Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the C30 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the C30 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 twenty-one autonomous reloads of the NIMS RAM code from CDS during the C30 encounter, one just before each science observation. Two software halts were detected during C30. The approach that we are taking to avoid data loss due to processor halts has proven to be very successful.

The NIMS grating became stuck some time between C22 and I24. NIMS can now return only 17 (of 408) wavelengths. This has caused a drastic change in NIMS science capabilities. Detectors 1, 2 and 7 now have very low sensitivity. Detectors 3 and 8 are still not functioning. NIMS now returns only 12 useful wavelengths. Interesting science can still be carried out given the current condition of the instrument.

The plots on the pages 3 and 4 show the geometry of the NIMS C30 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 C30 data returned.

The text on page 7 gives a 'recap' of the C30 playback events which affected which observations were returned.

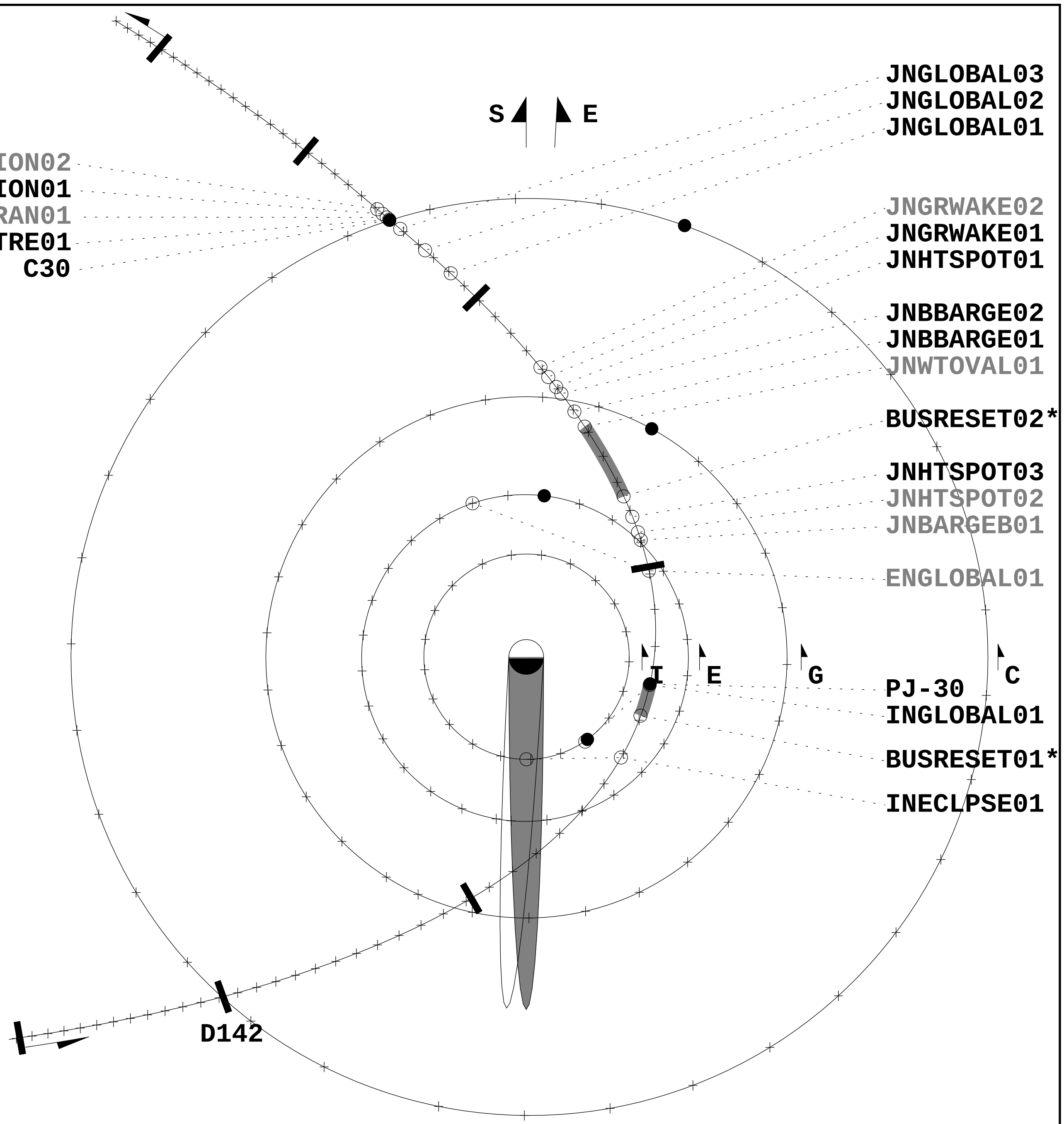
A Timeline of C30 playback events is on pages 7 through 19.

The text on pages 20 and 21 describes the C30 NIMS and Spacecraft Anomalies.

The text on page 22 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 23 and 24.

The text on page 25 is a guide to understanding the NIMS MASK.

NIMS C30 OBSERVATIONS



Time Ticks (Relative to PJ30)
Io - 2 Hrs
Europa - 3 Hrs
Ganymede - 6 Hrs
Callisto - 12 Hrs
Spacecraft - 2 Hrs

