Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the I25 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the I25 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 I25 was too short in duration to return all of the data recorded during the I25 encounter. Some of the I25 data were not recorded over during the E26 encounter and were later returned during E26 cruise.

There were twelve autonomous reloads of the NIMS RAM code from CDS during the I25 encounter, one just before each science observation. The NIMS processor halted in the middle of recording one observation, 25ENEQUATR01. NIMS halted two other times, but at times when NIMS was not taking data. The approach that we are taking to avoid data loss due to processor halts has proven to be very successful.

The spacecraft safed about 4 hours before the Io flyby. 9 of 13 NIMS observation were lost before the encounter sequence could be recovered.

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, 4 and 5 show the geometry of the NIMS I25 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' I25 data returned during I25 and E26 cruise.

The text on page 10 gives a 'recap' of the I25 playback events which affected which observations were returned.

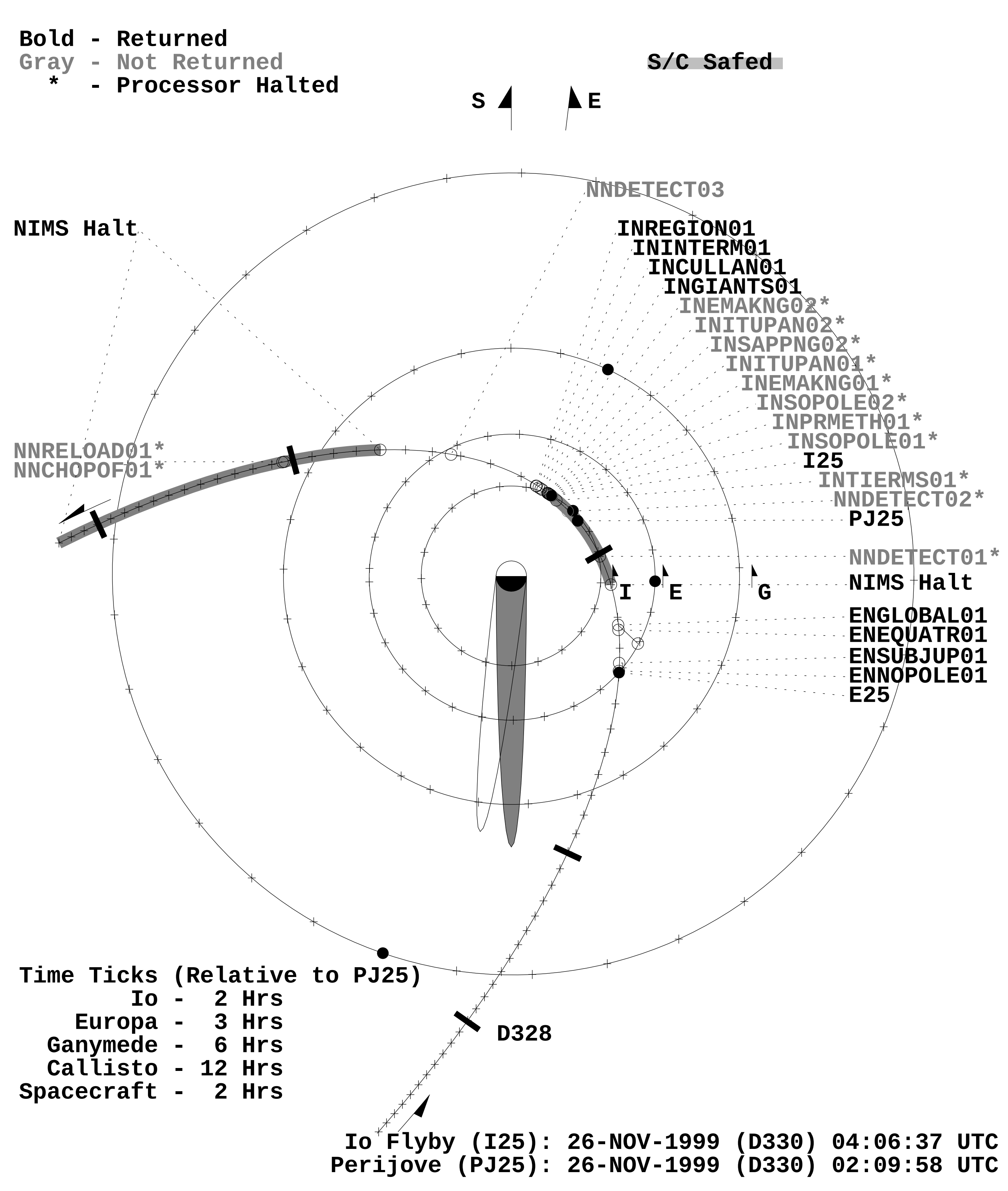
A Timeline of I24 playback events is on pages 10 through 24.

The text on pages 25 through 28 describes the I25 NIMS and Spacecraft Anomalies.

The text on page 29 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 30 and 31.

The text on page 32 is a guide to understanding the NIMS MASK.

