Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the I33 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the I33 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.

A spacecraft safing event occurred 28 minutes prior to the I33 Io Flyby causing the loss of all Io observations. The only NIMS observations performed were the three Jupiter Global Maps. About three tracks of I32 data were not recorded over, so that these data were still available for playback during I33 cruise.

There were five autonomous reloads of the NIMS RAM code from CDS during the I33 encounter, one during the post-safing sequence recovery and the others just before each science observation. One (major) software halt was detected during I33. The approach that we are taking to avoid data loss due to processor halts has proven to be very successful.

The NIMS grating became stuck some time between C22 and I24. NIMS can now return only 17 (of 408) wavelengths. This has caused a drastic change in NIMS science capabilities. Detectors 1, 2 and 7 now have very low sensitivity. Detectors 3 and 8 are still not functioning. NIMS now returns only 12 useful wavelengths. Interesting science can still be carried out given the current condition of the insturment.

The plots on the pages 3 through 5 show the geometry of the NIMS I33 observations using a north trajectory pole projection. The 'returned' observations are in Bold characters and the 'non-returned' in gray. The observations with an asterix were taken with the NIMS software halted.

The spreadsheets on pages 6 and 7 summarize the 'final' playback model for the I33 data returned during I33 cruise.

The text on page 8 gives a 'recap' of the I33 playback events which affected which observations were returned.

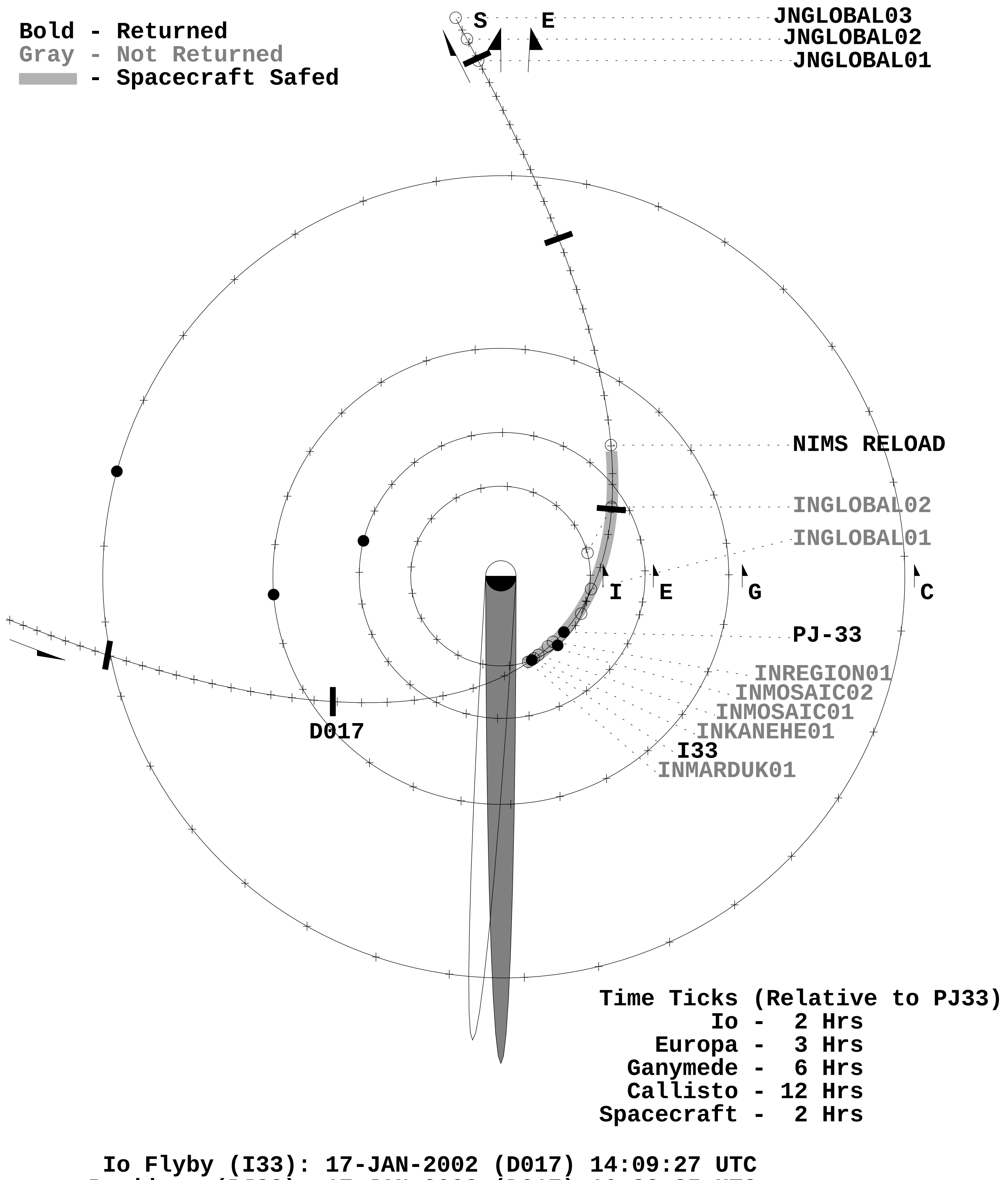
A Timeline of I33 playback events is on pages 8 through 20.

The text on pages 21 and 22 describes the I33 NIMS and Spacecraft Anomalies.

The text on page 23 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 24 and 25.

The text on page 26 is a guide to understanding the NIMS MASK.

