Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the I24 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the I24 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.

There were sixteen autonomous reloads of the NIMS RAM code from CDS during the I24 encounter, one just before each science observation. No primary observations were lost due to a NIMS processor halt. A single unprotected ride-along observation was lost due to an apparent processor halt. 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 spacecraft safed due to a CDS memory error during I24 inbound. CDS was restarted and the sequence recovered in time for the I24 Io Flyby.

The plots on the pages 3, 4 and 5 show the geometry of the NIMS I24 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 'returned' I24 data returned during I24 cruise.

The text on page 10 gives a 'recap' of the I24 playback events which affected which observations were returned.

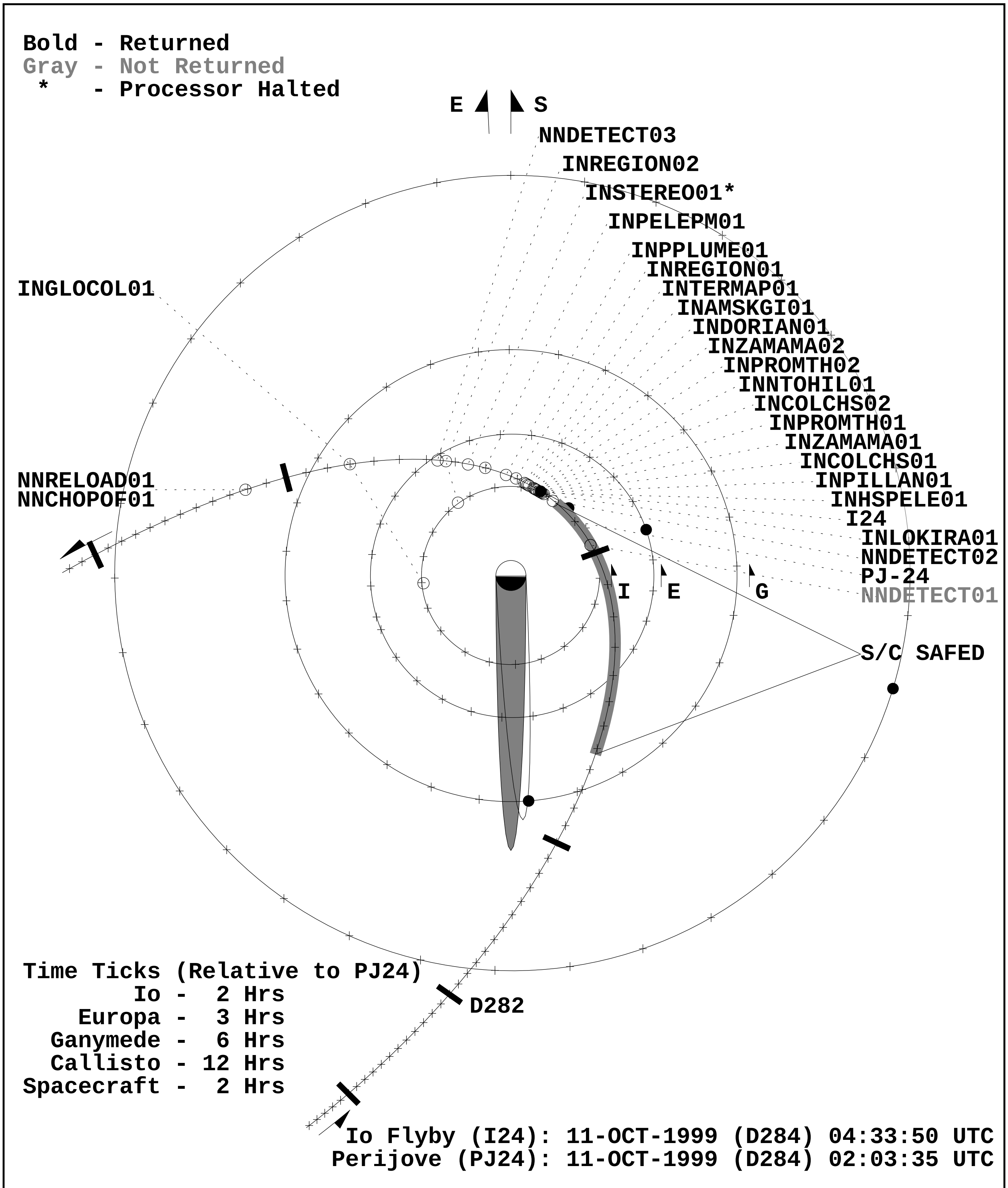
A Timeline of I24 playback events is on pages 10 through 19.

The text on pages 20 through 22 describes the I24 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.