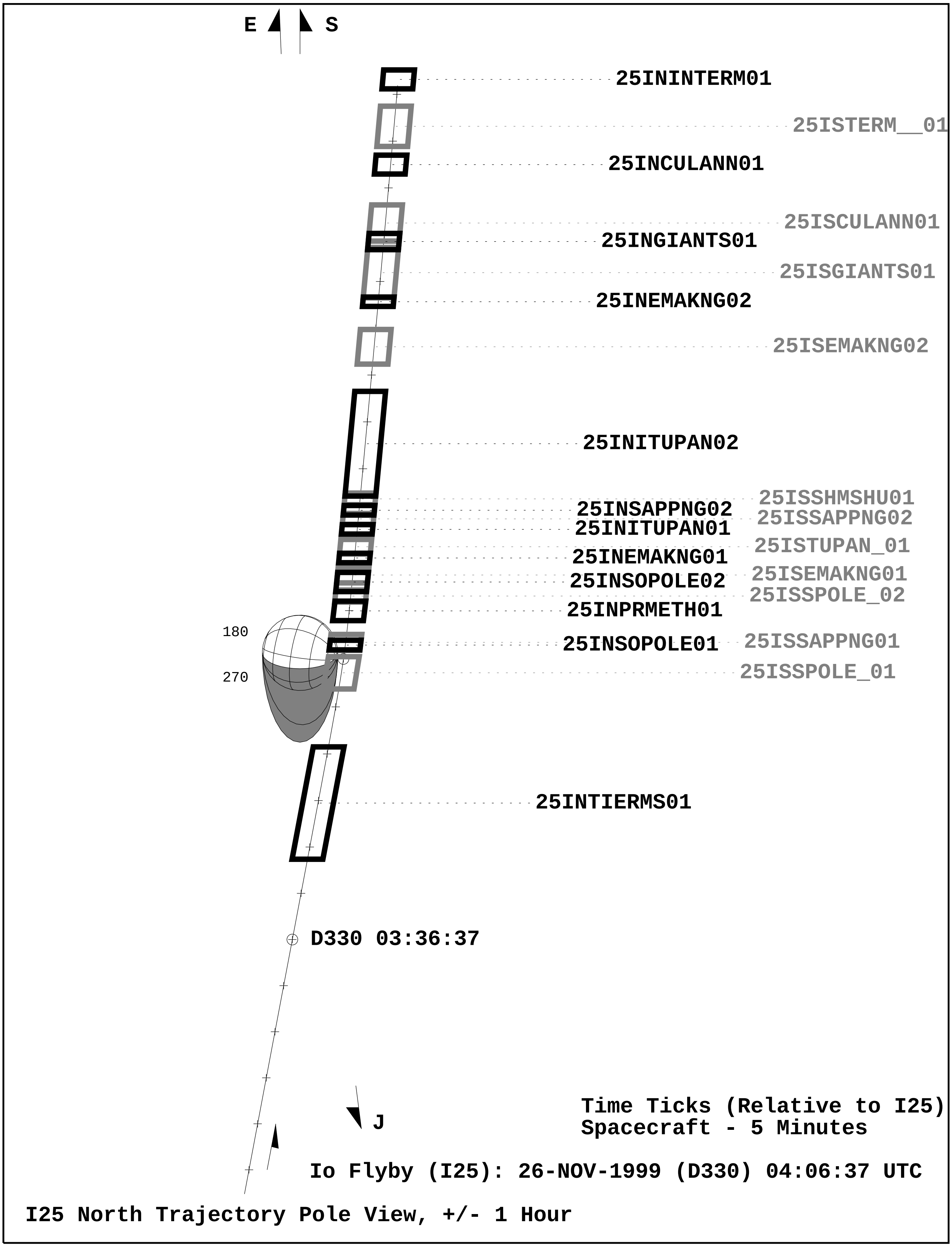
NIMS I25 OBSERVATIONS



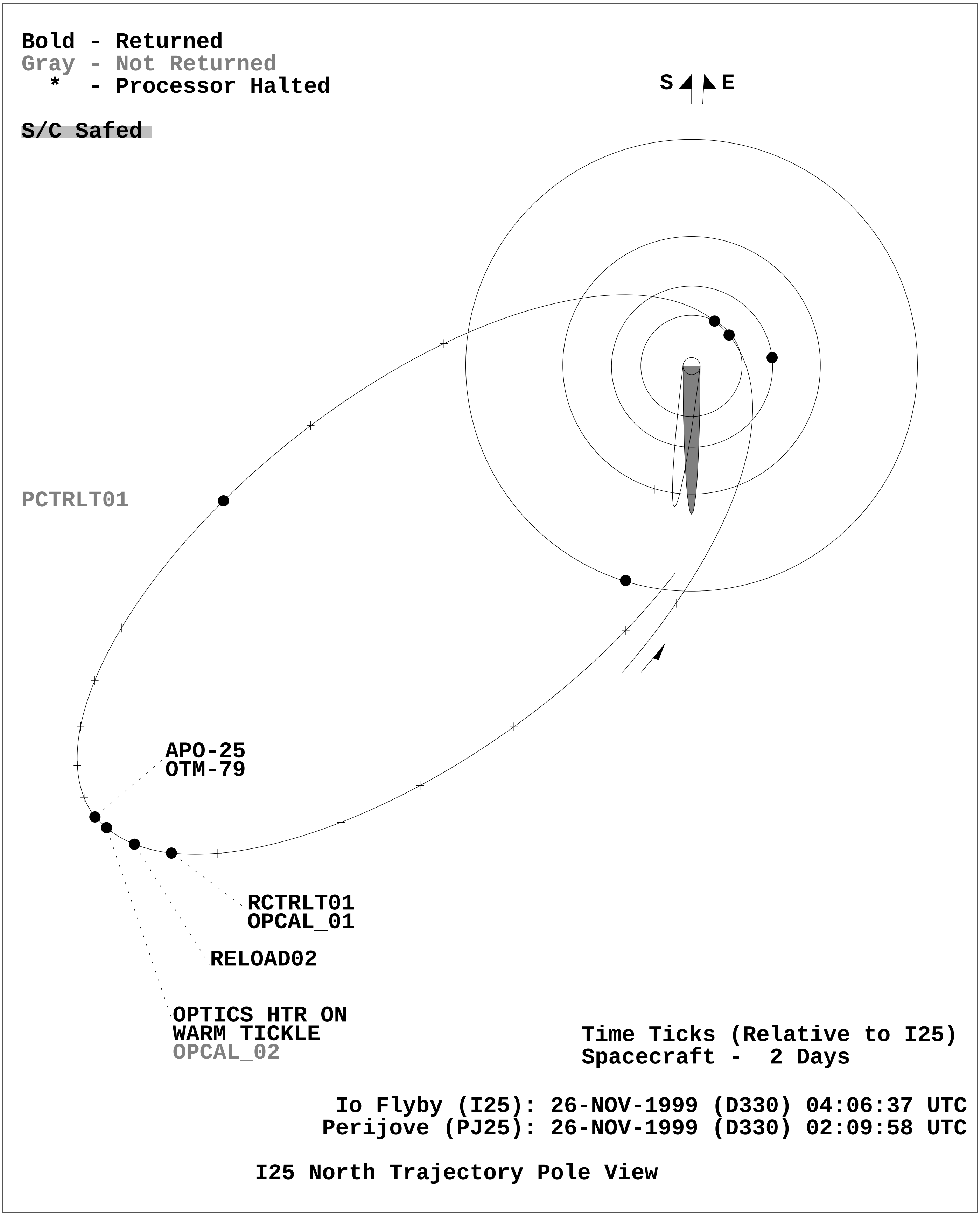
I25 North Trajectory Pole View

NIMS - FEL - 03/01/00

NIMS & SSI I25 IO FLYBY OBSERVATIONS



NIMS I25 CALIBRATIONS



NIMS - FEL - 12/20/99

NIMS I25 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format	PSID
25INGIANTS01-	Io Giant Calderas Obs.	I25ILM442	I25ILM288	LM	3	0	4	MPW	
25INCULANN01-	Io Culann Obs	I25ILM442	I25ILM288	LM	2	0	4	MPW	
25ININTERM01-	Io Obs. Near Terminator	I25ILM442	I25ILM288	LM	3	0	4	MPW	
25INREGION01-	Io Regional Observation	I25ILM442	I25ILM288	LM	2	0	4	MPW	
25NNPCTRLT01-	PCT Calibration	I25PCT252	R/T	LM	4	0	4	R/T	
25NNRCTRLT01-	RCT Calibration	I25RCT252	R/T	LM	1	0	4	R/T	
25NNROPCAL01	NIMS OPCAL	I25OPCAL48	R/T	LM	4	0	4	R/T	
25ENNOPOLE01-	Europa North Polar Meridional Obs.	I25ELM442	I25ELM216	LM	4	0	4	MPW	
25ENSUBJUP01-	Europa Subjupiter Point Regional Obs.	I25ELM442	I25ELM360	LM	3	0	4	MPW	
25ENEQUATR01-	Europa Equatorial Band	I25ELM442	I25ELM360	LM	3,4	0	4	MPW	
25ENGLOBAL01-	Europa Jupiter-Facing Hemisphere Global	I25ELM442	I25ELM216	LM	3	0	4	MPW	
25INGIANTS01-	Io Giant Calderas Obs.	I25ILM442	I25ILM72	LM	3	0	4	MPW	
25INCULANN01-	Io Culann Obs	I25ILM442	I25ILM72	LM	2	0	4	MPW	
25ININTERM01-	Io Obs. Near Terminator	I25ILM442	I25ILM72	LM	3	0	4	MPW	
25INREGION01-	Io Regional Observation	I25ILM442	I25ILM72	LM	2	0	4	MPW	
25INREGION01-	Io Regional Observation	I25ILM442	I25ILM360	LM	2	0	4	MPW	
25ENNOPOLE01-	Europa North Polar Meridional Obs.	I25ELM442	I25ELM144	LM	4	0	4	MPW	
25ENNOPOLE01-	Europa North Polar Meridional Obs.	I25ELM442	I25ELM360	LM	4	0	4	MPW	
25ENSUBJUP01-	Europa Subjupiter Point Regional Obs.	I25ELM442	I25ELM360	LM	3	0	4	MPW	
Pause Pb for test									
UVS donation									
Note: Additional I25 data were returned to Earth during E26.									