NIMS I33 OBSERVATIONS

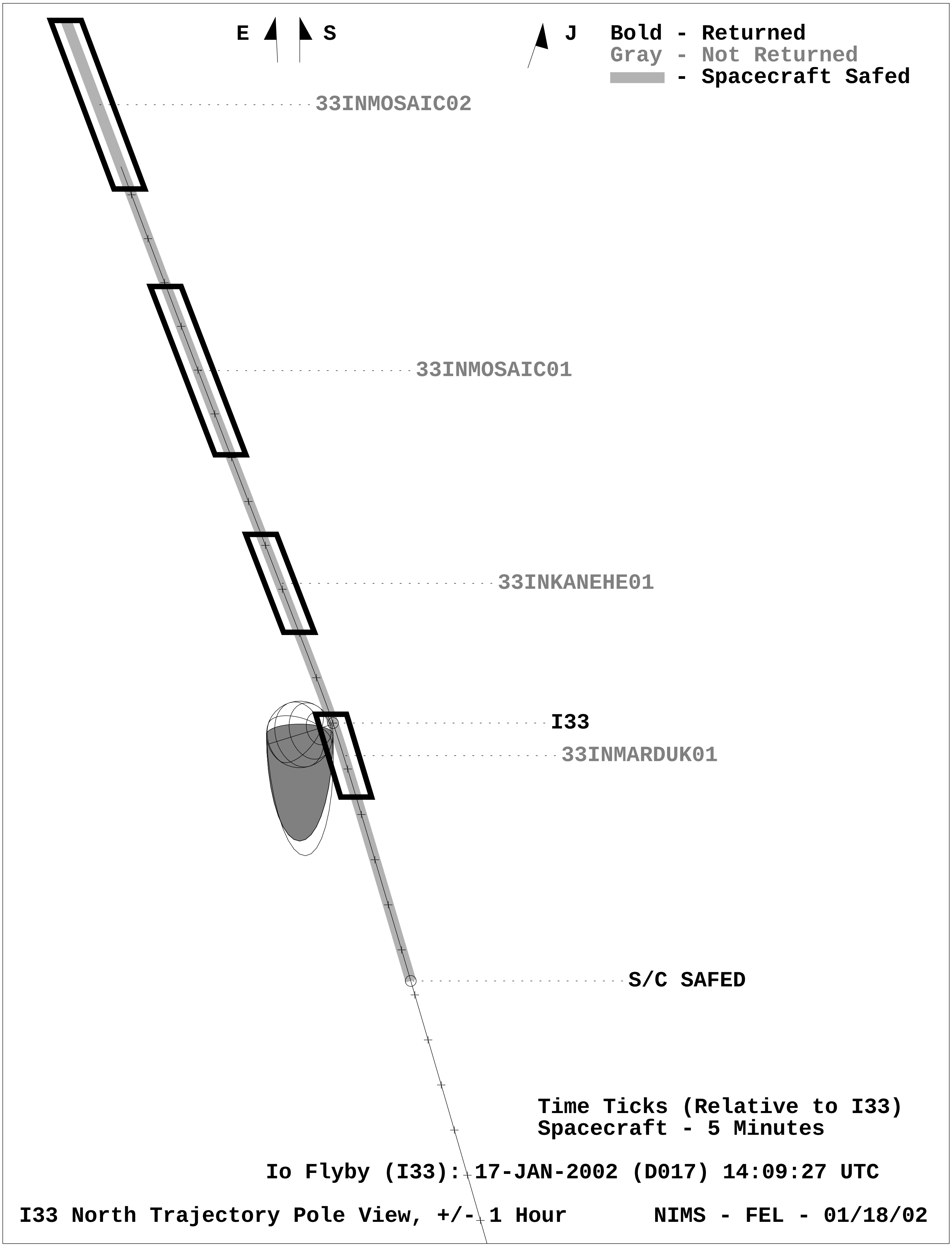


Io Flyby (I33): 17-JAN-2002 (D017) 14:09:27 UTC
Perijove (PJ33): 17-JAN-2002 (D017) 16:23:35 UTC

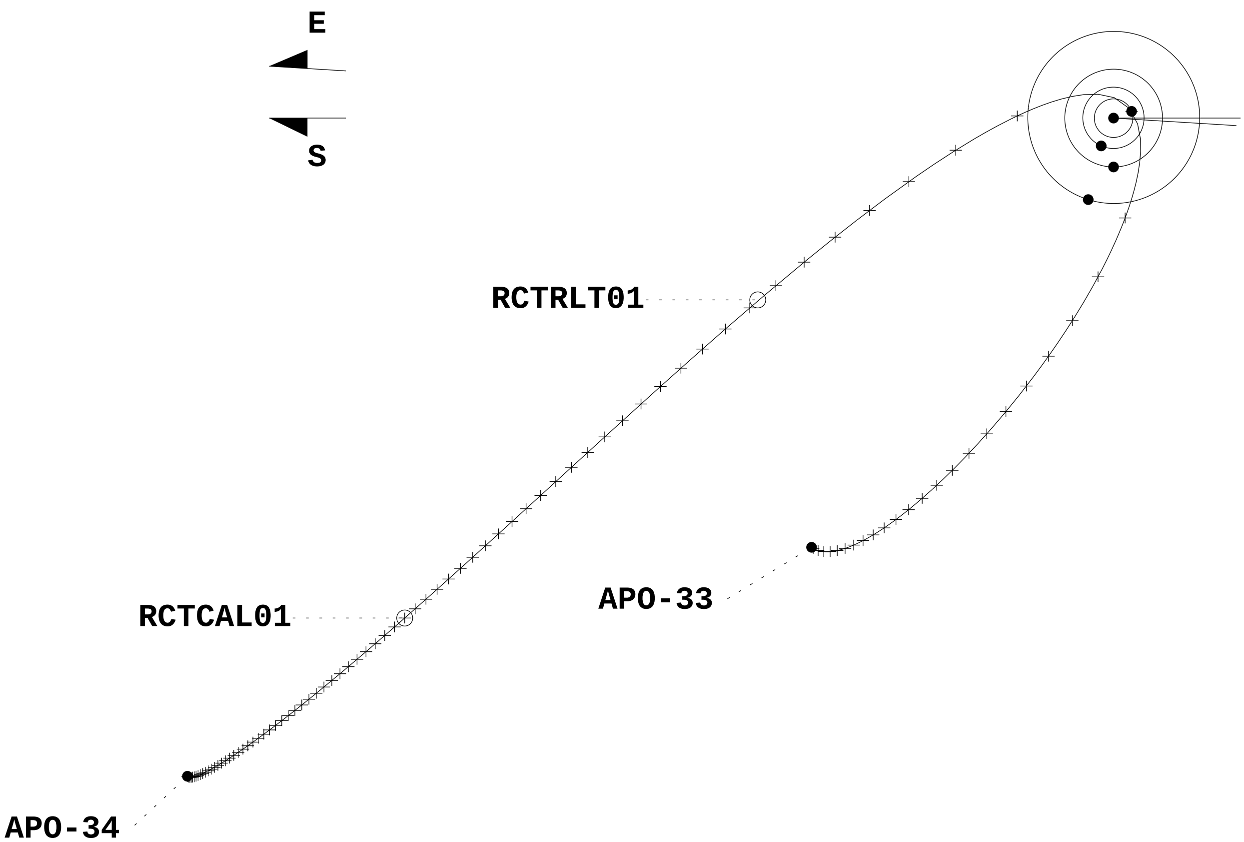
I33 North Trajectory Pole View

NIMS - FEL - 01/18/02

NIMS I33 IO FLYBY OBSERVATIONS



NIMS I33 CALIBRATIONS



Time Ticks (Relative to I33)
Spacecraft - 2 Days

Io Flyby (I33): 17-JAN-2002 (D017) 14:09:27 UTC
Perijove (PJ33): 17-JAN-2002 (D017) 16:23:35 UTC
Apojove (A34): 13-JUN-2002 (D164) 04:21:54 UTC

