Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the C22 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the C22 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 twelve autonomous reloads of the NIMS RAM code from CDS during the C22 encounter, one just before each science observation. No observations were lost due to a NIMS processor halt. The approach that we are taking to avoid data loss due to processor halts has proven to be very successful.

Detectors 3 and 8 are still not functioning and are expected to be lost for the rest of the mission.

The spacecraft successfully survived two CDS Bus Resets using the new CDS Bus Upset Reset Patch (BURP). Each BURP event caused the NIMS software to halt, but no observations were lost. One of the Bus Reset events caused the tape recorder to stop recording. The process to get the tape recorder re-synchronized with the tape turnaround (DTURN) dropped the two NIMS Europa observations from the recording.

AACS was in Cruise mode for the entire C22 encounter period.

The plots on the pages 3 and 4 show the geometry of the NIMS C22 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 5 and 6 summarize the 'final' playback model for the 'returned' C22 data.

The text on page 7 gives a 'recap' of the C22 playback events which affected which observations were returned.

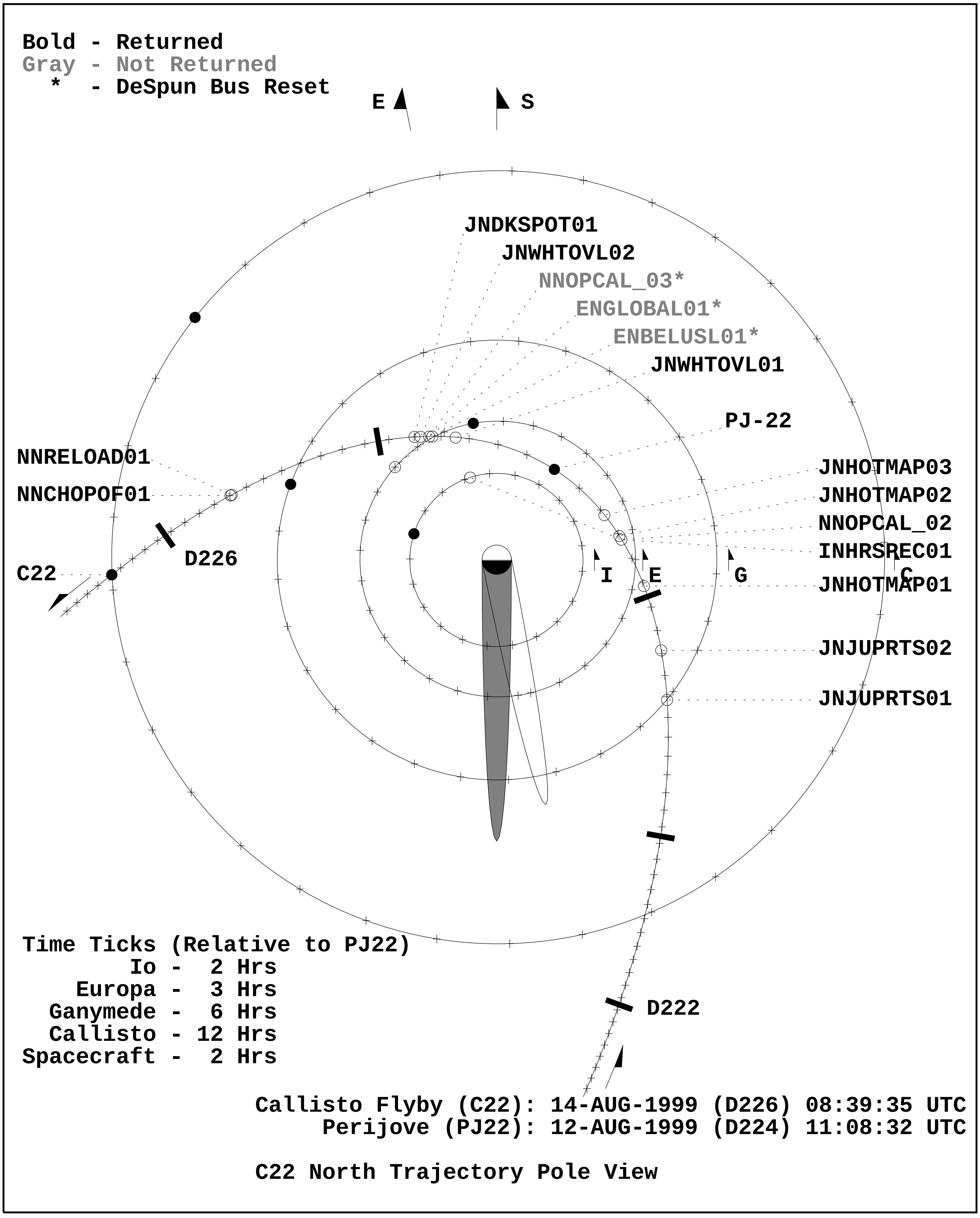
A Timeline of C22 playback events is on pages 7 through 15.

The text on pages 16 and 17 describes the C22 NIMS and Spacecraft Anomalies.

The text on page 18 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 19 and 20.

The text on page 21 is a guide to understanding the NIMS MASK.

