Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the C3 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the C3 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 C3 orbit was the second time that NIMS was able to reload its phase2 RAM software from CDS to restart NIMS after the processor had halted due to radiation hits. Five software reloads were inserted into the C3 command sequence to protect as many observations as possible. The processor halted twice during the C3 Encounter. The reloads did manage to save some observations, but the outbound observations were inadequately protected by reloads and were lost due to an untimely halt just after a reload. The software halts were detected by monitoring the SCLK values returned in the NIMS engineering telemetry.

In C3, five software reloads were inserted into the encounter timeline, but NIMS was still halted for almost 2 days (See the orbit plot on page 3 for the timing of the reloads). From this loss we learned that we need to insert many reloads into the encounter timeline to protect as many NIMS observations as possible.

Also, Detector 8 failed unexpectedly during C3. It has never recovered.

The plots on pages 3 and 4 show the geometry of the NIMS C3 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 NIMS C3 data return.

The text on page 7 gives a 'recap' of the C3 playback events which affected NIMS data return.

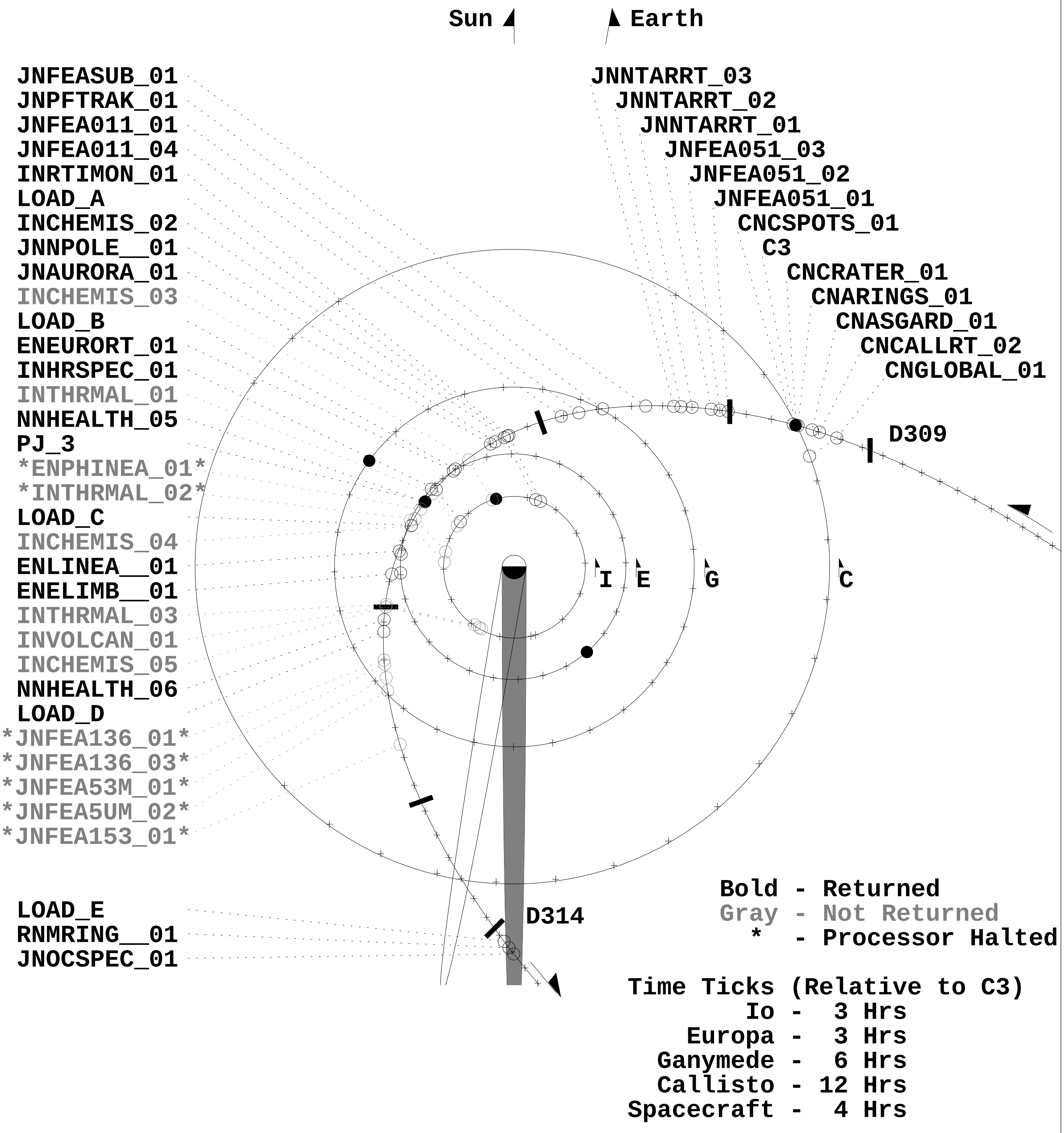
A Timeline of C3 playback events is on pages 7 and 8.