I33 North Trajectory Pole View

NIMS I33 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format	PSID
33JNGLOBAL01	Jupiter Global	I33JXM10	I33JXMFG10	XM	2	0	4	LPU	DH
33JNGLOBAL02	Jupiter Global	I33JXM10	I33JXMFG10	XM	2	0	4	LPU	DI
33JNGLOBAL03	Jupiter Global	I33JXM10	I33JXMFG10	XM	2	0	4	LPU	DJ
32INTHPELE01-gf	Io Pele Map 01	I32ILM442	I33ILM288	LM	1	0	4	MPW	DA
32INPELE__01+	SSI Pele ride-along	I32IXS17	I33IXS15	XS	1	0	4	IM8	IB
32INTHLOKI01-gf	Io Loki Map	I32ILM442	I33ILM288	LM	1	0	4	MPW	DB
32INTHPELE02-gf	Io Pele Map 02	I32ILM442	I33ILM288	LM	1	0	4	MPW	DC
32INEMAKNG02+	SSI Emakong ride-along	I32ILM442	I33ILM360	LM	1	0	4	IM4	ID
32INTOHIL_01+	SSI Tohil ride-along	I32ILM442	I33ILM360	LM	1	0	4	IM8	IF
32INITUPAN01-gf	Io Tupan Obs	I32ILM442	I33ILM288	LM	2	0	4	MPW	DF
32INTVASHT01+	Ssi Tvashtar ride-along	I32IXS17	I33IXS15	XS	1	0	4	IM8	IL
32INICHAAC01-gf	Io Chaac Obs	I32ILM442	I33ILM288	LM	2	0	4	MPW	DG
32INTERMIN01+	SSI Terminator 01 ride-along	I32ILM442	I33ILM360	LM	1	0	4	IM8	IJ
32INTERMIN02+	SSI Terminator 02 ride-along	I32ILM442	I33ILM360	LM	1	0	4	IM8	IK
32INREGION01-gf	Io Regional Map 01	I32IFMFG120	I32IFMFG84	FM	2	0	4	LPU	DI
32INREGION02-gf	Io Reginal Map 02	I32ILMFG252	I32ILMFG144	LM	2	0	4	LPU	DJ
33JNGLOBAL01-gf	Jupiter Global	I33JXM10	I33JXMFG10	XM	2	0	4	LPU	DH
33JNGLOBAL02-gf	Jupiter Global	I33JXM10	I33JXMFG10	XM	2	0	4	LPU	DI
33JNGLOBAL03-gf	Jupiter Global	I33JXM10	I33JXMFG10	XM	2	0	4	LPU	DJ
32INTHPELE01	Io Pele Map 01	I32ILM442	I33ILMFGDD72	LM	1	0	4	MPW	DA
32INTHLOKI01	Io Loki Map	I32ILM442	I33ILMFGDD72	LM	1	0	4	MPW	DB
32INTHPELE02	Io Pele Map 02	I32ILM442	I33ILMFGDD72	LM	1	0	4	MPW	DC
32INTHERML01	Io Thermal Map	I32ILM442	I33ILMFGDD72	LM	2	0	4	MPW	DD
32INITUPAN01	Io Tupan Obs	I32ILM442	I33ILMFGDD72	LM	2	0	4	MPW	DF
32INICHAAC01	Io Chaac Obs	I32ILM442	I33ILMFGDD72	LM	2	0	4	MPW	DG
32INHTSPOT01	Io Hot Spot Obs	I32ILM442	I33ILMFGDD72	LM	2	0	4	MPW	DH
32INREGION01	Io Regional Map 01	I32IFMFG120	I33IFMFGFW36	FM	2	0	4	LPU	DI
32INREGION01-gf	Io Regional Map 01	I32IFMFG120	I33IFMFGFW36	FM	2	0	4	LPU	DI
32INREGION02	Io Regional Map 02	I32ILMFG252	I33ILMFGFW108	LM	2	0	4	LPU	DJ
I33 Calibrations									
33NNRCTCAL01	Recorded RCT Calibration	I33RCTFG442	I33RCTFG408	LM	1	0	4	MPW	XE

NIMS I33 DATA RETURN

Activity ID	Mode	Mode Recorded	Wave-lengths Returned	Record Time (sec)	PB Time (sec)	Comp	Total BTG (Mbits) (w/4% o'head)	Data Reduction Factor (sBOT/BTG)	Pass
33JNGLOBAL01	XM	10	10	1405	1391	2.13	4.079	2.10	1
33JNGLOBAL02	XM	10	10	1223	1213	2.26	3.353	2.23	1
33JNGLOBAL03	XM	10	10	1041	1031	2.29	2.812	2.26	1
32INTHPELE01-gf	LM	360	288	243	146	1.38	0.731	2.30	2
32INPELE__01+	XS	17	15	15	13	1.21	0.201	0.00	2
32INTHLOKI01-gf	LM	360	288	611	73	1.39	0.363	2.32	2
32INTHPELE02-gf	LM	360	288	360	12	1.21	0.069	2.02	2
32INEMAKNG02+	LM	360	360	92	89	1.21	0.635	0.00	2
32INTOHIL_01+	LM	360	360	40	38	1.21	0.271	0.00	2
32INITUPAN01-gf	LM	360	288	550	48	1.28	0.259	2.13	2
32INTVASHT01+	XS	17	15	14	12	1.21	0.186	0.00	2
32INICHAAC01-gf	LM	360	288	558	92	1.3	0.489	2.17	2
32INTERMIN01+	LM	360	360	50	46	1.21	0.328	0.00	2
32INTERMIN02+	LM	360	360	50	46	1.21	0.328	0.00	2
32INREGION01-gf	FM	120	84	3876	808	1.22	2.671	1.87	2
32INREGION02-gf	LM	252	144	1943	59	1.29	0.158	2.30	2
33JNGLOBAL01-gf	XM	10	10	1405	20	2.1	0.059	2.07	2
33JNGLOBAL02-gf	XM	10	10	1223	115	2.2	0.327	2.17	2
33JNGLOBAL03-gf	XM	10	10	1041	46	2.2	0.131	2.17	2
32INTHPELE01	LM	360	72	243	239	1.38	0.299	9.20	3
32INTHLOKI01	LM	360	72	611	606	1.39	0.753	9.27	3
32INTHPELE02	LM	360	72	360	356	1.21	0.508	8.07	3
32INTHERML01	LM	360	72	186	182	1.85	0.170	12.33	3
32INITUPAN01	LM	360	72	550	545	1.28	0.736	8.53	3
32INICHAAC01	LM	360	72	558	553	1.3	0.735	8.67	3
32INHTSPOT01	LM	360	72	732	728	1.22	1.031	8.13	3
32INREGION01	FM	120	36	3876	3714	1.22	5.261	4.35	3
32INREGION01-gf	FM	120	84	3876	74	1.22	0.245	1.87	3
32INREGION02	LM	252	108	1943	1935	1.29	3.888	3.07	3
							31.077	Total	
							53.34	Allocation	
							22.263	Over/Under	
I33 Calibrations									
33NNRCTCAL01	LM	442	408	789	786	3.86	1.994	4.54	1

RECAP OF I33 PLAYBACK EVENTS

Data from the final Io encounter of the Galileo Millenium Mission (I33) was lost due to spacecraft safing, but a new sequence was uplinked in time to record the three planned NIMS I33 Jupiter observations. In addition to these we were able to recover an additional 30 Mbits or so of previously recorded I32 data, including a half-dozen SSI Io observation ride-alongs. Following playback of all of the NIMS data that could be obtained, a final RCT calibration was performed, with data recorded to tape and subsequently played back.

