difference between left aft RCS oxidizer and fuel thermodynamically derived quantities is more than 9.5% PVT. Indicates a leak of either helium and/or propellant OR the temperature/pressure sensor readings used to compute the quantities are erroneous.</p>	
97.3	41.5	--	14:00:01 / 03		EI+952 / EI+954		Debris B observed leaving the Orbiter	Time is for debris first seen well aft of Orbiter envelope.	EOC2-4-0024
<p>QBAR = min psf; Mach min ----- 32:14:00:00 ----- EI + 951 sec; WLE Stagnation Temp: -2800 F</p>									
98	41	--	14:00:01.540*		EI+952.540		BFS Fault Message announcement - L RCS LEAK	<p>Data located in BFS fault message buffer. Data is potentially error prone. Generated when difference between left aft RCS oxidizer and fuel thermodynamically derived quantities is more than 9.5% PVT. Indicates a leak of either helium and/or propellant OR the temperature/pressure sensor readings used to compute the quantities are erroneous.</p> <p>*Time info corrupted.</p>	
99	41	--	14:00:01.900*		EI+952.900		BFS Fault Message announcement - L RCS LEAK	<p>Data located in BFS fault message buffer. Data is potentially error prone.</p> <p>*Time info corrupted.</p>	
99.5	41.5	--	14:00:02 / 04		EI+953 / EI+955		Debris C observed leaving the Orbiter	Time is for debris first seen well aft of Orbiter envelope.	EOC2-4-0024
100			Deleted					Rationale for deletion: moved to 95.8 after further review of the videos	

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
101	43	--	14:00:02.654	EI+953.654		PASS Fault Message annunciation - L RCS LJET	Data is potentially error prone. Data located in PASS fault message. Generated when a left firing RCS jet on the left OMS pod has failed with a FAIL OFF, FAIL ON, or FAIL LEAK.	
102	44	--	14:00:02.660	EI+953.660	Beginning of 2 second period of reconstructed data	Start of last 2-seconds of the 32 second period of post-LOS data.	GMT derived by MER data personnel.	
							CAUTION: Data from this period is suspect because multiple bit errors were evident in this reconstructed data. Many of the parameters were 1 Hz data and therefore only one data sample was available. Where possible, high rate data and/or corroborating data were used to draw subsystem performance conclusions. However, some of the conclusions drawn below may be in error or misinterpreted.	
							During this final 2 second period of reconstructed data, the data indicates the following systems were nominal: APU's were running and WSB cooling was evident (although potentially overcooling). MPS integrity was still evident. Fuel cells were generating power and the PRSD tanks/lines were intact. Conv and navids systems in the forward fuselage were performing nominally. RSB, Body Flap, main engine, and right wing temps appeared active. With the exception of an apparent FES shutdown, ECLSS performance was nominal.	
							During this final 2 second period of reconstructed data, the data indicates the following systems were <u>off nominal</u> : All three Hyd systems were lost (zero pressure/zero rsrv qty's). The left inboard elevon actuator temps were either OSL or no data exists. WSB's appeared to be overcooling APU lube oil. The FES appeared to have shutdown. Majority of left OMS pod sensors were either OSH or OSL or no data exists. Multiple BFS and PASS fault message annunciations for left pod hardware were found in the buffer. (Note: All of the left RCS fault messages could be result of a real leak or loss of instrumentation. The OMS fault message could be a real loss of pressure or instrumentation problem. There is not enough data to determine the true cause of the messages associated with the left OMS pod.)	
							Elevated temps at bottom bondline centerline skin forward and aft of the wheel wells and at the port side structure over left wing were observed. EPDC shows general upward shift in Main Bus amps and downward shift in Main Bus volts. AC3 phase A inverter appeared disconnected from the AC Bus.	
							GNC data suggests vehicle was in an uncommanded attitude and was exhibiting uncontrolled rates. Yaw rate at the sensor maximum of 20 deg/sec. The flight control mode was in AUTO. (Note that all Nav-derived parameters (e.g., alpha) are suspect due to high rates corrupting the IMU state.)	
							Based on the nominal and off-nominal system performance described above, it appears that the fwd/mid/aft fuselage, right wing, and right pod were still intact.	
103	45	--	14:00:03.470*	EI+954.470*		BFS Fault Message annunciation - L OMS TK P	Data located in BFS fault message buffer after acquisition of data. Data is potentially error prone. *Time info corrupted. Note: Error is annunciated when left OMS oxidizer tank ullage pressure (V43P4221C) or fuel tank ullage pressure (V43P4321C) is out of limits high or low. Oxidizer limits - High: 288 psi; Low 234 psi; Fuel limits - High: 288 psi; Low: 234 psi.	

