Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the I32 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the I32 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 cruise portion of I32 was too short in duration to return all of the data recorded during the I32 encounter. Data were selected for playback to maximize science return. Due to a spacecraft safing event during the I33 encounter, some of the I32 data were not recorded over and were available for playback during I33 cruise.

There were fourteen autonomous reloads of the NIMS RAM code from CDS during the I32 encounter, one just before each science observation. One software halt was detected during I32. 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 I32 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 through 9 summarize the 'final' playback model for the I32 data returned during I32 and I33 cruise.

The text on page 10 gives a 'recap' of the I32 playback events which affected which observations were returned.

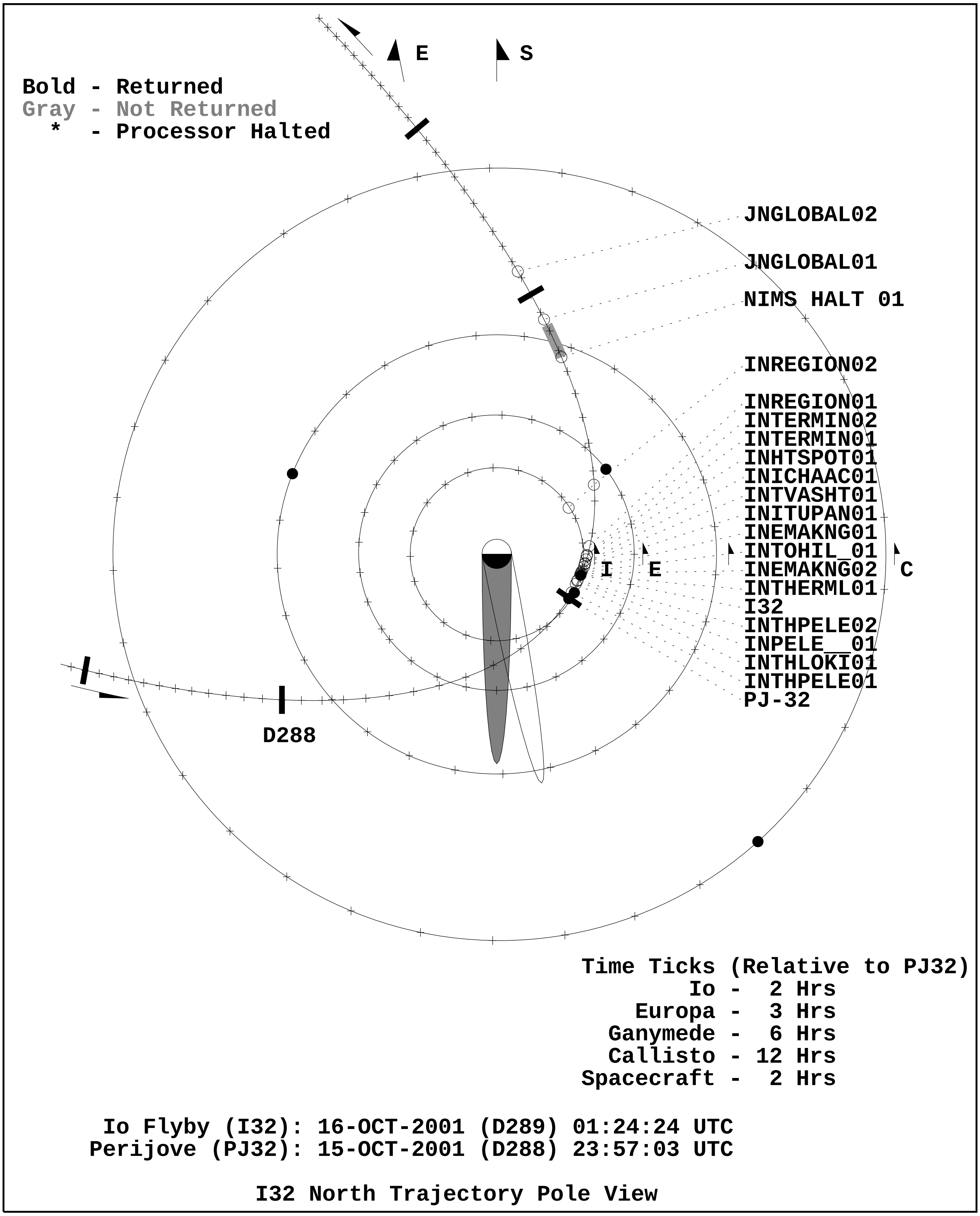
A Timeline of I32 playback events is on pages 10 through 17.

The text on pages 18 and 19 describes the I32 NIMS and Spacecraft Anomalies.

The text on page 20 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 21 and 22.