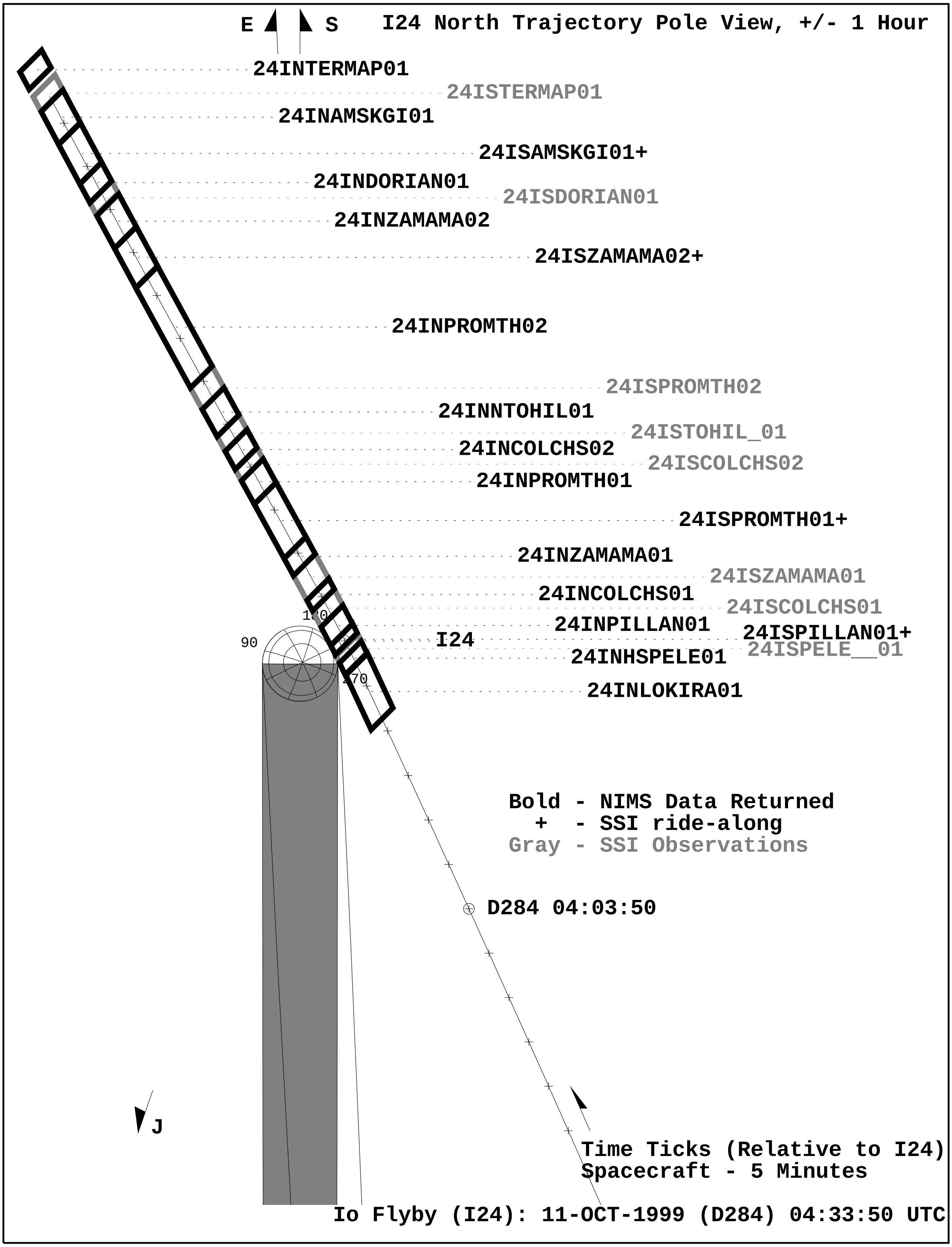
NIMS I24 OBSERVATIONS



I24 North Trajectory Pole View

NIMS - FEL - 09/15/00

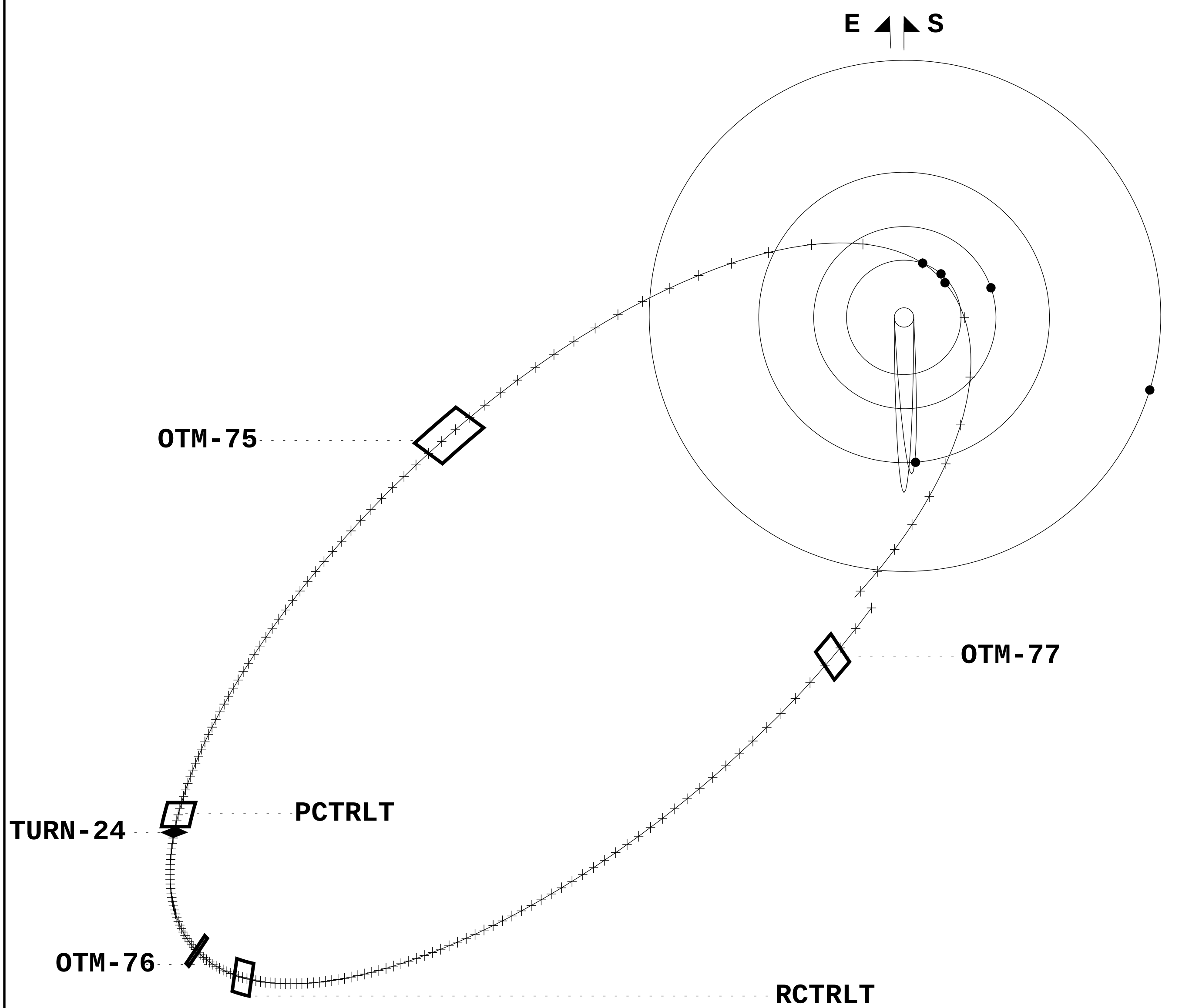
NIMS & SSI I24 IO FLYBY OBSERVATIONS



NIMS I24 CRUISE CALIBRATIONS

Io Flyby (I24): 11-OCT-1999 (D284) 04:37:21 UTC
Perijove (PJ24): 11-OCT-1999 (D284) 02:05:11 UTC
Apojove (AJ24): 02-NOV-1999 (D306) 17:00:00 UTC

