Chapter 7 - Data Return

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Introduction to Chapter 7

This chapter is a report on the NIMS data return for the E19 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the E19 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 eleven autonomous reloads of the NIMS RAM code from CDS during the E19 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 safed about 5 hours after perijove during sun acquisition during a science turn recovery. The outbound portion of the E19 encounter were lost.

The plots on the pages 3 and 4 show the geometry of the NIMS E19 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' E19 and E17 data returned during E19 cruise.

The text on page 7 gives a 'recap' of the E19 playback events which affected which observations were returned.

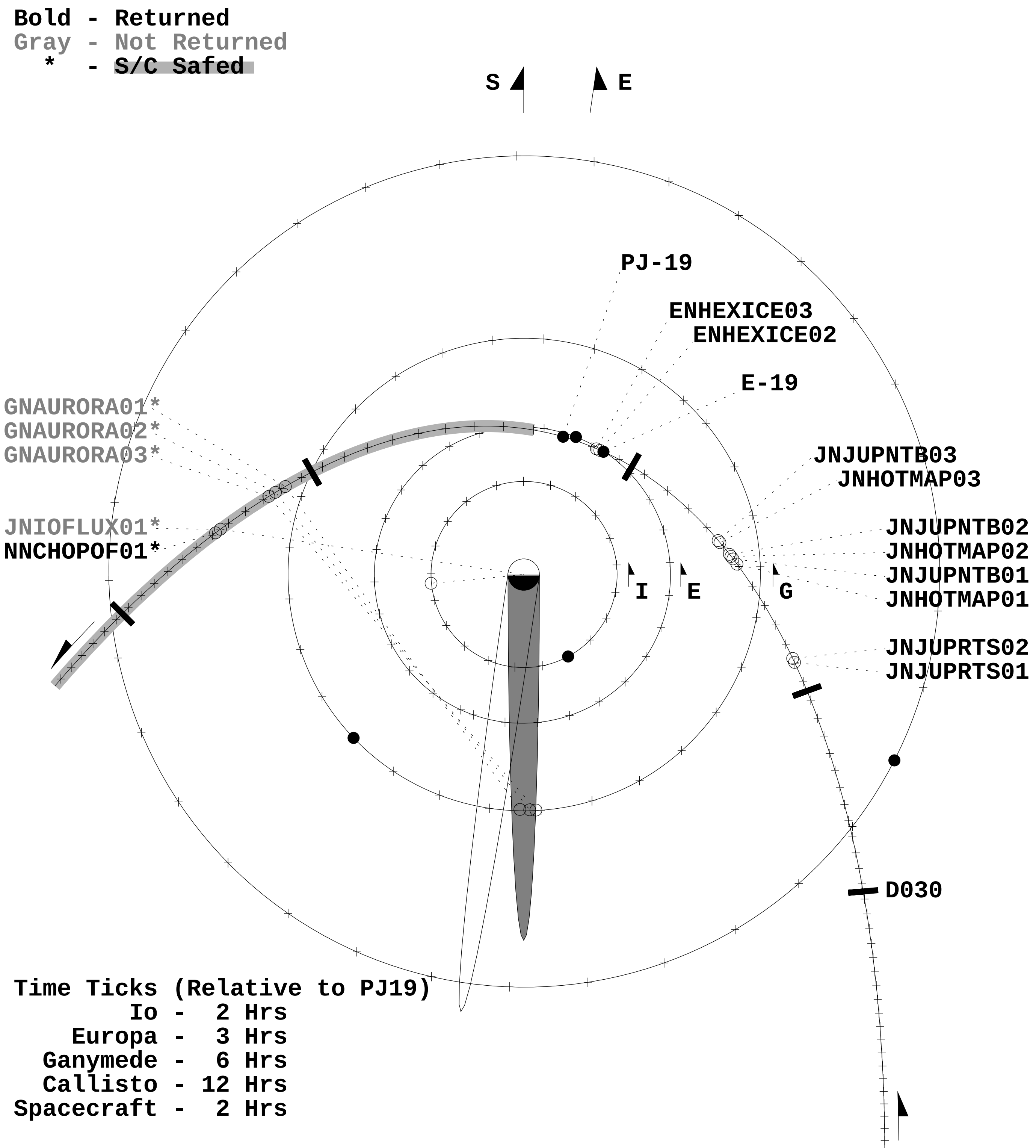
A Timeline of E19 playback events is on pages 7 through 13.