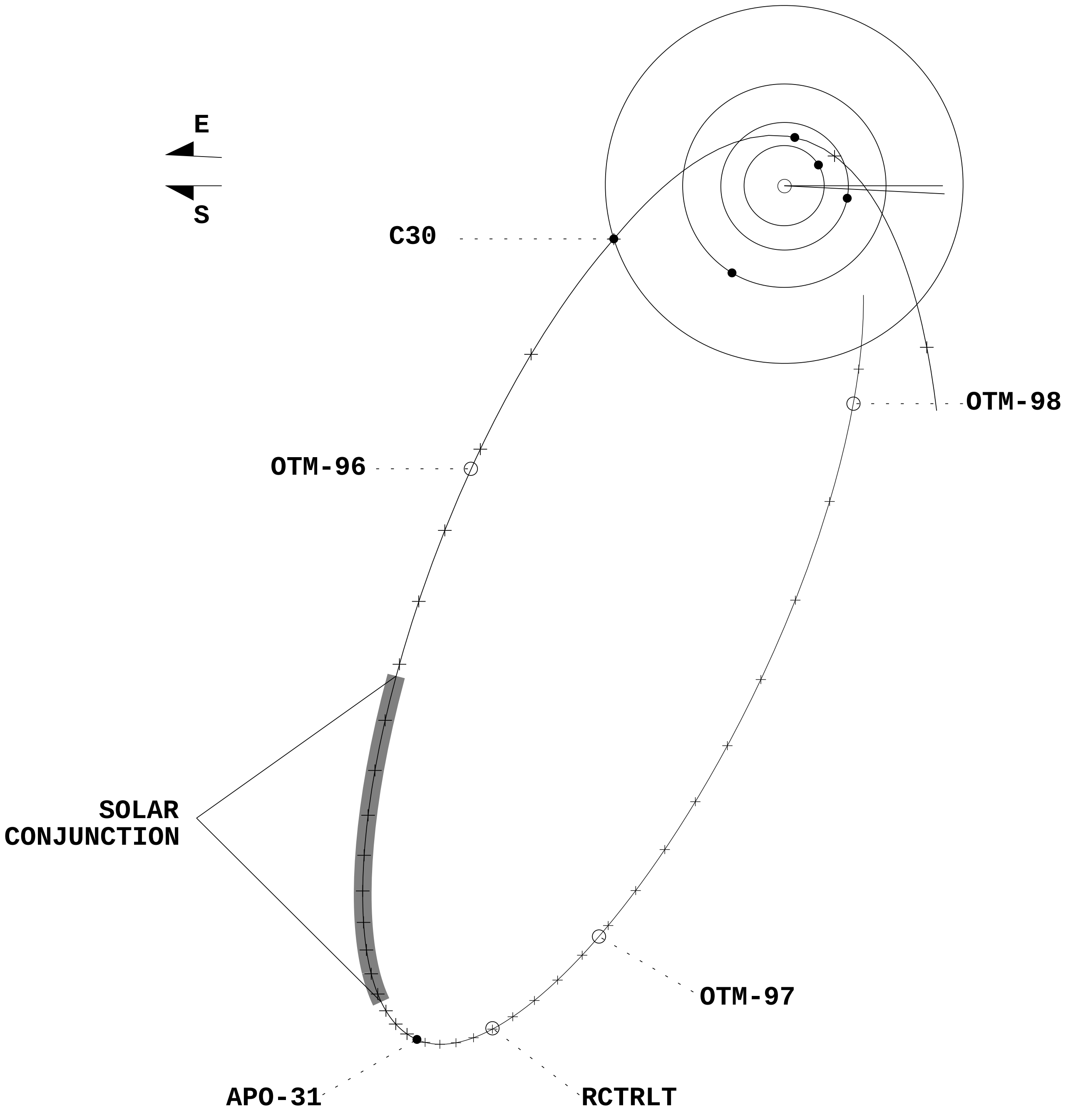
Bold - Returned
Gray - Not Returned
* - Processor Halted

Callisto Flyby (C30): 25-MAY-2001 (D145) 11:25:23 UTC
Perijove (PJ30): 23-MAY-2001 (D143) 17:34:12 UTC

C30 North Trajectory Pole View

NIMS - FEL - 11/30/01

NIMS C30 CALIBRATIONS



Time Ticks (Relative to C30)
Spacecraft - 2 Days

Callisto Flyby (C30): 25-MAY-2001 (D145) 11:25:23 UTC
Perijove (PJ30): 23-MAY-2001 (D143) 17:34:11 UTC
Apojove (A31): 29-JUN-2001 (D180) 23:46:40 UTC

C30 North Trajectory Pole View

NIMS - FEL - 03/26/01

NIMS C30 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format	PSID
30INECLPSE01-	Io Eclipse	C30ILM442	C30ILMFG36	LM	4	0	4	MPW	DF
30INGLOBAL01-	Io Global	C30ILM442	C30ILMFG36	LM	2	0	4	MPW	DA
30JNHTSPOT03-	Jupiter Hot Spot	C30JLMFG240	C30JLMFG16	LM	2	0	4	LPU	DE
30JNBBARGE01-	Jupiter Brown Barge	C30JLMFG240	C30JLMFG16	LM	2	0	4	LPU	DH
30JNBBARGE02-	Jupiter Brown Barge	C30JLMFG240	C30JLMFG8	LM	2	0	4	LPU	DI
30JNHTSPOT01-	Jupiter Hot Spot	C30JLMFG240	C30JLMFG16	LM	2	0	4	LPU	DJ
30JNGRWAKE01-	Jupiter GRS Wake	C30JLMFG240	C30JLMFG16	LM	2	0	4	LPU	DK
30JNGLOBAL01-	Jupiter Global	C30JXMFG10	C30JXMFG2	XM	2	0	6	LPU	DP
30JNGLOBAL01-	Jupiter Global	C30JXMFG10	C30JXMFG5	XM	2	0	6	LPU	DP
30JNGLOBAL03-	Jupiter Global	C30JXMFG10	C30JXMFG5	XM	2	0	6	LPU	DR
30CNFEATRE01-	Callisto Feature	C30CLM442	C30CLMFG36	LM	4	0	4	MPW	DS
30CNREGION01-	Callisto Regional	C30CLMFG253	C30CLMFG12	LM	4	0	4	LPU	DU
30INECLPSE01-	Io Eclipse	C30ILM442	C30ILMFG144FILL	LM	4	0	4	MPW	DF
30INGLOBAL01-	Io Global	C30ILM442	C30ILMFG36	LM	2	0	4	MPW	DA
30JNHTSPOT03-gf	Jupiter Hot Spot	C30JLMFG240	C30JLMFG16	LM	2	0	4	LPU	DE
30JNHTSPOT03-	Jupiter Hot Spot	C30JLMFG240	C30JLMFG16	LM	2	0	4	LPU	DE
30JNHTSPOT01-	Jupiter Hot Spot	C30JLMFG240	C30JLMFG16	LM	2	0	4	LPU	DJ
30JNGRWAKE01-gf	Jupiter GRS Wake	C30JLMFG240	C30JLMFG16	LM	2	0	4	LPU	DK
30JNGLOBAL02-	Jupiter Global	C30JXMFG10	C30JXMFG5	XM	2	0	6	LPU	DQ
30JNGLOBAL03-gf	Jupiter Global	C30JXMFG10	C30JXMFG5	XM	2	0	6	LPU	DR
(*) Pass 1 = SSI preview only									