Time Ticks (Relative to I24)
Spacecraft - 6 Hours



I24 North Trajectory Pole View, Perijove to Perijove

NIMS I24 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format	PSID
24NNDETECT01	Grating Step Test								
24NNDETECT02	Grating Step Test								
24INLOKIRA01-	Io Loki Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INHSPELE01-	Io Pele Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INPILLAN01-	Io Pillan Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INCOLCHS01-	Io Colchs Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INZAMAMA01-	Io Zamama Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INPROMTH01-	Io Prometheus Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INCOLCHS02-	Io Colchs Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INNTOHIL01-	Io Tohil Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INPROMTH02-	Io Prometheus Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INZAMAMA02-	Io Zamama Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INDORIAN01-	Io Dorian Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INAMSKGI01-	Io Amskgi Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INTERMAP01-	Io Termap Obs	I24ILM442	I24ILM360	LM	3	0	4	MPW	
24INREGION01-	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INPPLUME01-	Io Plume Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INPELEPM01-	Io Pele Plume Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INREGION02-	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24NNDETECT03	Grating Step Test								
24NNRCTRLT01-	RCT Calibration	I24RCT252	R/T	LM	1	0	4	R/T	
24NNROPCAL01	NIMS OPCAL	I24OPCAL48	R/T	LM	4	0	4	R/T	
24NNPCTRLT01-	PCT Calibration	I24PCT252	R/T	LM	4	0	4	R/T	
24INLOKIRA01-	Io Loki Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INPROMTH02-	Io Prometheus Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INREGION01-	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INPPLUME01-	Io Plume Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INPELEPM01-	Io Pele Plume Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INREGION02-gf	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	

NIMS I24 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format	PSID
24INREGION02-	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INGLOCOL01+	Io Global Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INHSPELE01-gf	Io Pele Obs	I24ILM442	I24ILM360	LM	4	0	4	MPW	
24INPILLAN01+	Io Pillan Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INPROMTH01+	Io Prometheus Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INCOLCHS02-gf	Io Colchs Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INNTOHIL01-gf	Io Tohil Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INPROMTH02-gf	Io Prometheus Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INZAMAMA01+ (A)	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INZAMAMA01+ (C)	Io Zamama Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INZAMAMA02-gf	Io Zamama Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INAMSKGI01+ (A)	Io Amskgi Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INAMSKGI01+ (B)	Io Amskgi Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INAMSKGI01-gf	Io Amskgi Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INREGION01-gf	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INSTEREO01+	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INREGION02-gf	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	
24INGLOCOL01+gf	Io Region Obs	I24ILM442	I24ILM360	LM	2	0	4	MPW	

NIMS I24 DATA RETURN

Activity ID	Mode	Record Format	Wave-lengths Returned	Record Time (sec)	PB Time (sec)	Selected Bits of Tape sBOT (MBITS)	Total Bits of Tape BOT(Mbit)	Mode Cycle (sec)	Comp	Thold	RT	Total BTG Mbits (4% ohead)	Data Reducton FActor (sBOT/BTG)	Pass
24NNDETECT01														
24NNDETECT02														
24INLOKIRA01-	LM	MPW	360	300.00	150.00	1.73	3.46	8.667	1.20			1.0800	1.60	1
24INHSPELE01-	LM	MPW	360	52.02	51.40	0.59	0.60	8.667	1.23			0.3610	1.64	1
24INPILLAN01-	LM	MPW	360	52.02	51.40	0.59	0.60	8.667	1.30			0.3416	1.73	1
24INCOLCHS01-	LM	MPW	360	52.02	51.40	0.59	0.60	8.667	1.45			0.3063	1.93	1
24INZAMAMA01-	LM	MPW	360	52.02	51.40	0.59	0.60	8.667	1.28			0.3469	1.71	1
24INPROMTH01-	LM	MPW	360	52.02	51.40	0.59	0.60	8.667	1.17			0.3796	1.56	1
24INCOLCHS02-	LM	MPW	360	52.02	51.40	0.59	0.60	8.667	1.23			0.3610	1.64	1
24INNTOHIL01-	LM	MPW	360	52.02	51.40	0.59	0.60	8.667	1.11			0.4001	1.48	1
24INPROMTH02-	LM	MPW	360	420.00	214.00	2.47	4.84	8.667	1.12			1.6508	1.49	1
24INZAMAMA02-	LM	MPW	360	156.00	155.35	1.79	1.80	8.667	1.11			1.2092	1.48	1
24INDORIAN01-	LM	MPW	360	52.02	51.40	0.59	0.60	8.667	1.22			0.3640	1.63	1
24INAMSKGI01-	LM	MPW	360	156.00	155.35	1.79	1.80	8.667	1.12			1.1984	1.49	1
24INTERMAP01-	LM	MPW	360	78.00	77.34	0.89	0.90	8.667	1.23			0.5432	1.64	1
24INREGION01-	LM	MPW	360	1,920.00	966.00	11.13	22.12	8.667	1.20			6.9549	1.60	1
24INPPLUME01-	LM	MPW	360	300.00	154.00	1.77	3.46	8.667	1.22			1.0906	1.63	1
24INPELEPM01-	LM	MPW	360	300.00	157.00	1.81	3.46	8.667	1.22			1.1118	1.63	1
24INREGION02-	LM	MPW	360	986.00	547.00	6.30	11.36	8.667	1.33			3.5533	1.77	1
24NNDETECT03														
24NNRCTRLT01-														
24NNROPCAL01														
24NNPCTRLT01-														
24INLOKIRA01-	LM	MPW	360	300.00	158.00	1.82	3.46	8.667	1.20			1.1376	1.60	2
24INPROMTH02-	LM	MPW	360	420.00	214.00	2.47	4.84	8.667	1.11			1.6657	1.48	2
24INREGION01-	LM	MPW	360	1,920.00	962.00	11.08	22.12	8.667	1.20			6.9261	1.60	2
24INPPLUME01-	LM	MPW	360	300.00	154.00	1.77	3.46	8.667	1.15			1.1570	1.53	2
24INPELEPM01-	LM	MPW	360	300.00	151.00	1.74	3.46	8.667	1.20			1.0872	1.60	2
24INREGION02-gf	LM	MPW	360	986.00	127.00	1.46	11.36	8.667	1.30			0.8440	1.73	2