NIMS C22 OBSERVATIONS



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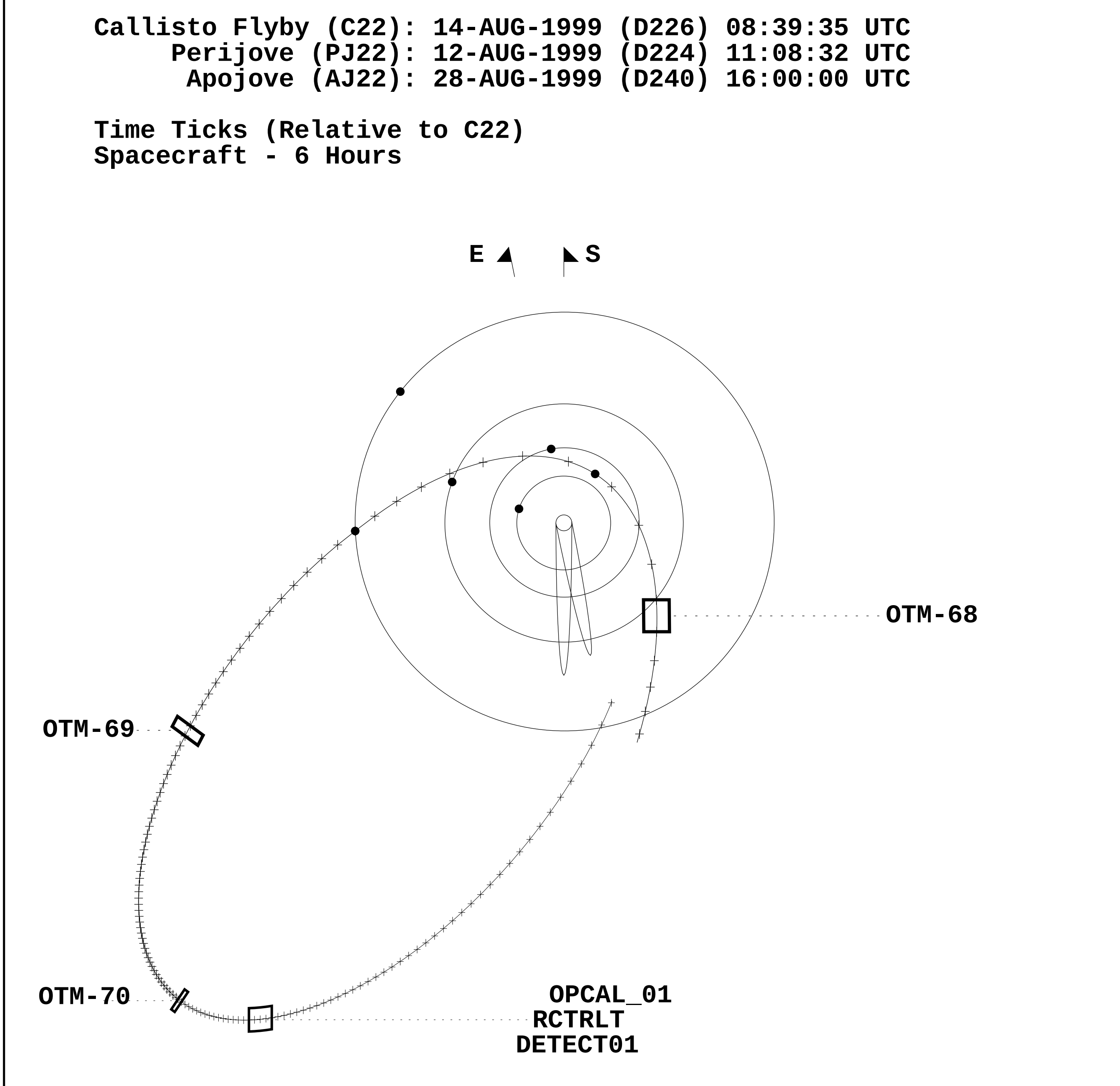
NIMS C22 CRUISE CALIBRATIONS



C22 North Trajectory Pole View, Perijove to Perijove

NIMS C22 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format	PSID
22JNJUPRTS01*	Jupiter Realtime Observation	C22JLM442/MB	R/T	LM	4	0	4	R/T	
22JNJUPRTS02*	Jupiter Realtime Observation	C22JLM442/MB	R/T	LM	2	0	4	R/T	
22JNWHTOVL01-	Jupiter White Oval	C22JSB253C	C22JSB132C	LM	2	0	4	LPU	
22JNHOTMAP01-	NIMS Jupiter HotMap	C22JSB253C	C22JSB76C	LM	2	0	4	LPU	
22INHRSPEC01-	Io monitoring	C22ILMDK243D	C22ILMDK228D	LM	4	0	4	LPU	
22INHRSPEC01_O	Europa Global(O)	C22OPCAL48	C22OPCAL48	LM	4	0	4	LPU	
22JNHOTMAP02-	NIMS Jupiter HotMap	C22JHT253A	C22JHT80A	LM	4	0	4	LPU	
22JNHOTMAP03-	NIMS Jupiter HotMap	C22JSB253C	C22JSB253C	LM	2	0	4	LPU	
22JNWHTOVL02-	Jupiter White Oval	C22JSB253C	C22JSB238C	LM	2	0	4	LPU	
22JNDKSPOT01-	Jupiter Dark Spot	C22JSB253C	C22JSB238C	LM	2	0	4	LPU	
22NNDETECT01-	Grating Step Test								
22NNRCTRLT01-	NIMS RCT Real Time Calibration	C22RCT252	R/T	LM	1	0	4	R/T	
22NNROPCAL01	NIMS OPCAL	C22OPCAL48	R/T	LM	4	0	4	R/T	
22JNHOTMAP01-	NIMS Jupiter HotMap	C22JSB253C	C22JSB177C	LM	2	0	4	LPU	
22JNHOTMAP02-	NIMS Jupiter HotMap	C22JHT253A	C22JHT46A	LM	4	0	4	LPU	