The text on pages 9 to 11 describes the C3 NIMS Anomalies, both Processor Halts and Detector 8 failure.

The text on pages 12 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 13 and 14.

The text on page 15 is a guide to understanding the NIMS MASK.

NIMS C3 OBSERVATIONS

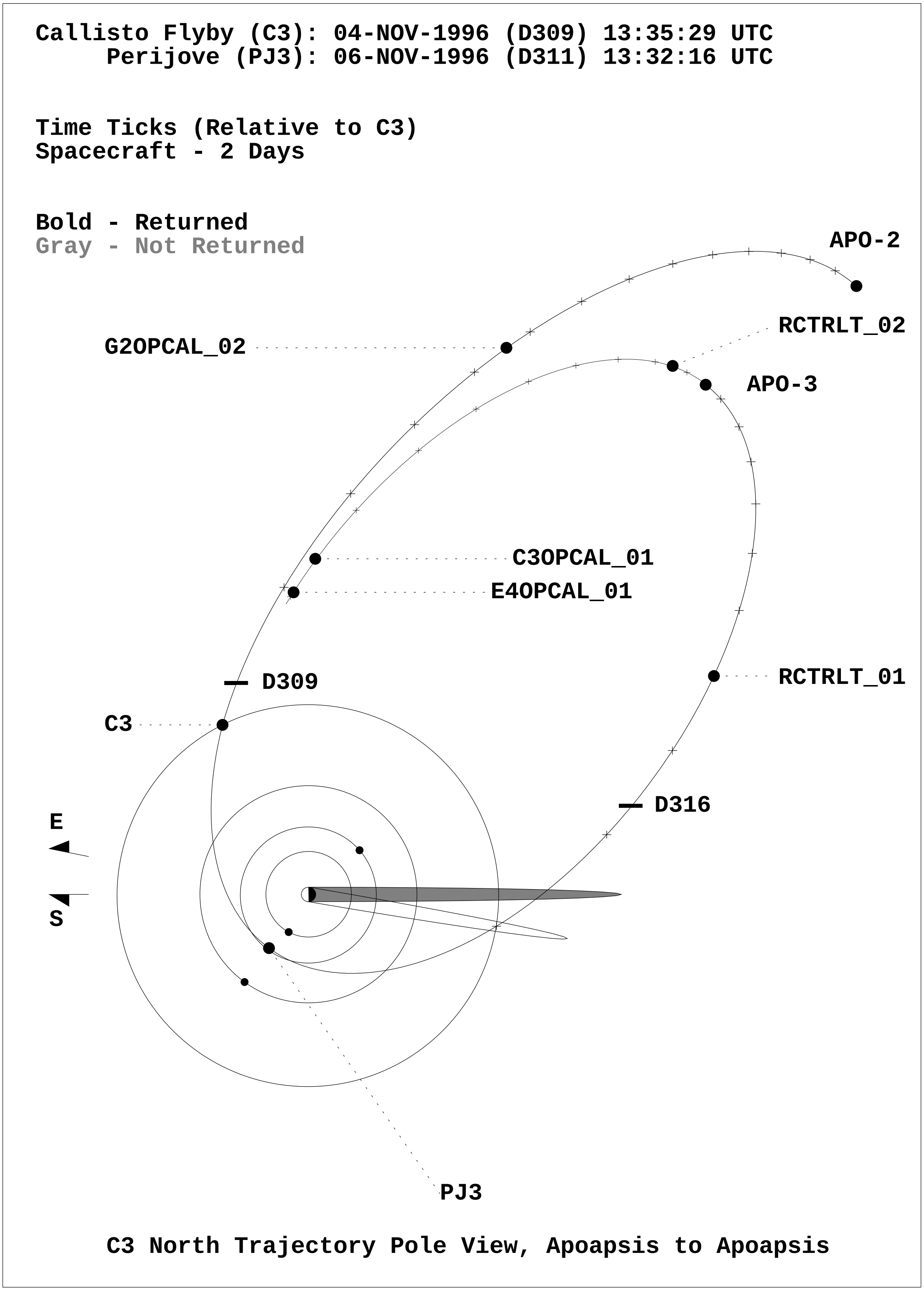


Callisto Flyby (C3): 04-NOV-1996 (D309) 13:35:29 UTC
Perijove (PJ3): 06-NOV-1996 (D311) 13:32:16 UTC

C3 North Trajectory Pole View

NIMS - FEL - 02/20/98

NIMS C3 CALIBRATIONS



C3 North Trajectory Pole View, Apoapsis to Apoapsis

NIMS C3 DATA RETURN

Activity ID	Observation Title	Mode	Gain	Record Format	NIMS Edit Table	NIMS PB Table	Grating Start	Grating Offset
C3CNGLOBAL01-	CALLISTO GLOBAL MOSAIC	LM	4	LPU	CLM245	CLM204	0	4
C3CNGLOBAL01-	CALLISTO GLOBAL MOSAIC	LM	4	LPU	CLM245	CLM204	0	4
C3CNGLOBAL01-	CALLISTO GLOBAL MOSAIC	LM	4	LPU	CLM245	CLM204	0	4
C3CNCALLRT02-	Callisto Real Time Obs.	LM	4	R/T	CLM408		0	4
C3CNASGARD01-	ASGARD BASIN COVERAGE	FM	4	LPU	CFM126	CFM102	0	4
C3CNARINGS01-	CALLISTO MULTI-RING STRUCTURE COVERAGE	LM	4	LPU	CLM245	CLM204	0	4
C3CNCRATER01-	BURR - CENTRAL PIT CRATER	SM	4	MPW	CSM119	CSM102	1	4
C3CNCSPOTS01-	CALLISTO BRIGHT SPOTS	FM	4	MPW	CFM221	CFM103	0	4
C3JNFEA05101-	JUPITER CAMPAIGN FEATURE 51 DEG PART 1	SM	2	LPU	JFT68C	JFT25A	1	4
C3JNFEA05102-	Jupiter Campaign Feature 53 dgrs. part 2	SM	2	LPU	JFT68C	JFT25A	1	4
C3JNFEA05103-	Jupiter Campaign Feature 53 dgrs. part 3	SM	2	LPU	JFT68C	JFT25A	1	4
C3JNNTARRT01+	Jupiter NIMS TAR Real Time Obs. No. 1	LM	2	R/T	JLM408		0	4
