Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the G1 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the G1 Encounter and Cruise, not all NIMS data recorded on the tape recorder or selected in real-time were returned. The previous 6 chapters nominally describe the planning and intention of the NIMS observations for this orbit, except the obstab section in chapter 4 which was updated to give the latest parameters for the data that were actually returned.

The G1 orbit was the first time that NIMS data were returned using phase2 CDS playback software. Two main factors dictated the playback of NIMS G1 data. First, the CDS playback software was still under development and not ready for playback of NIMS MPW or LPU data at the start of G1 playback. Second, the NIMS processor was (and still is) prone to halting due to radiation hits to the NIMS phase2 RAM code. The first problem was resolved during G1 playback. The second problem continued to be a problem, but certain measures were taken in later orbits to lessen the effects due to the halting of the NIMS processor.

In this orbit we learned that the NIMS software is prone to radiation 'hits' that presumably alter the RAM code, usually causing the NIMS processor to halt. In G1 the NIMS RAM took at least two 'hits'. The first 'hit' did not halt the processor but caused the data structure in RAM to get out of phase with the spacecraft timing so that the data were returned in a 'garbled' state. Data during this time period were almost completely recoverable. The second 'hit' halted the NIMS processor.

The plots on the pages 3 and 4 show the geometry of the NIMS G1 observations using a north trajectory pole projection. The 'returned' observations are in Bold characters and the 'non-returned' in gray.

The spreadsheets on pages 5 and 6 summarize the 'final' playback model for the 'returned' data.

The text on page 7 give a 'recap' of the G1 playback events which affected which observations were returned.

A Timeline of G1 playback events is on pages 8 and 9.

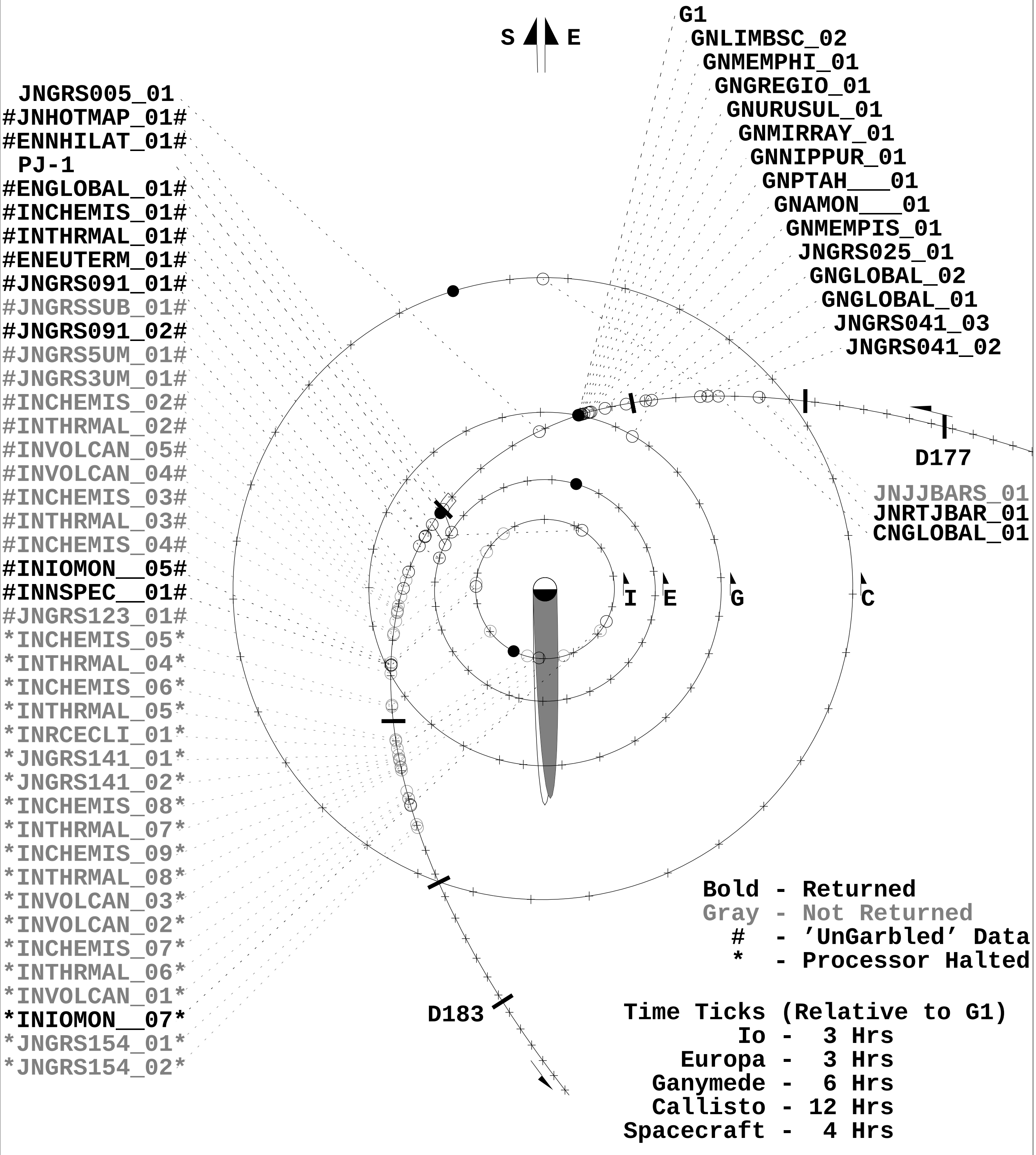
The text on pages 10 to 12 describe the G1 NIMS Anomaly in which the NIMS data were returned in a 'garbled' state.