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
103.5	45	--	14:00:0n.nnn			BFS Fault Message annunciation - Indeterminant		
104	45	--	14:00:0n.nnn*			BFS Fault Message annunciation - SM1 AC VOLTS	<p>Occurred after L OMS TK P message. Data is potentially error prone. *Time info corrupted.</p> <p>Note: Error message indicates that AC Bus 3 phase A, B, or C voltage (V76V1700A, V75V1701A, V76V1702A) is out of limits high or low. Low limit for all 3 parameters is 108VAC; high limit is 123VAC.</p>	
105	45	--	14:00:03.637	EI+954.637		PASS Fault Message annunciation - L RCS PVT	Data is potentially error prone. Data located in PASS fault message. Generated when RCS Quantity software does not have enough input data to calculate a quantity. At least one input and its backup are not within valid ranges.	
106	46	--	14:00:03.637	EI+954.637		PASS Fault Message annunciation - DAP DNMODE RHC	<p>Data located in PASS fault message buffer. Generated when the Flight Control System (DAP) downmodes from AUTO to CSS via an RHC deflection passed a threshold. The software process which logs the PASS message runs every 1.92 seconds, so event could have occurred as early as 14:00:01.717 GMT. The fault message was corroborated by an initialization flag for the DAP CSS roll stick function indicating that CSS was entered during the data gap.</p> <p>However, during this final 2 sec period, available vehicle data indicates RHC was in detent & DAP was in AUTO. Data is potentially error prone.</p> <p>Note: BFS downlist bits indicating CSS mode are initialized to "ON" for entry because BFS does not have an "Auto" mode, is always CSS, and will drive the eyebrow panel lights ON if engaged. These bits are always on in BFS through all of OPS 3 until touchdown.</p>	
107	47	--	14:00:04.826	EI+955.826	End of 2 second period of reconstructed data	Last identifiable OI Downlink frame	GMT derived by MER data personnel. Last recognizable Downlist frame (BFS & PASS) was approx 60 ms earlier.	

Appendix A.2 - STS-107 Mishap Investigation - Master Time Line

Note: Rev 19 BASELINE updates Rev 18 with the eastern most debris events (over Texas) and is the timeline used for the Final Report

Seq No.	Sum No.	OEX Data	GMT	EI secs	Milestone	Entry Event	Remarks	MSID / ID
			GMT Day 32					
107.1	--	--	14:00:05.2 / 06.2	EI+956.2 / EI+957.2		Late Flash 1	Sudden brightening of the Orbiter envelope	EOC2-4-0018 EOC2-4-0024 EOC2-4-0209-B EOC2-4-0221-3 EOC2-4-0221-4
107.15	--	--	14:00:06.2 / 07.2	EI+957.2 / EI+958.2		Late Flash 2	Sudden brightening of the Orbiter envelope, followed by a shower of debris seen aft of the Orbiter envelop during the next 4 seconds (shower seen only in EOC2-4-0221-4)	EOC2-4-0018 EOC2-4-0024 EOC2-4-0209-B EOC2-4-0221-3 EOC2-4-0221-4
107.2	--	--	14:00:08 / 12	EI+959 / EI+963		Debris D	Debris first seen slightly aft of Orbiter envelope and begins generating its own trail	EOC2-4-0018 EOC2-4-0209-B EOC2-4-0221-3 EOC2-4-0221-4
107.25	--	--	14:00:09 / 13	EI+960 / EI+964		Debris E	Debris first seen aft of Debris "D"	EOC2-4-0209-B EOC2-4-0221-3 EOC2-4-0221-4
107.3	--	--	14:00:10 / 14	EI+961 / EI+965		Debris F	Debris first seen aft of Orbiter envelope, which for a short time begins generating its own trail	EOC2-4-0209-B EOC2-4-0221-4
107.4	--	--	14:00:13 / 17	EI+964 / EI+968		Debris Shower	Multiple debris seen immediately aft of the orbiter envelope over the next 2 seconds	EOC2-4-0209-B EOC2-4-0221-5
107.5	47.5	X	14:00:13.439	EI+964.439		OEX PCM loss of sync		
108			deleted				Rationale for deletion: moved to 97.3 after further review of the videos	
109			deleted				Rationale for deletion: moved to 99.5 after further review of the videos	
109.3	48.3	--	14:00:17.8/18.8	EI+968.8 / EI+969.8		Catastrophic Event of an unknown nature (formally referred to as "Main Body Breakup) consisting of a sudden brightening of the Orbiter envelope followed by a definitive change in the character of the trail	Numerous debris seen aft of Orbiter envelope over the next 10 seconds, followed by disintegration of the main Orbiter envelope into multiple pieces	MIT-DV CAM-0001 EOC2-4-0018 EOC2-4-0024 EOC2-4-0209-B EOC2-4-0221-3 EOC2-4-0221-4
109.5	48.5	X	14:00:19.44	EI+970.44		FDM1 A end of data		
110			deleted				Rationale for deletion: moved to 109.3 after further review of the videos	
111	50	--	14:00:53	EI+1004	End of Peak Heating		Determined by analysis. The peak heating period represents the approximate time period during which the heating rate has flattened out at or near its maximum value.	

= Expected/Nominal performance or event

nn = data still needed