The failure to record data during the Io flyby was attributed to a previously unprecedented series of despun bus reset events, which overwhelmed the onboard software patch. In addition, for the first time ever, the spacecraft went into safe mode during the cruise period, at a distance of about 180 Rj from Jupiter. The resulting loss of data playback capability was not a significant factor.

As a result of the safing in I33, the NIMS I32 Io dataset will have the highest attainable signal to noise possible. Despite the disappointment of losing the encounter, the I33 data return constitutes a significant and valuable "final achievement" for NIMS science.

The following timeline details the most signifigant events of the I32 playback period. Most of the text below is excerpted from messages issued at the time.

I33 Playback Events Timeline (12-06-01 to 04-04-02)

12-06-01: The first delivery port for the I33 playback table is next Tuesday (11 December). The I33 Io flyby occurs on January 17, 2002. The provisional plan for I33 is to play back as much remote sensing data as possible in the first few weeks. The money will run out for remote sensing operations sometime around March. After that, only fields and particles data will be returned.
The present table assumes that all the NIMS data can be brought down. Approximately 66 Mbits of data are commanded for playback. When we receive our allocation, we will cut back to stay within our bits budget.
There are 10 remote sensing observations for NIMS in I33: 3 Jupiter global mosaics, 3 Io global mosaics (one named 33INREGION01), and 4 additional moderate to high resolution views of Io.

I33 Playback Events Timeline (12-06-01 to 04-04-02)

12-10-01: (Y. Anderson) Currently, I33 playback is initiated at 02-028/00:30, and will be paused at the end of B-load, which is on 02-092/02:54 (April 2). During this period, we have a capability of 148.57 MB. Most of these bits will be used to playback the remote sensing data. The allocation to MWG during this period is essentially zero, except the RTS usage. After taking out 4.457MB inefficiency and 3 MB SPOT margin, we have 141.116 MB to allocated to the teams. Here are the breakdowns: NIMS 52.385

12-21-01: (R. Lopes) We will need to make some changes to I33 playback. Region01 is our highest priority, and after talking with Sylvain I realized that he cannot do his SO2 mapping unless there are at least 6 samples. Past experience shows that otherwise the data are just too noisy. I'd be willing to cut the number of samples for the other observations to get this one.

01-04-02: (Y. Anderson) Sequence I33BED has a downlink capability of 150.965MB, of which 143.436 MB are distributed to the teams. SPOT keeps 4.529MB for inefficiency and 3 MB margin.
NIMS 53.339

01-08-02: The table delivered today includes new wavelength tables and a few minor timing changes. A strategy for 2-pass data return was implemented. We received a small increase in our allocation, to 53.34 Mbits, which should allow us to return most of what we are recording in I33.
Our strategy for the two passes over the tape is a little different this time. We are putting about 20% of our bits in the second pass (lower than usual). To make sure we obtain all of our Jupiter spatial coverage, we are bringing it all down at the end of the first pass, instead of splitting it between passes. Likewise we are bringing down all of our highest priority Io observation (33INREGION01) in the first pass. There is enough NIMS data in the second tape pass to help keep down losses due to slewing inefficiency. And, based on recent performance, we will have numerous gaps in our pass 1 data to fill as well. We are not being forced to do a "preview" (SSI-only) pass this time. Our charges for returning AACS data will be determined after this update. The I33 encounter begins on 15 January, and playback is initiated on the 27th.

01-11-02: (E. Theilig) The Galileo spacecraft is operating normally. Playback of data recorded during the Io 32 encounter is 97% complete and is scheduled to terminate on 1/14.
With radiation of the science sequence on 1/13, the spacecraft will be fully configured for the Io 33 encounter on 1/17. Close approach to Io will be at 6:44 a.m. PST (Earth-receive time) at a planned altitude of 100 km.

Perijove occurs almost two hours later at a range of 5.5 Rj. The science sequence begins Monday 1/14 at 6:35 p.m. PST (Earth-receive time). The attitude control subsystem was configured on 1/9 for the radiation environment close to Jupiter and the encounter attitude was established on 1/10. The final targeting maneuver has been cancelled as a result of accurate delivery from the apojove maneuver: the current B-plane errors are less than one sigma and the time of closest approach error is 5 seconds, about 3 sigma off of the aim-point. The closest approach observations will still be of scientific value, particularly if the lower resolution context images are obtained.

01-17-02: The spacecraft drops into safe mode at approximately 13:41 UTC, 28 minutes before Io close approach. Perijove occurs at 16:23:35 UTC.

01-17-02: (M. Segura) Unfortunately I don’t have good news to report. The spacecraft went into safing around the time of our first Io observation so the bad news is there will be NO NIMS Io data for I33 return. The first opportunity to recover will be on DOY 018/05:00:00 - hours before our Jupiter observations.

01-17-02: (E. Theilig) The Galileo spacecraft entered "safe" mode at approximately 6:16 a.m. PST (Earth receive time), only 28 minutes before closest approach to Io at 6:44 a.m. Our anomaly investigation is continuing, with all indications pointing to a recurrence of a Command Data Subsystem despun bus reset. This problem has occurred on almost every encounter since mid-1998 but is usually handled by a software patch loaded in 1999. The software patch normally recognizes the bus reset indicators and does not initiate the safing fault protection routines, thereby ensuring the continuation of the science sequence. This morning, the fault protection routine executed and halted the science sequence. The reason this particular bus reset was not caught by the software patch is unknown.
At the present time the spacecraft is quiescent and in command and telemetry contact with the ground.
As investigation continues and confirms a radiation-related bus reset as the cause of the spacecraft safing, the team is beginning the process of recovering the nominal spacecraft configuration and resuming the science sequence. The expected sequence restart time is 8:00 p.m. PST this evening. Prior to the safing event, the Deep Space Network successfully recorded the Radio Science Jupiter Occultation using the Radio Science Receiver over the Goldstone and Canberra 70-m antennas, between 2:58 a.m. and 5:41 a.m. PST (Earth-receive time). Approximately 3 tracks of remote sensing and closest approach fields and particles data were not acquired.