C3JNNTARRT02+	Jupiter NIMS TAR Real Time Obs. No. 2	LM	2	R/T	JLM408		0	4
C3JNNTARRT03+	Jupiter NIMS TAR Real Time Obs. No. 3	LM	2	R/T	JLM408		0	4
C3JNFEASUB01-	Jupiter Campaign Feature Sub-Spectra	LM	4	LPU	JSB253A	JSB215	0	4
C3JNPFTRAK01-	Jupiter Partial Feature Track part 1	SM	2	LPU	JFT68D	JFT26A	1	4
C3JNFEA01101-	Jupiter Campaign Feature 18 dgrs. part 1	SM	2	LPU	JFT68C	JFT25A	1	4
C3JNFEA01104-	Jupiter Campaign Feature 18 dgrs. part 4	SM	2	LPU	JFT68C	JFT25A	1	4
C3INRTIMON01-	Io Real Time Monitoring	XM	2	R/T	IXM8RT		21	4
C3INCHEMIS02-	MONITORING OF IO'S DAYSIDE	LM	2	LPU	ILM245	ILM102	0	4
C3JNNPOLE 01-	Jupiter North Pole Map #1	SM	2	LPU	JFT68D	JFT26A	1	4
C3JNAURORA01-	Jupiter Aurora	LM	2	LPU	JAU253A	JAU80A	0	4
C3ENEURORT01-	Europa Real Time Observation	LM	2	R/T	ELM408		0	4
C3INHRSPEC01-	HIGH SPATIAL & SPECTRAL OBS. OF IO	LM	2	MPW	ILM442	ILM408	0	4
C3INHRSPEC01-	HIGH SPATIAL & SPECTRAL OBS. OF IO	LM	2	MPW	ILM442	ILM408	0	4
C3NNHEALTH05-	NIMS Real Time Health Obs No. 5	LM	2	R/T	RT003		0	4
C3ENLINEA 01-	EUROPA LINEA REGION	LM	2	LPU	ELM245	ELM204	0	4
C3ENELIMB 01-	EUROPA OCCULTATION	FM	2	LPU	EFM126	EFM102	0	4
C3NNHEALTH06-	NIMS Real Time Health Obs No. 6	LM	2	R/T	RT003		0	4
C3RNMRING 01-	MAIN RING OBSERVATION	FM	4	LPU	C3RFM126	C3RFM102	0	4
C3RNMRING 01-	MAIN RING OBSERVATION	FM	4	LPU	C3RFM126	C3RFM96	0	4
C3JNOCSPEC01-	Jupiter Occultation Spectrum	LM	4	LPU	J35160	J35160	0	4
C3NNRCTRLT01-	RCT Calibration No. 1	LM	1	R/T	RCT252		0	4
C3NNRCTRLT02-	RCT Calibration No. 2	LM	1	R/T	RCT252		0	4
C3NNNOPCAL01-	OPCAL No. 1	LM	4	R/T	OPCAL48		0	4