NIMS C30 DATA RETURN

Activity ID	Mode	Record Format	Wave-lengths Returned	Record time (sec)	PB time (sec)	Selected Bits to Tape sBOT (MBITS)	Bits to Tape BOT (Mbit)	Mode Cycle (sec)	AACS Mbits c 2.5	Comp	Total BTG Mbits) wit 4% O'head	Data Reduct. Factor (sBOT/BTG)	Pass (*)
30INECLPSE01-	LM	MPW	36	362	359	4.14	4.17	8.667	0.021	1.21	0.256	16.1	2
30INGLOBAL01-	LM	MPW	36	866	427	4.92	9.98	8.667	0.025	1.22	0.302	16.3	2
30JNHTSPOT03-	LM	LPU	16	3314	1195	7.37	0.05	8.667	0.069	1.6	0.287	25.7	2
30JNBBARGE01-	LM	LPU	16	981	478	2.95	0.02	8.667	0.028	1.62	0.113	26.0	2
30JNBBARGE02-	LM	LPU	8	1582	244	1.50	0.01	8.667	0.014	1.65	0.028	53.0	2
30JNHTSPOT01-	LM	LPU	16	1582	960	5.92	0.04	8.667	0.055	1.84	0.200	29.6	2
30JNGRWAKE01-	LM	LPU	16	1582	1574	9.71	0.06	8.667	0.091	1.67	0.362	26.8	2
30JNGLOBAL01-	XM	LPU	2	1587	302	1.86	9.79	0.333	0.017	2.08	0.181	10.3	2
30JNGLOBAL01-	XM	LPU	5	1587	791	4.88	9.79	0.333	0.046	1.86	1.328	3.7	2
30JNGLOBAL03-	XM	LPU	5	1457	824	5.08	8.99	0.333	0.047	1.84	1.399	3.6	2
30CNFEATRE01-	LM	MPW	36	668	665	7.66	7.70	8.667	0.038	1.51	0.380	20.1	2
30CNREGION01-	LM	LPU	12	2253	182	1.12	13.90	8.667	0.010	1.85	0.028	39.6	2
30INECLPSE01-	LM	MPW	144	362	64	0.74	4.17	8.667	0.004	1.22	0.181	4.1	3
30INGLOBAL01-	LM	MPW	36	866	424	4.88	9.98	8.667	0.024	1.22	0.300	16.3	3
30JNHTSPOT03-gf	LM	LPU	16	3314	398	2.45	0.02	8.667	0.023	1.6	0.096	25.7	3
30JNHTSPOT03-	LM	LPU	16	3314	1289	7.95	0.05	8.667	0.074	1.6	0.309	25.7	3
30JNHTSPOT01-	LM	LPU	16	1582	390	2.41	0.01	8.667	0.022	1.84	0.081	29.6	3
30JNGRWAKE01-gf	LM	LPU	16	1582	276	1.70	0.01	8.667	0.016	1.67	0.063	26.8	3
30JNGLOBAL02-	XM	LPU	5	1452	570	3.52	8.96	0.333	0.033	1.83	0.973	3.6	3
30JNGLOBAL03-gf	XM	LPU	5	1457	28	0.17	8.99	0.333	0.002	1.84	0.048	3.6	3
									1.178		6.918		
											7.250	Allocation	
(*) Pass 1 = SSI preview only											-0.332	Over/Under	

RECAP OF C30 PLAYBACK EVENTS

In contrast with G28 and G29, C30 was severely limited in downlink resources. This was in part due to the occurence of solar conjunction (Galileo behind the Sun) during the cruise (playback) period. The total NIMS science data return was a little over 7 Mbits. By commanding for playback only the minimum number of samples, we were able to retrieve a dozen high-quality observations (two each for Io and Callisto, and 8 for Jupiter). Highlights included the discovery of an extremely hot new volcanic outburst on Io, and an excellent spatially resolved north polar aurora observation for Jupiter.

The Galileo spacecraft experienced two despun bus reset events during C30; both were handled by the onboard software. One NIMS software halt was recorded, but instrument reload commands within the sequence prevented the loss of any observations.

The following timeline details the most signifigant events of the C30 playback period. Most of the text below is excerpted from messages issued at the time.

C30 Playback Events Timeline (04-26-01 to 08-14-01)

04-26-01: This is the second delivery of the C30 playback table. The extremely limited downlink resources in C30 (probably less than 50 Mbits for all instruments) force us to face some difficult decisions regarding cutbacks in data returned. Compounding the problem, there are limits to how much we can reduce data playback for any given observation due to the "fill problem." If we select only a small percentage of the data recorded on tape for return, our downlink packets may not be generated fast enough to keep up with downlink data rates. In this case, fill packets are fed into the downlink stream, and a given NIMS observation requires more downlink bits than our models call for. This pleases no one. We know how to avoid this but in practical terms it means there is a minimum number of wavelengths we can command for return for any particular observation. This being the case, we cannot simply reduce the redundancy level; we must instead cut back on spatial coverage, or cut out some observations entirely. Significant cuts were outlined in today's noon meeting, principally by Kevin / atmospheres. However, employing the minimum number of wavelengths practicable for all observations, we are still about 30% over our current allocation of 10.3 Mbits. This number is expected to go down. By target:
Europa: 30ENGLOBAL01 deleted from playback plan (distant).
Io: 0.7 Mbits for 36/360 wavelengths of ECLIPSE, GLOBAL.
Callisto: 2.1 Mbits; all 4 observations selected, with 24/253 wavelengths or 36/360 wavelengths.

<u>C30 Playback Events Timeline</u> (04-26-01 to 08-14-01)

Jupiter: 10.5 Mbits. Partial playback of 30JNHTSPOT03; 50% reduction of BBARGEs; and playback of 4/10 wavelengths (not 5) of GLOBAL01-02. 03 which has the GRS is at 9 bands. BARGEb is not in the current table, however. Note that the 3 GLOBALS currently require 7.4 Mbits by themselves (about 75% of our total downlink allocation).