5/01/00

NIMS I24 DATA RETURN

Activity ID	Mode	Record Format	Wave-lengths Returned	Record Time (sec)	PB Time (sec)	Selected Bits of Tape sBOT (MBITS)	Total Bits of Tape BOT(Mbit)	Mode Cycle (sec)	Comp	Thold	RT	Total BTG Mbits (4% ohead)	Data Reducton FActor	Pass
24INREGION02-	LM	MPW	360	986.00	447.00	5.15	11.36	8.667	1.30			2.9707	1.73	2
24INGLOCOL01+	LM	MPW	360	51.00	49.00	0.56	0.59	8.667	1.30			0.3256	1.73	2
24INHSPELE01-gf	LM	MPW	360	52.02	12.00	0.14	0.60	8.667	1.20			0.0864	1.60	3
24INPILLAN01+	LM	MPW	360	32.00	30.00	0.35	0.37	8.667	1.15			0.2254	1.53	3
24INPROMTH01+	LM	MPW	360	23.00	21.00	0.24	0.26	8.667	1.15			0.1578	1.53	3
24INCOLCHS02-gf	LM	MPW	360	52.02	36.00	0.41	0.60	8.667	1.20			0.2592	1.60	3
24INNTOHIL01-gf	LM	MPW	360	52.02	20.00	0.23	0.60	8.667	1.10			0.1571	1.47	3
24INPROMTH02-gf	LM	MPW	360	420.00	23.00	0.26	4.84	8.667	1.11			0.1790	1.48	3
24INZAMAMA01+ (A)	LM	MPW	360	14.00	12.00	0.14	0.16	8.667	1.15			0.0902	1.53	3
24INZAMAMA01+ (C)	LM	MPW	360	14.00	12.00	0.14	0.16	8.667	1.15			0.0902	1.53	3
24INZAMAMA02-gf	LM	MPW	360	156.00	30.00	0.35	1.80	8.667	1.10			0.2356	1.47	3
24INAMSKGI01+ (A)	LM	MPW	360	14.00	12.00	0.14	0.16	8.667	1.15			0.0902	1.53	3
24INAMSKGI01+ (B)	LM	MPW	360	14.00	12.00	0.14	0.16	8.667	1.15			0.0902	1.53	3
24INAMSKGI01-gf	LM	MPW	360	156.00	30.00	0.35	1.80	8.667	1.10			0.2356	1.47	3
24INREGION01-gf	LM	MPW	360	1,920.00	298.00	3.43	22.12	8.667	1.20			2.1455	1.60	3
24INSTEREO01+	LM	MPW	360	102.00	100.00	1.15	1.18	8.667	1.30			0.6646	1.73	3
24INREGION02-gf	LM	MPW	360	986.00	114.00	1.31	11.36	8.667	1.30			0.7576	1.73	3
24INGLOCOL01+gf	LM	MPW	360	51.00	11.00	0.13	0.59	8.667	1.30			0.0731	1.73	4
												42.9041		
									Alloc.			47.9620		
									Over			-5.0579		

5/01/00

RECAP OF I24 PLAYBACK EVENTS

I24 represented the Galileo spacecraft's first return to the inner portions of Jupiter's magnetosphere since Jupiter Orbit Insertion (JOI), with the goal of imaging Io at high resolution. The more intense radiation experienced apparently caused a number of problems. A spacecraft safing occurred approximately 19 hours prior to Io close approach, but a revised encounter sequence was transmitted to the spacecraft in time for recording of the planned close approach observations. A location in one of the CDS memory buffers was permanently damaged, necessitating some adaptive maneuvering. Although no NIMS software crashes were noted, a problem involving either the grating drive electronics or the physical grating drive itself resulted in a "stuck" grating. It was determined that the grating appeared to have become stuck at one end of its range of motion, which had the effect of reducing the number of wavelengths that could be recorded from 360 (15 detectors x 24 grating steps) to 15 (15 detectors, single grating position). In addition, detectors 1, 2, and 7 began to record very low signal levels, due apparently to the shift in wavelength (due to the stuck grating) to a range where obscuration by the built-in blocking filters became a problem. On the other hand, oversampling of the 12 (or 15) wavelengths (due to no grating motion) resulted in high-quality, low-noise observations with great spatial detail. The extraordinary Io images that resulted received considerable attention, particularly since many of SSI's initial images came down in scrambled form.

The following timeline details the most signifigant events of the I24 playback period. Most of the text below is excerpted from messages issued at the time.