<u>I33 Playback Events Timeline</u> **(12-06-01 to 04-04-02)**

01-17-02: **(K. Schimmels) First, let me say thank you to all of you for pulling together and working so hard today to assist in the recovery efforts. I know that this is really a sad time for SPOT, and everyone worked very hard to ensure that we'd get the best return we can, given the circumstances.**
Second, I am requesting that each team email me by 11 AM tomorrow with an instrument status. The recovery commands and the truncated sequence have been sent up to the spacecraft now, we are locked up on packetized telemetry, so all is continuing at this point. Please check the SST white board for commanding details. The truncated sequence will start with state matching activities tonight at 018/04:00, and the first science activity will be the Amalthea Opnavs. Tomorrow - the OTM has been cancelled. There is no need for it. Also, we will be sending realtime commands to set up the tape to record buffer dumps on track 3 in I33B. These will overwrite the end of the C/A recordings (MWG and NIMS) at tic 5600 on track 3.
Yanhua and I will be talking about playback strategy tomorrow morning, as well. The current thought is for remote sensing to do a first-pass only playback table for all I33 data, and use the second pass for gap fill. I'm past worrying about efficiency at this point. Total data return is the important factor. So, keeping that in mind, and also what you'd like to recover from tracks 2, 3, and 4 (and early on track 1 prior to I33 recording) as far as I32 playback is concerned.

01-17-02: **(M. Segura) The spacecraft is now on it's way to recovery. We should be seeing Phase 2 science/engineering packets within the next hour or so. The recovery will be completed by 8:00 pm this evening. Our Jupiter observations will execute as planned (barring another safing of course). There were some adjustments made to the tape map which I try to encapsulate here.**
The I33A sequence began recording on Track 1 ~ tic 2100 with PPR observations. The safing occurred just prior the start of our Marduk observation (first Io activity for NIMS). The decision was made to continue the rest of the I33A recording without repositioning the tape. The rest of the record activity would easily fit on the remainder of track 1 preserving all other I32 data except the Jupiter globals. MWG has a small amount of recording (180 tics) planned for I33B which would record over the last 130 tics or so of I32 IOREGION02 since the tape positioning had to be done for this via real time command and a bit of whining and righteous indignation on my part resulted in a change to the tape position. So.... we will be able to return ALL the wavelengths and gaps for both REGION01 and REGION02 entirely as a part of the I33 playback plan. (The MWG recording will wipe out I32EMAKONG instead).

<u>I33 Playback Events Timeline</u> (12-06-01 to 04-04-02)

01-18-02: (W. Currie) S/C Safing Occurred around 017/14:06
I33A Sequence restarted 018/00:28=20
There appears to have been another bus reset event at 018/05:09:22 ERT, (04:30:09 SCET), though this one was handled nominally by the software patch.

01-18-02: (R. Mehlman) Good NIMS SCLKs began to appear again at 6390012 (SCET 18/04:47:29) and remain good three hours later. Seven have appeared so far. NIMS engineering looks good too: the Tfpa DN was steady at 3 and has now fallen to 2, other values appear normal. Hardware status word began showing gain state 2 and 63-hertz chopper mode, then went to chopper reference by 6390005 (SCET 18/04:40:49), just before the first good SCLK showed up.
Our first post-recovery observation (33JNGLOBAL01) is a day and a half off.

01-18-02: (E. Theilig) The Galileo spacecraft is operating normally and all activities appear to be as planned following recovery of the spacecraft from "safe" mode. The current status is from the Canberra pass at 7:00 a.m. PST (Earth receive time). The science sequence restarted at 8:35 p.m. PST (Earth receive time) on 1/17 with state matching activities included before the first Solid State Imaging camera observation of Amalthea. From the restart point to the end of the sequence on Monday, 1/21, the remote sensing instruments will acquire observations of Amalthea, Europa, and Jupiter. The Amalthea observations are planned for optical navigation of the next encounter in November. Telemetry from the camera suggests that it is operating normally. Continuous fields and particles data collection will continue until 1/28 at which time remote sensing playback will begin.
A second bus reset occurred at 7:20 p.m. PST (Earth receive time) on 1/17 and was handled by the software patch designed to avoid safing in the event of a radiation induced despun bus reset. It is still unknown as to why the patch did not keep the sequence running when the earlier reset happened just before closest approach.
The closest approach to Jupiter occurred at 8:58 a.m. PST at a range of 5.5 Rj. The peak radiation level was 915 (as measured by the star scanner in pulse counts). This is the highest level experienced by the spacecraft since Io 27 in February of 2000.
The only Io observations successfully acquired include Photopolarimeter-Radiometer data, a partial Near Infrared Mapping Spectrometer observation, and the Radio Science gravity experiment. The Navigation Team successfully delivered the spacecraft to within one sigma of the aimpoint and is expected to recommend cancelling the post-encounter, clean-up maneuver.

<u>I33 Playback Events Timeline</u> (12-06-01 to 04-04-02)

01-18-02: (Y. Anderson) Our delivery schedule for pbt delivery on Tuesday 3pm still stands. For this delivery, all we need is the singles for I33 data selected in pass 1. We can add I32 data selected in the next update. At this time, no change to allocations. But PPR seems to be in need of a few MB more, can SSI and NIMS each contribute some?

01-18-02: (K. Schimmels) Eilene brought up the possibility of commanding the RTS /Buffer dump data collection in I33B to be longer. Since the original constraints on the 10 days were a) BTG allocation and b) tape space for buffer dumps, and both of these restrictions do not exist any more, this is a possibility. Does remote sensing have any data they have not seen from track 4 that they really really don't want overwritten? This would mean delaying initiate playback, but for now still plan on delivering a PBT just in case.

01-21-02: (R. Mehlman) Engineering data is sparse far from closest approach, but we have: -A good SCLK and a good Hardware Status word in the hour before 33JNGLOBAL01, indicating no NIMS halts since the I33 sequence was restarted.
-Good SCLKs and status words between GLOBAL01 and GLOBAL02, indicating no halts during GLOBAL01.
-Good SCLKs and status words after GLOBAL03, indicating no halts during GLOBAL03.
We can't say anything about GLOBAL02, but there's no reason to expect any problems since it was so far from Jupiter.