The text on page 14 describes the E19 NIMS and Spacecraft Anomalies.

The text on page 15 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 16 and 17.

The text on page 18 is a guide to understanding the NIMS MASK.

NIMS E19 OBSERVATIONS



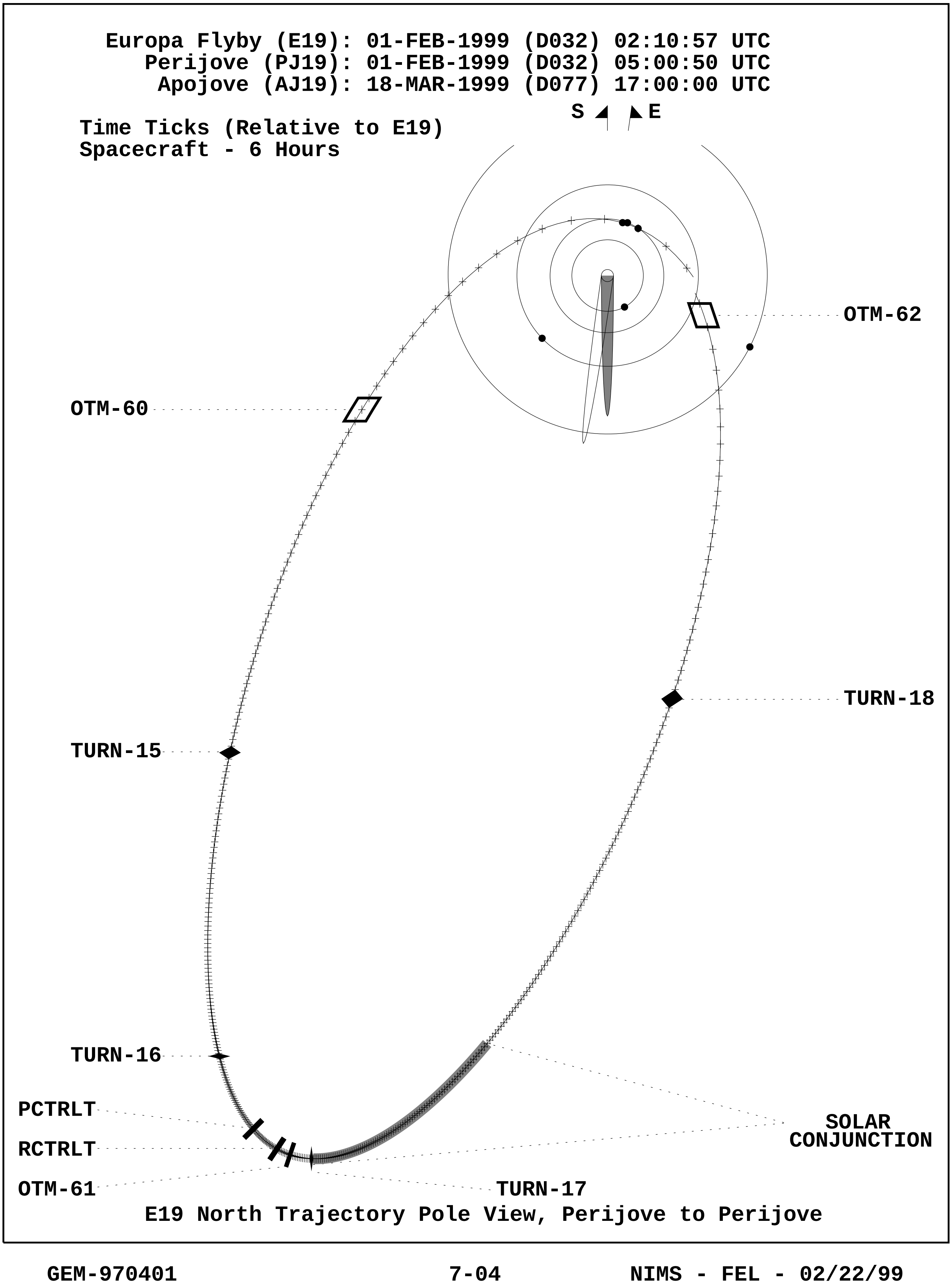
Time Ticks (Relative to PJ19)
Io - 2 Hrs
Europa - 3 Hrs
Ganymede - 6 Hrs
Callisto - 12 Hrs
Spacecraft - 2 Hrs