The text on page 13 gives a description of the NIMS 'ungarbling' model.

The text on pages 14 gives a brief discussion of the NIMS data files. Additional information about NIMS data formats, data types, data labels and data access is given on pages 15 and 16.

The text on page 17 is a guide to understanding the NIMS MASK.

NIMS G1 OBSERVATIONS



Ganymede Flyby (G1): 27-JUN-1996 (D179) 06:29:05 UTC
Perijove (PJ1): 28-JUN-1996 (D180) 00:31:24 UTC

G1 North Trajectory Pole View

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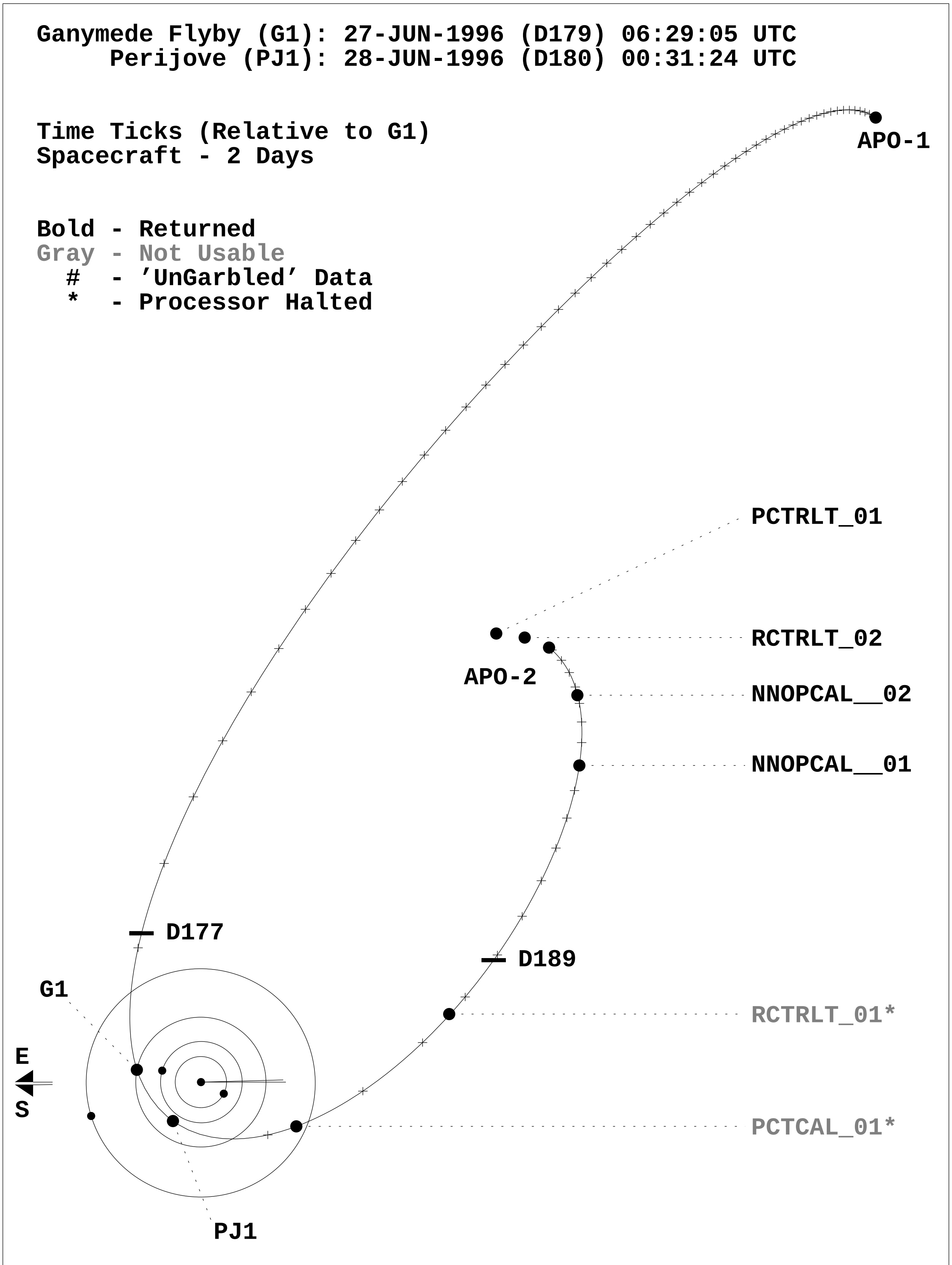
NIMS G1 CALIBRATIONS