I24 Playback Events Timeline (08-31-99 to 11-24-99)

08-31-99: **(M. Segura) The I24 sequence is designed very differently from anything we've ever done before. The I24 closest approach period has minimal to no stand-alone NIMS observations. All the targeting or pointing is done within the SSI observations. The bulk of the observations are sit and stare with NO planned scan platform motion. The observations have been very tightly integrated in time and tape space as well.**

09-02-99: **(J. Gross) Here are your first I24 PB allocations, based on the I24ABA and I24BDA products. The team allocations are based on percentages derived from the GEM OPG, with this minor exception: at the June PSG PPR was allocated 2.0 MB "off the top" for Jupiter radiometry experiments. SSI/NIMS/UVS/MWG/DDS have all seen their OPG percentages decrease slightly in order to accomodate PPR.**
NIMS 42.605

09-16-99: **(J. Gross) I've looked at the capability in the latest I24 cruise product (I24BFA) and we took a slight 2.5% hit. Here are your updated allocations:**
NIMS 41.742

<u>I24 Playback Events Timeline</u> (08-31-99 to 11-24-99)

09-23-99: **(J. Gross) There is a PBT delivery on the schedule for Thursday, Oct 7 (final I24B product is out Oct. 5), but we will most likely not need this delivery BEFORE playback initiates late Monday the 11th.**

09-30-99: **(J. Erickson) Decision Regarding Use of DMS Turns and DMS Track Changes in I24A. The purpose of this memo is to document the decision to use all Track Changes and no DMS Turns in I24A.**
Background: The goal in developing the I24A DMS strategy was to maximize the chances that the highest priority I24A science would be successfully recorded. The highest-priority science was the recordings roughly +/- one hour around Io closest approach, which used the entirety of Tracks 3 and 4. The nominal record plan began on Track 2, executed a DMS Turn from Track 2 to Track 3, executed a Track Change from Track 3 to Track 4, and executed a DMS Turn from Track 4 to Track 1. The record sequence then ended on Track 1. However, questions were raised about the use of DMS Turns. Testbed testing showed that there are a number of possible fault scenarios which could result from a Despun Bus Reset during a DMS Turn. A single Despun Bus Reset during a DMS Turn with BURP enabled could result in the DMS continuing to slew into the marker for 50 tincs until it is halted by fault protection. This would result in the loss of further I24A science recordings, but would not be fatal to the DMS. Based on the statistics of the Despun Bus Resets that have occurred up through and including C23, the total probability of this failure is estimated at 0.3 - 6.9%. A single Despun Bus Reset during a DMS Turn with BURP enabled could result in the DMS failing to recognize the edge of the marker as it slews out of the marker on the desired track. The DMS then continues slewing toward the opposite end of the tape in search of the other marker. This slew would be stopped by fault protection 50 tincs into the second marker. This fault would result in the loss of all I24A recordings after the start of the DMS Turn, but would not be fatal to the DMS. However, if a second Despun Bus Reset occurred during the slew across the tape, it could result in the tinc counter being reset in the middle of the tape. This could result in subsequent record activities writing over the marker and onto the tape beyond the marker. If the Beginning of Track marker is overwritten in this fashion, it is believed that the DMS could be recovered in time for I25A. If the End of Track marker is overwritten, it is believed that this would be a catastrophic loss of the tape recorder. The total probability of the two Despun Bus Resets resetting the tinc counter in the middle of the track is estimated at 0.01 - 0.2%.

A single Despun Bus Reset during a DMS Turn with BURP disabled will result in spacecraft safing and the loss of further recording in I24A, but would not be fatal to the DMS. Total probability of this failure is estimated at 1.7 - 17.2%. However, there are also risks associated with not doing DMS Turns. The function of the DMS Turn is to re-synchronize the tape and the CDS knowledge of the tape position by slewing to the edge of the marker and resetting the tinc count. This mitigates the problems that arise in the event that the DMS sticks and slips, which can result in a large mismatch between the actual tape position and the CDS tinc count. However, throughout the Prime Mission and GEM, there have been approximately 35000 DMS start/stop cycles with no evidence of sticking and slipping. Therefore the probability of sticking and slipping is estimated to be in the range of 0.003%.
Decisions: The two DMS Turns in I24A will be replaced with Track Changes. The risks associated with doing DMS Turns, either with BURP enabled or disabled, were deemed unacceptably high, given the above statistics. The cost of doing all Track Changes in I24A necessitated cuts of 140 tincs to the Track 1 record plan in order to meet the DMS rules on accumulated uncertainty and margin. The affected teams, SSI and NIMS, agreed that these cuts were preferable to the risks associated with doing DMS Turns.

10-10-99: Start of I24 encounter (04:00 UTC).

10-10-99: Spacecraft enters safe mode at approximately 09:30 UTC.

10-11-99: Perijove occurs at 02:03 UTC.

10-11-99: (M. Segura) The latest news is: Uplink of the I24 prime sequence was successful. The encounter load picked up ~ 284/03:30:00 SCET.
2. The instrument telemetry indicates all is well. The hardware status indicates chopper ref/gain state 4 and the clock reading indicates active phase 2 software just at the first memory copy command in the first grating step test segment.
3. Other engineering telemetry indicates that the scan platform and DMS are in working order and recording our first Io observation.
4. We did see a rise in temperature of the electronics of 5 DN but that dropped off fast and the instrument is now sitting at 169 DN as it was prior to the safing evnt.

10-11-99: Io close approach occurs at 04:33 UTC.

<u>I24 Playback Events Timeline</u> **(08-31-99 to 11-24-99)**

10-12-99: **(M. Segura) The memory error or corruption occurred in the circular buffer which stores the PPR Burst to Tape data and the NIMS LPU and LNR data on the record side of things (data is moved from instrument to buffer and then on to tape) and all SSI data is placed in that buffer area on the playback side (data is moved from tape to buffer for editing and then telemetered to ground). This memory error could well be a transient or a permanent memory failure and testing to determine which is the case will occur over the next few days.**

Meanwhile - all except the first BPT of PPR data was lost in I24 as well as the MWG torus recording (the BPTs due to the memory error and the torus due to safing recovery time). This has implications for both the playback of I24 data and the taking of I25 data for NIMS. The I24 data playback is a positive impact for now. The project, in order to give the troops time to diagnose the memory corruption (transient or permanent), pulled out all the SSI data return from the first few segments of playback. This means that all of the NIMS closest approach data should be on the ground by Monday, Oct 17th. The BTG allocation will undoubtedly increase somewhat due to the loss of the torus data.