Europa Flyby (E19): 01-FEB-1999 (D032) 02:10:57 UTC
Perijove (PJ19): 01-FEB-1999 (D032) 05:00:50 UTC

E19 North Trajectory Pole View

NIMS - FEL - 12/06/99

NIMS E19 CRUISE CALIBRATIONS



E19 North Trajectory Pole View, Perijove to Perijove

NIMS E19 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format	PSID
19JNJUPRTS01*	Jupiter Realtime Observation	E19JLM408/MB	R/T	LM	2	0	4	R/T	
19JNJUPRTS02*	Jupiter Realtime Observation	E19JRT204A/MB	R/T	LM	4	0	4	R/T	
19JNHOTMAP01-	NIMS Jupiter HotMap	E19JHT253A	E19JHT100A	LM	4	0	4	LPU	
19JNJUPNTB01-	Jupiter NTB Observation	E19JHT253A	E19JHT100A	LM	4	0	4	LPU	
19JNHOTMAP02-	NIMS Jupiter HotMap	E19JHT253A	E19JHT100A	LM	4	0	4	LPU	
19JNJUPNTB02-	Jupiter NTB Observation	E19JHT253A	E19JHT100A	LM	4	0	4	LPU	
19JNHOTMAP03-	NIMS Jupiter HotMap	E19JSB253C	E19JSB253C	LM	2	0	4	LPU	
19JNJUPNTB03-	Jupiter NTB Observation	E19JSB253C	E19JSB253C	LM	2	0	4	LPU	
19ENHEXICE02-	Europa Hexagonal Ice Obs. part 2	E19EXM17A	E19EXM15A	XM	4	0	4	MPW	
19ENHEXICE03-	Europa Hexagonal Ice Obs. part 3	E19EXM17A	E19EXM15A	XM	4	0	4	MPW	
19NNRCTRLT01-	NIMS RCT Real Time Calibration	E19RCT252	R/T	LM	1	0	4	R/T	
19NNROPCAL01-	NIMS OPCAL	E19OPCAL48	R/T	LM	4	0	4	R/T	
19NNPCTRLT01-	NIMS Real-Time PCT Calibration								
19JNJUPNTB01-	Jupiter NTB Observation	E19JHT253A	E19JHT100A	LM	4	0	4	LPU	
19JNJUPNTB02-	Jupiter NTB Observation	E19JHT253A	E19JHT100A	LM	4	0	4	LPU	
19JNJUPNTB03-	Jupiter NTB Observation	E19JSB253C	E19JSB253C	LM	2	0	4	LPU	
19ENHEXICE02-	Europa Hexagonal Ice Obs. part 2	E19EXM17A	E19EXM15A	XM	4	0	4	MPW	
19ENHEXICE03-	Europa Hexagonal Ice Obs. part 3	E19EXM17A	E19EXM15A	XM	4	0	4	MPW	