G1 North Trajectory Pole View, Apoapsis to Apoapsis

NIMS - FEL - 02/12/98

NIMS G1 DATA RETURN

August 30, 1996

Activity ID	Observation Title	Mode	Gain	Record Format	NIMS Edit Table	NIMS PB Table	Extra Det	Grating Start	Grating Offset
G1JNRTJBAR01-	R/T Jupiter Jail Bars	LM	2	R/T	G1JFE408			0	4
G1CNGLOBAL01-	Callisto Global Composition Map	LM	4	LPU	G1CLM245	G1CLM228	11,12	0	4
G1JNGRS04102-	GRS 41 Phase #2	SM	2	LPU	G1JFT68C	G1JFT23A		1	4
G1JNGRS04103-	GRS 41 Phase #3	SM	2	LPU	G1JFT68C	G1JFT23A		1	4
G1GNGLOBAL01-	GANYMEDE GLOBAL SURFACE MAP, part 1	LM	2	LPU	G1GLM245D	G1GLM228D	5,6	0	4
G1GNGLOBAL02-	GANYMEDE GLOBAL SURFACE MAP, part 2				G1GLM245D	G1GLM228D			
G1JNGRS02501-	GRS 25 Phase #1	SM	2	LPU	G1JFT68A	G1JFT19C		1	4
G1GNMEMPIS01-	Memphis Facula Furrows/Palimpsest	LM	3	LPU	G1GLM245F	G1GLM228F	13,14	0	4
G1GNAMON__01-	AMON Bright rayed crater/groove terrain	LM	2	LPU	G1GLM245E	G1GLM228E	3,4	0	4
G1GNPTAH 01-	RAYED CRATER PTAH	LM	2	LPU	G1GLM245C	G1GLM228C	6,7	0	4
G1GNNIPPUR01-	NIPPUR SULCUS (furrows/dark/groove)	LM	3	LPU	G1GLM245B	G1GLM228B	7,8	0	4
G1GNMIRRAY01-	Mir a dark rayed crater	LM	3	LPU	G1GLM245A	G1GLM228A	11,12	0	4
G1GNURUSUL01*	NIMS ride with SSI on Urus sulcus	SM	3	IM4	G1GSM119	G1GSM102		0	4
G1GNGREGIO01*	NIMS ride with SSI on Galileo Regio	SM	3	IM4	G1GSM119	G1GSM102		0	4
G1GNMEMPHI01*	NIMS ride with SSI on Memphis	SM	3	HIS	G1GSM119	G1GSM102		0	4
G1GNLIMBSC02*	Limb Scan for atmosphere	XS	4	MPW	G1GXS17	G1GXS17		1	4
G1JNGRS00501-	GRS 5 Phase #1	SM	2	LPU	G1JFT68A	G1JFT19C		1	4
G1JNHOTMAP01-	HOTMAP	LM	2	LPU	G1JHT238A	G1JHT238A		0	4
G1ENNHILAT01-	EUROPA NORTH HIGH LATITUDE COVERAGE	LM	2,3	LPU	G1ELM245	G1ELM228	6,7	0	4
G1ENGLOBAL01*	Europa coordinated science NIMS/SSI	XM	2	HCA	G1EXM17	G1EXM17		0	4
G1INCHEMIS01-	MONITORING OF IO'S DAYSIDE	LM	2	LPU	G1ILM245	G1ILM228	9,10	0	4
G1INTHRMAL01-	MONITORING OF IO'S NIGHTSIDE	XM	2	LPU	G1IXM10	G1IXM10		21	4
G1ENEUTERM01*	Europa Terminator SSI ride-along	XM	2	IM4	G1EXM10	G1EXM10		21	4
G1JNGRS09101-	GRS 91 Phase #1	SM	2	LPU	G1JFT68A	G1JFT68A		1	4
G1JNGRS09102-	GRS 91 Phase #2	SM	2	LPU	G1JFT68A	G1JFT68A		1	4
G1INIOMON_05-	R/T Io Monitoring	XM	2	R/T	G1IXM8RT			21	4
G1INNSPEC 01-	NIGHTSIDE SPECTRA AT HIGH RESOLUTION	LM	4	MPW	G1ILM442	G1ILM408		0	4
G1NNNOPCAL01	R/T Opcal 01	LM	4	R/T	G1OPCAL48			0	4
G1NNNOPCAL02	R/T Opcal 02	LM	4	R/T	G1OPCAL48			0	4
G1NNRCTRLT02	R/T RCT Calibration	LM	1	R/T	G1RCT252			0	4
G1NNPCTRLT01	R/T PCT Calibration	LM	4	R/T	G1PCT252			0	4