NIMS C22 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	R/T BTG MBits	Total BTG Mbits (4% ohead)	Data Reduction Factor	Pass
22JNJUPRTS01	LM		360								0.32			
22JNJUPRTS02	LM		360								0.32			
22JNWHTOVL01	LM	LPU	132	600	590	3.64	3.70	8.667	1.45	0		1.289	2.82	1
22JNHOTMAP01	LM	LPU	76	600	590	3.64	3.70	8.667	1.61	0		0.668	5.44	2
22INHRSPEC01	LM	LPU	228	360	182	1.12	2.22	8.667	1.18	0		0.844	1.33	2
	LM	LPU	48	360	55	0.34	2.22	8.667	1.36	0		0.047	7.28	2
22JNHOTMAP02	LM	LPU	80	600	590	3.64	3.70	8.667	1.07	0		1.059	3.44	2
22JNHOTMAP03	LM	LPU	253	600	590	3.64	3.70	8.667	1.31	0		2.735	1.33	2
22JNWHTOVL02	LM	LPU	238	1020	920	5.67	6.29	8.667	1.43	0		3.675	1.54	2
22JNDKSPOT01	LM	LPU	238	1110	667	4.11	6.85	8.667	1.46	0		2.609	1.58	2
22JNHOTMAP01	LM	LPU	177	600	590	3.64	3.70	8.667	1.5	0		1.671	2.18	3
22JNHOTMAP02	LM	LPU	46	600	590	3.64	3.70	8.667	1.3	0		0.501	7.26	3
Resource Totals												**15.097**	**Total**	
												15.174	**Allocation**	
												-0.0768	**Over/under**	

5/31/00

RECAP OF C22 PLAYBACK EVENTS

The downlink allocation for NIMS in C22 was less than for any other orbit in the entire Galileo mission. Fewer than 10.5 Megabits were allocated for NIMS playback. In the end NIMS received about 46% more than that due to the loss of one fields and particles observation due to a stoppage of the tape recorder (DMS). This event was an unanticipated consequence of Galileo's occasional radiation-induced "despun bus resets" and the software patch that had been constructed to adapt to them. The negative consequence for NIMS of this event was a failure to record two Europa observations (22ENBELUS01, 22ENGLOBAL01).

The encounter and playback (cruise) periods were not uneventful, making this a typical Galileo orbit. We received a number of excellent observations of Jupiter, with full spatial and wavelength coverage, during C22.

The following timeline details the most signifigant events of the C21 playback period. Most of the text below is excerpted from messages issued at the time.

C22 Playback Events Timeline (04-21-99 to 09-12-99)

04-21-99: (B. Paczkowski) Here are the results of the allocation of add-back tape for C22. The current estimate of available tape on C22 is 840 tics. This number may be less depending on the final tape plan that is developed and the tape uncertainties associated with that plan. I'm allocating all of the add-back tape in this orbit to NIMS. NIMS has proposed a new Europa observation to characterize the recently found sulfuric acid on Europa. In addition, they are adding some additional coverage to an existing Europa global observation.
The primary reasons for this decision are:
1) The NIMS request seems like some good science
2) NIMS has stated that because of the importance of the new observation they *WILL* playback data from both these observations; the SSI requests are not currently planned to be played back.
3) The NIMS requests has far less integration issues. This is an extremely important factor at this time since we have a significant amount of sequences being worked on concurrently, C22, C21, G28, and C20 playback. Our science operations personnel are being stretched to the limit. During the Europa phase of GEM, we had a lot more people resources available to work these add-back integration issues than we do now.

<u>C22 Playback Events Timeline</u> (04-21-99 to 09-12-99)

05-10-99: (K. Schimmels) Below are your OPG allocations for C22. A few things to keep in mind with this orbit - there are expected to be about 1 - 2 weeks of down time at the 43-station. The final negotiations have not been solidified that I know of, as our DSN scheduler has been out ill. As of today, we have only received about 2 14-passes to make up for this loss, and a number of stations have been converted to two-way. Also, Radio Science BTG were not accounted for in the OPG, and the policy is to take their bits off the top. All of these reductions in BTG will be more tangible when the a and b products come out this week and next, but in general, expect a significant decrease in BTG for C22.
I am concerned about the efficiency of a two-pass playback plan with such a bit limited orbit. We have 4 weeks of playback. If pass two is less than 1.5 - 2 weeks long, we won't have a chance to affect the end of the second pass after the first pass is down and bested. This means the best you can do to split your bits 50/50 between passes, the better off we'll be. Also, the cost of the inefficiency could out-weigh the benefits of doing two-pass playback, we may want to consider a strategy of a limited 2 pass plan (e.g. not all 4 tracks have 2 passes thru).
NIMS allocation is 10.340 Mbits.

05-20-99: (K. Schimmels) It appears that the 17% increase in science bits to ground is probably realistic for the STALF changes that have been seen since the OPG. So, I am releasing the new allocations by OPG percentage to you now. HOWEVER, expect up to a 5 MB hit to the total over the next cruise load release due to more station changes and additional cruise activities that require pausing and resuming playback. This decrease may be lower than 5 MB, but I'm giving you a worst case conservative idea to keep in mind.
NIMS allocation is 11.914 Mbits.