NIMS I25 DATA RETURN

Activity ID	Mode	Record Format	Wave-lengths Returned	Record Time (sec.)	PB Time (sec.)	Selected Bits to Tape sBOT (MBITS)	Total Bits to Tape BOT (Mbit)	Mode Cycle (sec)	AACS Mbits c 2.5	Comp	Total BTG (Mbits) (w/4% ohead)	Data Reduct Factor (sBOT/BTG)	Pass
25INGIANTS01-	LM	MPW	288	104	104	1.20	1.20	8.667	0.01	2.04	0.3524	3.40	1
25INCULANN01-	LM	MPW	288	52	52	0.60	0.60	8.667	0.00	1.18	0.3046	1.97	1
25ININTERM01-	LM	MPW	288	52	52	0.60	0.60	8.667	0.00	1.13	0.3181	1.88	1
25INREGION01-	LM	MPW	288	2,702	1510	17.40	31.13	8.667	0.09	1.24	8.4167	2.07	1
25NNPCTRLT01-													
25NNRCTRLT01-													
25NNROPCAL01													
25ENNOPOLE01-	LM	MPW	216	660	341	3.93	7.60	8.667	0.02	1.24	1.4255	2.76	2
25ENSUBJUP01-	LM	MPW	360	190	95	1.09	2.19	8.667	0.01	1.31	0.6265	1.75	2
25ENEQUATR01-	LM	MPW	360	790	240	2.76	9.10	8.667	0.01	1.19	1.7425	1.59	2
25ENGLOBAL01-	LM	MPW	216	503	211	2.43	5.79	8.667	0.01	1.12	0.9766	2.49	2
25INGIANTS01-	LM	MPW	72	104	104	1.20	1.20	8.667	0.01	1.38	0.1302	9.20	3
25INCULANN01-	LM	MPW	72	52	52	0.60	0.60	8.667	0.00	1.20	0.0749	8.00	3
25ININTERM01-	LM	MPW	72	52	52	0.60	0.60	8.667	0.00	1.20	0.0749	8.00	3
25INREGION01-	LM	MPW	72	2,702	1510	17.40	31.13	8.667	0.09	1.33	1.9618	8.87	3
25INREGION01-	LM	MPW	360	2,702	1175	13.54	31.13	8.667	0.07	1.33	7.6328	1.77	3
25ENNOPOLE01-	LM	MPW	144	660	341	3.93	7.60	8.667	0.02	1.20	0.9820	4.00	4
25ENNOPOLE01-	LM	MPW	360	660	318	3.66	7.60	8.667	0.02	1.20	2.2895	1.60	4
25ENSUBJUP01-	LM	MPW	360	190	103	1.19	2.19	8.667	0.01	1.30	0.6845	1.73	4
Pause Pb for test											2.3		
UVS donation											-0.979		
											29.3145	Total	
Note: Additional I25 data were returned to Earth during E26.											32.536	Allocation	
											-3.2215	Over/Under	

NIMS E26 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Ofset	Record Format	PSID
26NNDETECT01-	Grating Step Test P2								
26NNDETECT02-	Grating Step Test Copy								
26INHSLOKI01-	Io Loki Observation	I26ILM442	I26ILM360	LM	2	0	4	MPW	
26NNDETECT03-	Grating Step Test P2								
26NNDETECT04-	Grating Step Test Copy								
26INRELOAD01-	NIMS Software Reload								
26NNCHOPOF01-	NIMS Chopper Off								
26NNMROGRT01-	Grating MRO								
25INCULANN01-gf	Io Culann Obs	I25ILM442	I25ILM288	LM	2	0	4	MPW	
25INREGION01-gf	Io Regional Observation	I25ILM442	I25ILM288	LM	2	0	4	MPW	
25ENNOPOLE01-gf	Europa North Polar Meridional Obs.	I25ELM442	I25ELM360	LM	4	0	4	MPW	
25ENNOPOLE01-gf	Europa North Polar Meridional Obs.	I25ELM442	I25ELM144	LM	4	0	4	MPW	
25ENEQUATR01-gf	Europa Equatorial Band	I25ELM442	I25ELM360	LM	3,4	0	4	MPW	
25ENGLOBAL01-	Europa Jupiter-Facing Hemisphere Global	I25ELM442	I25ELM144	LM	3	0	4	MPW	
25ENGLOBAL01-	Europa Jupiter-Facing Hemisphere Global	I25ELM442	I25ELM216	LM	3	0	4	MPW	
26INHSLOKI01-gf	Io Loki Observation	I26ILM442	I26ILM360	LM	2	0	4	MPW	
26INHSLOKI01-	Io Loki Observation	I26ILM442	I26ILM360	LM	2	0	4	MPW	
25INREGION01-gf	Io Regional Observation	I25ILM442	I25ILM288	LM	2	0	4	MPW	

NIMS E26 DATA RETURN

Activity ID	Mode	Record Format	Wave-lengtrhs Returned	Record Time (sec)	PB Time (sec)	Selected Bits to Tape sBOT (MBITS)	Total Bits of Tpae BOT (Mbit)	Mode Cycle (sec)	Comp	Thold	RT	Total BTG Mbits (4% ohead)	Data Reduction Factor	Pass
26NNDETECT01-														
26NNDETECT02-														
26INHSLOKI01-	LM	MPW	360	400.00	207.00	2.38	4.61	8.67	1.29			1.3864	1.72	1
26NNDETECT03-														
26NNDETECT04-														
26INRELOAD01-														
26NNCHOPOF01-														
26NNMROGRT01-														
25INCULANN01-gf	LM	MPW	288	52	29	0.33	0.60	8.67	1.18			0.1699	1.97	2
25INREGION01-gf	LM	MPW	288	2,702	408	4.70	31.13	8.67	1.24			2.2742	2.07	2
25ENNOPOLE01-gf	LM	MPW	360	660	60	0.69	7.60	8.67	1.24			0.4180	1.65	3
25ENNOPOLE01-gf	LM	MPW	144	660	41	0.47	7.60	8.67	1.24			0.1143	4.13	3
25ENEQUATR01-gf	LM	MPW	360	790	15	0.17	9.10	8.67	1.19			0.1089	1.59	3
25ENGLOBAL01-	LM	MPW	144	503	99	1.14	5.79	8.67	1.20			0.2851	4.00	3
25ENGLOBAL01-	LM	MPW	216	503	110	1.27	5.79	8.67	1.20			0.4752	2.67	3
26INHSLOKI01-gf	LM	MPW	360	400.00	36.00	0.41	4.61	8.67	1.29			0.2411	1.72	3
26INHSLOKI01-	LM	MPW	360	400.00	223.00	2.57	4.61	8.67	1.29			1.4935	1.72	3
25INREGION01-gf	LM	MPW	288	2,702	21	0.24	31.13	8.67	1.24			0.1171	2.07	4
												7.0836	**Total**	
												6.935	**Allocation**	
												0.1486	**Over/Under**	

RECAP OF I25 PLAYBACK EVENTS

I25 was an extremely eventful orbit for Galileo and for NIMS playback. A spacecraft safing event occurred about 4 hours prior to Io close approach, which was successfully recovered from thanks to the efforts of the Sequence Team, who uplinked a revised sequence to the spacecraft within hours. Nearly 75% of the NIMS data that was in the original plan was successfully recorded.