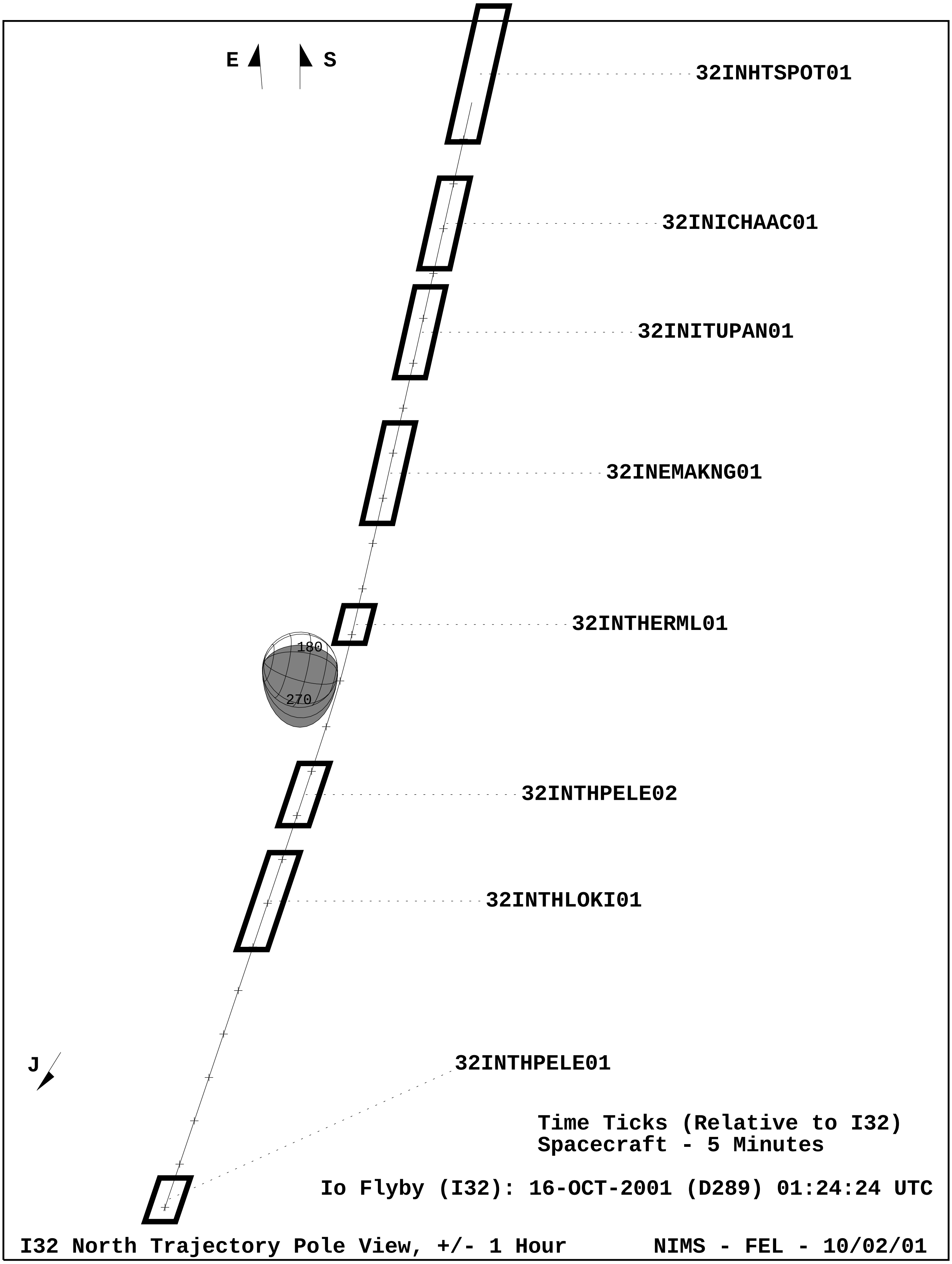
The text on page 23 is a guide to understanding the NIMS MASK.