NIMS C3 DATA RETURN

ACTID	Obs Cost Tics	Wave-lengths ret	Record Time (sec)	PB Time (sec)	Total Bits of Tape BOT (Mbits)	Sel Bits of Tape (SBOT)	Mode cycle time (sec)	Thold	Comp	Total BTG Mbits (4% ohead)	Data Reduct Factor (SBOT/BTG)	Pass
C3CNGLOBAL01-	528.1656	204	2249	736	13.87	4.54	8.667	2	1.75	2.059	2.20	1
C3CNGLOBAL01-	528.1656	204	2249	625	13.87	3.86	8.667	2	2.07	1.478	2.61	2
C3CNGLOBAL01-	528.1656	204	2249	647	13.87	3.99	8.667	2	1.91	1.658	2.41	2
C3CNCALLRT01-		408										
C3CNASGARD01-	414.4816	102	1764	1123	10.88	6.93	4.333	2	1.58	3.480	1.99	1
C3CNARINGS01-	157.3448	204	667	663	4.11	4.09	8.667	2	1.58	2.055	1.99	1
C3CNCRATER01-	194.6002	102	218	217	2.52	2.51	2.330	2	1.48	1.335	1.88	1
C3CNCSPOTS01-	324.6774	103	366	121	4.23	1.40	4.333	0	2.02	0.296	4.72	2
C3JNFEA05101-	26.0808	25	107	105	0.66	0.65	2.330	0	2.26	0.104	6.25	1
C3JNFEA05102-	26.0808	25	107	105	0.66	0.65	2.330	0	1.94	0.121	5.36	1
C3JNFEA05103-	26.0808	25	107	105	0.66	0.65	2.330	0	2.31	0.101	6.38	1
C3JNNTARRT01+		408										
C3JNNTARRT02+		408										
C3JNNTARRT03+		408										
C3JNFEASUB01-	82.8056	215	349	339	2.15	2.09	8.667	0	2.07	0.844	2.47	1
C3JNPFTRAK01-	99.2136	26	419	409	2.58	2.52	2.330	0	1.84	0.516	4.89	1
C3JNFEA01101-	207.0376	25	879	399	5.42	2.46	2.330	0	1.92	0.464	5.31	1
C3JNFEA01104-	97.5728	25	412	402	2.54	2.48	2.330	0	1.53	0.586	4.23	2
C3INRTIMON01-		8										
C3INCHEMIS02-	59.6000	102	250	239	1.54	1.47	8.667	2	1.21	0.484	3.05	2
C3JNNPOLE 01-	245.9480	26	1045	975	6.45	6.01	2.330	0	1.30	1.741	3.45	1
C3JNAURORA01-	707.9504	80	3016	2824	18.60	17.42	8.667	0	1.08	5.020	3.47	2
C3ENEURORT01-		408										
C3INHRSPEC01-	836.1972	408	948	444	10.96	5.13	8.667	2	1.39	3.128	1.64	1
C3INHRSPEC01-	836.1972	408	948	503	10.96	5.81	8.667	2	1.26	3.909	1.49	2
C3NNHEALTH05-		3										
C3ENLINEA01-	760.9248	204	3242	278	20.00	1.71	8.667	0	1.35	1.008	1.70	1
C3ENELIMB01-	222.9768	102	947	564	5.84	3.48	4.333	0	1.26	2.192	1.59	1
C3NNHEALTH06-		3										
C3RNMRING01-	152.4224	102	646	182	3.98	1.12	4.333	0	2.07	0.431	2.61	1
C3RNMRING01-	152.4224	96	646	360	3.98	2.22	4.333	0,2	2.70	0.614	3.61	2
C3JNOCSPEC01-	87.9624	160	371	300	2.29	1.85	8.667	0	1.60	0.720	2.57	1
C3NNRCTRLT01-		252										
C3NNRCTRLT02-		253										
C3NNNOPCAL01-		48										
Total				Alloc.			Allocation	**>**	33.414	34.344	< Model	