Thus it appears we will be forced to prioritize further, in order to make the needed cutbacks of more than 30% to the present plan.

04-27-01: (F. Leader) If you guys get creative and start changing playback edit tables in the middle of an observation, please note that it would make ground data processing much easier if these wavelength edit table changes were commanded at RIM roll-over. The ground data processing software will not look for a new Obstab entry unless there is a RIM roll-over.

05-03-01: (Y. Anderson) C30 Playback Allocation Update --
Based on the latest products C30AGA and C30BEA, we have only 46.094 MB playback capability -- 9 MB reduction from what was planned during GMM Scoping Meeting. For now, SPOT plans to hold 1.422 MB for inefficiency and 1.0 MB for margin, which leaves us 43.672 MB for playback.

	Total Allocation	Playback Allocation	Playback Usage	RTS Usage	Unused Bits
Total:	44.98	43.67	54.74	1.310	-11.07
SSI	25.522	25.522	30.571		-5.049
NIMS	6.940	6.840	13.365	0.100	-6.525

AACS allocation was deducted from NIMS (1.881 MB) and MWG (0.092 MB).

05-03-01: (D. Bindschadler) Additional notes regarding allocations: During OAP planning and BTG allocations last fall, MWG and Torrence agreed that 9 MBTG represented a minimum for C30. If MWG usage stays below 9 MBTG (it’s currently ~8.1 Mbit), the remainder will be redistributed to SSI, NIMS, and PPR. The cost of moving the SSI 30JSHOTSPT observations out to DOY 147 (~22 hours after the last recorded observation in the C30 OAP) is roughly 1.5 MBTG (due to delay of the IPB). Because the cause of the move is the loss of SSI summation mode capabilities (i.e., outside of SSI’s control), the loss in capability will be distributed amongst the teams per OPG percentage.

05-07-01: (K. Baines) I am willing to cut one of the globals back even further, just to get +20 to -20 degrees lat or so. This one should be the one that is on the opposite side of the GRS (the anti-Great-Red-Spot hemisphere) (However, we don’t want to miss the white oval or the barge...). Looking at the actual plots.... It seems to me that we can drop the southern part of Global 03. It has the GRS on the limb, but we get a much better view in Global 01. It has a barge, so we want to get the northern hem. So let’s return at least scans 4-6 (counting from the north pole downward

on the plot). If possible, let's tack on scans 7-8. This would then get is the GRS on the limb. This means we would only be returning 5 out of the 10 scans on this global. On Global 02, again return at least 4-6. The white oval is on the limb in scan 8/9. So getting back 4-9 would be great. Another cut would be to get back 4-6, then 8-9, leaving out 7 on Global02. (7 could also be left out of Global 03, if need be, so we'd be getting 4-6 and 8 on Global 03)...

05-07-01: (M. Segura) Callisto playback priorities....
30CNFEATRE01 - keep all
30CNCTBRAN01 - keep first scan
30CNREGION01 - keep first scan
30CNREGION02 - first on the chopping block to NOT return.

05-08-01: My rule of thumb up to now has been to request ALL of the AACS (pointing) data for our observations which have cone angles of 165 or higher. For this orbit, however, we end up paying 1.2 Mbits for our AACS, out of a total allocation of 8 Mbits. Lucas, would you be comfortable with half or less of the AACS, for observations with cone angles of 175 or so?? What are the upper and lower limits of a comfort zone..? What subsets of the AACS are most significant (near limb?)

05-15-01: (Y. Anderson) Based on the latest products C30AGD and C30BEE, we have total capability of 43.94 MB. Subtracting the realtime science usage (1.20 MB for UVS/EUV and 0.10 MB for NIMS), we have 42.64 MB for playback.
NIMS 6.494 Mbits
Just wanted you to know the situation of inefficiency of the C30 pbt. We have about 9840 tics inefficiency for the pbt C30PCA, of which 1040 tics are from pass 1 and the rest from pass 2. It costs 1.39 MB at 40 bps, and 2.12 MB at 60 bps. There are two major areas where no data are selected for a long period of recordings. One is among these recordings
30INGLOBAL01-, 30ASOPNAV_02, 30ENGLOBAL01-,
30JNBARGEB01-, 30JNHTSPOT02-, 30JNHTSPOT03-.
I noticed that NIMS will be selecting 30INGLOBAL01 and 30JNBARGEB01 in pass 2 in the next delivery, so some inefficiency here will be eased. It would be even better if NIMS could select part 30JNHTSPOT02 and/or 30JNHTSPOT03 in pass 2.
Another big gap is at the beginning of c/a, where between 30JNWTOVAL01-, 30JNBBARGE01-, 30GSTRMMAP01, 30JNBBARGE02-, 30JNHTSPOT01-, 30JNGRWAKE01-, 30JNGRWAKE02-, 30GSGLOCOL01, 30JNGLOBAL01-, 30JNGLOBAL02-, and 30JNGLOBAL03- no data selected in pass 2.
The cost of this gap alone is 4368 tics. Although NIMS will be selecting 30JNWTOVAL01 and 30JNGLOBAL02 in pass 2 in the next delivery, we still need more selects from these recordings in pass 2 in order to lower the inefficiency.

<u>C30 Playback Events Timeline</u> **(04-26-01 to 08-14-01)**

05-16-01: **The playback table delivered yesterday will be uplinked to the spacecraft and will go active on 27 May (a couple of days after the Callisto flyby). The NIMS downlink allocation has shrunk to approximately 8 Mbits, and many significant changes to the playback plan were implemented in this delivery. The painful cuts are detailed by target below. In this delivery we have placed about 40% of our bits in the second playback pass, to reduce the production of fill while slewing over tape. In addition we are experimenting with selecting a relatively tiny amount of spectral data for two short snippets of observations (30JNBBARGE02, 8 wavelengths of 240 recorded, and 30CNREGION01, 12 wavelengths of 253 recorded). In C3 we experienced a significant problem when doing this, during intervals of high data rates (80-160 bps). In this orbit we reach a maximum of 60 bps, with typical data rates of 40 and lower. The C3 problem was a result of the slowness of creation of AACS downlink packets, together with the sparse selection of NIMS data. We are performing this experiment to see if we can safely return fewer wavelengths so we can obtain correspondingly higher spatial coverage. If we see the same result as in C3 ("autonomous fill"), we will adopt a more conservative approach in pass 2. If autonomous fill is observed, the amount should be small enough to represent an insignificant impact on our allocation. If we do not see significant amounts of fill we may be able to significantly increase our spatial coverage for Callisto.**

Callisto:

CNFEATRE01, highest resolution, is coming down in full (spatially) at 36/360 wavelengths, in pass 1.