07-21-99: (K. Schimmels) As most of you know already, we have decided to go to a non first-in/first-out strategy for playback of C22. This means that your next (and final) playback table update prior to uplink needs to reflect this new strategy, basically by changing some pass numbers in your SINGLEs and by eliminating inefficiencies as I stated in a previous message. Playback will begin with PPR Cooldown, which is a ride-along in the latter portion of the MWG perijove recording.
The following SINGLEs should have a pass number of 1: From the PPR Select for the Cooldown on track 3, (MWG should select into the Perijove playback at 99-224/13:07:19.066) to the end of the record sequence on track 2 (SSI feature track observations).

The following SINGLEs should have a pass number of 2: From the beginning of the record sequence (track 2), starting with the MAG Calcoil recording, through the end of the record sequence (track 2). This will include the first pass through all data recorded prior to the PPR Cooldown start time, and the second pass through PPR Cooldown to the end of the record sequence on track 2.
The following SINGLEs should have a pass number of 3: The Second pass through data from the beginning of the record sequence (Calcoil, track 2) up TO (not thru) the PPR Cooldown (99-224/13:07:19.066) on track 3.

07-28-99: The playback table delivered today is the final, pre-uplink version. Due to compressed schedules, the final .sef (spacecraft event file) was not available until today, forcing a fast turnaround cycle with little margin for error. It should also be noted that this orbit features a non-standard playback strategy. Instead of first-recorded, first played back, playback will start in the middle of the record sequence. There are 3 pass numbers but only 2 physical passes over the tape.
NIMS will begin taking C22 data on 13 August. Our downlink allocation is very modest at 11.8 Mbits. However, we have several interesting observations planned. Paradoxically, none of these image Callisto. There is a distant 22INHRSPEC01, taken at cone 58 degrees, which will have some boom obscuration. There are two Europa observations, one which sits and stares at the dark material near Belus Linea, using Long Spectrometer mode, and a two-scan global taken about the same time. We are presently selecting only half of this due to downlink bits limitations. In addition there are 2 realtime and 6 recorded Jupiter observations. White Ovals and a new dark spot are among the targets. We are bringing down only 76 wavelengths for the dayside observations, and 80 for the thermal-range observations. There is one open issue which concerns the longitude range for the dark spot observation. We presently have bits to bring down only half of the spatial coverage here. This is commanded for playback in pass 2, which will give us time to determine the optimal spatial coverage for return.

07-29-99: (K. Schimmels) C22 has been modeled, and the capability has decreased from 155.76 to 144.11 MB, a difference of 11.65 MB. About half of this is due to an early terminate playback, and that difference has been deducted from SPOT margin. Below are your new allocations vs. usage in the final C22 playback table prior to uplink.
NIMS 11.189% 11.861 Mbits.

08-11-99: C22 encounter starts at 14:00 UTC.

08-12-99: Perijove occurs at 11:08:32 UTC.

08-12-99: (M. Segura) The DMS went to ready mode during the latter part of the MWG perijove crossing record. There is still no explanation for this (engineering data will be played back to help with analysis). The DMS executed the remaining observations on Track 3 which included NIMS White Oval 01. The plan is to complete the recordings on track 3 - allow the DTURN in the background sequence to execute - moving the DMS to track 4. Unfortunately, this means the loss of the PWS Chorus recording and the two NIMS Europa observations are lost due to the time needed to execute the DTURN (the time allocated for this activity in the sequence is 54 minutes shorter than needed and the lost observations were due to execute in this time period).
About 20 minutes after the DTURN from track 3 to 4 completes, the NIMS WHTOVL02 followed by DKSPOT01 will execute followed by SSI plume search observations. There will be a "slew to tic" commanded via real time to adjust the starting position of the next recording to fix the tape map to protect the observations on track 4, track 1 and track 2.
The impact on NIMS is thus: The loss of two observations (ENBELUS and ENGLOBAL) - both will be removed from playback. Jupiter observations will (barring any other surprises) all be recorded and based on the bits available should have a very healthy return this orbit.

08-12-99: (C22 DMS (Tape Recorder) Anomaly and NIMS Playback) During recording of the MWG perijove observation this morning, the tape recorder stopped recording and went to "ready" mode. Reasons for this event are not yet known. Later portions of 22MBPRJOVX01 were not recorded, but commands in the sequence to record the following observation successfully restarted the DMS. Unfortunately the failure to record a portion of track 3 threw off the timing of the following track change ("DTURN"). This was not completed until after the predefined record time of 22ENBELUS_01, and thus this observation and the following 22ENGLOBAL01 were not recorded.
As playback was to begin tomorrow at about 1 pm, starting off with the observation where the problem occurred, a new playback table is being generated for uplink immediately. Changes to this table are being entered by the playback coordinator. A copy of the new table should become available later today.
Commands to play back 22ENBELUS_01 and 22ENGLOBAL01 were deleted from the table. In addition, recording of 22JNWHTOVL02 began precisely at the marker for the end/beginning of the subsequent track.
Due to positioning uncertainties we cannot access the data within 12 tics of the marker, and so we are losing approximately 1 minute of data from the start of this observation. This observation is nearly 17 Rims in duration so the loss is probably not a catastrophic one.