J. Shirley

7/5/04

Recap of C3 Playback Events

Considerably more NIMS data were recorded to tape during C3 than could be returned to Earth within the downlink bit allocation of about 34 Megabits. In particular, only 9% of the Europa C3ENLINEA01 observation could be played back, and of 9 recorded Io observations, only 2 could be returned. Since Callisto was the primary target for C3, Europa received limited playback resources. For Io, when actual compression estimates derived from G2 experience were entered into the models, predicted downlink requirements exceeded the available amount by more than 10 Mb. As a result only C3INHRSPEC01 and C3INCHEMIS02 could be returned.

Radiation "hits" resulted in two NIMS processor halts in C3, the first occurring shortly after Jupiter closest approach on D311, and the second occurring just after the SCITURN on D312. The first halt caused the loss of the two observations C3ENPHINEA01 and C3INTHRMAL02. The subsequent software reload restarted NIMS, saving the 7 ensuing observations. The second halt caused the loss of the 5 NIMS outbound high-phase-angle Jupiter observations. NIMS remained halted until the fifth reload on D314 just before solar occultation, which restarted NIMS and saved the last two observations.

C3 was the first orbit in which multiple passes over the tape were planned as a routine playback strategy. Playback of several observations was split between passes in order to reduce playback inefficiency and the generation of downlink fill packets. As one result, 3 Rims of the Rings observation C3RNMRING01 were specified for pass 1 playback to obtain information on compression performance, with the balance coming down in pass 2.

The entire C3 playback period occupied only about 5 weeks. Near the end of playback, in early December, the Project took extraordinary measures to ensure the return of an SSI "Wedges" observation, including the appropriation of 0.4 Mb of NIMS downlink allocation. This action, coupled with uncertainties in compression performance for the later NIMS observations, eliminated the return of the planned pass 2 portion of C3ENLINEA01.

C3 Playback Events Timeline (10-30-96 to 12-15-96)

10-30-96: Use of newly available Io compression values results in deletion of 8 of 9 Io observations from the playback plan due to insufficient downlink allocation.

11-02-96: C3 encounter begins.

11-06-96: First radiation hit halts NIMS instrument near perijove.

11-07-96: Second radiation hit halts NIMS instrument before recording of Jupiter high-phase observations begins.

<u>C3 Playback Events Timeline</u> (10-30-96 to 12-15-96)

11-09-96: NIMS fifth software reload resets instrument for observations C3RNMRING01, C3JNOCSPEC01, which are recorded as planned.

11-11-96: Playback initiated.

11-12-96: First playback table update. The downlink bits that were allocated to the lost observations are re-allocated. The 3.4 Mb representing the Jupiter high-phase observations go to increase wavelength coverage for C3FEASUB01 from 80 to 215 wavelengths and C3JNAURORA01 from 65 to 130 wavelengths.

11-20-96: Second playback table update. High-resolution Callisto observations compressed at 1.6, significantly lower than predicted (2.1). This consumes 2 Mb more than planned, forcing cuts in later playback of C3CNGLOBAL01. Pass 2 portions of C3CNASGARD01, C3CNCSPOTS01 are deleted from plan. A contribution to SWG from AWG (atmospheres) enables reinstatement of C3INCHEMIS02.