01-22-02: All indications are that recording of the I33 NIMS Jupiter global observations occurred as planned, following recovery from the spacecraft safing event last week. In today's playback table we are including singles to play back these observations only. This buys us time to generate gap-fill singles for returning those portions of our I32 data that were not successfully brought down in I32. Due to the very spotty performance of the DSN over the holidays, we have a very large number of unfilled gaps to pursue.
The current table plays back all 10 recorded wavelengths for the 3 Jupiter globals, in the first pass over the tape. This amounts to some 12.5 Mbits of downlink allocation. Before the safing event, our allocation stood at more than 53 Mbits. I expect we may be able to make good use of perhaps 75% of this total, as the complexity of our data return strategy in I32 makes it technically challenging to return many tiny gaps using different wavelength selection tables, without creating new gaps. It makes far more sense to command the complete complement of grating steps for return, for the times of the gaps.
There is a question regarding the prioritization of our remaining data, as MWG would like to expand their RTS, which would involve overwriting some of the I32 data. More on this later.

<u>I33 Playback Events Timeline</u> (12-06-01 to 04-04-02)

01-22-02: We have a LOT of gaps to fill in the I32 Io data that remains on the tape. Kathy mentions track 4 where there are 3 NIMS observations and 3 SSI ridealongs that we probably want to go after. Track 3 has 4 NIMS and 3 SSI. Only track 2 is mostly free of NIMS data-we have 32INTHPELE01 there at the start of the track. It has 4 gaps right now. I sent Kathy this info and said we would be unhappy if tracks 3 and 4 were overwritten.
Although we have gaps in our observations "on paper," due to grating steps redundancy we may already have fully acceptable products on the ground (please review Lucas' latest products) It would be helpful to know which observations have visible gaps remaining, and which observations really need more grating steps for noise reduction (note, 32INREGION01 and 32INREGION02 are not affected by the current issue; they will not be overwritten). The decision to extend fields and particles RTS beyond the nominal 10 days (now ending on the 27th) will probably need to be made soon.

01-22-02: I have just spoken with Kathy Schimmels regarding the question of overwriting NIMS I32 data for I33 MWG RTS. SSI is also unhappy with the idea of affecting track 4. It turns out that a relatively small amount of tape will be needed, and track 2 will be the destination, if the extended RTS is approved. Currently MAG is not responding to requests for their input. The decision will most probably be made tomorrow. Thus we do not have to do in-depth triage for our I32 gap fills at this time.

01-22-02: (K. Schimmels) The MWG has decided not to pursue additional RTS data collection beyond what is already in the I33B sequence. The workload involved in doing an RBS, the out of order tape recording due to buffer dumps and complicating factors in playback were all considered, as well as the science request for this not being overwhelming strong. We will continue on the path of positioning on track 1 prior to IPB this weekend.

01-23-02: (Y. Anderson) Playback will initiate on Sunday (1/27) at 5:05 PM PST and terminate for remote sensing playback on Monday (4/1) at 7:30 PM PST.
The I33 playback is a little bit unusual: there are I32 data carried over (unfortunately) and it's not done in a first-in/first-out fashion.
We will start with playing back I33 remote sensing data on track 1 (MWG data on track 1 won't be selected at this time) and have them selected in pass 1. After finishing those, we will pick up I32 data on track 2, 3 and 4 (remote sensing data only) in pass 2. [Note that it has to be pass 2 because of a time regression from I33 to I32 data, although the playback has just gone through one track of the tape.]
In the current playback table -- I33PCB, only I33 data playback are included.

<u>I33 Playback Events Timeline</u> (12-06-01 to 04-04-02)

01-24-02: **Since we have an excess of downlink allocation in I33, it occurs to me that it might be useful to bring down data for detectors 1, 2, 7 in the I32 Io MPW observations. One reason to do this would (possibly) be to perform noise studies. Another would be to have an end-of-mission record of their performance/problem. Would it make sense to get any data from 3 and 8? If these generate only random noise then probably not. If you disagree let me know soon, as it is relatively easy to add these to the playback plan at this stage.**
The Jupiter observations and the large Io REGION observations did not record the non-functioning detector data to tape, so we are only talking about the 8 Io encounter MPW observations.

01-24-02: **In response to your request I have modeled the downlink bits totals for NIMS data playback in I33. This includes the recorded I33 observations, playback of selected SSI ride-alongs additional wavelengths (completing data return for observations partially played back in I32), and commands to fill the remaining 26 or so gaps. The total downlink required for this is approximately 32 Mbits. We want to hold at least an additional 10 Mbits as insurance for gaps occurring in our first physical tape pass. Thus I think 42 Mbits is a reasonable number for us. This is about 80% of our pre-anomaly downlink bits allocation.**

01-30-02: **Playback of the NIMS I33 Jupiter global observations is underway. We have requested 100% of the data recorded in the first tape pass, anticipating that there will be gaps to fill later on.**
The table delivered today includes commands for playing back I32 data that was not recorded over due to the spacecraft anomaly. Last week's table consisted of 3 sets of playback commands, while today's has 42. Several new wavelength edit tables were created. The data return strategy may be summarized as follows:
We are returning NIMS recorded data for 6 SSI I32 Io observations (32ISPELE__01, 32ISEMAKNG01, 32ISTOHIL_01, 32ISTVASHT01, 32ISTERMIN01, 32ISTERMIN02), as recommended by Frank. These are coming down with 15 detectors (360 wavelengths).
We will fill a very large number of existing gaps in our I32 encounter period Io observations. The wavelengths commanded here correspond to those returned during the I32 playback period (288 wavelengths total, 12 detectors, 24 samples each). Only one observation remaining on tape had no gaps (32INTHERML01), while one other (32INEMAKNG01) was written over with new data.

I33 Playback Events Timeline (12-06-01 to 04-04-02)

In our first pass over 32INREGION01 and 32INREGION02 we will fill gaps remaining after I32 playback was completed. As with the encounter observations, we return the same set of wavelengths/detectors as in I32 (84 wavelengths for the FM LPU REGION01, 144 wavelengths for the LM LPU REGION02). In the final playback pass over the tape (for the mission) we will fill any gaps in our Jupiter globals, before returning yet more unseen I32 Io data. For the encounter observations we are commanding return of data from detectors 1, 2, and 7, for analysis purposes and completeness, and for an end-of-mission record. These detectors were not recorded for the two large REGION observations, but a considerable number of samples that have not been played back remain on the tape for these. Thus we will finish by returning approximately 9 Mbits of as yet unseen data from these two observations. The final products for these observations should have excellent signal to noise ratios.
The model estimate for NIMS data return in the I33 playback period is 32.4 Mbits. We have sufficient allocation at present to fill any gaps that may occur during our first physical pass over the tape.