NIMS E19 DATA RETURN

Activity ID	Mode	Record Format	Wave-lengths Returned	Record Time (sec)	PB Time (sec)	Selected Bits of Tape sBOT	Total Bits of Tape BOT	Mode Cycle (sec)	Comp	Thold	RT BTG Mbits	Total BTG Mbits (4% ohead)	Data Reduct Factor (sBOT/BTG)	Pass
19JNJUPRTS01	LM	R/T	360								0.16			
19JNJUPRTS02	LM	R/T	204								0.16			
19JNHOTMAP01	LM	LPU	100	600	573	3.53	3.70	8.667	1.28	0		1.074	3.29	1
19JNJUPNTB01	LM	LPU	100	610	607	3.74	3.76	8.667	1.4	0		1.041	3.60	1
19JNHOTMAP02	LM	LPU	100	600	583	3.60	3.70	8.667	1.26	0		1.110	3.24	1
19JNJUPNTB02	LM	LPU	100	1207	606	3.74	7.44	8.667	1.35	0		1.077	3.47	1
19JNHOTMAP03	LM	LPU	253	600	584	3.60	3.70	8.667	1.58	0		2.244	1.61	1
19JNJUPNTB03	LM	LPU	253	1220	1100	6.78	7.52	8.667	1.65	0		4.048	1.68	1
19ENHEXICE02	XM	MPW	15	664	658	7.58	7.65	0.333	1.48	0		4.166	1.82	1
19ENHEXICE03	XM	MPW	15	1394	182	2.10	16.06	0.333	1.24	0		1.375	1.52	1
19JNJUPNTB01	LM	LPU	100	610	35	0.22	3.76	8.667	1.4	0		0.060	3.60	2
19JNJUPNTB02	LM	LPU	100	1207	616	3.80	7.44	8.667	1.37	0		1.079	3.52	2
19JNJUPNTB03	LM	LPU	253	1200	113	0.70	7.40	8.667	1.65	0		0.416	1.68	2
19ENHEXICE02	XM	MPW	15	664	48	0.55	7.65	0.333	1.48	0		0.304	1.82	2
19ENHEXICE03	XM	MPW	15	1394	183	2.11	16.06	0.333	1.23	0		1.394	1.51	2
Resource Totals											**Total**	**19.388**		
											Alloc.	**17.624**		
											Over.	**1.764**		

RECAP OF E19 PLAYBACK EVENTS

For the third time in four orbits, the Galileo spacecraft went into safe mode during the encounter period. In E19 this occurred after perijove, after about 70% of the planned recordings had been completed, and for a completely new reason. Galileo was commanded to re-orient itself using "sun acquisition" which depends on a pair of dedicated sensors. The overlap between the two sensors was insufficient, and when Galileo reached this blind spot, it had no choice but to drop into safe mode and wait for instructions.

As a result of the safing we were not able to record a number of observations of Ganymede designed to search for auroral emissions. NIMS also lost one night side Jupiter observation that might have detected the footprint of the Io flux tube. On the other hand, NIMS brought down several nice observations of a portion of Jupiter's north temperate belt, along with a series of HOTMAPs. Two observations of Europa, optimized for detecting particular crystalline forms of ice, were also recorded and returned.

E19 was made complex by new rules for encounter development (based on lessons learned from prior orbits), and by events occurring during the cruise period.

The following timeline details the most signifigant events of the E19 playback period. Most of the text below is excerpted from messages issued at the time.

E19 Playback Events Timeline (11-16-98 to 05-01-99)

11-16-98: Encounter development begins with new constraints for rates of scan platform slewing mandated in order to minimize the probability of problems due to incorrect data from the gyros.

12-09-98: NIMS allocation is 18.565 Megabits.

01-09-99: Today's delivery is most probably the last one prior to uplink. We received roughly 1.5 Megabits of additional downlink allocation this time due to receiving some additional DSN station coverage due to the problems experienced by NEAR. The additional bits were employed to increase wavelength coverage for the Jupiter nightside observations 19JNJUPNTB01-02 and 19JNHOTMAP01-02. Coverage was increased to 100 wavelengths (full spectral resolution from 4.01-5.2 microns).