10/15/99 **(J. Erickson) The Galileo spacecraft is operating normally. The primary activities over the past week have been the pre-encounter safing on October 10, the safing recovery, the Io 24 encounter, and the beginning of the Io 24 playback. At 3:09 a.m. PDT ground receipt time (19 hours prior to the Io 24 close approach on 10/10, a memory chip error caused a spacecraft safing. The spacecraft was returned to normal operations, and a revised encounter sequence was transmitted to the spacecraft to avoid the use of the suspect memory area. This was accomplished in time to resume normal encounter operations at 8:00 p.m. ground receipt time. All observations for Io close approach were made as planned, but some pre-encounter PPR observations and fields and particles Io torus recording was not accomplished due to the memory anomaly.**

Playback of the Io 24 data began on 10/11, but the initial playback will be done without playback of SSI data. The bad memory chip is located in a buffer area used for recording three types of data (PPR and two types of NIMS), and is also used for the playback of imaging data. Memory testing is continuing, in order to identify the particular bit (or bits) that is bad, with a goal of beginning imaging data playback during the week of 11/18. The area of failed memory has been isolated to a unique 127-byte area.

10-15-99: **Problems with detectors 1, 2, and 7 in data tubes are reported (J. Shirley, R. Mehlman). This is the first indication of the stuck grating.**

10-20-99: (J. Gross) Duane and I have come up with a plan for releasing the "unusable" MBTG from MWG and PPR. After estimating the remaining need for BTG for PPR and MWG, there were 41.5 MB available for release. We set aside 13.5 MB as SPOT Margin to cover expected/feared station losses in the coming weeks. That left 28 MB to be given out. The OPG split between SSI/NIMS was roughly 3:1, so SSI was given 21 additional MB and NIMS received 7 MB.
Therefore, as of Monday AM, October 18, here is how the allocations v. usage for each team looked:

	TOTAL	PB	PB	RTS	UNUSED
NIMS	48.582	47.962	37.129	0.620	10.833

2-Pass inefficiency margin = 10.481 MB
SPOT Margin = 15.5 MB

10-22-99: A revised version of our playback table was delivered this afternoon. Ten sets of singles have been added to the table, commanding playback of the NIMS data embedded within the AI8, IM4, and IM8 SSI recordings. Only a minority of the SSI observations contained NIMS data in useful quantities, and in some cases we could not retrieve our data because we were issuing instrument commands to NIMS while the SSI data was being recorded. (The I24 sequence was packed very tightly and therefore commands to reload the NIMS software were sometimes placed within the periods when SSI data was recorded).
For all of the ride-along observations listed below we will receive one (or more) strip(s) of 20 pixels, in which data recorded over at least 0.5 of an instrument cycle is present. The total downlink bits required amounts to about 1.9 Mbits. The new observation names are differentiated from our own by the addition of the plus sign (+) at the end of the name. In the playback singles, in addition, the observation description field contains the words "with SSI."

Observation	Duration (sec)	PSID
24INPILLAN01+	30	EB
24INPROMTH01+	21	EC
24INTOHIL_01+	6	ED
24INZAMAMA01+ (A)	12	EF
24INSAMAMA01+ (B)	12	EG
24INZAMAMA01+ (C)	12	EH
24INAMSKGI01+ (A)	12	EJ
24INAMSKGI01+ (B)	12	EK
24INSTEREO01+	100	EL
24INGLOCOL01+	49	EZ

Of these, only the last can be returned in the current tape pass (2). The balance will come down during November.

10-22-99: (J. Erickson) Testing of the memory failure discovered at I24 was completed on Saturday, October 16. There is a hard failure in HLMB in an area used as a buffer during burst PPR to tape. Fortunately, the stuck bit is outside the area used for SSI playback processing and for NIMS LNR and LPU recording. Efforts are underway to patch the flight software to work around the bad address.

A reserved box sequence was generated to acquire fields and particles, dusk side observations. This sequence uses the maneuver box and will end on November 1, a few days short of apojove.

Prior to OTM-75, some of the AACS parameter changes made for the I24 encounter were removed by real-time commanding. Fault monitors 1 (Acquisition Sensor Output), 23 and 24 (Spin Rate too high/low) were enabled and the default POR table was updated to match the current fault monitor states and to disable the spin detector. In addition, gyro scale factors were updated.

Data from the auto-gyro drift calibration performed prior to OTM-75 indicated that the drift rate had significantly increased since the previous calibration. The drift rate is different from the scale factors. The later have not changed significantly.

The I25 development schedule has been adjusted to allow for reworking the SSI observation strategy to use IM8 rather than AI8 imaging mode. The latter mode experienced difficulties at I24 in the high radiation environment.

Real-time commanding is being done to investigate the NIMS grating behavior. Data returned from I24 indicate that the grating experienced a problem that progressively got worse during the encounter. NIMS memory loads are being checked for fidelity and then attempts will be made during the PCT calibration on Friday to move the grating to a new position. On Saturday, the instrument may be powered off, its memory reloaded, and the grating motion tested by an optical calibration.

Playback of I24 data is proceeding nominally. We are currently playing back SSI data from the closest approach track. Because of the wide variety of known and potential problems facing playback, SPOT is holding an unusually large amount of margin (15.5 MBTG). Bits that were initially allocated to returning the MWG's recording of the Io torus passage and for PPR BPT observations have been re-distributed as (1) 13 days of RTS for the MWG in the dusk sector near apojove, (2) additional playback BTG to NIMS and SSI, and (3) SPOT margin.

10-22-99: (M. Segura) The command conference for the power cycle, reload, and opcal has occurred and all were approved. The op-cal/e-cal will occur at 297/04:48 SCET ~ between 12 midnight and 1 am PDT Saturday/ Sunday.

Due to I25 workload, the anomaly investigation activities will go on hiatus until Wednesday next week. SSI is reworking every observation in the sequence except small satellites which means rework of some magnitude for us (yet to be determined). We have some adjustments to make including changing the LPU records for Europa to MPW. (This was announced at 2:00 this afternoon.) I'll be around to monitor for the instrument activities this weekend so that we can provide Erickson with an update (via e-mail) of the results. He is aware that the grating offset command yielded no change.