The NIMS software halted at least 4 times during I25: During the recording of 25ENEQUATR01, about 1.75 hours before the spacecraft safing event, at the time of the spacecraft safing again near the end of the encounter sequence.

Playback was made complex by the adoption of a non-FIFO (first in first out) strategy, resulting in some confusion regarding pass numbers. This was adopted to allow carryover of some MAG data for playback in later orbits.

Rapid adaptation to the safing caused major revisions of the playback plan on the fly. In the end a remarkable Io dataset was obtained, together with several unique observations of the Jupiter-facing side of Europa. A preventable series of events caused an early termination of playback just before New Years, resulting in the failure to return the last 2.9 Mbits of Europa data commanded for return. A portion of this was recovered in E26.

During the cruise period commands were uplinked to exercise NIMS in hopes of freeing the "stuck" grating. These attempts were not successful. The grating test took place on 16 December.

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.

I25 Playback Events Timeline (10-20-99 to 01-04-00)

10-20-99: (K. Schimmels) I realize there isn't an official OPG to use yet (it's in the last stage of revisions!), but here are the OPG allocations that were distributed in a Memo by Duane B. on 7/9/99 via email. Please design your playback tables to this until newer numbers are released. I will have newer allocations by Friday PM based on the newest I25 product.
Due to changes being made to the I25 record sequence, the PBT delivery schedule has been modified.

First Delivery:	Monday, Nov. 1
Second Delivery:	Wednesday, Nov. 10
Final Delivery (if needed)	Friday, Nov. 19

<u>I25 Playback Events Timeline</u> (10-20-99 to 01-04-00)

Files are all due EOD, no later. We are short a delivery due to the compressed schedule, so the products need to be as close to the final product as possible. We are also pushing the last delivery very close to uplink, so the sooner we have a flight-ready PBT, the easier it will be to adapt to late changes in the sequence, if necessary.
I25 Bit to Ground Allocations (in Mbit)

Team/WG	Total MBTG	Europa	Io	Io Torus
NIMS	45.7	14.7	31.0	0.0

Notes: (1) MWG Io Torus data will be carried over into E26 and I27 and returned during playback in these orbits.

10-22-99: (K. Schimmels) Here's the new MBTG allocations based on the recently released I25XBA OP product. This is a pretty significant decrease in capability from the OAP estimate of 142 MB. Total Science Capability is now 104.410 MB, representing a 26% decrease.
NIMS 32.908

10-28-99: (K. Schimmels) There was some confusion over the I25 playback strategy, so let me re-iterate for you what the plan is as it stands in the OPG (based on what was presented, discussed, and agreed upon at the PSG in June):
Track 1, 3, and 4 will be played back in I25. This means that only track 2 MWG Torus data will be maintained for definite playback partially in E26, finishing in I27.
Now, not all three tracks will be recorded over by E26 data. Either track 1 or track 3 will contain the E26 recording (at about 4277 tics I believe), which will be determined in the near future. This does not mean we are preserving I25 data on the other 2 tracks for playback in E26, or in I27. It just means it is not overwritten yet... until I27. In I27, we overwrite tracks 1, 3, and 4, maintaining the remaining track 2 Torus data to finish playing back in I27.
This means all data wished to be played back from I25 recording on tracks 1, 3, and 4, should be played back in I25 cruise (even despite the reduced MBTG allocations....)
With this in mind, the current playback plan is as follows:
Begin on track 3 with C/A data. This means we playback tracks 3, 4, then 1, skip 2. Then we get a second pass thru tracks 3, 4, and 1, and stop. This eliminates slewing over an additional track of tape, thus reducing our inefficiency greatly over a plan which begins playback on track 1.
This means the following in terms of pass numbers in your playback table delivery next week:
Observations on tracks 3 and 4: First pass thru == Pass 1, Second pass thru == Pass 2
Observations on track 1: First pass thru = Pass 2, Second pass thru = Pass 3.

<u>I25 Playback Events Timeline</u> (10-20-99 to 01-04-00)

11-01-99: **(E. Barbinis) I delivered the I25 PBT today. Jim and I discussed how to deal with the reduction of the I25 BTGs (only 32.908 MBits for NIMS) last week. We are returning everything that we are recording for the Io observations except for 25INREGION01 where we are returning 20 minutes out of the 45 minutes of the record duration. For the Europa observations, we are returning 2 minutes out of the 8 minutes of the record duration for 25ENGLOBAL01 and only 228 wavelengths for 25ENGLOBAL01 and 25ENSUBJUP01. This is the first delivery for I25 PBT. Depending on the results from the grating test we will do revisions in our second delivery (on 11/10).**

11-17-99: **(K. Schimmels) I25 allocations have decreased by ~1 MB overall. The new allocations follow:**
NIMS 31.366% 30.534

11-18-99: **The final pre-uplink I25 playback table was delivered today. There were many significant changes made. A few of these concern the timing and order of playback of our observations, but most relate to the selection of wavelengths for return.**
As usual we have insufficient downlink bits allocation to return the data that will be recorded. To make the best use of the resources, we are limiting the playback wavelengths of nearly all of our observations. Although it is possible that the grating will be functional once more during the I25 encounter over Thanksgiving, the current playback strategy assumes that it will remain stuck.
That being the case, it is simplest to discuss the return of data in terms of detectors, rather than wavelengths.
In I24 we returned data from all 15 functioning detectors, but found that the signal was unexpectedly low for detectors 1, 2, and 7. We believe this is due to blocking of the incident photons by the built-in blocking filters, which is in turn a result of the grating sticking in a position at one extreme of its range of motion. Although some signal is recorded for these detectors, their data are significantly less useful than that from the other detectors where blocking is not a problem. Thus in our bit-limited circumstances it is reasonable to optimize our science return by not selecting for playback the data from detectors 1, 2, and 7. (Note: If the grating is working by I25, we will be able to return to a more normal playback strategy during the initial playback table update cycle).
Our allocation stands at about 66% of what we would require to bring down all our data. The distribution of resources between Io and Europa has been 2:1. We have about 20 Mbits to spend on Io, and 10 for Europa. The following strategy works within these constraints.

<u>I25 Playback Events Timeline</u> (10-20-99 to 01-04-00)

Europa: We will bring down data from 9 detectors for three of our four observations. Not selected for playback are 3 and 8 (nonfunctioning); 1, 2, 7 (low signal); and 15, 16, 17 (lowest signal levels and lowest priority of the remaining functioning detectors). For the well-lit 25ENEQUATR01, we will get all of the above plus the thermal detectors (15-17). With this strategy we will be able to bring down our full spatial area coverage for the four observations.
Io: To check on the position of the grating and the function of detectors 1, 2, and 7, we will bring down 2 RIMS of data with all 15 detectors selected in pass 1. (This observation is the day side 25INTUPAN02). For all other observations we will bring down the data from 12 detectors (4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17). In the current plan we wanted to obtain as much spatial coverage as possible. We are not succeeding in getting all all of it. About 7.5 RIMS of 25INREGION01 (about 35% of the second scan) is not in the playback plan at present. Returning this would require an additional 2.3 Mbits of allocation.
To have greater flexibility to adapt during playback, greater portions of two observations were shifted into pass 2. One of these is 25INTUPAN02, where we are receiving 15 detectors in pass 1 (but only 12 in the larger pass 2 portion). Secondly we are returning only the first 2 RIMS of 25INTIERMS01 in pass 1. Note: This observation replaces 25INCREIDN01. It is 4 RIMS earlier in time, and is obtained at an improved cone angle (still in the 40 degree range however). We will receive about .7 Mbits of data for this one in pass 1, and 1.75 Mbits more in pass 2. There is one additional consideration for Io data return, and that is the observation 25INSOPOLE01, now in pass 2. This was recorded with NIMS in safe mode, and the question of how and whether to play it back is still open.