Yesterday's excitement was created by AACS' discovery that one of the stars in the star set needed during the E19 encounter would be obscured due to proximity to the cone pole. Following modeling and discussions of strategies involving changing the sequence at short notice it was decided to fly the sequence as is. Current information suggests that the star scanner should be able to successfully lock on to the two remaining stars, enabling the sequence to execute as planned.

E19 Playback Events Timeline (11-16-98 to 05-01-99)

A contingency plan exists in case the spacecraft goes into safing around perijove. This will recover from safing and reset all instruments prior to the time when the Ganymede observations (and subsequent Jupiter feature track observations) are taken.

01-11-99: (J. Gross) Allocations. You will notice that your allocation listed below is less than you expect. Here's why they've gone down, and why you shouldn't get too worked up about it.

A) There were 20 some stations that were one-way in the first E19C product that are now turned to 2-way. These stations are two-way to support the uplink of the CDS patch prior to C20. It is currently unknown how much of this two-way coverage will actually be needed; what is in the latest E19C product is a worst-case scenario. In all likelihood, we will get some of this coverage back, although not until E19C is executing.

B) By the end of the week, SST should have a new telemetry profile that will include ~10 new stations from NEAR, so your allocations will soon be going back up. BUT, whether our NEAR gains will offset our two-way losses is anyone's guess for now.

NIMS (allocation) = 17.099 MB
NIMS AACS Charge = 0.209 MB

Two-pass strategy. Currently our bits are split nearly 50-50 between passes. Given that we have such poor downlink rates, I'm not expecting very much inefficiency from the few long slews over unselected data that we have. Therefore, other than having NIMS and PPR ride-alongs synch up in a few cases, I will not be implementing any further changes.

01-15-99: NIMS allocation is 20.504 with new telemetry.

01-18-99: (D. Bindschadler) The purpose of this message is to present a strategy for commanding of science instruments in E19 in the event of a safing and the subsequent decision to utilize an E19A' sequence to recover observations starting with the E19 Ganymede Aurora and Atmospheric Feature Track observations. In the event of safing in E19A, it is possible that sufficient time will remain to recover the s/c, perform state matching, and execute an A' sequence that will capture significant science. At a high level, the proposed activities go something like this:

1) Bring up String A or B, if necessary.
2) Restart the SVM (+ position DMS, de-select RTS)
3) uplink and execute a state matching RBS.
4) uplink and execute E19A', which begins with SITURN#3, and then contains E19A observations from the Ganymede Aurora onward.

NIMS: Safing leaves NIMS off, with no Phase2 memory and Chopper off. No R/T commands are contemplated for NIMS. RBS sequence will include NIMSON library sequence. Memory load and Chopper ON will occur as part of normal E19A activities in E19A'. No special commanding is required in E19A'.

E19 Playback Events Timeline (11-16-98 to 05-01-99)

01-31-99: E19 encounter starts at 02:00 UTC.

02-01-99: Europa encounter occurs at 02:10:57.
Perijove occurs at 05:00:50.
Galileo spacecraft drops into safe mode during sun acquisition soon thereafter.

02-01-99: (R. Mehlman) As you may know, Galileo went into safing after Jupiter closest approach, and we will lose our Ganymede aurora observations and the Jupiter Io fluxtube observation. However all other Jupiter observations should be on tape, and a spacecraft clock value returned in the middle of the last of these indicates that NIMS was still running. The Europa HEXICE observation was also executed, but we don't have any clock values from that period yet.