<u>C22 Playback Events Timeline</u> **(04-21-99 to 09-12-99)**

08-12-99: (J. Erickson, 4:00 p.m. PDT) The Galileo spacecraft is operating normally, after completing the passage through the high radiation environment of the Jupiter close approach region. The spacecraft experienced three faults, and on board fault protection and the new bus reset protection software handled all of them correctly.
The spacecraft is continuing to perform the planned observations and has completed approximately 33% of the total recording planned for the encounter.
At 6:07 a.m. PDT on 8/12, the radiation environment near our Jupiter close approach appears to have caused a despun bus reset. The bus reset protection software succeeded in keeping the encounter going, but the tape recorder truncated the recording of an observation. On board algorithms in the CDS continued the recording sequence, but had to skip recording several other observations to get back on track. This error resulted in the truncation of 10% of a fields and particles recording, the loss of two Near Infrared Mapping Spectrometer observations, and the loss of another fields and particles observation.
At 8:21 a.m. PDT on 8/12, the radiation environment appears to have also caused a backup spin source to experience a hardware error. The spin detector is monitored by on board fault protection, which disabled the spin detector and data compression of the Plasma Wave instrument. Data compression will not be re-enabled until 5:00 p.m., due to ground transmitter problems.
The bus reset protection software again proved it's value, as another bus reset occurred at about 10:29 a.m. PDT on 8/12. The software handled it as planned, and the sequence continued unaffected.

08-13-99: (R. Mehlman) NIMS software halted sometime between Jupiter closest approach and the time NIMS was reloaded and the chopper turned off. This is a period of about a day. A dearth of returned SCLKs prevents us from determining the time any more accurately. This period includes the observations JNWHTOVL01, JNWHTOVL02 and JNDKSPOT01. (It also includes ENBELUSL01, ENGLOBAL01 and NNOPCAL_03 but these did not go onto tape due to the tape recorder anomaly). All of these were preceded by reloads so the halt would affect our data only if it occurred during one of these observations, or a reload failed. Unless there was more than one halt, it probably occurred during or after JNDKSPOT01, the last observation.
The last good SCLK was received by CDS at 224/15:01 (SCLK 5123101). It was followed by three bad SCLKs, with identical values, at 225/02:13, 04:37 and 12:42 (SCLKs 5123766, 5123908 and 5124388). The unusual thing is that the bad SCLKs seem to be off in the future, probably meaning that the SCLK bytes in NIMS memory were hit by radiation (probably) after the halt. A good SCLK was not received until 225/23:22 (SCLK 5125021) -- some 8 hours after the NIMS chopper was turned off.

08-14-99: Callisto close approach occurs at 08:39:35 UTC. By this time all encounter recording had ceased and data playback had begun. No observations of Callisto were planned for C22.

08-16-99: The loss of our C22 Europa observations and some early information on C22 Jupiter data compression (1.45 for 22JNWHTOVL01) made it desirable for us to enter some immediate changes. Thanks go to D. Bindschadler and K. Schimmels (SPOT Team Chief and Playback Coordinator) for helping to make this happen outside of the regular schedule.
We shifted 22JNHOTMAP01 and 22JNHOTMAP03 from the final pass (3) to the upcoming pass (2). This lets us fill gaps in the final pass and gives us needed information on compressions for these close-in observations. We also added singles to bring down the last Rim of the 22INHRSPEC01 recording with 48 wavelengths. (We could not capture all of the final instrument cycle of this due to DMS rules for track 2 playback).
We added more wavelengths to our 22JNHOTMAP03 and 22JNWHTOVL02 commands since these are now our highest priority observations of the orbit. And, we entered improved compression estimates for some other observations.
These changes give us much better visibility into our compression performance and will help prevent nasty surprises late in the playback process.

08-18-99: (K. Schimmels) Playback is currently running on schedule. We are in the midst of the SSI feature track playback, which has been undercompressing by all told about 1.0 MB so far.
Due to the early resume playback after the OTM, we have gained approximately 1.0 MB of capability, effectively balancing out the effect of SSI's undercompression. This extra capability is being retained as margin to cover large inefficiencies still expected in playback.

08-27-99: Some good news, some possibly not so good. We have about 4 Mbits to spend on the remaining data on tape. The HOTMAP03 that is all down with all wavelengths is very nice. HOTMAP02 with the longest 80 wavelengths also looks good. The longitudes coverage for these two overlaps but only by about 3 degrees (8 or 9 instrument cycles). I don't see any correlation of the hot spot features in the overlap regions but the current products don't have lat/lon in the backplanes...
Our recording for the DKSPOT01 stopped at longitude 255.75. The last estimate for its location I have seen was 252-258 degrees. So if we are lucky we will get it. We can get all wavelengths and the region from 262-255 longitude at a cost of 1.7 Mbits (increase of 1 Mbit over prior plan). We can also get the rest of the bands in HOTMAP02 for 2.3 Mbits.

I have not looked at our other option, HOTMAP01 which is really a dark oval. We got 76 of the 253 wavelengths. The targeting problems (where we are not getting quite what we hoped) appear to be due to misleading pointer plots. The existing versions show better coverage of the dark spot and more overlap of the HOTMAPS. However, Jupiter is rotating rapidly in the direction of our scan motion, and in the later parts of the observations, the pointer plots become more and more inaccurate. We should routinely get center and end time plots also in any future cases where this could be a problem...