11-26-96: Playback performance dictates reduction in C3JNAURORA01 wavelengths from 130 to 90, and permits reinstatement of C3CNCSPOTS01.

12-02-96: Very poor SSI Io compression puts playback 36 hours behind schedule.

12-03-96: Project appropriates .4 Mb from NIMS to give to SSI. Pass 2 begins. C3JNAURORA01 wavelengths cut from 90 to 80. Wavelengths increased from 50-103 for C3CNCSPOTS01, at corresponding cost in reduced spatial coverage. Two thirds of pass 2 Rings observation thresholded to save bits.

12-05-96: Playback continues to run behind schedule. Plans to terminate playback of C3INHRSPEC01 early are suggested but not implemented (again, in order to safeguard SSI Wedges observation).

12-06-96: Project decides to eliminate remaining pass 2 part of C3ENLINEA01 to ensure return of Wedges. This would amount to 0.8 Mb.

12-08-96: C3JNAURORA01 compresses very poorly (1.07) due to high noise level during recording. This requires 1.5 Mb more downlink bits than planned, putting playback behind schedule.

12-15-96: C3 playback ends. All planned SSI and NIMS data are returned successfully before playback terminates.

<u>NIMS Anomaly Report - C3 Sequence</u>

Two types of anomalies occurred during the C3 Encounter: The NIMS processor halted twice and NIMS detector 8 failed. The processor Halts were recoverable, but the detector 8 failure turned out to be permanent.

<u>Processor Halts</u>

<u>Facts:</u>

0. Between the start of the C3 Encounter and the first Halt NIMS returned 7 realtime observations and successfully reloaded from CDS twice. The NIMS SCLK engineering channels were continuously monitored for detecting a processor halt.

1. A processor halt was detected at SCLK 03686026 from the analysis of the NIMS SCLK engineering telemetry channels S-1931 and S-1932. This occurred about six minutes after C3 perijove. A third reload occurred about 2 hours and 20 minutes later. Two more 'good' SCLK values were received, followed by a fourth reload which occurred about 13 hours after perijove. A second Halt was detected at SCLK 03686824, about 40 minutes after the reload. The NIMS processor remained halted for almost 2 days until the fifth reload. A table of the NIMS engineering SCLK values near the time of the Halts follows (Note that the NIMS engineering SCLK value is normally 2 Rims behind the CDS SCLK Rim when it is reported):

NIMS SCLK	CDS SCLK	CDS SCET	GROUND ERT
03685915	03685917.43	1996-311T11:49:02.224	1996-311T12:55:03.112
03686026	03686135.05	1996-311T15:29:02.216	1996-311T16:36:28.833
03686350	03686352.58	1996-311T19:09:02.208	1996-311T20:30:29.153
03686733	03686735.05	1996-312T01:35:42.194	1996-312T02:22:43.234
03686824	03686952.58	1996-312T05:15:42.186	1996-312T06:24:27.983
03686824	03687117.43	1996-312T08:02:22.179	1996-312T09:02:16.588
03686824	03687150.40	1996-312T08:35:42.178	1996-312T09:29:13.186
03686824	03687335.05	1996-312T11:42:22.171	1996-312T14:59:17.097
03686824	03687552.58	1996-312T15:22:22.163	1996-312T16:07:05.016
03686824	03687717.43	1996-312T18:09:02.157	1996-312T21:48:06.895
03686824	03687750.40	1996-312T18:42:22.156	1996-312T21:48:29.495
03686824	03688152.58	1996-313T01:29:02.141	1996-313T02:22:42.117
03686824	03688317.43	1996-313T04:15:42.135	1996-313T05:29:55.216
03686824	03688350.40	1996-313T04:49:02.133	1996-313T05:57:14.436
03686824	03688535.05	1996-313T07:55:42.126	1996-313T09:03:44.569
03686824	03688752.58	1996-313T11:35:42.118	1996-313T20:47:32.418
03686824	03689352.58	1996-313T21:42:22.096	1996-313T22:49:48.477
03690148	03690150.40	1996-314T11:09:02.066	1996-314T14:54:04.418
03690333	03690335.05	1996-314T14:15:42.059	1996-314T15:21:16.217

2. CheckSums of NIMS RAM locations 1000 to 14BC were returned just before each reload.

3. The two NIMS observations between the times of the first Halt and the third reload which were lost are C3ENPHINEA01 and C3INTHRMAL02. The five NIMS observations between the times of the second Halt and the fifth reload which were lost are C3JNFEA13601, C3JNFEA13603, C3JNFEA53M01, C3JNFEA5UM02 and C3JNFEA15301.