NIMS I32 OBSERVATIONS

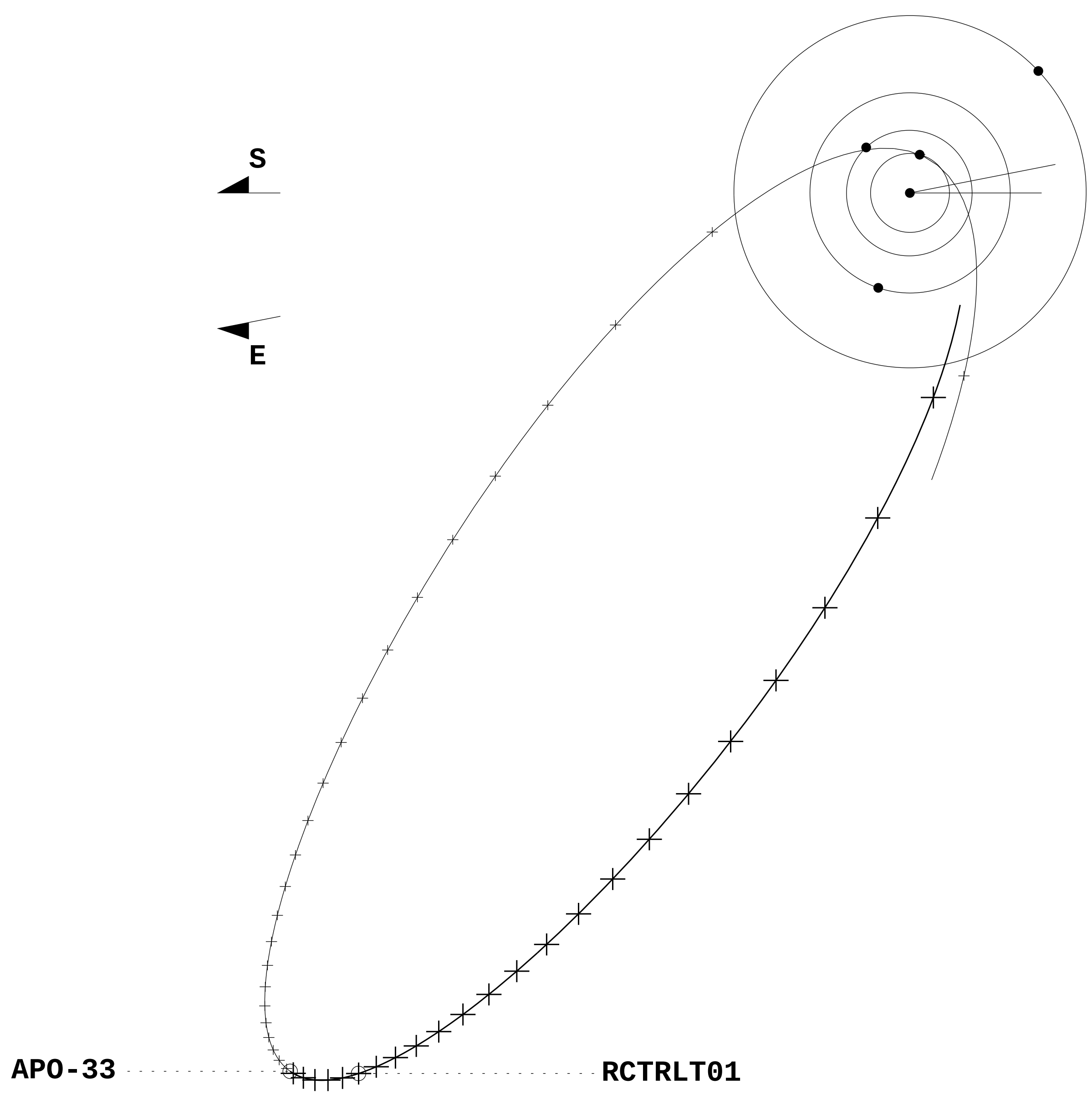


NIMS - FEL - 03/06/02

NIMS I32 IO FLYBY OBSERVATIONS



NIMS I32 CALIBRATIONS



Time Ticks (Relative to I32)
Spacecraft - 2 Days

Io Flyby (I32): 16-OCT-2001 (D289) 01:24:24 UTC
Perijove (PJ32): 15-OCT-2001 (D288) 23:57:03 UTC
Apojove (A33): 01-DEC-2001 (D335) 21:36:02 UTC