10-26-99: (J. Gross) As of 6 AM Tuesday morning, we were in Segment 11 at Track 1, Tinc 3227, playing back SSI Io Stereo. We are running about 1.5 days ahead, due to continued NIMS over-compression. To date we have returned 71.43 MB of data and have 5.16 MB of losses. We are currently about 37% of the way thru playback.

10-28-99: (J. Gross) I'd like to hear from each team when they think they will need another I24 PB update. Currently Segment 14 is the latest Segment on-board. Segment 15 begins with ISPROMTH01 (284/04:42) and is scheduled to go active next Thursday afternoon. That means that if you want to update Segment 15, we need to have it on board before then. We have no uplink passes available next Wednesday, so that means we'd have to uplink it Tuesday, which means an update to Segment 15 would have to be delivered on Monday, Nov 1 @ 3 PM.

10-29-99: Due to a shortage of timely uplink passes next week, an early playback table update was approved, with files due Monday. We are able to enter or modify commands in segment 15 and beyond. In this update I entered nine new sets of playback singles, all to fill gaps in data returned earlier. The gaps are in 24INPROMTH02, 24INREGION01, and 24INREGION02. In addition two sets of SSI ridealong singles from last week were deleted, as Frank pointed out that during the recording of those data the chopper was not at reference but at 63 Hz. The Project has approved a fourth pass over the tape in order to squeeze out the last little dregs of useful SSI data before playback terminates. It is conceivable that we may want to place more gap fill singles in the 4th pass, if gaps appear in our current gap fills (some of which are substantial). As of now we have about 5.6 Mbits of unused playback allocation (wish I had it in some earlier orbits). We will hold on to this, as there is no interest in trading bits in this orbit for scarcer bits in I25. These bits will serve as insurance for us and will at the same time help SSI to accomplish their goals, as there will be considerable inefficiency in the 4th pass. Our unused capability will offset some of this inefficiency.

I24 Playback Events Timeline (08-31-99 to 11-24-99)

11-04-99: (J. Gross) Next week's update will begin with Segment 19. That's the last segment in Pass 3. It begins at 284/10:45:56.733, which is the beginning of INREGION02. Anything in REGION02 or later can be affected for Pass 3. Also, this delivery is where I must have everyone's Pass 4 plan. There is theoretically an opportunity to do a final PBT update on Wed Nov 17. At that time there will be one week remaining in playback. Whether or not the teams will actually want/need to use that update port is TBD.

11-11-99: Our pass 3 gap-fills came down intact. In particular there are no gaps in the 3-Rim 24INREGION01 gap fill. Thus there is only one new set of singles in the table delivered today. This fills a small gap in our ridealong data (with SSI) on 24ISGLOCOL01, which will come down near the end of playback.

11-12-99: (J. Gross) As of 6 AM Friday morning, we were in Segment 18 at Track 1 Tinc 2920, playing back SSI Io Stereo. We were running less than a day ahead of the old schedule at that time. To date we have returned 145 MB and lost 10 MB. We are approximately 75% thru playback.

11-16-99: (J. Gross) As of 4 PM Tuesday, we were in Segment 20, Track 3, Tinc 4079, playing back SSI Io Zamama 01. We were running about one day ahead of the I24PFH schedule, for unknown reasons. To date we have returned about 171 MB and have losses of about 8.5 MB.

11-19-99: (W. Sible) The Galileo spacecraft is operating normally. The primary activity over the past week has been the playback of Io 24 recorded data. Playback is 92% complete, and is on schedule. Playback will complete on 11/23.
We are still on schedule to modify the Command and Data Subsystem (CDS) to work around the bad memory location.
The patch to change the PPR (Photo Polarimeter/Radiometer instrument) buffer use is now fully tested, and scheduled for uplink on 11/19/99.

11-23-99: Playback terminated as planned.

11-24-99: (T. V. Johnson) It has come to my attention that some of you are being asked questions about whether we have been completely open about difficulties and data losses during I24. Immediately following the encounter we put out a press release on the success of the encounter, but noted some of the problems we encountered and what we knew about them at that time. This was followed by the first I24 image press release which also described some of the problems with the instruments, including NIMS and the AI8 imaging mode.
Since then we (you) have been very busy trying to understand the problems, revise I25 in response to those problems, and, of course, analyze the great data we got. We certainly want to avoid even the appearance of not being forthcoming about our problems. Therefore I am writing this to give you a brief update on where I think we are and how we did at I24, as objectively as I can.

<u>I24 Playback Events Timeline</u> (08-31-99 to 11-24-99)

There were four main areas of science loss during I24:

1.) MWG: loss of the inbound torus recording due to spacecraft safing. This was an important but secondary objective. The primary near encounter MWG data are apparently great.
2.) PPR: loss of BPT (due to memory location). This eliminated many PPR observations including most global and regional maps. Ride-along observations on specific targets produced excellent data however.
3.) NIMS: grating inoperative. With the grating stopped NIMS operates in "fixed map" mode, producing 14 spectral channel maps for composition and thermal mapping. Major loss is the ability to search for new compositional components on the surface.
   [UVS grating has also been inoperative for the last two orbits. This is not a major impact to Io science in I24 or I25 but will impact auroral and plasma torus science in the GMM if we cannot get the grating working again.]
4.) SSI: AI8 anomaly. This is the most complex of the I24 problems, and we still don't fully understand it or its impact on the data. This affected 122 of the 156 images taken (the remaining 34 are actually better than expected due to less severe degradation by radiation noise than our worst-case models). Some of the affected AI8 images are usable - in fact most of the new images released at the 19 Nov. Space Science Update were reconstructed AI8 images - but many (the SSI team estimates ~90) are probably unusable. A brief description of the problem as we understand it currently was made available to the press at the Update and is posted on our Web site.
   To put the I24 data and problems in perspective you should keep several points in mind:
   - The spacecraft is in good shape and several key elements for dealing with the radiation environment worked well - BURP and Single Star ID.
   - All the experiments got excellent data and the science teams are extremely happy with the results.
   - None of the problems resulted from bad design, sequence errors or sloppy work. The natural environment of Jupiter, which we are in the process of exploring, is the culprit. Everyone knowledgeable about Galileo expected some problems at Io at this stage of the mission. The spacecraft and its instruments are in fact doing far better than many of its designers dared to hope (wish I'd bet a few more bags of potato chips in the right places). If you want to play the Project Scientist's Percentage Game, I would estimate that, given significant hits in each major area (MWG and Remote Sensing), we got about 50% of what we tried for (what, you were expecting 70% maybe?). I think that's pretty darned good given the circumstances.