02-13-02: Playback is proceeding uneventfully. We received our I33 Jupiter observations at the end of January, with some gaps. In this week's table I included six new sets of commands to fill these. The additional downlink bits requirement is about 0.6 Mbits.
The Jupiter observations compressed well and look good, aside from a correctable problem due to wobble (we were looking "in the cone pole", down the long axis of the spacecraft). The white oval (a focus of scientific interest right now) appears in one of the 3 global observations. These are the final NIMS observations of the mission, aside from calibrations.

01-17-02: (S. Thompson) DSS 63 (pass #4516): Both FCD's dropped lock at 21:25 ERT. The station also saw the "FSR Safing Carrier Detected" alarm at the same time. All other indications showed that the spacecraft was not in safing. The station rebooted several pieces of equipment and attempted locking up on the spacecraft in residual mode (just in case), but was unsuccessful. All indications were that this was a problem on the ground, but the cause was unknown. All data from 21:25-EOT were lost.
DSS 14 (pass #4517): Both FCD's failed to lock up throughout the pass. The station also saw the "FSR Safing Carrier Detected" alarm throughout the pass, but all other indications showed that the spacecraft was not in safing. The station rebooted the DGT, and attempted to lock on the spacecraft in residual mode the same as DSS 63 had previously attempted to do, but was also unsuccessful. There were no successful transfer frames during the pass.

I33 Playback Events Timeline (12-06-01 to 04-04-02)

02-18-02: (E. Theilig) The spacecraft is presently quiescent and in command and telemetry communication with the ground following entry into safe mode over the weekend. Preliminary analysis indicates that the spacecraft entered safing at 1:25 p.m. PST (Earth receive time) on February 16 as a result of the Command and Data Subsystem (CDS) "A string" being taken down by a bus parity error. A command to switch the telemetry to the "B string" was sent Sunday evening after multiple, unsuccessful attempts to lock up on "A string" telemetry. The cause of the bus parity error is unknown but could be related to a despun bus reset. A software patch designed to continue nominal spacecraft operation in the event of a despun bus reset is incompatible with playback of recorded data and is disabled during the cruise part of the orbit. As investigation continues and confirms that it is safe to do so, the CDS "A string" will be brought back up to restore redundancy to the spacecraft. The spacecraft will then be reconfigured to the pre-anomaly state and the science playback software enabled before the onboard sequence is restarted. If all goes as planned, the spacecraft could be back in normal operation by Thursday, February 21.

02-19-02: (E. Theilig) Spacecraft recovery from "safe" mode is proceeding smoothly. The "A string" of the Command and Data System has been restored to normal operation and the science data processing software has been reloaded but has not yet been enabled. That step will occur shortly before the background sequence and playback are restarted on Thursday, February 21. All indications point to a "standard" despun bus reset on the A string. This is the first such occurrence of this type of anomaly outside 30 Rj since Galileo arrived at Jupiter.

02-19-02: (Y. Anderson) Playback will be re-initiated on Thursday Feb. 21 at 5:30 PM PST. The termination for playback is on Monday Apr. 1 at 7:30 PM PST (time unchanged).
The current PBT starts from the beginning of the previous segment 5 in I33PCF. The first selected data in the current I33PDB are 32ISGSHBAR01, at tic 3826 on track 4. The segmentation of I33PDB is the same as that in I33PCF, except each segment has a different number now.

02-19-02: (K. Schimmels) Here’s the startup info and plans for the calibrations, and a list of what I need from you all tomorrow to pick the date. I’m focusing on this executing no later than March 20 / 21st: NIMS cal will be first, followed by SSI Calibration. Recording will be on Track 4.

<u>I33 Playback Events Timeline</u> (12-06-01 to 04-04-02)

02-22-02: **(E. Theilig) The Galileo spacecraft is once again operating normally following last weekend's safing event. A Command and Data System (CDS) despun bus reset occurred on 2/16 taking the CDS A string down and placing the spacecraft in a safe mode. These events have occurred both during interplanetary cruise and during the extended mission; however, this is the first occurrence in the extended mission with the spacecraft out in the solar wind about 180 Rj away from the planet.**
The root cause of a despun bus reset is considered to be debris generated in the slip rings that transfer power and signals between the spun and despun portions of the spacecraft. Debris in this area can cause shorts in a line that normally indicates to the CDS despun section that the CDS subsystem has experienced a power on reset. In that circumstance the despun section performs a reset and prepares for recovery. In the case of this erroneous reset, the rest of the CDS notes the despun section reset, and calls the on-board safing algorithm.
Recovery efforts consisted of diagnostic readouts on 2/17, bringing the A string up on 2/18, loading and restarting the software used to process science data on 2/19, and loading the background sequence and a playback table on 2/20. Normal sequence operations began on 2/21.

03-05-02: **(B. McLaughlin) Galileo operations have returned to normal after recovery from an unexpected safing event on the spacecraft last week. A Command and Data System computer reset occurred on Saturday, February 16, which caused the spacecraft to shut down operations and phone home for help. We believe that similar resets, which have occurred since 1998, are due to accumulated radiation effects, so we were somewhat surprised that this one occurred so far out from Jupiter and its intense radiation field. At the time of the reset, the spacecraft was nearly 180 Jupiter radii (12.9 million kilometers or 8 million miles) from the planet. This most recent event may be more similar to anomalies that occurred during Galileo's interplanetary cruise, prior to arrival at Jupiter in 1995. This just goes to show that space exploration is unpredictable at best!**
Playback of the tape recorded data from the January 17 flyby of Io continues. In addition, data remaining on the tape from the October flyby is still available for playback. Continuous data collection by the Magnetometer, the Dust Detector, and the Extreme Ultraviolet Spectrometer instruments also occupies our attention.
Plans are also being made to perform a final set of calibrations for the Near Infrared Mapping Spectrometer and the Solid State Imaging camera. These calibrations will take place Monday night, March 18. They will provide a final measurement of the sensitivity of the instruments against which we can compare recent science measurements.

<u>I33 Playback Events Timeline</u> (12-06-01 to 04-04-02)

03-05-02: The table delivered today includes a few new sets of commands for filling gaps in our 32INREGION01. This will be our 4th pass over this data, and hopefully we can get it down intact (at last).
This gap-fill is coming down with 84 wavelengths (same as in pass 2). This has higher priority than our low-signal detectors playback in pass 3, so we are stopping in the middle of that playback, changing wavelength edit tables, and then playing back our gap fills, before resuming playback of the low-signal detectors data (with detectors 1, 2, 7 selected). The total number of downlink bits required is about the same as before. In connection with the low-signal detectors playback, as I have noted in SPOT meetings, there is a larger uncertainty for the compression estimates. If the data are not too noisy they should compress well; if it is full of noise, they may compress poorly. I believe that in either case, the current playback plan will function as intended, as there is a reasonable "pad."
We also have some gaps in our I33 Jupiter GLOBAL02, but we cannot access these recordings again. Thanks to Bob M (as always) for providing SCETs of gaps.
Playback will terminate in a little under 2 weeks, at which time NIMS calibration data will be recorded. There will be a new playback table created to return that data.