I32 North Trajectory Pole View

NIMS - FEL - 10/31/01

NIMS I32 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format	PSID
32INTHPELE01	Io Pele Map 01	I32ILM442	I32ILM144 A	LM	1	0	4	MPW	DA
32INTHLOKI01	Io Loki Map	I32ILM442	I32ILM144 A	LM	1	0	4	MPW	DB
32INTHPELE02	Io Pele Map 02	I32ILM442	I32ILM144 A	LM	1	0	4	MPW	DC
32INTHERML01	Io Thermal Map	I32ILM442	I32ILM144 A	LM	2	0	4	MPW	DD
32INEMAKNG01	Io Emakong Obs	I32ILM442	I32ILM144 A	LM	2	0	4	MPW	DE
32INITUPAN01	Io Tupan Obs	I32ILM442	I32ILM144 A	LM	2	0	4	MPW	DF
32INICHAAC01	Io Chaac Obs	I32ILM442	I32ILM144 A	LM	2	0	4	MPW	DG
32INHTSPOT01	Io Hot Spot Obs	I32ILM442	I32ILM144 A	LM	2	0	4	MPW	DH
32INREGION01	Io Regional Map 01	I32IFMFG120	I32IFMFG36	FM	2	0	4	LPU	DI
32INREGION02	Io Regional Map 02	I32ILMFG252	I32ILMFG72A	LM	2	0	4	LPU	DJ
32JNGLOBAL01	Jupiter Global Obs 01	I32JXM10	I32JXMFG7	XM	2	0	4	LPU	DK
32JNGLOBAL02	Jupiter Global Obs 02	I32JXM10	I32JXMFG7	XM	2	0	4	LPU	DL
32INTHPELE01	Io Pele Map 01	I32ILM442	I32ILM144 B	LM	1	0	4	MPW	DA
32INTHLOKI01	Io Loki Map	I32ILM442	I32ILM144 B	LM	1	0	4	MPW	DB
32INTHPELE02	Io Pele Map 02	I32ILM442	I32ILM144 B	LM	1	0	4	MPW	DC
32INTHERML01	Io Thermal Map	I32ILM442	I32ILM144 B	LM	2	0	4	MPW	DD
32INEMAKNG01	Io Emakong Obs	I32ILM442	I32ILM144 B	LM	2	0	4	MPW	DE
32INITUPAN01	Io Tupan Obs	I32ILM442	I32ILM144 B	LM	2	0	4	MPW	DF
32INICHAAC01	Io Chaac Obs	I32ILM442	I32ILM144 B	LM	2	0	4	MPW	DG
32INHTSPOT01	Io Hot Spot Obs	I32ILM442	I32ILM144 B	LM	2	0	4	MPW	DH
32INREGION01	Io Regional Map 01	I32IFMFG120	I32IFMFG48	FM	2	0	4	LPU	DI
32INREGION01-gf	Io Regional Map 01	I32IFMFG120	I32IFMFG84	FM	2	0	4	LPU	DI
32INREGION02	Io Regional Map 02	I32ILMFG252	I32ILMFG72B	LM	2	0	4	LPU	DJ
32JNGLOBAL01-gf	Jupiter Global Obs 01	I32JXM10	I32JXMFG7	XM	2	0	4	LPU	DK
32JNGLOBAL01	Jupiter Global Obs 01	I32JXM10	I32JXMFG7	XM	2	0	4	LPU	DK
32JNGLOBAL02-gf	Jupiter Global Obs 02	I32JXM10	I32JXMFG7	XM	2	0	4	LPU	DL
32JNGLOBAL02	Jupiter Global Obs 02	I32JXM10	I32JXMFG7	XM	2	0	4	LPU	DL
32INTHPELE01-gf	Io Pele Map 01	I32ILM442	I32ILM144 B	LM	1	0	4	MPW	DA
32INTHLOKI01-gf	Io Loki Map	I32ILM442	I32ILM144 B	LM	1	0	4	MPW	DB
32INTHPELE02-gf	Io Pele Map 02	I32ILM442	I32ILM144 B	LM	1	0	4	MPW	DC
32INEMAKNG01-gf	Io Emakong Obs	I32ILM442	I32ILM144 B	LM	2	0	4	MPW	DE
32INITUPAN01-gf	Io Tupan Obs	I32ILM442	I32ILM144 B	LM	2	0	4	MPW	DF
32INHTSPOT01-gf	Io Hot Spot Obs	I32ILM442	I32ILM144 A	LM	2	0	4	MPW	DH

Note: Additional I32 data is scheduled for return in I33.

NIMS I32 DATA RETURN

Activity ID	Mode	Wave - lengths Returned	Record Time (sec)	PB Time (sec)	Comp	Total BTG (Mbits) (w/4% o'head)	Data Reduction Factor (sBOT/BTG)	Pass
32INTHPELE01	LM	144	243	239	1.38	0.599	4.60	2
32INTHLOKI01	LM	144	611	606	1.39	1.507	4.63	2
32INTHPELE02	LM	144	360	356	1.21	1.017	4.03	2
32INTHERML01	LM	144	186	182	1.85	0.340	6.17	2
32INEMAKNG01	LM	144	434	430	1.17	1.270	3.90	2
32INITUPAN01	LM	144	550	545	1.28	1.471	4.27	2
32INICHAAC01	LM	144	558	553	1.3	1.470	4.33	2
32INHTSPOT01	LM	144	732	728	1.22	2.062	4.07	2
32INREGION01	FM	36	3876	3870	1.22	5.482	4.35	2
32INREGION02	LM	72	1943	1935	1.29	2.592	4.60	2
32JNGLOBAL01	XM	7	2354	1459	1.85	3.448	2.61	2
32JNGLOBAL02	XM	7	2140	1269	2	2.774	2.82	2
32INTHPELE01	LM	144	243	239	1.35	0.612	4.50	3
32INTHLOKI01	LM	144	611	606	1.40	1.496	4.67	3
32INTHPELE02	LM	144	360	356	1.24	0.992	4.13	3
32INTHERML01	LM	144	186	182	1.87	0.336	6.23	3
32INEMAKNG01	LM	144	434	430	1.18	1.259	3.93	3
32INITUPAN01	LM	144	550	545	1.29	1.460	4.30	3
32INICHAAC01	LM	144	558	553	1.30	1.470	4.33	3
32INHTSPOT01	LM	144	732	728	1.21	2.079	4.03	3
32INREGION01	FM	48	3876	3790	1.22	7.158	3.27	3
32INREGION01-gf	FM	84	3876	68	1.18	0.232	1.80	3
32INREGION02	LM	72	1943	1935	1.29	2.592	4.60	3
32JNGLOBAL01-gf	XM	7	2354	53	1.86	0.125	2.62	3
32JNGLOBAL01	XM	7	2354	887	1.86	2.085	2.62	3
32JNGLOBAL02-gf	XM	7	2140	17	2.00	0.037	2.82	3
32JNGLOBAL02	XM	7	2140	857	2.00	1.874	2.82	3
32INTHPELE01-gf	LM	144	243	28	1.35	0.072	4.50	4
32INTHLOKI01-gf	LM	144	611	20	1.40	0.049	4.67	4
32INTHPELE02-gf	LM	144	360	131	1.24	0.365	4.13	4
32INEMAKNG01-gf	LM	144	434	295	1.18	0.864	3.93	4
32INITUPAN01-gf	LM	144	550	28	1.29	0.075	4.30	4
32INHTSPOT01-gf	LM	144	732	13	1.21	0.037	4.03	4
Note: Additional I32 data is scheduled for return in I33						49.302	TOTAL	
						48.86	ALLOCATION	
						0.442	OVER/UNDER	