02-02-99: The E19 encounter sequence did not run to completion. Following the Europa encounter, the spacecraft was performing a "Sun acquisition" to bring it back to a near-Earth-pointed orientation. Part way through this turn, it appears that a sensor failed to see an expected signal, causing the spacecraft to go into safe mode. This prevented recording of the distant Ganymede aurora observations and the subsequent Jupiter feature track and Io flux tube observations.
For NIMS these events resulted in the loss of about 30% of the data that was planned for playback. On the upside, we were not bringing down anywhere near all of our recorded data (and still cannot, under present conditions).
The total amount of downlink bits available to Galileo is still somewhat uncertain. It is likely that we will receive some increases in our allocation later. Solar conjunction occurs from 22 March to 10 April, and E19 playback continues until the start of May. Some other missions are, however, looking to grab some of our DSN passes. In light of the uncertainties, both SSI and NIMS are adopting an unusual strategy of front-loading the playback tables, as opposed to splitting playback between the two passes over the tape. Thus about 90% of our current allocation is in pass 1 this time. In pass 2 we will be adding gap-filling playback commands, and may also use any available bits to increase wavelength and spatial coverage of the successfully recorded observations.
Jupiter observations now comprise about 70% of the playback plan. The HOTMAP and JUPNTB (north temperate belt) observations will be coming down very early (since they were recorded early in the sequence), with full spatial coverage. The dark-side observations are coming down with 100 thermal wavelengths of the 253 recorded. We may be able to get more wavelengths in pass 2 if downlink bits are available. There is one instance (19JNHOTMAP02) where we are commanding the return of the balance of the 253 wavelengths in pass 2. The dayside observations have the full 253 wavelengths selected.

The 19ENHEXICE02 observation is fully selected as before but is now coming down all in pass 1. Playback of 19ENHEXICE03 was increased to 3 Rims in pass 1 and 1 Rim in pass 2. There will be about 19 Rims of this data left behind on the tape unless we receive more allocation. The spacecraft is still in safe mode pending new commands to bring it back to a nominal attitude. Playback will not begin until after this is accomplished.

02-04-99: (T. Johnson) I have had a number of requests for a little more information on where we stand on E19 following the safing event and on the status of our plans.
A brief summary is:

* The spacecraft is ok at the moment.
* The problem was probably (remember analysis is not yet complete) not either gyro, despun bus reset, or radiation related.
* We think (again preliminary) that the science sequence executed correctly through closest approach up to the turn back toward earth where the safing occurred.
* Observations after the safing, including Jupiter feature track, Europa global color and Io were lost.
* Once the spacecraft is checked out and returned to Earth point we should be able to start playback and proceed normally. The schedule is still TBD but we hope we can be up and running within the week.
* In this particular case (E19) I think it is important to emphasize several things:
  - The spacecraft is NOT falling apart - it's mostly just doing what we tell it to (damn it). There is no evidence that any of our recent problems are the result of progressive failure of systems due to radiation, with the possible exception of the gyro offsets, which do not seem to be getting much worse.
  - We think the E19 encounter was by and large very successful, with the highest priority closest approach data on the tape recorder. We won't know for sure until we start playing data back of course, as for any other encounter. By the priorities and allocations we set ourselves in the GEM OPG, we probably got 70 % or more of our goals accomplished (groan - there's Johnson and his 70% again!?).

02-04-99: (B. Paczkowski) At the GEM Staff meeting this morning it seems unlikely that we will get E19 playback started by Monday. It also seems optimistic that we will get it up and running by Wednesday. The more likely case might be Friday of next week. As a result, the playback tables that we are in the process of developing are probably not useable. Using Jerod's plot of p/b bits vs. time, by next Wednesday we will lose about 15Mbits and by Friday 21Mbits of our playback capability. The primary reason for this delay is that as a result of the anomaly, AACS has switched to backup hardware (sun acq sensor, spin detector, and thrusters) that the Project is uncomfortable using since the h/w hasn't been calibrated. The Project is in the process of deciding on how to proceed and hopefully by tomorrow we will have a better idea of the upcoming schedule.