CNCTBRAN01 is in pass 2 with 24/253 wavelengths, with only the first (of 2) spatial scans selected.

CNREGION01 is employed for the fill-test in pass 1 with 3 RIMS of data; the first scan (of 2) is also planned for return in pass 2 at 24/253 density.

CNREGION02 is not selected due to lack of bits.

Europa:

30ENGLOBAL01 will not be returned due to insufficient downlink allocation.

Io:

INECLPSE01 comes down first with 36/360 density.

INGLOBAL01 has the same spectral density but is split between passes 1 and 2 to minimize slewing inefficiency.

Jupiter:

30JNHTSPOT02 and 30JNGRWAKE02 are not being returned due to lack of bits.

JNGLOBAL01, 02 and 03 are reduced from the desired 9 wavelengths/detectors to 5, and a significant amount of spatial coverage is being left behind.

01 has the Red Spot. Of the 10 scans, we will get the top 2 (at 2 wavelengths only) for aurora, and we will get scans 3-8 with 5 detectors (4, 6, 10, 11, 17).

We get the same 5 for scans 4-8 of GLOBAL02, and for scans 4-9 of GLOBAL03.

<u>C30 Playback Events Timeline</u> (04-26-01 to 08-14-01)

An obscure switch in the Pointer software was set incorrectly during generation of our designs for several Jupiter observations of specific features. In nearly all cases there are significant errors on the plots. However we have been rather lucky and in most cases we will image all or at least part of the desired feature. Affected are: JNHTSPOT01-03, JNBBARGE01-02, JNGRWAKE01-02, and JNBARGEB01. JNWTOVAL01 was not significantly impacted.

05-22-01: Start of C30 encounter sequence.

05-23-01: (R. Mehlman) At SCLK 6048880 (SCET 143/16:05) CDS received a watchtimer SCLK value of 6048863, 17 minutes earlier, from NIMS. This is evidence of a NIMS software halt between our Io Eclipse and Io Global observations. Since we have a reload before the Io Global, it should be harmless.

05-23-01: Perijove occurs at 17:34 UTC.

05-23-01: (E. Theilig)
Galileo Callisto 30 Status Report #1 - 4:30 p.m. PDT
The Galileo spacecraft is operating normally with the exception of the SSI camera as discussed below, and all activities appear to be as planned. Close approach to Jupiter was at 10:33 a.m. PDT on 5/23 (Earth Receive Time), and at an altitude of 6.3 Jupiter radii. All planned atmospheric and Io observations to date appear to have been recorded successfully. The DSN successfully recorded the Radio Science Jupiter Occultation using the RSR over DSS-43 (Canberra, Australia), between 6:20 p.m. (5/22) and 12:50 a.m. (5/23) PDT. The spacecraft has now passed Jupiter close approach and the peak radiation level was around 350 (measured by the star scanner in pulse counts), significantly lower than the maximum of 1400 seen in previous GEM orbits. The only identified radiation related effects so far have been a standard bus reset, handled normally by the on-board recovery software without any effect on the planned sequence, and possibly the SSI issue discussed below.
As anticipated, the SSI camera baseline voltage anomaly is recurring in association either with instrument commanding or the radiation environment or both. Results of cycling instrument power off and on to clear the problem are unknown because of telemetry outages. More instrument engineering data should be available around 5:00 a.m. Thursday morning.

05-25-01: (E. Theilig)
Galileo Callisto 30 Status Report #3 - 11:50 p.m. 5/24
The Galileo spacecraft is operating normally and all activities appear to be as planned. The current status is from the DSS 43 pass at 10:30 p.m. PDT on 5/24. All observation recording is proceeding according to plan.
The Solid State Imaging camera has returned to its normal state following realtime commands to power cycle the instrument and reload its memory. As has been the case in previous encounters, the Near Infrared Mapping Spectrometer

and the Energetic Particle Detector both experienced memory upsets around perijove. In both cases, sequenced memory loads corrected the problem with minimal loss of data.
A second standard bus reset occurred Wednesday night and was handled normally by the on-board recovery software without any effect on the planned sequence.

05-25-01: Callisto close approach occurs at 11:25 UTC.

05-25-01: (E. Theilig) The Galileo spacecraft is operating normally at the end of the Callisto closest approach observations. The current status is from the DSS 63 pass at 10:30 a.m. PDT on 5/25. Close approach to Callisto was at 4:24 a.m. PDT, at an altitude of 138 km. All planned Callisto observations appear to have been recorded successfully. The Radio Science Callisto occultation experiment over DSS 63 started at 3:11 a.m. (5/25) and ended at 6:14 a.m. (5/25) and was successfully recorded.

05-25-01: (Y. Anderson) As you know, SSI was in anomalous state for some period of time. As a result, the playback strategy has been changed. Currently, we plan to play back the SSI data (only) in pass 1, and add playback of data from other instruments in pass 2 and pass 3. The reason for doing this is we'd like to assess, as quickly as possible, to what extent the SSI data were damaged. I don't know yet as to how this will impact on the team allocations and playback inefficiency. It'll become clearer in a week or so.

06-04-01: Start of solar conjunction.

06-07-01: Since I will be out of town from June 20-July 10, and a new C30 pbt may be required in the interim, I have generated and delivered a new one to /c30/pbt/delivery on donatello, dated 010607. The only change from the prior version is a modification of all pass numbers (which have been incremented by one). Unless we receive a windfall of new downlink bits, our playback strategy will remain unchanged until we have a substantial proportion of our initial data return on the ground.