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									

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									

RECAP OF I32 PLAYBACK EVENTS

The NIMS I32 dataset is of very high quality due to a relative abundance of downlink allocation bits that permitted us to return a large number of samples for observations covering very large areas. The Io REGION observations covered large portions of the visible surface, resulting in the detection of a number of new hot spots. A new, extremely hot area detected in I31 was imaged successfully in I32 (32INHTSPOT01).

The I32 encounter went very well, with no spacecraft 'despun bus resets' and only one harmless NIMS software halt. The latter occurred prior to a sequenced instrument software reload and had no negative effect on the recording of our observations.

One new type of spacecraft anomaly occurred during playback. DMS (tape recorder) was stopped by on-board fault protection software for a short period, interrupting playback. The favored explanation is a worn area on the physical tape, which had been used repeatedly as a stopping point during normal operations. Playback also paused autonomously due to a shortage of onboard playback commands, partly due to an oversight and partly due to a dearth of 2-way command passes for uplinking new segments of the playback table.

A very large number of data gaps due to problems at DSN stations occurred in December. We were able to fill the largest of the gaps in a 4th tape pass. Additional I32 gap-fill data is planned for return in I33 due to spacecraft safing during that encounter.

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.

I32 Playback Events Timeline (09-14-01 to 01-14-02)

09-14-01: (Y. Anderson) I32 Playback Allocation Update - 9/14/01
Playback will be initiated at 01-292/12:36, and will be terminated at 02-015/01:50
We currently have 257.567 MB for I32. Since SPOT holds 10.2 MB for margin and 7.73 MB for inefficiency, a total of 239.64 MB is allocated to the teams.
Compared with the total allocation (194.8 MB) at OAP, we have a 23% increase.

	Total Allocation	Playback Allocation	RTS Usage	OPG Allocation	MBTG Increase
SSI	77.748	77.748	0.000	63.2	14.548
NIMS	47.977	47.877	0.100	39.0	8.977
PPR	5.413	5.413	0.000	4.4	1.013
UVS/EUV	2.460	1.080	1.380	2.0	0.460
MWG	106.042	99.892	6.150	86.2	19.842
DDS	0.000	0.000	0.000	--	
RadioSci	0.000	0.000	0.000	--	
Total:	239.640	232.010	7.630	194.8	44.84

<u>I32 Playback Events Timeline</u> (09-14-01 to 01-14-02)

We have not taken out the bits-loss due to OPNAV activities in I32B in the above figures. The I31 OPNAVs (there are 8 of them) cost about 1.87 MB. For I32, we have only two OPNAVs planned so far. If this is the case in the final I32B sequence, the cost will be in the vicinity of 0.5 MB.

09-26-01: **This is the first delivery of this playback table, on a truncated schedule. The playback commands have reasonably accurate times, but data reduction factors and wavelength tables have not been tuned up. Mirage scripts to model the downlink bits requirements are not yet showing correct values, but this will be corrected soon. All singles are selecting the entire record time of their observations. All are showing pass 2 since the first pass will be for SSI preview purposes.**

09-27-01: **(Y. Anderson) Playback will now be initiated at 01-299/03:15, and terminated at 02-014/08:50. Initiate playback has been delayed by one week because of the extension of RTS data collection. MWG is willing to pay for the cost, 9.33 MB. It's likely that the terminate playback will be moved 7 hours earlier in the next sequence, but this bits-reduction has not been taken into account in this allocation update.**
We currently have a total capability 260.004 MB and playback capability of 255.074 MB for I32. (Note, playback capability = total capability - RTS bits. For I32, the RTS bits are 1.38 MB for EUV, 0.10 MB for NIMS & 2.65 MB autonomous fill due to NIMS reloads, 0.3 MB for DDS, and 0.5 MB for MAG.)
NIMS: 47.81 MB

10-09-01: **The table delivered today reflects a new strategy for 2-pass data return. In previous orbits we have placed about 1/3 to 1/2 of our bits in the second tape pass. This is done to prevent the spacecraft from generating and beaming down "fill." (This occurs when insufficient data is selected for playback; the multi-use buffer (MUB) may be emptied of data while the DMS is slewing across large expanses of tape to reach the next data selected for playback). The down side of placing observations or portions of observations in the second tape pass is the inability to fill gaps that may occur.**
Now that we are returning multiple samples from each detector (due to the stuck grating) we can play back a minimum set of samples for the full spatial area of observations in the first pass, and play back a complementary set of samples in the second pass. As long as the pass 1 and pass 2 gaps do not coincide, we will obtain full spatial coverage for our observations. With this strategy we can split our bits more or less evenly over the two passes, while having a much higher probability of receiving complete spatial coverage. In addition the potential for generation of fill packets ("inefficiency") in the second pass is significantly reduced.