02-05-99: (J. Erickson) The Galileo spacecraft is presently in safing, stable, and expected to resume normal operations on or about 2/12/99. The primary activity over the past week has been the Europa 19 encounter on 1/31. Four hours after completing the close approach science recordings, the spacecraft went into safing during a sun acquisition turn designed to move us from the science data taking attitude back to the nominal earth pointed attitude. During that turn the on-board fault protection program determined that the sun acquisition had stopped, and correctly called the safing program.
The flight team is still investigating the cause of the sun acquisition halt, but it appears to be the result of a failure of two acquisition sensors to provide the complete overlap they were designed for. This failure appears to have no impact on the rest of the planned extended mission.

02-08-99: (J. Gross) As you're probably aware, we are intending to resume "normal" spacecraft operations by Wednesday afternoon. This means that I'm going to need new PBTs from the teams by Tuesday at 1 PM!!!!
In terms of allocations, we've lost approximately 18% of our original capability. Torrence decided to apply this cut evenly across the teams (except for PPR, which has already given up approx. 0.5 MB.). If this decision doesn't please you, feel free to take it up with him. On the plus side of the ledger, Brian P. has released 1.0 of the 5.0 MB he was keeping back to cover potential E19C station losses.
NIMS - 16.790 MB (this must also cover the cost of your AACS)

02-09-99: Recovery from the spacecraft safing should be completed by Wednesday afternoon (02-10-99). We expect to begin playback of E19 observations at that time. The time consumed in recovery activities has cost us nearly 20% of our total downlink allocation. Thus for this final pre-uplink table we were forced to make cuts amounting to about 3.5 Mbits.
The "easy" cuts were eliminating the fill-in wavelengths coverage for 19JNHOTMAP02 in pass 2, and the extra spatial coverage of 19ENHEXICE03, also in pass 2. The additional 1.5 Mbits were cut from the Jupiter North Temperate Belt series of observations. For 19JNJUPNTB02, on the dark side, we reduced playback from 20 Rims to 10, while retaining in the plan those longitudes that are also seen in the other two JUPNTB observations. In addition we deselected from playback the first 2 Rims of 19JNJUPNTB03 (dayside), retaining the other 18 Rims. The longitudes deleted are not seen in the other two observations of the series.

02-26-99: (J. Erickson) AACS anomaly resolution is ongoing on two fronts - the failed sun acq and the gyros. There are no R/T activities planned for E19C in this regard other than some parameter cleanup.

A gyro test was performed on DOY 43 and there was an appreciable worsening of some axes. Analysis is proceeding and we await the results of the gyro test after apojove. We are anticipating a scale factor update before C20.
Until yesterday's 43 pass, playback was proceeding normally and about 1 day ahead of schedule and 41% complete. Prior to DSS43 pass yesterday it was reported that the station had a hardware failure and would not be ready to support Galileo. As a result, a pause playback was sent near the end of the DSS14 pass. Fortunately, DSS43 was repaired using some old spare hardware and was available to support Galileo. Unfortunately, we decided not to resume playback during that DSS43 pass. As a result, we lost about 1.35 Mbits of playback. A command to resume playback will be sent during Thursday's DSS43 pass.
The first observation (ESRHADMAN01) to show any significant pointing offset has just begun to be played back. This observation occurred about 21 minutes before Europa C/A. The pointing offset for this observation is about 4 mrad. We will be anxiously awaiting the playback of subsequent observations to see if this pointing offset persists, possibly indicating the start of the gyros going bad in this orbit.

03-04-99: (J. Gross) This Sunday we're going to lose about 1.5 MB of capability. Part of the loss is due to six-hour period in which we have no station coverage but no FILL commands in the sequence. The other part of the loss is due to Erickson's decision to allow Voyager to take the first 4 hours of our scheduled 43-pass. With this loss, our playback capability is actually 1.5 MB less than it was with the old C load!
On the bright side, however, the 4.0 MB of "Paczkowski" margin which was being held to cover any degradation of our E19C capability are now being released. An additional 0.14 MB is being given to MWG to cover the costs of the upcoming PLS RTS for instrument health.