03-13-02: The final calibration activity for NIMS will occur on Monday. After a warm-up period for the target, an RCTCAL will be performed and recorded to tape. The playback table to return the data delivered today has only one set of commands. We are returning all the data (Long Map, MPW, 408 wavelengths, about 13 RIMS). I believe the compression estimate (2.0) is reasonable and fairly conservative. It will require about 3.8 Mbits of downlink allocation to bring it down.

03-13-02: (Y. Anderson) Calibrations data playback will initiate next week, Tuesday (3/19) at 4:30 PM PST, and terminate on Monday (4/1) at 7:30 PM PST.
We will first play back the six buffer dumps at the end of track 3, which were recorded during the I33 B-load. Then we pick up the calibration data which will be recorded on track 4. All data are played back in a single pass.

03-15-02: (E. Theilig) The Galileo spacecraft is operating normally. The primary activity this week has been the continuation of playback of data recorded during the Io 32 and Io 33 encounters. Playback is 75% complete and is scheduled to terminate on 3/17. The remainder of playback will be used for remote sensing calibrations planned on 3/18.

I33 Playback Events Timeline (12-06-01 to 04-04-02)

03-20-02: (K. Schimmels) Just a clarification on our earlier discussion - Eilene has requested that we still not plan on a nominal second pass of playback, however, just to keep in mind that if we have a good reason, such as a LARGE loss of data, we will consider the option of an additional pass to recover this data.

04-04-02: This message is to let you know that the final NIMS playback commands of the Galileo Mission and its extensions executed successfully. The RCTCAL recorded during I33 cruise was returned to Earth late in March, with only one minor gap (7 packets).
I expect that this will be the final installment of this series of email messages documenting data return decisions made and events occurring. Readers of these messages should be aware that a permanent record of playback decisions and events exists in each of the NIMS Guides which are available on the NIMS web site (http://jumpy.igpp.ucla.edu/~nims/).
G1 playback initiated on July 8, 1996, five years and eight months ago. Many people have contributed significantly to the success of the NIMS data return effort during these years. Decisions concerning the prioritization of data for return have been a team effort, involving too many individuals to mention here. However, I would like to recognize the following individuals, who have worked directly with the files, programs, and processes involved on the operations side:

NIMS Team Members:
- Marcia Segura
- Frank Leader
- Elias Barbinis
- Bob Mehlman
- Lucas Kamp
- Rosaly Lopes
- Bill Smythe
- John Hui
- Adriana Ocampo
- Paul Herrera
- Kevin Baines
- Jim Shirley

Galileo Science Planning and Operations Team Members:
- Alan DiCicco
- Jeff Culwell
- Kathy Schimmels
- Dave Schranck
- Yanhua Anderson
- Jerod Gross

Thanks to all of you. May we meet again, in future projects, with similar success!

The NIMS grating became stuck prior to the I24 encounter. The grating continued to be stuck for the I33 encounter. This development caused a drastic change in NIMS operations. Detectors 1, 2 and 7 now have very low sensitivity. Detectors 3 and 8 are still not functioning. NIMS now returns only 12 useful wavelengths.

The NIMS processor halted twice during I33, once during encounter and once during cruise. Both events were coincident with a spacecraft safing event. The first spacecraft safing event occurred just before the I33 Io Flyby. The second occurred well past Callisto’s orbit away from the hardest radiation. All Io observations were lost. Only the three Jupiter Global observations were saved.

The spacecraft safed during the I33 Encounter due to an unusual CDS Bus Rest Event that the CDS BURP patch could not handle. The second Bus Reset resulted in safing because the BURP patch is disabled during playback.

Stuck Grating (from the I24 NIMS Guide)

At I24, NIMS experienced a fundamental change in the way that it operates. Sometime between C22 and I24, the NIMS grating became stuck at a position corresponding to a pshift of about 14.5. This unusual grating position produces wavelengths for each detector far shorter than previously used. With the stuck grating, NIMS is permanently in a "fixed grating" mode. At this new grating position, Detectors 1, 2 and 7 return very low DN, as their new wavelengths are outside of the passband of their blocking filters and therefore are of minimal use. As before, detectors 3 and 8 are still not functioning.

There is no ground calibration for the wavelengths corresponding to this pshift. Flight calibration was derived from the I24 RCT and PCT calibrations. Details of this new flight calibration will be discussed in the as yet unpublished NIMS calibration report.

The spectral capability of the NIMS instrument shrank from 408 wavelengths to 17 wavelengths with the stuck grating. Now all commanded modes, Long Map, Full Map, Short Map or Fixed Map, select the same 17 wavelengths. Two effects of the stuck grating have been put to good use: spatial editing and noise reduction.

Even though the grating is stuck, the grating cycle still plays an important role. The playback edit table can now be used for spatial data editing. In Long Map mode, each mirror scan can be selected or deselected using the playback edit table. This allows a range of spatial density versus areal coverage choices.

If an observation is performed in Long Map mode at the Long Map scan rate, the 24 mirror scans over a single grating cycle can be averaged together to increase the signal to noise level. The adverse effects of the high levels of radiation-induced noise encountered close-in to Jupiter are greatly alleviated by this averaging.

NIMS Anomaly Report - I33 Sequence

Response to Stuck Grating Anomaly (I33)

At I33 the cause of the stuck grating was not known (and is still not clearly understood). No attempts were made during I33 to unstick the grating.

Processor Halts

There were two NIMS processor halts during I33, both due to spacecraft safing. In both instances, the NIMS software was reloaded as part of the sequence recovery and also prior to the NIMS observations 33JNGLOBAL01 and 33NNRCTRLT01.

Spacecraft Anomaly

The spacecraft safed about 28 minutes before I33 Io closest approach. All Io observations were lost. The safing event was due to an unusual CDS Bus Upset that the CDS BURP software could not handle. A second more typical CDS Bus Rest occurred 9 hours later that was handled properly by the CDS BURP code. A second spacecraft safing event occurred during I33 cruise far from Jupiter's hard radiation environment. This event was similar to those encontered during interplanetary cruise prior to G1.

Anomaly Timing:

6389115	02-017/13:41:10	Spacecraft Safing Event #1
6389890	02-018/02:44:56	Second CDS BURP Event
6389984	02-018/04:19:39	NIMS Power On (Sequence Recovery)
6389990	02-018/04:25:34	NIMS Software Reload
6432265	02-047/20:50:56	Spacecraft Safing Event #2
6439692	02-053/01:59:47	NIMS Software Reload

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.