11-23-99: (K. Schimmels) Playback initiates Friday, November 26 at 4:33 PM PST. (99-331/00:33:00 SCET-UTC).
Playback terminates on Friday, December 31 at approximately 3:56 PM PST. (99-365/23:56:00 SCET-UTC)
Playback is being done in a non-first-in/first-out fashion again this orbit. We are starting pass 1 with track 3 - closest approach data. As such, the pass numbers are funky.
Pass 1: first time through tracks 3 and 4
Pass 2: first time through tracks 1 and 2, and second time through tracks 3 and 4.
Pass 3: second time through track 1 only. There is no second pass through track 2 due to BTG limitations.
This non FIFO strategy allows us to playback C/A data first, and to reduce downlink loss to slewing over a track of data we do not intend to playback during I25.

11-25-99: I25 encounter begins at 04:00 UTC.

I25 Playback Events Timeline (10-20-99 to 01-04-00)

11-26-99: Spacecraft goes into safe mode at 00:02 UTC.
Perijove occurs at 02:09 UTC, and
Io close approach occurs at 04:06 UTC.
Recovery sequence goes active at 04:28 UTC.

11-26-99: (J. Erickson) Approximately 4 hours before Io 25 closest approach, at 4:44 pm PST (Earth Received Time), the Galileo spacecraft entered safing. Preliminary analysis shows that at about 4:39 pm PST a standard despun bus reset error occurred on the spacecraft, and was handled correctly by the onboard software. Within 5 minutes, the CDS (Command and Data Subsystem) "B" string High Level Module experienced a DBUM bus transaction error. Current analysis is that there is an error in the flight software patch designed to work around the failed memory bit in the CDS HLM "B" (the failed bit that caused the Io 24 safing), but the error is not identified yet. A work around to the probable error has been identified and used in the creation of new command sequences.
As of 8:06 pm PST, the Galileo spacecraft had resumed normal operations. After the spacecraft entered safing, commands to restore the spacecraft to normal operations were generated and sent within two hours, and a truncated science observation sequence generated and transmitted within two and one half hours. The truncated science observation sequence resumed recording at 9:12 pm PST (Earth Received Time), approximately 32 minutes after close approach to Io.
A subsequent despun bus reset was also handled correctly by the onboard software. A summary of the encounter observations successfully recorded:
1. All of the planned observations of the Jupiter facing hemisphere of Europa.
2. Approximately half of the Io torus recording.
3. One of two planned tracks of high resolution Io observations (Track 4, all recorded 32 minutes or greater after close approach).

One key loss was the fields and particles measurements to be taken during the actual close approach. These measurements would have been used to resolve the question of an internal magnetic field for Io.

11-26-99: (R. Mehlman) It's hard to tell from Jim Erickson's ERT times just where recording of NIMS observations resumed, so I phoned the ACE and got SCET times of the safing (330/00:02) and when recording resumed (330/04:28). The safing was a couple of hours before our first Io observation. But recording resumed in time for 25INITUPAN02 and presumably continued through EMAKNG02, GIANTS01, CULANN01, TERMAP01 and REGION01. We do have a good SCLK a few hours after REGION01, so we didn't halt within it. (Actually recording resumed in time for GIANTS01).

I would guess we lost TIERMS01, SOPOLE01, PRMETH01, SOPOLE02, EMAKNG01, ITUPAN01 and SAPPNG02. We also know from returned SCLKs that NIMS halted at 5273069 (~329/22:15 SCET) 1 hour and 45 minutes before the reported safing. This is well after our last Europa observation.

11-27-99: (D. Bindschadler) The purpose of this message is to give SPOT some details regarding the anomaly and recovery during I25, and to request some after-the-fact checking of the sequences that were sent, as well as status reports from each instrument team.
S/C safing occured near 330/00:00, about two hours prior to perijove. Because of the extremely short time before Io c/a, a truncated version of the contingency sequence (i25aqb, in /i25/scg/loada/safing/qb/) was generated and sent to the spacecraft. That sequence was followed by a second sequence which contained commands to take GLL through the end of the original I25A load.
Executed sequence info:

```
I25 contingency part 1:  i25aqb
Location:               /i25/scg/loada/qb2/
*BEGIN                  99-330/04:11:00.000
*CUTOFF                 99-331/01:15:00.000
Last sequenced cmd:     99-330/09:00:01.066
                        (Dummy record followingPPR RCT)
Contents:               1) State matching
                        2) Track 4 observations, all
                           trk 4 records

I25 contingency part 2:  i25a2b
Location:               i25/scg/loada/safing/2b/
*BEGIN                  99-331/01:17:00.000
*CUTOFF                 99-348/08:00:00.000
Last sequenced cmd:     n/a  (same as nominal I25A -
                             i24adf)
Contents:               1) DMS TRKCHG 4-->3 for PB
                        2) Deselect F&P RTS
                        3) PWS SEARCH COIL CAL (PSID 260NF)
                        4) MAG OPT AVE On
                        5) Safe EPD for cruise
```

Important note: There is a 16 hour gap in commanding between the part 1 and part 2 sequeunces. None of the instrument commands that were put into the nominal I25A sequence executed during this 16 hour span. RT commands were sent to take EPD out of chicken mode and to configure MAG.
NIMS appears to have suffered a memory corruption event like those seen in previous orbits. NIMS is checking to establish the time of the event. They will be pursuing commands to reload instrument memory and then turn off their chopper.

<u>I25 Playback Events Timeline</u> (10-20-99 to 01-04-00)

Due to the anomaly, a new playback table was generated (i24pdb). This table begins playback on Track 4 and continues through data return of Track 1 (Europa) data. A playback update is planned for this week on the nominal schedule (Wed.), but stay tuned for updates. The only changes to the playback SINGLES that were made for I24pdb were (1) removal of all track 3 SINGLEs and (2) removal of UVS SINGLEs.

11-27-99: (M. Segura) As all of you have probably heard (from voice -mail and e-mail), the spacecraft experienced a safing event about 4 hours before closest approach. A truncated sequence recovered the encounter at approximately DOY 330 04:42 (Io EMAKNG02 observation for NIMS). Preliminary analysis of the engineering data has been done - temperatures were within the expected range for a safing event. The electronics temperature rose 6 DN over the few hours that the instrument was powered off and the heaters were on. Analysis of the NIMS clock has been completed for the period of time just prior to the safing event through the end of NIMS activities with the results detailed below:

RIM	Observation	Comment
5273071	after ENGLOBAL01	spacecraft safing caused software halt; first grating step position data lost
5273452	EMAKNG02	first NIMS observation after recovery - LOST - no reload
5273456	INGIANTS01	first NIMS data after recovery (see note)
5273578	after INREGION01	first valid NIMS clock value after recovery
5273890	after second grating position data taken	NIMS software stopped

Note: While there is no telemetered clock values during the time period after sequence recovery (INGIANTS through INREGION), there is also no reason to believe that the observations did not execute. Playback of these observations should continue as planned.