09-01-99: NIMS has only 3 observations remaining in the playback plan. Two will come down early next week (22JNWHTOVL02, 22JNDKSPOT01), with the final observation (22JNHOTMAP01) arriving near the end of the playback period, perhaps on about the 10th of the month. A new schedule will be available tomorrow.
MWG released 8 Mbits of downlink allocation, and we received 3.34. We put this to good use on our Jupiter observations. Our total allocation is 15.174 Mb, of which about 8.2 Mbits remains to come down. Since there is still some uncertainty regarding compressions for the remaining observations, we are retaining about .3 Mbits as insurance against undercompression.
We have sustained some negative consequences as a result of a pointer operator error. Normally our pointer plots are produced with the "territory adjustment" parameter ON. This was not the case this time. As a result, the spatial coverage shown on our plots was somewhat different than what we actually saw. The discrepancies between the pointer plots and shortfiles (amounting to 10 degrees of longitude on Jupiter in some cases) were not noticed until recently. The impact on our observations is significant. The planned overlap of HOTMAPs 2 and 3 of about 10 degrees shrank to a couple of degrees. And, we may not see the dark spot southeast of the Great Red Spot that was the main objective of 22JNDKSPOT01. We will know more next week. There has been some confusion concerning the names and nature of our observations in this orbit. To clear this up I will recap them one by one.
22JNHOTMAP01: This is in fact an observation of a white oval. It was recorded with the table JSB253C, which includes many significant wavelengths at the visible end of our range. All recorded wavelengths will be returned. We obtained 76 in pass 2 and will get the remainder in pass 3.
22JNHOTMAP02: A true hot map at 7 degrees N latitude. This was recorded with JHT253A which includes no visible-range wavelengths. 80 wavelengths at the thermal end were returned in pass 2.

22JNHOTMAP03: Another accurately named hotmap. However this was recorded with the JSB253C table, which does include some visible range wavelengths. All wavelengths and the full spatial coverage were returned in pass 2. Overlap of this and the prior observation was reduced as a result of the pointer problem noted earlier.
22JNDKSPOT01: We are returning 11 of the 17 Rims of this observation, with 238 wavelengths. There were 253 recorded but to save bits we removed the detector 11 wavelengths from about 3.2-3.4 microns. The record table (JSB253C) has visible range wavelengths. As previously noted this one was affected by the pointing problem.
22JNWHTOVL01: This observation was added to the record plan to employ available tape. It was targeted to a fairly nondescript region. It should have been given a fairly low priority for playback but that information did not reach me in time (due to the nonstandard playback strategy, this was our first observation in the playback plan). We received 132 of the 253 wavelengths (JSB253C again).
22JNWHTOVL02: This observation is really a HOTMAP. We will receive more than 15 of the 17 Rims recorded. Once again JSB253C, with some visible-range data, was used for recording. We will get 238 bands (no detector 11 as with 22JNDKSPOT01). This sees a region far removed from those imaged in HOTMAPs 2 and 3.
The problems with the nomenclature of the observations came about due to changes made in the targeting late in the development process. The other mistakes were not caught due to high work loads (multiple orbits in development) and limited staffing. On the positive side, we have brought down some very interesting and valuable data, despite the problems.

09-02-99: (K. Schimmels) Playback is currently running on schedule, and is about 68% complete. We are in the midst of the MWG Perijove playback, in Segment 6. As of 2 PM, we are at tic 3307, track 3. The perijove playback will be finished on Sunday, 9/5/99.
Due to the early resume playback after the OTM, we have gained approximately 1.78 MB of capability, effectively balancing out the effect of SSI's undercompression. This extra capability is being retained as margin to cover large inefficiencies still expected in playback. Playback Terminates on Sunday, 9/12/99 shortly after noon PDT.
8.0 MB was released by the MWG as follows: NIMS: 3.34, SSI: 4.66. All inefficiency margin and SPOT margin is being retained to cover inefficiencies and filling of large gaps expected due to occasional possible loss of downlink over DSS-43.
NIMS allocation: 14.368% 15.096 Mbits.

09-07-99: Thanks to a special nonstandard update cycle approved by SPOT and SST, we were able to modify our playback plan to take advantage of new information on our compression performance. The only change made this week was to add new commands to return the full spatial coverage of 22JNHOTMAP02, with a new complement of wavelengths. We previously returned 80 wavelengths from the thermal end of the NIMS range. This time we will obtain an additional 46 wavelengths, comprised of three sets, located near 2.7, 3.0, and 4.0 microns. This particular observation is of value because of its unusual geometry (recorded near the terminator), in comparison with other similar observations obtained previously.
We were able to obtain these new wavelengths in part because 22JNWHTOVL02 compressed better than predicted. Thanks to E. Barbinis for generating 3 new wavelength tables last week, in anticipation of this possibility.

09-07-99: (K. Schimmels) Playback is currently running about 6 hours ahead of schedule, and is about 85% complete. We are in the midst of the second pass through the SSI feature track data, in Segment 8. As of noon today, we are at tic 1039, track 1.

09-12-99: Playback terminates at about 19:00 UTC.