NIMS G1 DATA RETURN

August 30, 1996

Activity ID	Obs. Cost Tracks	Obs. Cost Ticks	Number Wavelengths Returned	Observation Record Time (sec)	Observation Playback Time (sec)	Bits of Tape BOT (Mbit)	Selected Bits on Tape (sBOT, Mbit)	Mode cycle time (sec)	Comp	Total BTG Mbits (4% ohead)	Data Reduct Factor (SBOT/BTG)
G1JNRTJBAR01-			408								
G1CNGLOBAL01-	0.0030	21	228	82	80	0.51	0.49	8.667	3	0.146	3.38
G1JNGRS04102-	0.0221	154	23	650	648	4.01	4.00	2.33	1.95	0.682	5.86
G1JNGRS04103-	0.0122	85	23	354	352	2.18	2.17	2.33	1.95	0.371	5.86
G1GNGLOBAL01-	0.0513	358	228	1518	1518	9.36	9.36	8.667	2.17	3.828	2.45
G1GNGLOBAL02-			228	732	732	4.52	4.52	8.667	2.02	1.983	2.28
G1JNGRS02501-	0.0225	157	19	660	660	4.07	4.07	2.33	2	0.560	7.27
G1GNMEMPIS01-	0.0166	116	228	485	485	2.99	2.99	8.667	1.78	1.491	2.01
G1GNAMON__01-	0.0102	71	228	296	294	1.83	1.81	8.667	2.03	0.792	2.29
G1GNPTAH__01-	0.0082	57	228	235	233	1.45	1.44	8.667	1.87	0.682	2.11
G1GNNIPPUR01-	0.0227	158	228	667	665	4.11	4.10	8.667	1.73	2.103	1.95
G1GNMIRRAY01-	0.0183	127	228	535	533	3.30	3.29	8.667	1.78	1.638	2.01
G1GNURUSUL01*			102	33	33	0.38	0.38	2.33	1.71	0.176	2.16
G1GNGREGIO01*			102	36	34	0.41	0.39	2.33	1.68	0.184	2.13
G1GNMEMPHI01*			102	45	45	0.52	0.52	2.33	1.61	0.255	2.04
G1GNLIMBSC02*			17	181	181	2.09	2.09	0.1667	1.99	1.929	1.08
G1JNGRS00501-	0.0238	166	19	700	700	4.32	4.32	2.33	2	0.594	7.27
G1JNHOTMAP01-	0.0887	619	238	2633	2621	16.24	16.17	8.667	0.97	15.434	1.05
G1ENNHILAT01-	0.0610	426	228	1808	1205	11.15	7.43	8.667	0.97	6.797	1.09
G1ENGLOBAL01*			17	26	26	0.30	0.30	0.361	0.97	0.263	1.14
G1INCHEMIS01-	0.0023	16	228	60	60	0.37	0.37	8.667	0.97	0.338	1.09
G1INTHRMAL01-	0.0005	4	10	7	7	0.04	0.04	0.361	0.97	0.042	1.04
G1ENEUTERM01*			10	9	8	0.10	0.09	0.361	0.97	0.048	1.94
G1JNGRS09101-	0.0110	77	68	318	318	1.96	1.96	2.33	0.97	1.990	0.99
G1JNGRS09102-	0.0243	170	68	716	150	4.42	0.93	2.33	0.97	0.939	0.99
G1INIOMON_05-			8								
G1INNSPEC_01-	0.0204	142	408	159	159	1.83	1.83	8.667	0.97	1.605	1.14
G1NNNOPCAL01-			48							44.869	
G1NNNOPCAL02-			48								
G1NNRCTRLT02			252								
G1NNPCTRLT01			252								

Recap of G1 Playback Events

NIMS data playback during G1 was affected by a number of significant events, some of which occurred on board the spacecraft, and some of which occurred on Earth. There were at least four of these events that occurred on board the spacecraft:

1) Partway through the record sequence a radiation hit to the NIMS RAM altered its processing so that the resulting data were 'scrambled.'

2) Somewhat later in the sequence, additional radiation apparently caused the instrument software to stop working entirely. No permanent damage was incurred and a later reload of the instrument software brought things back to normal.

3) Partway through playback, through an unanticipated CDS software 'feature', one observation was played back using an incorrect wavelength selection.

4) Near the end of the playback process, the spacecraft went into 'safe' mode, and it was not possible to recover in time to complete playback of the remaining useful NIMS observations left on the tape.

Events on the ground that significantly affected NIMS G1 playback derived from the immaturity of the CDS software in connection with NIMS playback. In the weeks just prior to initiation of NIMS data return, there was concern that playback of NIMS observations in MPW mode might cause CDS software to crash, with the potential loss of data return from all instruments. Therefore it was decided to make two passes over the tape. In the first tape pass, no NIMS data were to be selected. In the second pass, NIMS data were selected, along with small amounts of data from other instruments.