I32 Playback Events Timeline (09-14-01 to 01-14-02)

In the table delivered today, all of the Io observations are played back twice, with full spatial coverage. The times of the selects and deselects are the same in the two passes; only the wavelengths (samples) selected for return are different. For the close-approach observations, we will get 12 samples in the initial tape pass, and the complementary 12 samples in the second pass.
For 32INREGION01, we will get 3 samples in the initial pass, and 2 more in the second pass. For 32INREGION02 we will get 6 samples in the initial pass and 6 more in the last one. Note that NIMS will be leaving behind 50% of the data recorded for these two observations. If we had an additional 16 Mbits of allocation we could get it all.
We cannot apply this strategy to the Jupiter global observations in this orbit since they are in fixed map mode with no redundancy of samples. We will get about 2/3 of the spatial coverage of each of these in the initial pass, with the rest following in the final pass. We are giving priority (first pass playback) to the southern hemisphere scans of 32JNGLOBAL01, and to the northern scans of 32JNGLOBAL02.
We are not returning data from detectors 5 and 16 in order to stay within our allocation.

10-12-01: (E. Theilig) The Galileo spacecraft is operating normally. Playback of data recorded during the Io 31 encounter is 95% complete and is scheduled to terminate on 10/13.
This week was spent preparing the spacecraft for the Io 32 encounter on 10/15. Close approach to Io will be shortly after 7:00 p.m. PDT (Earth-receive time) at a planned altitude of 181 km. The science command sequence is loaded and scheduled to begin Saturday 10/13 at 7:41 p.m. PDT (Earth-receive time). The attitude control system was configured on 10/12 for the radiation environment close to Jupiter. Other pre-encounter activities of note include a successful test of the camera flight software patch loaded last week and a routine conditioning of the tape recorder, scheduled for 10/13. The final targeting maneuver also occurs on 10/13. OPNAV images acquired earlier this week in support of maneuver development were only partly successful but confirm the radiometric orbit determination solution.

10-15-01: Perijove occurs at at 23:57 UTC. Io close approach occurs an hour and a half later at 01:24 on 10-16 (UTC).

10-15-01: (E. Theilig) Galileo Io 32 Status Report #1 - 10:30 p.m. PDT
The Galileo spacecraft is operating normally and all activities appear to be as planned. Close approach to Jupiter was at 5:37 p.m. PDT on 10/15 (Earth-receive time) at a range of 5.8 Jupiter radii. At 7:04 p.m. PDT Galileo achieved its closest approach to Io at a targeted altitude of 181 km. All planned Jupiter and Io observations to date appear to have been recorded successfully using two and three

quarter tracks of tape. Telemetry from the Solid State Imaging camera remains nominal. Earlier today, the DSN successfully recorded the Radio Science Jupiter Occultation using the RSR over DSS-43 (Canberra, Australia), between 11:58 a.m. and 2:34 p.m. PDT.
The spacecraft has now passed Jupiter close approach and the peak radiation level was 534 (measured by the star scanner in pulse counts), significantly lower than the maximum of 1400 seen in previous GEM orbits. There have been no radiation-related effects identified so far. All observation recording is proceeding according to plan. The expected end of the radiation danger is around 4:00 a.m. Tuesday morning.

10-16-01: (R. Mehlman) Cumulative from NIMS realtime engineering data:

SCLK	SCET	Position	Item
6255902	289/00:48	Between THPELE01 and THLOKI01	Good SCLK, so THPELE01 OK
6255928	289/01:14	Last RIM of THPELE02	Nominal HWSTAT: gs1, chop ref
6255935	289/01:21	Between THPELE02 and THERML01	Good SCLK, so THPELE02 OK
6256113	289/04:21	Just after REGION01 and	Nominal HWSTAT: gs2, chop ref
6256120	289/04:28	3 hours before REGION02	Good SCLK, so REGION01 OK
6256331	289/08:01	An hour after REGION02	Nominal HWSTAT: gs2, chop ref
6256337	289/08:07		SCLK, so REGION02 OK
6256888	289/17:25	Four hours before GLOBAL01	Anomalous HWSTAT (X00)
6256895	289/17:31		CDS rec'd SCLK of 6256885, indicating NIMS S/W halt 10 RIMS before receipt. But there's a reload coming.

10-16-01: (E. Theilig) Galileo Io 32 Status Report #2 - 4:30 p.m. PDT. The Galileo spacecraft is operating normally and all activities appear to be as planned. The current status is from the DSS 43 pass at 3:30 p.m. PDT. All observation recording is proceeding according to plan. The only identified radiation related effect so far has been a NIMS memory upset which was corrected by a memory reload built into the science sequence. The critical part of the encounter is over with almost 90% of the remote sensing observations complete. There remains a PPR calibration and a NIMS observation tonight and a series of SSI observations of Jupiter and the gossamer rings on Thursday. Continuous fields and particles data collection will continue until October 26 at which time playback will begin.
At this time both spacecraft health and remaining propellant allow us to plan a nominal Io 33 encounter in January.