03-05-99: The playback table delivered today differs from prior versions only in that it includes ten new sets of playback singles commanding gap-fill data return during the second tape pass of E19 playback. There are two gaps from pass 1 playback of 19JNJUPNTB01, and eight gaps in 19JNJUPNTB03. The estimated downlink needed for the gap fills is about .47 Mbits which places us a little over our allocation. As this is perhaps the last chance to get these gaps (they are near the start of the record sequence), the Project is letting us go ahead with this 'deficit spending.' Some margin remains in the bank. If the Europa HEXICE observations compress particularly poorly, we may end up in the doghouse.

03-08-99: **(J. Gross) Over the weekend, SSI Europa Plumes severely undercompressed (expected C/R = 4.0, actual C/R ~ 1.4), meaning that we're running behind schedule. In fact, we're so far behind schedule that Pass 2 will not begin until approximately a week AFTER conjunction!**

03-22-99:

Solar conjunction (no data playback occurs).

04-10-99:

04-14-99: **Only one change to the playback table was entered this week. A new set of playback singles to return the first half of 19JNJUPNTB02 was added. Although there are a number of gaps in 19ENHEXICE02, Bob indicated that the available data was sufficient or analysis, and that the Jupiter observation should receive higher priority. We should have another chance to go after these gap-fills later, IF we receive more margin bits.**
Downlink data rates have been at 32 bits per second and lower following solar conjunction. The last 1/2 Rim of 19ENHEXICE02 is coming down now, and it should be a week or so before we see 19ENHEXICE03. E19 playback will continue until the start of May (C20 begins on May second).

04-26-99: **(J. Gross) Here's the situation: between Saturday AM and Monday AM, we finished Segments 6,7,8, and 9, and then sat autonomously paused for just over five hours. It's still unclear why we went through these segments so incredibly fast.**
Right now Segment 10 is loaded, and will go active with our first coverage tomorrow morning. The segment only has about 0.33 MB selected, so we will autonomously pause again before we get to an uplink pass.
P.S. Total amount of capability lost of autonomous FILL in this scenario will be 0.93 MB.

04-27-99: **Over the weekend, playback accelerated rapidly and unexpectedly, completing all the commands that were then present in spacecraft memory, and pausing. A rapid-turnaround table was requested for delivery by 11 am today. Since very little remains on the tape aside from NIMS data, we were asked to add in an additional 1.5 Mbits of data for playback prior to termination of E19. As a result there are 5 new sets of commands in the new table. There are 3 gap-filling sets for filling the biggest holes in 19ENHEXICE02. Several other tiny gaps will remain. In addition there are two new sets of commands for 20ENHEXICE03. We have already received data from the early part of the observation at phase angle ~ 105 degrees. We will now also receive 2 Rims recorded at phase 100 degrees, and one final Rim recorded at phase ~96 degrees.**

05-01-99: **Playback terminates at 05:12 UTC.**

NIMS Anomaly Report - E19 Sequence

There were no NIMS processor halts detected during the E19 Encounter. Detectors 3 and 8 are still not functioning and are expected to be lost for the rest of the mission.

Also, the spacecraft went into safe mode about 5 hours after E19 perijove. The outbound portion of the E19 encounter was lost.

Processor Halts

There were no NIMS processor halts in E19.

Spacecraft Anomaly (Galileo ISA 11055)

The spacecraft performed a science turn during E19 to get a better view of Europa during the E19 flyby. The spacecraft safed while turning back to earth pointing after the Europa flyby and E19 perijove.

The science turns are normally performed with the aid of the gyros. But, since the gyros had been unreliable lately, the turn was performed using the sun sensor. The sun acquisition maneruver was started at 63 degrees off sun. Thrusters were fired to reduce the sun angle. At about 43 degrees a transition between sun sensors E and I/G was reached. Unfortunately, at this transition angle, the sun signal was too low and fell below the detection threshold. This effect stopped the sun acquitision maneuver. Subsequently the spacecraft was safed.

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.