Timing:

SCLK	Comments
03603020:00	C3 Perijove
03686135.05	Anomalous 03686026 SCLK reported
03686069:00	Start of C3ENPHINEA01
03686081:00	End of C3ENPHINEA01
03686119:00	Start of C3INTHRMAL02
03686132:00	End of C3INTHRMAL02
03686159:06	Start of NIMS CDS Reload #3
03686352.58	Good SCLK 03686350 reported
03686735.05	Good SCLK 03686733 reported
03686784:06	Start of NIMS CDS Reload #4
03686952.58	Anomalous 03686824 SCLK reported
03686960:00	Start of C3JNFEA13601
03686976:00	End of C3JNFEA13601
03686990:00	Start of C3JNFEA13603
03686996:00	End of C3JNFEA13603
03687082:00	Start of C3JNFEA53M01
03687098:00	End of C3JNFEA53M01
03687117.43	Anomalous 03686824 SCLK reported
03687150.40	Anomalous 03686824 SCLK reported
03687176:00	Start of C3JNFEA5UM02
03687186:00	End of C3JNFEA5UM02
03687335.05	Anomalous 03686824 SCLK reported
03687552.58	Anomalous 03686824 SCLK reported
03687569:00	Start of C3JNFEA15301
03687594:00	End of C3JNFEA15301
03687717.43	Anomalous 03686824 SCLK reported
03687750.40	Anomalous 03686824 SCLK reported
03688152.58	Anomalous 03686824 SCLK reported
03688317.43	Anomalous 03686824 SCLK reported
03688350.40	Anomalous 03686824 SCLK reported
03688535.05	Anomalous 03686824 SCLK reported
03688752.58	Anomalous 03686824 SCLK reported
03689352.58	Anomalous 03686824 SCLK reported
03689668:06	Start of NIMS CDS Reload #5
03690150.40	Good SCLK 03690148 reported

NIMS Anomaly Report - C3 Sequence

Summary:

1. Two NIMS processor halts occurred during the C3 Encounter.

2. Continous monitoring of the NIMS SCLK channels led to a rapid identification that processor halts had occurred.

3. The 5 software reloads from CDS greatly lessened the potentially disastrous effects of the C3 Halts and protected most of the NIMS observations in the encounter.

4. Checksums of NIMS memory space verified that the reloads had executed properly.

5. Frequent NIMS realtime observations, both science observations and instrument health monitoring observations, verified that NIMS was functioning normally at various time points throughout the encounter.

6. The error avoidance measures applied to the C3 Encounter as determined in the analysis of the G1 and G2 processor halts (points 2, 3, 4 and 5 above) were shown to be the proper response for dealing with the inevitable occurrence of radiation-induced processor halts.

7. The loss of the C3 outbound observations showed that more NIMS reloads are needed while the spacecraft is inside Ganymede's orbit.

Detector 8 Failure

0. Detector 8 failed sometime during C3 outbound. Its response is random, independent of what NIMS is looking at.

1. Detector 8 was first observed to have unusual behavior in the two C3 RealTime RCT calibrations. Detector 8 was also found to be 'bad' in the two occultation observations C3RNMRING_01 and C3JNOCSPEC01.

2. Detector 8 DN seems to vary randomly, bouncing between 0 and 1023.

3. Detector 8 DN values were inspected in earlier C3 data and no anomalous behavior observed.

4. It is not ascertainable whether Detector 8 failed abruptly or over a couple of days since 2 days of outbound NIMS data before the occultation data were lost due to a processor halt.

5. NIMS power was turned off for about 15 minutes and then turned back on near the end of C3 Cruise on D349 in an attempt to revive Detector 8. DN values from Detector 8 were then returned in the E4 OPCAL on D350 at the start of E4. Detector 8's behavior did not improve - the power cycle did not revive Detector 8. Detector 8 has not returned reasonable DN values since the C3 Encounter.

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 name 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.

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.