09-13-99: (K. Schimmels) C22 Playback finished nominally, playing back all of the MWG perijove data gaps as planned. We finished at 99/255-05:18:03.984, about 14 hours prior to the terminate playback, and ~2.0 MB short of the total capability. This equates to the margin which was held to protect the gap fill in the perijove recording, in the case of large gaps due to DSN problems or stations needed by other projects. The gaps in data were much larger than in previous orbits, but our margin and inefficiency policy (and conservativeness in the model) allowed us to fill all the gaps received in the first pass of playback, despite the fact that the SSI data continued to undercompress throughout playback. Bottom line, we finished playback as planned and got all the data despite the challenges (high data rates, high ineffiencies, large gaps, loss of downlink during 2-way 43-passes, SSI data undercompression, several quick turn-around updates, etc. etc. etc.)

NIMS Anomaly Report - C22 Sequence

There was one NIMS processor halts detected during the C22 Encounter. Detectors 3 and 8 are still not functioning and are expected to be lost for the rest of the mission.

The spacecraft survived two CDS bus resets. The new CDS bus reset patch (BURP) executed properly so that the spacecraft did not safe itself. The first bus reset caused the recorder to stop. To get the recording re-sychronized, two NIMS Europa observations were dropped from the sequence. Each BURP event should have caused the NIMS software to halt, but no halts were detected due to the sparse reporting of NIMS SCLK values and the software reloads before each NIMS observation.

Processor Halts

Facts:

0. A single NIMS processor halt was detected outbound in C22 well after all NIMS observations had occurred. A subsequent NIMS reload at the end of the C22 encounter reset the software.

1. A NIMS processor halt was detected at SCLK 05123886 from the analysis of the NIMS SCLK engineering telemetry channels S-1931 and S-1932. The reported SCLK values, 5145104 is much later in time that the reporting time. NIMS was halted for at least 12 hours.

Timing:

SCLK	Comments
5123101.40	Good SCLK returned: 5123099
5123464:16	NIMS Reload
5123886.05	Bad SCLK Returned: 5145104
5124223.58	Bad SCLK Returned: 5145104
5124524:16	NIMS Reload
5125206.05	Good SCLK returned: 5125204

Spacecraft Anomaly

As noted above, CDS experienced two Bus Reset events in C22. CDS recovered both times using the BURP patch. The tape recorder stopped recording during one of the Bus Resets recoverys. Three NIMS observations, ENBELUS01, ENGLOBAL01 and OPCAL_03, were dropped from recording in the process of getting the recording re-synchronized with the planned tape turnaround (DTURN).

NIMS Anomaly Report - C22 Sequence

Grating Anomaly

Testing of the NIMS grating anomaly continued in C22. Two Opcals were inserted into the C22 encounter sequence, one inbound and one outbound, as was done in C20. The inbound Opcal was performed just after 22INHRSPEC01 to compare Opcal-determined grating parameters to those derived from fitting Io SO2 spectral shapes. The outbound Opcal was lost due to the spacecraft anomaly.

A new test (DETECT01) was devised to return the NIMS grating position engineering data to verify the grating parameters being determined using the Opcal data. NIMS engineering values had been removed from the data stream in the Phase 2 scheme, but the values still reside within NIMS RAM and are updated every half minor frame. In the test, a segment of NIMS memory containing the grating position DN was copied to CDS (6MCOPY) for every minor frame over a grating cycle, sampling every other grating position. This was done in both Long Map mode and Short Map mode using both Phase 0 and Phase 2 NIMS code. The CDS memory locations containing the NIMS engineering DN were then sent to ground via MRO. The inflation value derived from the engineering DN agreed very well with the inflation value derived from the Opcal data and show that the inflation of the grating step size is uniform across the grating cycle.

NIMS Archived EDRs and CUBEs

The NIMS data are stored in EDRs (Experimental Data Records) produced by JPL-MIPS (Multi-mission Image Processing System). The NIMS Phase2 EDR is described in the NIMS EDR SIS (Software Interface Specification) Number 232-08. The same information is available in both human and machine-readable form in the PDS (Planetary Data System) structure files EDRHDR.FMT and EDRDATA.FMT in the LABEL directory of the NIMS EDR CD-ROM. Each observation has at least one EDR. The EDR file name is derived from the 12 character observation name plus a single character which allows an observation to be broken up into multiple EDRs. The EDRs have a Vicar label, followed by a PDS/ISIS label, binary header records and the data records. For archiving on CD-ROM, the Vicar labels are detached from the EDR (but kept separately on CD) and the file is renamed so as to conform to the 8.3 DOS file-naming convention. The 8.3 EDR name consists of a 2 character orbit identifier, a single character target identifier, a 3 digit counter and the suffix EDR. For example, the MIPS EDR G1GNGLOBAL01A.1 becomes G1G001.EDR. More information about NIMS EDRs can be found in the VOLINFO.TXT file on the EDR CD-ROM.

NIMS EDR data typically require considerable processing before they are readily amenable to science analysis. Normally, the EDRs are processed into spectral image cubes by one of several sets of software. MIPS systematically processes the EDRs into CUBEs (band sequential image files) and MASKs (spatial/spectral summary images) which are distributed on the NIMS CUBE CD-ROMs. Information about the structure of the NIMS CUBEs can be found in the VOLINFO.TXT file on the CUBE CD-ROM. The name of the CUBE file is derived from the input EDR filename. For archiving on CD-ROM, the CUBE files are renamed so as to conform to the 8.3 DOS file-naming convention. The 8.3 CUBE name consists of a 2 character orbit identifier, a single character target identifier, a 3 digit counter, a single character cube-type identifier, a single character data unit-type (DN, radiance or IOF) and the suffix QUB. For example, the MIPS IOF radiance cube for the observation G1GNGLOBAL01A.1 (G1G001) becomes G1G001CR.EDR. The summary MASKs on the CD-ROM have the same 6 character name as the EDR name with the suffix JPG or GIF to denote its graphics format.