After NIMS data return was well along, it was determined that MPW mode playback could cause no problems, but LPU mode could potentially cause CDS to crash. Although about a dozen LPU mode observations had been returned by that time, the project decided to not permit any additional NIMS LPU playback. Nine NIMS observations were affected, from JNGRS5UM01 to INCHEMIS04.

<u>G1 Playback Events Timeline</u> (06-19-96 to 08-25-96)

Wed 06-19: First playback update cycle begins. NIMS downlink allocation is 47 Mbits.

Thu 06-20: NIMS allocation increases by 10.2 Mbits due to successful JOCD (Galileo Probe data) playback.

Sun 06-23: G1 Encounter starts.

Wed 06-26: Playback table update. All recorded wavelengths are planned to be returned for almost all observations. Total Mbtg is 56.5 and allocation is 58.0.

Thu 06-27: DMS (Tape Recorder) constraints force changes to 18 of 55 observations; deselect times moved onto valid data (loss of 3 minor frames per observation).

Fri 06-28: Perijove. The NIMS HOTMAP observation is truncated about 10 minutes early by commands from the ground to avoid possible DMS problem. The first NIMS instrument anomaly begins scrambling data written to the tape recorder (but this is not known until much later). The second NIMS instrument anomaly results in stoppage of the instrument (but this is not known until later).

Mon 07-01: Problems with CDS software 'Playback Manager' cause the project to decide to NOT play back any NIMS data during July; a separate NIMS tape playback pass is approved. Early image return (pass 1) begins with 9 SSI images selected for playback.

Mon 07-08: Non-NIMS playback begins after termination of early image return.

Tue 07-16: NIMS anomaly investigation determines that observations after G1JNGRS12301 are not recoverable. NIMS has excess playback capability and donates 2 Mbits to SSI.

Wed 07-17: Playback Table update: Observations after GRS12301 deleted; G1INNNSPEC retained to help diagnose the first NIMS instrument anomaly.

Thu 07-25: Delivered NIMS playback table includes G1JNJJBARS which was recorded in MPW mode.

Sun 07-28: Anticipation of possible problems with CDS software MPW playback force deletion of JJBARS from playback table while software patch is tested.

Thu 08-01: NIMS data playback begins.

Wed 08-07: Playback Table update. CHEMIS05 (Io) observation added back for anomaly diagnosis purposes and to use downlink bits since total allocation of about 55 Mbits has not changed.

<u>G1 Playback Events Timeline</u> (06-19-96 to 08-25-96)

Fri 08-09: First NIMS instrument anomaly causes problems with playback. Data compression for the bit-shifted 'scrambled' data reverts to backup mode beginning with the large G1JNHOTMAP observation. Estimated compression was 2.0, actual compression becomes 0.97. An 'emergency' playback table update is required to employ the next available uplink window. Remaining NIMS observations must be cut by more than 60%. Three large atmospheres observations are deleted (GRSSUB01, GRS5UM01, GRS3UM01). Wavelengths returned for GRS09102 are reduced from 68 to 4. The G1ENNHILAT01 observation is cut by 33%, and one Io observation (CHEMIS05) is deleted. A cushion of 5 Mbits (to enable later playback of JJBARS) is requested. Delivered table includes 16.2 Mbits.

Wed 08-14: Playback Table updated. Fourth pass through tape to recover JJBARS is approved. Available allocation allows reinstatement of some atmospheres bits (5 micron map 80 wavelengths).

Fri 08-16: A potential CDS software problem with LPU mode playback is found. As a result, project declared that LPU was unsafe to use for playback.

Mon 08-19: New playback table required immediately with no LPU mode observations included. The new table however includes 7 newly-generated observations (playback of data recorded automatically during SSI image capture, i.e. SSI ride-along).

Wed 08-21: Playback is terminated by commands from the ground when it is discovered that the new, updated table has not been correctly loaded, and an old one is being executed. As a result part of GRS09102 comes down with 68 wavelengths instead of the specified 4.

Thu 08-22: Playback is initiated with correct table in memory. The Io NNSPEC observation at 408 wavelengths is returned but late-addition SSI ride-alongs do not play back as expected.

Thu 08-25: Spacecraft goes into SAFE mode before initiation of playback of JJBARS. Diagnosis and recovery take time and no additional G1 data playback is possible. Spacecraft safing is later determined to be caused by the presence of too many delayed-action commands (DACs) in the buffer.

NIMS Anomaly Report - G1 Sequence

Facts:

0. NIMS realtime provided flawless data of G1RTJBAR01 at SCLK 3496232. Perijove occurred at about SCLK 3498679 - a possible highest radiation event. We will have no information on data quality between SCLK 3496232 and SCLK 3499671 (IOMON05) until NIMS playback is started.