06-23-01: End of solar conjunction period.

06-24-01: (Y. Anderson) Below is the approval information for the C30 playback table update, C30PED. This is the first C30 playback update, from segment 4 and beyond. Playback is currently 7% complete.
The previous playback table (C30PEB, 3 segments) is a PBT exclusively for SSI data. At the end of Segment 3 we will have been through the entire tape once. Now all singles from NIMS, PPR and F&P were added into the playback table, with pass 2 starting from Segment 4.

07-02-01: (Y. Anderson) C30 playback table update:
As expected, the SSI Jupiter hot spot data of C30 are not good. Currently, C30 playback is 4 days ahead of the schedule. We will send segment 6 on Wed. Thus, for this week's update we will start from segment 7 (which is the beginning of Callisto c/a recordings). To lessen workload, the 2nd delivery of I31 pbt is postponed to Friday 5PM (7/6), one day delay from what's on the schedule.

07-05-01: (R. Lopes) The NIMS eclipse observation in orbit C30, obtained May 23, 2001, shows a very bright hot spot at approximately 50S, 72W. This is probably a new hot spot (I cannot find any previous reference to it). There is a prominent black caldera near that location. A single-component temperature fit by Lucas yields about 1000K, which is very high for a single-component fit (even Pillan was not that high). This is probably a major eruption. We need more samples to be able to determine the hotter components. We only have 3 samples out of 24. I have spoken with Bob and he has agreed that we should get all the samples for that region. It's not very much, about 1 1/2 rims. Bob M. looked at the tube and the rims for this area range from 6048720.78 to 6048722.26. If necessary, we can do away with the gap fill in order to get these data. The whole observation is great: There are 14 hot spots plus 3 that are very faint and I cannot tell for sure. The hot spots include well-known ones (Prometheus, Gish Bar, Zal) as well as some that NIMS had not detected before (Uta, Catha). Let me know if we can adjust the playback tables to get these data.

07-05-01: (R. Mehlman) I rechecked the extent of the hot spot in the DN tube and saw that the feature almost exactly coincides with the 4th RIM of the observation. If bits-to-ground are at a premium, the playback request need only cover one RIM. And if this is also too much, the request could be trimmed back to fewer than the 12 detectors originally selected.

07-06-01: (Y. Anderson) Playback is currently about 2.5 days ahead of schedule. Playback is currently 18% complete.

07-10-01: (K. Schimmels) As most of you know already, playback went into a limited search this weekend for an unknown reason, and recovered as expected without real time commands being sent. We did, however, lose 1.2 MB of capability during the 14 hours of slewing across tracks 4 and 1.
This loss will impact playback BTG for C30. From what I can tell, we have 0.7 MB of SPOT margin and 1.3 MB of ineff. margin retained. If we were to take 1.2 MB of that, then we only have 0.8 MB remaining to cover inefficiencies. So far, I've calculated that we have rec'd 0.210 MB of NET inefficiency, as of the last checkpoint, and I don't have an estimate of the remaining inefficiency we expect to get from here on. I would like to let Yanhua have some time this week to check the following:

1) how much remaining ineff. We expect from the last checkpoint on,
2) tell me if the remaining margins I stated above are correct
3) update SSI's allocation based on what was spent for c30 opnav playback (very very little) and restore the remaining to the margin, if this hasn't been done already.
4) talk to me about the answers to the above, and make recommendations on whether we have the margin bits to pay for this or whether allocations need to change.

As for playback updates for C30, I am recommending that we do NOT do an update this week to Segment 8, unless someone has a very compelling reason to do so. Segment 8 is the middle of Calliso C/A data, and we are still in the first pass thru for most teams (second for SSI). Given that we are behind schedule a bit, we may have the option next week to affect segment 8, but that is uncertain still. The decision on that will be made next Monday (7/16). Also, the SST has a really large workload with I31A, I31B, OTM-97, and a new SIE, and Yanhua is out this week.
IN SUMMARY: There will not be a C30 PBT update this week, unless I am told otherwise at the SPOT meeting tomorrow, and new allocations will be out next week reflecting any cuts due to limited search.

07-10-01: (F. Leader) NIMS packets and DMS limited search mode (not guilty): Regarding the query about the DMS limited search mode and NIMS packets: NIMS received all requested data for 30JNGRWAKE01. The NIMS packet sequence count continued without a gap into the next requested NIMS observation 30JNGLOBAL01.

07-11-01: As you know we have a paltry 7.5 Mbits of downlink allocation in C30. Due to a limited search event on the S/C we are likely to see a drop in allocation (about 1 Mb, divided among the teams). We have already consumed about 4.5 Mbits (60%) not counting any Callisto data return in the first pass over the tape. Some good news is that our experiment with very high data reduction factors has not so far led to the generation of fill packets, as far as I can tell.
Please think about how we can cut and/or reprioritize our observations:
Io issues:
To get the rest of the wavelengths (12*24 - 36 = 252) for the RIM containing the new hot spot in 30INECLPSE01 will cost us .31 Mbits. This is about the same as is required for the entire second pass playback for 30INGLOBAL01. Note that the remaining part of the global is the southern hemisphere, including the hot spot (lat/lon coverage for the two is similar, but the gain states are 4 and 2). I think we could cut the wavelengths from 36 to 24 for the global (based on data reduction factor issue only). I think the key question is, do we really need ALL of the other 21 wavelengths x 12 detectors for the hot spot, or can we make do with fewer? Or can we ignore some detectors for this replay?

Callisto issues:
We have about .55 Mbits in the second pass for CNBRAN and CNREGION01, at 24/253 wavelengths. However we won't see the first pass data for a couple of weeks.
Jupiter issues:
There are 5 observations that can be affected in the second pass. Do we need them all (a third barge observation, 2 hot spot observations, a white oval, and the GLOBAL02)? What do the GLOBALs that are down look like (01 auroral zone with 2 bands, 01 and 03 with 5 bands)? Based on what we have, what can we forego in the second pass?