10-17-01: (R. Mehlman) Update from NIMS realtime engineering data

SCLK	SCET	Position	Item
6257128	289/21:27	Last RIM of GLOBAL01	Nominal HWSTAT: gs2, chop ref
6257135	289/21:34	Six minutes after GLOBAL01	Good SCLK, so reload and GLOBAL01 OK
6257200	289/22:39	4 1/2 hours before GLOBAL02	Good SCLK
6257488	290/03:32	Eight minutes after GLOBAL02	Nominal HWSTAT: gs2, chop ref
6257495	290/03:38	14 minutes after GLOBAL02	Good SCLK, so GLOBAL02 OK

I32 Playback Events Timeline (09-14-01 to 01-14-02)

10-17-01: No changes to last week's playback table were made for this delivery. NIMS requests for AACS data were expanded to include the ends as well as the beginnings of data-taking slews for 32INREGION01, 32INREGION02, 32JNGLOBAL01, and 32JNGLOBAL02.
Playback will begin on October 26.

10-17-01: (K. Schimmels) I want to congratulate the whole team on a job well done with I32. It was a lot of work, and we did a lot of contingency planning and I want to thank all of you for your inputs into the contingency and jump start process last week. Since we were well prepared, we didn't even need any of it. Thank you for your hard work! Also, this has been the first orbit since E19 that we haven't experienced a BURP during the encounter!

10-31-01: I made no changes to the prior version of the playback table for today's delivery as no NIMS data has reached the ground and no changes to allocation have been made.

11-13-01: On-board fault protection software detected a problem with the DMS (tape recorder) and shut it down, interrupting playback.

11-14-01: (E. Theilig) Data collected during a test of the Galileo tape recorder Wednesday evening indicate that the tape successfully moved one tic as commanded and the recorder locked up on data being read from the tape. This plus normal motor currents suggest that the problem detected by fault protection on 11/13 may be the result of surficial coating or damage to a small section of the physical tape. The problem location is a commonly used stopping point and may have accumulated damage through time. At this time there is no indication of a hardware failure in the tape recorder.
The next step is to reposition the tape and to restart playback, probably by Thursday night 11/15.

11-16-01: (S. Thompson) MCT DAILY SUMMARY
The DMS was moved successfully to TINC 700 (REVTK2) as hoped per CMD file 01E174. A "GO" was then given to send the Initiate Playback command and Playback Table.
Reception of playback packets was verified at 07:20.

11-16-01: (E. Theilig) The primary activity over the past week has been the investigation and recovery of a tape recorder DMS (Data Memory Subsystem) anomaly. As of 03:00 PST on 11/16, the tape has been repositioned and playback resumed.
Since the initial problem, all tape motion has been normal suggesting that the problem detected by fault protection on 11/13 may be the result of surficial coating or damage to a small, localized section of the physical tape. This damage could prevent the tape manager from synchronizing with data

being read from the tape and, after a certain number of out-of-synch counts, tripping fault protection that stops the tape and locks out subsequent commands. Prior to repositioning the DMS for playback, the tape was moved in both the forward and reverse directions over the suspect location while buffering DMS status and motor current measurements in onboard memory. These data will be read out on 11/17 and be used to characterize the damaged area. Slewing across the suspect area confirms that we can proceed with normal usage of the tape; however, the routine tape conditioning commands will be changed to avoid stopping the tape at this location.
Playback is scheduled to terminate on 1/14/02.

10-16-01: (Y. Anderson) This playback table starts from where we left off. The first SELECT in I32PDB corresponds to tic 679 on track 2, which was near the end of 32MBTOTUS_01. Everything from this restart point to the end of Segment 4 in the previous I32PCD becomes the new Segment 1 in I32PDA. The rest of segments are the same as before.
UPDATE SCHEDULE: No update next week. The following week (after Thanksgiving) will be the first opportunity to affect Segments 5 and 6 (old segments 8 and 9).

11-29-01: (Y. Anderson) Playback is currently in Segment 4. Track 4, Tic 4888 (as of 5:40 AM, 11/29). We are a little ahead of schedule and playback is about 40% complete.

12-10-01: I have delivered a new I32 playback table today. Only one change has been made. I have increased the number of pass 3 grating steps played back for 32INREGION01 from 2 to 4. This has been made possible by better-than-predicted compression of our Io and Jupiter data so far.
The next scheduled update for I32 is not until 7 January.

12-14-01: There will be a pbt update next week for I32, and we will be able to go after our Jupiter globals gaps. If there are any highly desirable SSI Io ridealongs, let me know (no word on pass 4 yet).