The final reload and instrument housekeeping activities in the sequence were removed during the mad dash to recover. This leaves NIMS in the"crashed" software state and the PCT calibration due to execute on DOY 335 (3 days from now). My goal is to reload the instrument software before the calibration and the SST supports this activity. There will be a command conference tomorrow afternoon at 3 PM - with uplink over the next available pass.

Detailed analysis of the Europa time period still must be done but at first glance, it appears that all the observations executed with active software. Playback should proceed as planned.

The grating step data stored in CDS memory (from after IO) should be returned as soon as possible - the telemetry shows fluctuations in the current not evident in I24. We need to determine if that is due to an actual change in the grating or just due to a higher telemetry rate. This will be worked once the instrument phase 2 software is functioning again.

11-28-99: (M. Segura) Here are a few more details regarding the I25 safing event. It appears that the spacecraft experienced a bus reset prior to the safing. The time lines up nicely (?) with the NIMS software stoppage at 329/22:15 or so. The safing occurred at 330/00:02 - 6 mcopy commands of the first grating position activity had executed.
Current instrument status - based on the NIMS clock updates the software halted well after our last observation and is still in that state. The telemetry readings of the clock channels have taken on a strange pattern - S1931 continues to increment by one and S1932 is frozen at 34. As well, some of the NIMS telemetry channels are returning 0 - this began to occur at the bus reset and continues until present. We did see one valid reading on Doy 330 07:11 with values well within normal operating ranges. I suspect there may have been ground system problems or that this may be due to an artifact of safing recovery and not more instrument problems. More investigation to follow.
A PCT calibration is planned for Wednesday. The commands to reload the instrument and read out the physical grating position directly from NIMS will be uplinked tomorrow and will execute on Tuesday morning ~ 3 a.m.
As I mentioned in the previous message, we did see some fluctuation in the grating current so I have requested an MRO of the CDS locations where the I25 grating position data was stored. That will execute this evening. The command conference for this occurs at 3 pm today.

11-29-99: The Galileo spacecraft entered safe mode about two hours prior to perijove and about four hours prior to Io close approach. In another extraordinary effort by the flight team, a recovery sequence was generated and uplinked in time to resume data recording about 32 minutes after Io close approach.
The consequence for NIMS was the loss of 9 planned Io observations, the majority of these being short "tag-along" (with SSI) observations. Playback of the first observations recorded after recovery is already underway (25INGIANTS01 and 25INCULANN01 are on the ground).
The observations lost comprised 26% of the NIMS data planned for playback in I25. They represent 39% of the recorded Io data in the initial playback plan. Although we lost our highest-resolution Io observations, we believe that the very large 25INREGION01 was recorded successfully. This may turn out to be as spectacular as our best I24 observations. It also appears that all of our Europa observations were recorded as planned.

<u>I25 Playback Events Timeline</u> **(10-20-99 to 01-04-00)**

We will have no trouble making use of our full downlink allocation for I25. We will now be able to return the full spatial coverage of 25INREGION01 and will be able to increase the number of wavelengths selected for playback for the balance of our observations. Under the circumstances, we have been very fortunate. The NIMS I25 dataset is likely to be of great scientific value.

11-29-99: (F. Leader) Detectors 9-14 saturated for most of 25INGIANTS01. So, detector 7 might be useful. I hope we have bits enough to return the deselected detectors.

11-29-99: (P. Fieseler) There has been a understandable amount of confusion over what what sequences were created for I25A and where they are located on Donatello. A summary follows:

I25ADF - The original sequence. Not sent to spacecraft.
located on Donatello - /i25/scg/loada/df/

I25ADX - SSF only - all spacecraft commands same as version I25ADF but with CDS memory management changed.
Sent to spacecraft.
located on Donatello - i25/scg/loada/df
Active from 99-329/04:00 to ~99-330/00:02 SCET

I25AQA - The first truncated sequence that folks reviewed.
located on Donatello - i25/scg/loada/safing/qa/

I25AQB - The final truncated sequence that was not sent.
located on Donatello - i25/scg/loada/safing/qb/

I25AQB - The post-safing truncated sequence that was sent. Same name was used as its predecessor to save time in the SEQGEN/SEQTRAN process.
located on Donatello - i25/scg/loada/qb/
Active from 99-330/04:11 to 99-331/01:15

I25A2A - The intended follow-on to the first I25AQB truncated sequence. Not sent.
located on Donatello - i25/scg/loada/safing/2a/.

I25A2B - The follow-on to the flown truncated sequence

I25AQB. Was sent. Active now.
located on Donatello - i25/scg/loada/2b/
Active from 99-331/01:17 to 99-348/08:00

11-29-99: (K. Schimmels) We are going to go ahead and do an early PBT update TODAY to playback more of the Europa data on track 1 in the first pass. This means we need to overwrite segment 3, which is already on board the spacecraft.
1) You may make changes to all track one recordings starting at 99-329/13:23:19.133.

2) You MUST start with a teamstrip, located in /i25/pbt/current/teamstrips. These include your pass 1 SINGLEs for track 4 and 1 (one pass only) as you submitted them in the last delivery.
3) All track 1 and 2 data selected (Europa track and Torus data) should be Pass #2 in the SINGLEs.
4) MWG - the plan is for you to select Torus data on track 2. Duane will be sending out an email with Select/Deselect times later today. I will supply both the MWG and PPR with the latest time we have data recorded on track 2 by later today.

PBTs are due FIRST THING Tomorrow AM (Tuesday 11/30). Assuming enough data is selected in this update, we can wait until next week to do another update for selecting data on track 4,1, and 2 for a second pass thru.

11-29-99: An early update was accomplished today to adapt to the new conditions engendered by the events during I25 encounter. We lost 9 observations of Io leaving us with about 8 Mbits of available downlink allocation. Due to technical problems we could only modify playback commands for the first physical pass over the tape today. We could not enter commands for Io playback in pass 2; however I have produced a model for I25 playback that uses all of our available allocation.

Changes made today: To get some visibility into our grating position and function, I increased the spectral coverage on 25ENSUBJUP01 and 25ENEQUATR01 to 15 detectors (up from 9 and 12 respectively). Both 25ENNOPOLE01 and 25ENGLOBAL01 remain at 9 detectors, to retain some flexibility for pass 2 contingencies. (About 50% of the spatial coverage of each of the four Europa observations is commanded for playback in pass 2).

Playback of 25INREGION01 (12 detectors) will continue nearly all of this week. The first of the above Europa observations should come down Friday, and the last (25ENGLOBAL01) next week some time, following the SSI Europa global.

Strategy for pass 2: Based on the Europa data for detectors 1, 2, and 7, we can decide whether it would make sense to bring down the Io data for these detectors. We should certainly get all of the spatial coverage for 25INREGION01 as our first priority. We can get the rest of the detectors for 25INGIANTS01, 25INCULANN01, and 25INTERMAP01 at a modest cost (.3 Mbits).

We can do all of this, AND get all 15 detectors for 25INREGION01, with our current allocation. However, in this plan we will not be able to fill out our spectral coverage for the Europa observations in pass 2. We may perhaps wish to re-prioritize when we have data from all 15 detectors on the ground. Note also that we may be able to retrieve some I25 data during E26.