1. An anomaly was detected in realtime data for IOMON05 on Friday, June 28 at about 11am. IOMON05 started execution at SCLK 3499671:84. Data from this observation appear semi-systematic and may be recoverable in full or in part.

2. An anomaly was found the the realtime data for IOMON07 on Saturday, June 29 at about 10am. IOMON07 started execution at 3500756:84. This data does not appear recoverable.

3. Engineering channel S-1931 appeared normal on 8am Saturday morning (2 sequential values the same, which was normal). S-1932 also looked normal on Saturday morning, since the value had changed from Friday morning (Workstation software problems prevented seeing the history of values between Friday and Saturday - which would have shown a possible problem in channel S-1932). S-1932 had a repeating value of 13 on

SCLK 3499905:43 SCET 180T21:10:21 ERT 180T21:48:50
SCLK 3499938:40 SCET 180T21:43:41 ERT 180T22:21:51

(the next update was received 9 hours later). It is probable that the instrument program stopped running sometime after SCLK 3499738 (which was reported through the instrument at SCLK 3499740:58). (S-1931 and S-1932 are watchdog timers which report the last two bytes of the s/c RIM).

4. Observations after CPU stoppage and which are presumably lost include:

G1INCHEMIS05
G1INTHRMAL05
G1INRCECLIO01
G1JNGRS14101
G1JNGRS14102
G1INCHEMIS08
G1INTHRMAL07
G1INVOLCAN03
G1INVOLCAN02
G1INCHEMIS07
G1INTHRMAL06
G1INVOLCAN01
G1INIOMON_07
G1JNGRS15401
G1JNGRS15402
G1NNPCTCAL01
G1NNRCTRLT01

10 Io observations, 4 Jupiter GRS observations, 1 PCT calibration, 1 RCT calibration.

5. A memory readout of the entire instrument RAM was radiated on Day 185/04:37 and executed successfully. Miscompares occurred at locations

1036 STACK POINTER MAINTENANCE
103A STACK POINTER MAINTENANCE
114C DARK CYCLE PROGRAM COUNTER
140F 3RD MIRROR POSITION JUMBLE
1430 3RD MIRROR POSITION JUMBLE
1432 3RD MIRROR POSITION JUMBLE
1440 3RD MIRROR POSITION JUMBLE
15B6-BD FORMATTER RESET

(STACK IS LOCATED AT 15FF)

The final cause of failure is almost certainly stack underflow, which clobbered 15B6-BD.

None of the above locations are near a known danger area for READ-DISTURB problems of the TCC244 chip. The variable storage area, 14C0-1597 and 15BE-15FF, COULD have had read-disturb problems, but it is not simple to know what values should be there.

6. No unusual thermal events were seen.

Observations:

1. A non-fatal instrument software error occurred at least 200 rims before the watchdog timer failed. Since stack errors are nearly always immediately fatal, then a less serious software modification must have occured first. This could be interpretted as either two events or a single event which eventually lead to failure.

2. The instrument has been operating since day 122 with no failures - including during the IFL. It was reloaded on day 145 as a part of the IFL sequence. Realtime data received from the first Jupiter observation, G1JNRTJBAR01 (3496232) was flawless. This could be interpretted as 58 or more days of operation with no failure.

3. It is difficult to reconstruct the events and data with realtime data alone, because of the paucity of timing information contained in the realtime data.

4. Possible sources of program failure include Read/disturb, SEU (single event upset), CDS writing on NIMS, spare interrupts, critical instrument timing, or software error.

The read/disturb locations are not near the RAM program locations which changed. However, the variable area could contain suspect locations.

SEUs are not a common event on this spacecraft. If two events are required to explain the instrument behavior, there is a decreased probability that an SEU alone explains the problem.

CDS writing to NIMS is technically possible - but is regarded as unlikely.

No spare interrupts were detected by other subsystems.

The instrument timing is critically dependent on the phase lock to 63 hz, and can be temperature sensitive. No extraordinary temperature excursions were noted. In general, the phase II software has significant timing margin.

Software error is always a possibility. However, this software has been executed frequently for more than a year, and no errors have been detected. It also executed for around 60 days in flight with no errors. There is a residual possibility that the level of commanding and activity in the flight sequence caused the problem, since this particular string of sequence events has not been tested with the instrument on the ground. The sequence has been re-examined for commanding errors, none has been found.

The most straightforward, and least testable hypothesis is that an SEU occurred.

Testing:

1. Reload the instrument, perform weekly checksums
2. Perform an opcal prior to and after the RCT cal (which is scheduled for early August).
3. Checksum before G2
4. Run the NIMS G1 commanding sequence on the testbed with the engineering model.

Error avoidance for G2:

Reload NIMS software frequently during G2 encounter (dangerous unless loaded from CDS). If done once, could better protect the PCT and Io observations, which, once again, are at the end of the sequence.

Pre-approve memory readouts and memory loads during the active period.

Institute 24 hour monitoring of watchdog timer

Add checksums to sequence, since watchdog parameters have variable frequency and are not a reliable check for data corruption.