- Painful as some these problems are to us, we are actually learning things from them that may help in the design of future missions to the system. Previous spacecraft (Pioneer, Voyager and Ulysses) were designed with large margins to survive brief flybys of Jupiter. Galileo is the first spacecraft where we can observe the effects of long term radiation dosage on our parts and radiation hard systems designs, far beyond the original design specifications. This in fact is one of the technical justifications for continued operation in GMM.

NIMS Anomaly Report - I24 Sequence

The NIMS grating became stuck prior to the I24 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.

There was a single NIMS processor halt detected during the I24 Encounter.

The spacecraft safed due to CDS memory corruption. The error was resolved and a new sequence uploaded in time to save the I24 Io flyby.

Stuck Grating

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.

<u>Response to Stuck Grating Anomaly</u> (I24)

When it was determined that the grating appeared to be stuck, the cause of this sticking was not known (and is still not clearly understood). Several attempts were made to try to 'unstick' the grating during I24 Cruise based on various models of how it could be stuck.

The first thing done (IAP ref 99S313) was to have CDS MRO the NIMS grating step position engineering data to ground that had been written to CDS RAM during the I24 Encounter (This procedure was developed in C21 to use the NIMS grating position engineering values to confirm the grating step size inflation). The MRO returned a value of 00x for all grating positions. This implied that the grating was not moving and that it is at an unusual location (00x).

The next step (IAP ref 99S315) was to command the NIMS grating offset to 7, instead of the nominal value of 4, in the middle of the PCT calibration to see if there was any effect. There was no noticeable change in the NIMS data after the grating offset change. The command to change the grating offset from 4 to 7 did not move the grating.

The third step (IAP ref 99S318) was to power cycle the NIMS instrument, reload the phase 2 software, change instrument mode to long map, perform MRO readout of the grating position engineering, perform 2 Opcals and 1 Ecal, again MRO to readout the grating position engineering then turn off the chopper. The MROs returned 00x again. The power cycle of the instrument did not 'free up' the stuck grating. The Opcal calibration data did not 'see' the Opcal lamp at .9 microns, which was interpretted to mean that the grating was not moving. The Ecal returned nominal values.

The fourth step (IAP ref 99S324 and 99S325) was an attempt to force the grating out of the stuck position by running the instrument in band edge mode (mode 8) for about 12 hours. The band edge mode that was commanded jumped between grating positions 11 and 23 every minor frame. After running in this mode for 6 minutes, the grating position engineering was MRO'd and an Opcal performed. Eleven hours later the instrument was put into safe mode and the chopper turned off. The MRO returned 00x for the grating position and the Opcal did not show anything different.

More drastic experiments were performed in I25 to free the stuck grating, to no avail.

NIMS Anomaly Report - I24 Sequence

Processor Halts

NIMS suffered a single processor halt in the outbound segment of I24 between planned NIMS observations. The NIMS observations after the halt were protected by a software reload that was executed before the start of the next observation. But the NIMS data in the ride-along observation 24INSTEREO01 was corrupted by the halt. This ride-along observation was not protected by a software reload since it was not originally planned for data return. The halt was inferred from an unusual NIMS hardware status word in the engineering data and from analysis of the returned data.

Timing:

SCLK	Comments
5207881	HWSTAT Engr word: 11x (GS4, chopper ref) - nominal
5208008	Good SCLK
5208138	NIMS reload
5208142:00	Start 24INPELEPM01 (GS4)
5208146:80	End 24INPELEPM01 -- observation apparently OK
5208176	HWSTAT Engr word: 00x (GS2, 63hz chopper)
	(Uncommanded state - interpretted to be a sign that)
	(something unusual had happened to NIMS)
5208212:13	Start 24INSTEREO01 (GS4, SSI ridealong)
5208213:63	End 24INSTEREO01 -- decompression erratic, 1/3 bad
5208219	HWSTAT Engr word: 00x (GS2, 63hz chopper)
5208241	HWSTAT Engr word: 00x (GS2, 63hz chopper)
5208294	NIMS reload
5208300	Start 24INREGION02 (GS2)
5208303	Good SCLK
5208316:17	End 24INREGION02 -- observation apparently OK
5208339	HWSTAT Engr word: 01x (GS2, chopper ref)

Spacecraft Anomaly

A CDS memory chip error caused the spacecraft to safe during the inbound portion of the I24 encounter. The spacecraft was returned to normal operations, and a revised encounter sequence was transmitted to the spacecraft to avoid the use of the suspect memory area. This was accomplished in time to resume normal encounter operations before the Io flyby. All observations for Io close approach were made as planned, but some pre-encounter PPR observations and fields and particles Io torus recording were not accomplished due to the memory anomaly.

The CDS memory corruption occurred in the circular buffer which stores the PPR Burst to Tape data and the NIMS LPU and LNR data on the record side of things (data is moved from instrument to buffer and then on to tape) and all SSI data is placed in that buffer area on the playback side (data is moved from tape to buffer for editing and then telemetered to ground). This memory error proved to be a permanent memory failure. A patch to the SSI playback portion of the failure was tested and sent up to the spacecraft in time for I24 SSI data return. Coding of a patch to the PPR and NIMS portion of the memory failure was put off to a later time.

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.