<u>I25 Playback Events Timeline</u> (10-20-99 to 01-04-00)

11-30-99: (M. Segura) Real time commands were sent yesterday afternoon to reload the NIMS software and turn the chopper off. The commands executed around 3 am this morning successfully. The instrument is now up and running again in time for the PCT cal due to execute from the background sequence tomorrow. The "lost" telemetry channels also were recovered with the reload. The grating current is stable at 137 DN. The MRO of the grating position revealed nothing new - it's still stuck as of this morning. The warming activity will occur before December 14. I plan to target mid next week at the latest. The window of opportunity after December 14 is virtually non-existent due to maneuvers and other engineering activities.

11-30-99: (K. Schimmels) Playback is currently on schedule. As of 6:16 AM 11/30, we're playing back NIMS INREGION01, and were about 30% thru that observation. Due to an early Resume Playback after OTM-78, ~3 3/4 hours extra playback gained us ~ 0.53 MB additional capability. The current schedule continues until DOY 348, allowing us to do a standard update next week starting with Segment 5, Pass 3. This will begin with selecting some I24 data for return on track 3.

12-02-99: (J. Erickson) Further analysis of the safing during the Io 25 sequence indicates that the event was caused by two errors that have been present in the original Command and Data Subsystem software since pre-launch. Analysis indicates that the flight software has not been correctly protecting itself from its own code being inadvertantly overwritten on the "B" CDS string. Evaluation of the coding errors is proceeding, and a decision on how to accomodate the errors are expected shortly.

12-06-99: (K. Schimmels)

1) Our capability has been reduced by 1.7 MB due to the delay in initiating playback last week. This was taken out of the SPOT Margin, and your allocations remain unaffected.
2) We are currently on schedule in Segment 4, playing back ESGLOBAL, which is undercompressing.
3) We will complete pass 1 playback (thru Track 2 Torus data) on Tuesday, December 14th (approximately).
4) There will be a playback table update this week - nominal schedule - for pass 2.
   This will include all pass 2 SINGLEs for:
   - track 3 I24 gap fill data if desired (not required!)
   - track 4 Io data
   - track 1 Europa data
   - track 2 Torus/PPR Io data (if desired, and if BTG allow)
5) Pass numbers on SINGLES: Please pay attention to the following, otherwise your SINGLEs will be tossed out if you have the wrong pass numbers in the merge process. If you are unsure what pass number to use in your SINGLEs, please don't hesitate to ask.

Track 3 data: Pass #3
Track 4 Io data: Pass #3
Track 1 Europa data: Pass #4
Track 2 Torus/PPR Io data: Pass #4.

6) Teamstrips: There are currently NO teamstrips to start with for this update. Our uplinked product had all second pass playback removed. If you cannot start from your own file or NEED some sort of teamstrip, see me and I can set one up for you to start with. If you do use an old file as a starting point, please be aware that pass numbers and segment boundaries will be different now.
7) Finally, there will be at least one more update opportunity in I25 playback after this week to allow gaps on track 1 Europa data from pass 1 playback to be bested and filled in pass 2.

12-08-99: The table delivered today has commands for numerical tape passes 3 and 4 only. These pass number changes were necessitated by the requirement that we play back some data from track 3, which currently contains I24 data, before proceeding with the balance of the I25 playback.
There appears to have been a NIMS software crash part way through 25ENEQUATR01. We received about 3 RIMS of nice data for this, followed by small amounts of questionable data for the other 3.5 RIMS in pass 2 (physical pass 1). In this update I deleted the balance of 25ENEQUATR01 from the playback plan. With the savings we are able to retrieve all recorded wavelengths for the remaining observations, while maintaining a cushion of about 1 Mbit to help pay for the upcoming grating test exercise.
Since we are replaying ALL of the Io data from earlier passes (with fill-in wavelength tables commanded), it does not make sense to attempt to fill gaps at this time. Starting and stopping playback to change wavelength tables in the middle of an observation inevitably creates a small gap. We are fortunate this time because we will have the opportunity to go back and fill all our gaps during E26 playback.
Although we lost 25ENEQUATR01, we will have good coverage of the central portion of the Jupiter-facing hemisphere with 25ENSUBJUB01 and 25ENGLOBAL01 (which overlaps the former). 25ENSUBJUP01 shows interesting spatial variations for almost all detectors.

12-10-99: (K. Schimmels) Playback is currently running ~ 1 day ahead of schedule. As of 10 AM Friday 12/10, we are about 43% thru playback, and are almost finished with the MWG track 2 Torus playback (track 2, tic 3587).
The next (and final) update will be on schedule next week (files due Wednesday 12/15 at 3 PM, approval Thursday 12/16 at 3:30 PM). It will cover segments 6, 7, and 8.

12-14-99: (K. Schimmels) Ok, I looked at the losses finally. (Jim - these were missing in the checkpoint report last week). Your BTG look like this:

Allocation:	30.177
Usage (rec'd and lost):	28.994
Unused BTG:	1.183
Cost of pausing pb:	2.3
UVS BTG donation:	0.979
Remaining cost:	1.321
BTG released from margin:	1.38

Bottom line:

Alloc:	32.536	
Usage:	31.294	
Unused:	1.242	(to use in this playback table update, or to donate to MWG or SSI)

12-16-99: (K. Schimmels) Playback is currently ahead of schedule by about 20 hours. As of noon today (12/16), the tape is at tic 4505, track 4, playing back SSI ISCULANN01, and was about 30% thru that observation.
Due to an early Resume Playback after OTM-79, ~8 hours extra playback gained us ~ 0.4 MB additional capability. Changes to this playback table are relatively minimal. In order to maximize the capability use at the end of playback, teams were released the rest of the margin and were allowed to slightly over-select data beyond their allocation. While this should mean we will use ALL the capability we have, there is still always the possibility that we will run ahead of schedule and still end up with a small amount of unused capability. Then again, we could also run behind schedule and not complete all the playback selected. In this case, bits will be available in E26 for playback of anything missed at the end of I25.

12-16-99: Elias Barbinis delivered a new I25 playback table while I was in San Francisco this week. We received additional downlink allocation due to a release of margin bits. There was only one observation that was not fully selected in the existing plan. We recorded data AFTER the completion of the third scan of 25ENGLOBAL01. I do not know at present where the scan platform was pointed during recording of this data, but this will be derived from the AACS data accompanying the recording. Some will most probably be on Europa, and some will probably see dark sky. This may be valuable for noise assessment and other purposes.
The new schedule shows the next NIMS observation to come down will be 25INCULANN01, approximately next Tuesday, followed by 25INREGION01 starting on Christmas eve.

12-16-99: (M. Segura) The NIMS grating warming began this afternoon around 2 pm. Approximately one hour into the test the phase 2 software crashed. Big surprise - the software doesn't enjoy heat any better than radiation.

A discussion with Bill brought about a plan to recover part of the test. Run in Phase 0 software. The commands were uplinked to power cycle the instrument and set the instrument in the same configuration as previously commanded in the sequence. We got the commands generated and uplinked to the spacecraft in time to recover the last 3 hours of the test. The temperatures just prior the end of the warming cycle of 10 hours was: Chopper: -62.6 C, Telescope: -25.0 C, and Grating: -82 C with optics heater 1 on.
The grating current prior to the software crash was 134 DN; after power cycle it was and continues to be in the 114 DN range. The MROs of the actual grating position still show hex "00" after 10 hours of warming.
There will be some real time packets of opcal/ecal data HOWEVER the instrument is currently running phase 0 software with CDS phase 2 real time so if anything does appear, it may be less than useful. The NIMS instrument state at the end of the test will be: chopper off, safe mode, with phase 0 software in place. I would like to leave the instrument in this state until E26 at which time the encounter sequence will reload the Phase 2 software just before the Io observation we have planned. There are two reasons for doing this - we could more easily convince the project to repeat the activity with optics heater 2 before E26 if the only work required by the SST is a simple parameter edit to an existing file. The second reason is to reload the instrument, it will require the same people to do the work as supported this activity and I suspect there will be some resistance to doing both....
The downside of this is that any data SSI is taking in E26 prior to our Io observation will have no NIMS data embedded.