12-14-01: (K. Schimmels) In order to consider a fourth pass, we need to a) analyze the remaining capability and inefficiency expected thoroughly, to be sure we'll finish the playback planned in pass 3 and have enough time to do a 4th pass (this is significant work for Yanhua, but needs to be done anyway)...
b) know where the data is you plan to pick up in pass 4. If it's on the first track, that's easier than going further - we are in much higher data rates now, hence much more inefficient. I don't know that other teams want to sign up to spending bits on inefficiency in pass 4, either, they would need to be polled. The cost of slewing half a track

alone could cost NIMS' entire 0.5 MB at this point in our capability. Yanhua would again have to analyze the approximate cost of slewing involved to get to your data. c) who is last on the tape, i.e. who is last currently in the playback table? If it's NIMS you could overselect and take your chances perhaps, but that depends on other teams, again. 0.5 MB isn't much to go into a 4th pass with, so I don't know how likely it is unless there is much more desire from other teams (and bits to pay for it)

12-18-01: There is a delivery of the I32 playback table tomorrow and I have a little nit-picky choice of strategies question. This involves choosing the lesser of 2 evils, and not making the on-the-ground processing any harder than it has to be. We commanded 3 samples / grating steps for return in the first pass over the tape, and we are asking for 4 more in the next pass.
We have a couple of gaps (1 RIM, 1/3 RIM) in the first try data. If we don't change anything, and we don't get gaps over the same data in the next pass, we will have complete spatial coverage, with fewer samples than average in the gap areas. Nothing to complain about.
However, we have about .5 Mbits available, a 4th pass does not seem to be feasible (high data rates, lots of inefficiency), and we could do the following:

- **stop part way through the next pass playback (4 samples),**
- **change the wavelength table to get 7 samples for the gap,**
- **stop playback, change the WET back to 4 samples, start again.**

Due to DMS realities, we will still have chunks of time where we do not have all the desired samples. However, these will be only about 1 grating cycle long. There would be one chunk at the start of the gap, and one more at the end. But we would get all the samples, over most of the big gap we now have. If the area turns out to be interesting, having more samples would be desirable.
In processing, there would be 3 chunks of final-pass data, using 2 wavelength tables, where there is now only one block of data with one wavelength table. This is, I think, a downside.

12-19-01: The playback table delivered today has six new sets of commands for filling gaps in our data. Four of these are for 32JNGLOBAL01-02; these employ the same wavelength edit tables as in pass 2. For 32INREGION01 we are doing something a little different. As of last week we planned to replay this from start to finish using a table commanding a complementary set of wavelengths to that brought down originally. However there is a significant gap in our pass 2 data that we will fill in the current pass (3). Thus now the first and third sets of playback commands for 31INREGION01 in pass 3 will contain the complementary set

of wavelengths as before. The second set (for the gap) returns all 7 grating positions. A new OBSTAB will be required for processing this data. (The grating positions are 1,3,5,6,7,9,11).
It is possible that a some additional downlink allocation may become available later on. The next potential update is in the week of January 2. We are currently about .4 Mbits under our allocation.

12-20-01: (Y. Anderson) The spacecraft went into autonomous pause last night. It was at about 7:15. Seg 11 was sent around 10:40. Took 35 minutes to get there. So we lost about 4 hours (from 7:15 to 11:15) playback. The capability during this period is 1.065MB. Sorry this happened.
The remaining SPOT margin is just able to cover it.

01-03-02: Happy new year..! The holidays were not kind to us. Problems at various DSN stations occurred almost daily. More than two dozen gaps are present in the NIMS observations returned since about 20 December.
We have sufficient remaining downlink resources to make use of a 4th pass over the tape. In today’s update I added 6 new sets of playback commands to fill the largest of the gaps in the observations returned over the holidays. Many small gaps could not be commanded for return due to a software limitation of the on-board playback manager. When a large number of 3-byte edit groups is required to specify the wavelength selection for playback, we can enter only about 3 sets of commands in any given "segment," and only 4 segments may be present on-board the spacecraft at one time. If the CDS runs out of segments, playback pauses until new segments can be uplinked. In the present situation, entering commands to fill all our gaps would result in pausing playback several times, defeating the purpose.

01-13-02: (R. Mehlman) Looks like we got some or all of our last gap-fill request (INHTSPOT01) and the MCT summary indicates playback is already on track 4, ahead of schedule, beyond our last request.

NIMS Anomaly Report - I32 Sequence

The NIMS grating became stuck prior to the I24 encounter. The grating continued to be stuck for the I32 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 once during the I32 Encounter. There was no CDS Bus Reset (BURP) event at the same time. The halt occurred at a time when NIMS was not taking data. A NIMS software reload restarted the flight software.

The spacecraft did not safe during the I32 Encounter and did suffer any Bus Resets which would precipitate a NIMS halts.

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.

Response to Stuck Grating Anomaly (I32)

At I32 the cause of the stuck grating was not known (and is still not clearly understood). No attempts were made during I32 to unstick the grating.

Processor Halts

There were one NIMS processor halt during I32. The halt was detected by the NIMS engineering but was not coincident with any CDS Bus Reset event. The halt occurred at a time when NIMS was not taking any data. The NIMS software reload prior to the NIMS observation 32JNGLOBAL01.

Anomaly Timing:

6256888	01-289/17:25:12	Anomalous Hardware Status Word (x00)
6256895	01-289/17:31:52	6256885 SCLK reported (anomalous)
6257101	01-289/21:00:09	NIMS Software Reload (30INGLOBAL01)
6257135	01-289/21:34:32	6257133 SCLK reported

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.

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.