NIMS Data Format - Data types - Data Labels - Data Access

Data Format

All data files have PDS labels. The raw data (EDR) file contains time-sequential, 16 bit integers. Reduced data files (TUBES and CUBES) may be viewed as images or spectra. They contain VAX real numbers, are band sequential (BSQ - the images are stacked in band order) and have geometry information appended as backplanes after the last NIMS band.

Data Types

Mask files contain summary images (3 band BSQ) and spectra of up to six selected regions that provide a quick indication of data location, data quality and spectral content. A Guide to understanding the NIMS mask is available.

Cube files contain data that have been projected and resampled. The core data are BSQ - spatial in the first two dimensions, and spectral in the third. Cubes of the satellites are projected in point-of-view, and, with few exceptions have no photometric correction applied. Cubes of Jupiter are (generally) projected as simple cylindrical. Cubes of Europa, Ganymede, and Callisto have been despiked. The cubes are available both in radiance and I/F (intensity divided by flux) form.

Tube files contain data in (almost) time order and normally have a NIMS-related 20 pixel spatial dimension (20 x n or n x 20). Projection coordinates are contained in backplanes, but the data have not been resampled. The data are in units of radiance and no despiking has been applied. All data in cubes are also available in tube form. Some data (such as spatially undersampled data) appear in tube form only.

A spike file contains a list of pixels that have been identified as spikes, but not replaced, in the tube. Spike files can be used to remove spikes from both tube and EDR files.

EDR files contain the most primitive form of the data available. They should be used only for advanced data analysis. The format is complex and the files do not form images or spectra without prior processing.

NIMS Data Format - Data types - Data Labels - Data Access

Data Labels

A data label (PDS form) is attached to the front of each file (except masks, which have an attached VICAR label and a detached PDS label). The labels are in ASCII keyword=value format and contain pointers to various data objects in the file, descriptions of the data objects and descriptions of the observation associated with the file. A history object in similar format follows and describes the processing steps that produced the file. Much of this information is necessary for understanding and viewing the cube. In particular, the label contains the offset to the cube, the dimensions of the cube, axes labels, and explicit wavelength information.

Data Access

Software for processing this data is called ISIS and is available for DEC VAX VMS, SUN Solaris, DEC Alpha Digital Unix, Silicon Graphics Unix and PC LINUX systems. The Unix versions are available from the USGS Astrogeology team. Images from NIMS cubes and tubes can be viewed with any image display program which allows an offset from the beginning of the file to the selected image. Packages tested include ISIS, VICAR, ENVI, SAO IMAGE, and NASAVIEW. ISIS and ENVI (and soon NASAVIEW) additionally display spectra. The ISIS viewer is named CV (UNIX) or QL3 (VMS).

Labels may be displayed with some editors (eg DOS edit), and with most "type" and "search" functions. Some editors do not recognize the PDS line termination conventions. The label may be listed by the ISIS function LHLIST (VMS) or LABEL (UNIX).

Software for converting EDRs to cubes exist in both ISIS (DEC VAX VMS) and VICAR (DEC Alpha VMS) versions only. A primitive list of values in an EDR may be obtained with the program EDRDMP2.

Understanding the NIMS Mask

The NIMS mask is designed to provide a quick summary of the contents of a NIMS data cube (or tube). It displays a view of both the spatial and spectral content of the data.

The mask has four regions. Starting from the upper left and proceeding clockwise: a spatial display; six or fewer representative spectra; annotation; and a spectral histogram.

The spatial display of an observation which has been projected and resampled (a cube) has a maximum size of 600x600 pixels. This is overlaid with surface coordinates and is embedded in a 700x700 grid of pixel coordinates. It is accompanied by two 1-dimensional histograms describing the raw image and the image stretched for display. The data image can range from a simple combination of up to 3 NIMS bands displayed in the RGB planes, to complicated arithmetic functions of NIMS bands displayed in the RGB planes. (The formulas appear as annotation below the histograms.) The graphics directly below the image show the input and output data histograms for the three color planes. The "shortest" color for each bin displays in front. The image also contains from one to six numbered rectangles, which show the from which averaged spectra (displayed on the right) were taken.

The spatial display of an observation in time sequence (a tube) is a graphic showing a footprint of the observation over a grid of surface coordinates on the target body. Numerals 1-6 on the graphic mark the locations of the average spectra displayed on the right.

The spectra to the right of the image may display either BDRF or radiance (or both). If both are displayed, then a vertical "radiance fence" line will appear where the breakpoint occurs. This permits display of both atmospheric data, which have significant reflectance and thermal components, and I/F satellite surface data which have strong absorptions at longer wavelengths (such as water spectra.) The spectra are labelled with wavelength in microns and location in both pixel and latitude-longitude space.

The annotation provides information about the observation, including its name, a brief description, its geometry, instrument and projection parameters. TCA is the time from Galileo's closest approach to the target body.

The 2-dimensional spectral histogram in the lower left corner shows the number of pixels at a given radiance for each wavelength. If a surface contains spatial mixtures with significantly different spatial fractions for several components, the spectra of the components will be evident in this display.