12-28-99: Playback pauses and is not successfully restarted.

01-04-00: (D. Bindschadler) During playback, we autonomously paused at the end of segment #7 because no addtional segments had been placed on board. Subsequently, segs. 8 and 9 were uplinked. Instead of the expected nominal resumption of playback, the DMS slewed across the remainder of track 1, turned and proceeded across track 2, and then stepped back up to track 1. If this had been a simple limited search, playback should have proceeded with processing track 1 data from the 2nd time window in segment 8.
When the tape continued to slew, commands were sent to MRO areas of memory that contained playback time markers and to terminate playback. Analysis of the MROs made it clear that playback had read a corrupted restart time at the end of segment 7, when playback autonomously paused. The restart time was significantly later in time that any I25 data, meaning that the playback process was searching for a time marker on the tape that did not exist. This kind of anomaly has occurred previously, although not in the context of an autonomous playback pause.

Given the limited time remaining for I25 playback (< 2 days by the time the anomaly was understood) and the workload of generating a new PBT, we simply re-initiated playback, starting with segment 9. Unfortunately, this segment (which contained MWG gap fill singles only) did not contain a RECFMT. The result was that no additional data were played back. If teams wish to recover data from segments 8 and 9, they will have to do so during E26 playback. None of the affected data were overwritten by the E26 recordings.

01-04-00: Playback paused autonomously at the end of segment 7 of the active playback table, following downlink of 25ENSUBJUP01. The following segments, uplinked later, did not execute correctly because a corrupted time value was obtained by the controlling software at the end of segment 7. All of this occurred on and after 12-28-99. Playback was terminated and re-initiated with a truncated table starting with segment 9. This was missing a required RECFMT command, so none of the commanded data was successfully retrieved from the tape thereafter. As a result about 8 Mbits of expected data were not received. Most of this was SSI's global Europa coverage, but we lost a significant amount (2.9 Mbits) of our own 25ENGLOBAL01. It will be possible to play back some or all of this in E26. However, we may face a shortage of bits due to grating tests and some prioritization will no doubt be requried.

NIMS Anomaly Report - I25 Sequence

The NIMS grating became stuck prior to the I24 encounter. The grating continued to be stuck for the I25 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 were two NIMS processor halts detected during the I24 Encounter.

The spacecraft safed during the I25 encounter about 4 hours before the Io flyby. 9 of the 13 planned NIMS Io observations were lost due to this safing event.

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.

<u>Response to Stuck Grating Anomaly</u> (I25)

At I25 the cause of the sutck grating was not known (and is still not clearly understood). An attempt was made during I25 cruise to unstick the grating by heating up the NIMS instrument by turning on the NIMS Optics heaters. This attempt was not successful in freeing up the stuck grating.

On Day 349 NIMS Optics Heater 1 was turned on in an attempt to heat up the NIMS grating mechanism. The optics heater was to be turned on for about 10 hours. The NIMS engineering telemetry showed a rise in the Telescope, Grating and Chopper temperature, a slight rise in the Shield temperature and no change in the FPA and Electronics temperatures. NIMS was commanded to band edge mode (as in I24) to have the grating jump between grating positions 11 and 23 every minor frame. MROs were commanded once per hour during this 10 hour period to return the NIMS grating position engineering to test if the grating was moving (unstuck).

About 10 minutes into this exercise the NIMS Phase 2 software (RAM) halted, most probably due to the elevated temperatures. Real time commands were sent to the spacecraft to power cycle the NIMS instrument. NIMS was left running the original Phase 0 software (ROM). NIMS was again commanded to band edge mode. The NIMS SCLK values in the engineering stream continued to show NIMS halted but this was due to running the Phase 0 code which does not save the SCLK in RAM where is picked up and returned by CDS. MROs of the grating position engineering continued. No changes in the grating position were noted - the engineering values remained 00x as before.

After the NIMS Optics Heater was turned off, real time commands were sent to reload and run the NIMS Phase 2 software.

On day 353 the RCT calibration took place. The RCT data confirmed that the grating was not moving.

Processor Halts

NIMS suffered three processor halts during the I25 encounter. The first halt occurred during the inbound segment of the encounter in the middle of recording 25ENEQUATR01, resulting in data corruption in the second half of this observation. The second halt occurred before the Despun Bus reset error just prior to the spacecraft safing event. The third halt occurred in the outbound segment of I25 between the orbits of Europa and Ganymede after all of the NIMS I25 science observations had been recorded.

The first halt was not detected by analysis of the NIMS SCLK engineering values. The halt was inferred by the onset of bad data in the playback data. A software reload at the beginning of the following observation put NIMS back in working order.

The second halt occurred before the despun bus reset error about 4 hour prior to Io closest approach. NIMS has been observed to halt when the BURP patch executes. It is believed that NIMS lost RTI synch with CDS at this time.

The third halt, which occurred on D300 at about 16:00, was detected by the NIMS SCLK engineering. No NIMS observations were affected by this halt. NIMS was scheduled to reload the software about 8 hours later, but these commands were dropped from the spacecraft safing recovery sequence. NIMS remained halted until 12:00 on D334 when real time commands reloaded the NIMS software.

<u>Timing</u>:

SCLK	Comments
5272893:11	Software reload prior to 25ENEQUATR01
5272902:00	Start of 25ENQUATR01 observation
5272905:19	Halt #1 (start of anomalous data)
5272916:11	Software reload prior to 25ENGLOBAL01
5273071:00	Halt #2
5273133:40	Anomalous SCLK 5273071 reported
5273175	CDS Despun Reset Reported
5273180	Spacecraft Safed
5274402:00	Halt #3
5274615:58	Anomalous SCLK 5274402 reported
5279590:32	Software Reload (real time commanded)

Spacecraft Anomaly

A standard despun bus reset error occurred in CDS, followed by a DBUM bus transaction error in the B-string High Level Module. As a result, an error in the CDS flight software patch caused the spacecraft to safe at 00:07 on D330, about two hours prior to perijove and about four hours prior to Io closest approach. After the spacecraft entered safing, commands to restore the spacecraft to normal operations were generated and sent within two hours, and a truncated science observation sequence generated and transmitted within two and one half hours. The truncated science observation sequence resumed recording at 4:39 on D330, approximately 32 minutes after Io closest approach.

9 out of 13 planned NIMS Io observations were lost due to the spacecraft safing event:
25INTIERMS01, 25INSOPOLE01, 25IMPRMETH01, 25INSOPOLE02, 25INEMAKNG01, 25INITUPAN01, 25INSAPPNG02, 25INITUPAN02, 25INEMAKNG02.

In the rush to recover the Io flyby sequence as soon as possible, the original sequence was truncated shortly after the Io encounter, leaving a gap of about 16 hours with no commands to the spacecraft. A NIMS software reload in the oubound segment of I25 was part of the original sequence that was cut from the recovery sequence. NIMS suffered a software halt during this time and remained halted for almost 4 days.

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.