Add short realtime observations to sequence to monitor data quality. This can be small enough to have unmeasurable impact on MUB loading, but would have significant (CA 2-300 byte total over encounter) impact on CDS bytes.

G1 recovery.

It is important to recover the photometric calibration. The various trials and tribulations of the s/c have prevented any form of this calibration since Gaspra. G1 and G1 cruise have a nearly unique opportunity, since the off-sun angle is less than 5 degrees (it is above 8 after otm 9 and for G2). The observation requires that the spacecraft be placed in all-spin.

NIMS Ungarbling Process

At least two NIMS anomalies occurred during the G1 encounter. Beginning with the G1JNHOTMAP01 observation, near Galileo's closest approach to Jupiter, NIMS data appeared 'garbled', though in a systematic way which gave hopes of recovery. Sometime after the G1INNSPEC01 observation, the data were still garbled, but no longer in a systematic way. Subsequent analysis concluded that the phase 2 NIMS RAM software had halted at that point, presumably due to radiation, but that CDS was still picking up garbage out of the NIMS buffer. (A later reload of the RAM software restored functionality.)

The data acquired between the first and second anomalies was mostly reconstructed, based on an analysis of the RAM processing and the systematic appearance of the data. It was concluded that radiation most likely altered a variable in the RAM so that the formatter (*) lost synch with the code. An algorithm was developed involving bit shifts and byte order re-arrangements, based on the assumption that the formatter was one step ahead of the code (in a cycle of 4 steps, one for each mirror position in an RTI). Since the 'ungarbled' data appeared plausible to NIMS scientists (especially off-limb data which could be assumed to be dark) and since there was a reasonable scenario for the behavior of the RAM software, the NIMS team feels justified in distributing the ungarbled data with a high probability that it is correct.

The description above assumes that all wavelengths were selected, as in the G1INNSPEC01 observation. In such cases, the original data could be completely reconstructed, except for a couple of bits at one end of the observation. But when wavelength editing in the instrument was selected, as in G1JNHOTMAP01 and most of the other garbled observations, this was not entirely true. Due to the interaction of the garbling mechanism and the wavelength editing code, and depending on the edit pattern selected, data from some wavelengths lost two bits of significance, and data from some others were entirely lost.

(*) See the NIMS instrument paper and VOLINFO.TXT on the EDR CD-ROM for background to this discussion, and for further details of the algorithm and limitations on the accuracy of some of the ungarbled data.

NIMS Archived EDRs and CUBEs

The NIMS data are stored in EDRs (Experimental Data Records) produced by JPL-MIPS (Multi-mission Image Processing System). The NIMS Phase2 EDR is described in the NIMS EDR SIS (Software Interface Specification) Number 232-08. The same information is available in both human and machine-readable form in the PDS (Planetary Data System) structure files EDRHDR.FMT and EDRDATA.FMT in the LABEL directory of the NIMS EDR CD-ROM. Each observation has at least one EDR. The EDR file name is derived from the 12 character observation name plus a single character which allows an observation to be broken up into multiple EDRs. The EDRs have a Vicar label, followed by a PDS/ISIS label, binary header records and the data records. For archiving on CD-ROM, the Vicar labels are detached from the EDR (but kept separately on CD) and the file is renamed so as to conform to the 8.3 DOS file-naming convention. The 8.3 EDR name consists of a 2 character orbit identifier, a single character target identifier, a 3 digit counter and the suffix EDR. For example, the MIPS EDR G1GNGLOBAL01A.1 becomes G1G001.EDR. More information about NIMS EDRs can be found in the VOLINFO.TXT file on the EDR CD-ROM.

NIMS EDR data typically require considerable processing before they are readily amenable to science analysis. Normally, the EDRs are processed into spectral image cubes by one of several sets of software. MIPS systematically processes the EDRs into CUBEs (band sequential image files) and MASKs (spatial/spectral summary images) which are distributed on the NIMS CUBE CD-ROMs. Information about the structure of the NIMS CUBEs can be found in the VOLINFO.TXT file on the CUBE CD-ROM. The name of the CUBE file is derived from the input EDR filename. For archiving on CD-ROM, the CUBE files are renamed so as to conform to the 8.3 DOS file-naming convention. The 8.3 CUBE name consists of a 2 character orbit identifier, a single character target identifier, a 3 digit counter, a single character cube-type identifier, a single character data unit-type (DN, radiance or IOF) and the suffix QUB. For example, the MIPS IOF radiance cube for the observation G1GNGLOBAL01A.1 (G1G001) becomes G1G001CR.EDR. The summary MASKs on the CD-ROM have the same 6 character name as the EDR with the suffix JPG or GIF to denote its graphics format.

NIMS Data Format - Data types - Data Labels - Data Access

Data Format

All data files have PDS labels. The raw data (EDR) file contains time-sequential, 16 bit integers. Reduced data files (TUBES and CUBES) may be viewed as images or spectra. They contain VAX real numbers, are band sequential (BSQ - the images are stacked in band order) and have geometry information appended as backplanes after the last NIMS band.

Data Types

Mask files contain summary images (3 band BSQ) and spectra of up to six selected regions that provide a quick indication of data location, data quality and spectral content. A Guide to understanding the NIMS mask is available.

Cube files contain data that have been projected and resampled. The core data are BSQ - spatial in the first two dimensions, and spectral in the third. Cubes of the satellites are projected in point-of-view, and, with few exceptions have no photometric correction applied. Cubes of Jupiter are (generally) projected as simple cylindrical. Cubes of Europa, Ganymede, and Callisto have been despiked. The cubes are available both in radiance and I/F (intensity divided by flux) form.

Tube files contain data in (almost) time order and normally have a NIMS-related 20 pixel spatial dimension (20 x n or n x 20). Projection coordinates are contained in backplanes, but the data have not been resampled. The data are in units of radiance and no despiking has been applied. All data in cubes are also available in tube form. Some data (such as spatially undersampled data) appear in tube form only.

A spike file contains a list of pixels that have been identified as spikes, but not replaced, in the tube. Spike files can be used to remove spikes from both tube and EDR files.

EDR files contain the most primitive form of the data available. They should be used only for advanced data analysis. The format is complex and the files do not form images or spectra without prior processing.

NIMS Data Format - Data types - Data Labels - Data Access

Data Labels

A data label (PDS form) is attached to the front of each file (except masks, which have an attached VICAR label and a detached PDS label). The labels are in ASCII keyword=value format and contain pointers to various data objects in the file, descriptions of the data objects and descriptions of the observation associated with the file. A history object in similar format follows and describes the processing steps that produced the file. Much of this information is necessary for understanding and viewing the cube. In particular, the label contains the offset to the cube, the dimensions of the cube, axes labels, and explicit wavelength information.

Data Access

Software for processing this data is called ISIS and is available for DEC VAX VMS, SUN Solaris, DEC Alpha Digital Unix, Silicon Graphics Unix and PC LINUX systems. The Unix versions are available from the USGS Astrogeology team. Images from NIMS cubes and tubes can be viewed with any image display program which allows an offset from the beginning of the file to the selected image. Packages tested include ISIS, VICAR, ENVI, SAO IMAGE, and NASAVIEW. ISIS and ENVI (and soon NASAVIEW) additionally display spectra. The ISIS viewer is named CV (UNIX) or QL3 (VMS).

Labels may be displayed with some editors (eg DOS edit), and with most "type" and "search" functions. Some editors do not recognize the PDS line termination conventions. The label may be listed by the ISIS function LHLIST (VMS) or LABEL (UNIX).

Software for converting EDRs to cubes exist in both ISIS (DEC VAX VMS) and VICAR (DEC Alpha VMS) versions only. A primitive list of values in an EDR may be obtained with the program EDRDMP2.

Understanding the NIMS Mask

The NIMS mask is designed to provide a quick summary of the contents of a NIMS data cube (or tube). It displays a view of both the spatial and spectral content of the data.

The mask has four regions. Starting from the upper left and proceeding clockwise: a spatial display; six or fewer representative spectra; annotation; and a spectral histogram.

The spatial display of an observation which has been projected and resampled (a cube) has a maximum size of 600x600 pixels. This is overlaid with surface coordinates and is embedded in a 700x700 grid of pixel coordinates. It is accompanied by two 1-dimensional histograms describing the raw image and the image stretched for display. The data image can range from a simple combination of up to 3 NIMS bands displayed in the RGB planes, to complicated arithmetic functions of NIMS bands displayed in the RGB planes. (The formulas appear as annotation below the histograms.) The graphics directly below the image show the input and output data histograms for the three color planes. The "shortest" color for each bin displays in front. The image also contains from one to six numbered rectangles, which show the from which averaged spectra (displayed on the right) were taken.

The spatial display of an observation in time sequence (a tube) is a graphic showing a footprint of the observation over a grid of surface coordinates on the target body. Numerals 1-6 on the graphic mark the locations of the average spectra displayed on the right.

The spectra to the right of the image may display either BDRF or radiance (or both). If both are displayed, then a vertical "radiance fence" line will appear where the breakpoint occurs. This permits display of both atmospheric data, which have significant reflectance and thermal components, and I/F satellite surface data which have strong absorptions at longer wavelengths (such as water spectra.) The spectra are labelled with wavelength in microns and location in both pixel and latitude-longitude space.

The annotation provides information about the observation, including its name, a brief description, its geometry, instrument and projection parameters. TCA is the time from Galileo’s closest approach to the target body.

The 2-dimensional spectral histogram in the lower left corner shows the number of pixels at a given radiance for each wavelength. If a surface contains spatial mixtures with significantly different spatial fractions for several components, the spectra of the components will be evident in this display.