07-11-01: (R. Lopes) We need the global Io observation to locate the hot spot more accurately, but since it is a daytime observation it is not much good for temperature determination. Cutting the number of wavelengths is a possibility. I'd rather do that than cut anything on the hot spot area in the eclipse observation. We need all we can to get a high-temperature component for the hot spot.

07-11-01: We are facing some wicked decisions regarding our last-pass playback of C30 Jupiter observations.

1. **Our overall allocation has been cut and now we are over by .5 Mbits.**
2. **There are a couple of large gaps in the data that is down (30JNHOTSPOT03, 30JNGRWAKE01).**
3. **The global01 looks very nice (5 bands middle latitudes), and there are striking aurora in the north polar scan we brought down with 2 wavelengths. Global02 is yet to come down and represents our largest pot of bits.**
4. **Very high priority is given to a replay of 1 RIM of the Io eclipse, where a hot new eruption is seen, and more data is needed to constrain temperature fits and location. This will require .2 to .3 Mbits. A 33% cut for the remaining Io saves only .1 Mbits.**

Bottom line, if we are to retrieve the Io data, we need to cut .6 Mbits from the remaining Jupiter and Callisto observations (more if we want to fill the gaps noted above). Some decisions need to be made by next Wednesday.
Candidates for cuts are:
JNBARGEB01 .1 Mbits
JNHTSPOT03 (10 additional RIMS of the observation) .275 Mbits
JNWTOVAL01 .337 Mbits
JNHTSPOT01 (last third of observation) .133 Mbits
JNGLOBAL02 (longitudes coverage adjoins 01, 03) 1.18 Mbits
There are also 2 Callisto observations with .55 Mbits, at the end.
What to cut?

07-11-01: (Y. Anderson) C30 Playback Allocation Update
Currently, we have 0.7 MB of SPOT margin and 1.3 MB of ineff. margin retaining. As Kathy pointed out earlier, we lost 1.2 MB of downlink capability, due to a limited search this weekend. So far, we have recorded 0.2 MB of NET

inefficiency, as of the last checkpoint, and the estimated remaining inefficiency from the checkpoint on is 1.7 MB. To cover the altogether 3.1 MB loss and inefficiencies, teams need to share a cut of 1.1 MB. It breaks down as: SSI 0.66, NIMS 0.23, PPR 0.01, MWG 0.20.

07-13-01: (R. Lopes) I extracted some parts of Sylvain's last email to me regarding C30:

> I had a quick and dirty look at the new Io global observation from C30. It's so pretty and covers a very nice range of longitudes!. Even if the upper part is still missing. When will we have the rest of the disk? I picked up score of spectra and compared then with typical spectra from global I24INREGION02. The morphology of the C30 individuals is quite different from those present in I24.

This affects our playback strategy. I thought C30 global would not be too useful for SO2 mapping because of the low resolution, but I had not thought about the new longitudes. Looks like we should not cut GLOBAL...

07-18-01: Multiple changes to the table were made this week to respond to new conditions and opportunities. Our allocation has dropped to under 7.2 Mbits, and the detection of a new (very) hot spot in high south latitudes of Io made it desirable to spend additional bits there. We were forced to cut three observations from the plan.

Io:

We are replaying 1 RIM of 30INECLPSE01 with 144 wavelengths which are complementary to the 36 returned the first time through. 21/24 samples are being returned for detectors 4, 5, 6, for best signal enhancement, while an additional 9 samples are coming down for the thermal range detectors 9-17. We will also return the second half (southern hemisphere) of 30INGLOBAL01 (also showing the hot spot). This was trimmed slightly at the end for bits savings.

Callisto:

Playback of 30CNREGION01 was cut. 10 seconds of data playback remain in the table as a placeholder. We may be able to add this observation back next week as a freebie. Since it is near the end of the tape, we should be allowed to reinstate it, with the understanding that it is there to avoid the embarassment of terminating playback before our last DSN pass comes to an end.

Jupiter:

Kevin's desire to get two views of the North equatorial belt hot spots (to look for changes) led to the deletion of 30JNBARGEB01 and 30JNWHTOVAL01. We will get overlapping coverage of longitudes 20-45 W in the observations 30JNHTSPOT01 and 30JNHTSPOT03. We ended up not filling a large gap at the beginning of the latter observation because it did not fall in the contiguous overlap area.

Most of the data reduction factors in this table have been changed to reflect actual compression performance. There will be one more update next week. Playback will terminate on 3 August.

07-23-01: **(Y. Anderson) There is also an allocation change for the teams. Remember, about three weeks ago, teams shared 1.1 MB cut due to the limited search. At that time MWG had a cut of 0.2 MB. But since MWG has a lien on 9 MB floor at the OPG planning, MWG needs to have the 0.2 MB back. As a result, an additional 0.2 MB cut will be distributed to SSI, NIMS and PPR.**

07-23-01: **(K. Schimmels) First, I am going to suggest that the 0.2 MB cut to restore BTG to MWG only come from NIMS and SSI, PPR's percentage of this is totally in the noise. We should have cut the 1.1 from NIMS/SSI only in the first place, but I had also forgotten about the MWG minimum number of BTG needed. SSI - Herb -It has come to the point where you must adjust the remaining compression numbers in your next playback table to be realistic. We are too close to the end of playback not to be able to see a realistic schedule, and most of that is due to SSI being over allocation by 4.612 MB (artificially, I assume). Please take the time to edit your remaining PBT SINGLEs accordingly. In addition - SSI is last on the tape, you may plan on overselecting bits in the CSGLOCOL observation, but not in anything prior to that in order to assure we get to the last PPR data for gap fill if necessary. All teams: I am not pleased that we need to do this week's update off schedule, with this being the last week of S&CG for I31, I don't like putting extra pressure on teams, including SST, to do an update on a day that is not scheduled. However, since there is not going to be a chance to see the end of Pass 2 this week prior to even an on schedule update, it looks like we have to have an additional update next week, again, being off schedule. This is NOT something that I want SPOT to get in the habit of requesting. We simply do not have the time or staff to do this repeatedly and from now on, off schedule updates must be requested and cleared in advance not only by me, but by the SST team chief and SIE's as well. We have an encounter in 2 weeks, and squeezing in and additional update is not what we would have liked to be doing next week.**
We now face the following issues:

1) **We have an unrealistic schedule to gauge playback by, and we have no visibility into the last half of pass 3 yet.**
2) **We need to decide whether to do an off schedule update either this week OR next.**
3) **We are definitely in need of an off schedule update early next week if we wish to be able to affect the third pass of playback thru tracks 1 and 2. This means an approval and uplink Tuesday of next week i.e. files due monday, and no chance at seeing data bested next week prior to the final update.**
4) **Can SST support doing an off schedule update this week and next, given a delta product for I31A and OTM-98 next week? I doubt that the answer will be yes, but we need to ask the question ASAP.**

A general plea - I would like for teams to be thinking ahead a bit more on the updates from now on. You should assume when you do an update that there is a chance you will NOT be able to affect the following segments in the next week, and plan accordingly. We updated segment 9 AND BEYOND last week, and allocations have not changed this week that I am aware of. Needing an update to Segment 10 this week surprises me, and I can't say that I will agree to it yet, as there are obviously other issues to consider here. The last pass thru the observations in Segment 10 was around DOY 189 if not earlier, a full week and a half prior to last week's update, and that should be plenty of time to know whether or not a team needs to update the observation in the next pass. Yanhua and I will talk to SST and look at the affects of skipping the update to 10 and updating 11 and beyond next Monday. A decision will be made early Tuesday, but for now do not plan on being able to affect segment 10 unless you can give me a really strong reason ASAP.

07-24-01: (Y. Anderson) The decision was that we cancel the early update this week! We will send segment 10 from C30PEH tomorrow.
This is the last C30 playback allocation update (7/24). The only change from the previous allocations is that 0.2 MB is given back to MWG, which is compensated by a cut of 0.15 MB for SSI and a cut of 0.05 MB for NIMS. The last pbt update for C30 is Thurs., at 3 PM. Last but not least, the allocations.

-- MWG can now give 0.2 MB back to SSI (0.15MB) and NIMS (0.05MB), because they gained 0.382 MB back from the buffer dumps allocation that was taken from them at the beginning of C30 playback. Since they did not plan to add gap fills, this 0.382 MB gain put MWG fairly close to their allocation.
-- There is extra bits (0.1MB) from AACS. We use it to cover PPR's over allocation, if they choose to replay the EWSCAN data, and all other noises.
-- With 0.05 MB back, NIMS is within their allocation
-- With 0.15 MB back, SSI needs to cut 0.2 MB. C30 playback has been a tough one. Thanks to every team's cooperation, we finally made it!

07-26-01: We have a problem. Callisto compression was lower than expected. We may have to cut the BRAN crater observation in today's update, UNLESS we cut back to 12 samples here (from 24) too. Kevin has been happy with single sample observations such as his globals; probably Callisto will be ok with no oversampling too.

07-26-01: This is the final update for C30. Playback will terminate on 3 August. Changes to this table include the addition of 3 sets of gap-fill singles for 30CNFEATRE01, and the reduction of spatial coverage (by one scan) of 30JNGLOBAL02. I also deleted our "placeholder" singles for 30CNREGION01.

Compression values for remaining observations were updated based on pass 2 performance. We are presently a tiny bit under our allocation; total NIMS downlink for the orbit is estimated to be 7.21 Mbits. The cut in spatial coverage for 30JNGLOBAL02 was needed due to undercompression of pass 2 Callisto data. By making this cut we are able to return the complete first scan of 30CNCTBRAN01, as previously planned.

07-29-01: (R. Mehlman) NIMS playback is already done for both Io observations, and for most Jupiter observations including over 1/3 of 30JNGLOBAL02. This means we're once again ahead of schedule, though we don't get any more coverage until Tuesday afternoon, which is about when GLOBAL02 was to begin. Guess there's hope for Callisto.

08-02-01: (R. Lopes) We now have all the data from C30.

08-14-01: (R. Mehlman) 30CNCTBRAN01 never came back. We lost the last few days of playback entirely. It stopped after some 30JNGLOBAL03 gap-fill.

NIMS Anomaly Report - C30 Sequence

The NIMS grating became stuck prior to the I24 encounter. The grating continued to be stuck for the C30 encounter. This development caused a drastic change in NIMS operations. Detectors 1, 2 and 7 now have very low sensitivity. Detectors 3 and 8 are still not functioning. NIMS now returns only 12 useful wavelengths.

The NIMS processor halted twice during the C30 Encounter as a result of CDS Bus Reset (BURP) events. No NIMS observations were lost due to this halt.

The spacecraft did not safe during the C30 Encounter but did suffer two Bus Resets which precipitated the NIMS halt.

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.

NIMS Anomaly Report - C30 Sequence

Response to Stuck Grating Anomaly (C30)

At C30 the cause of the stuck grating was not known (and is still not clearly understood). No attempts were made during C30 to unstick the grating.

Processor Halts

There were two NIMS processor halts during C30. The halts were detected by the NIMS SCLK engineering and were coincident in time with the reported CDS Bus Reset events. The two Bus Resets occurred outside of NIMS observations so that the software halts did not affected any NIMS observations. Each NIMS observation was preceded by a software reload so that no NIMS observations were lost due to the halts.

A hardware status word 0 was returned during the encounter, indicating chopper 63Hz mode, at RIM 6049473. This occurred after the 30JNBARGEB01 observation. No data were returned for this observation so the chopper status was not confirmed. The chopper mode was reset by the software reload of the subsequent observation. We dont really understand how the instrument could have gotten into chopper 63Hz mode. There could have been an undetected instrument halt at this time.

Spacecraft Anomaly

During the C30 encounter two standard CDS bus resets occurred and were handled normally by the on-board recovery software without any effects on the planned sequence. The BURP events occurred at about D143/015:49 and D144/04:34.

Anomaly Timing:

6048864	01-143/15:49:00	CDS Bus Reset 01
6048880	01-143/16:05:19	6048863 SCLK reported
6048961	01-143/17:27:19	NIMS Software Reload (30INGLOBAL01)
6049473	01-144/02:05:19	Chopper 63Hz HW Status Word
6049976	01-144/02:08:41	NIMS Software Reload (30JNHTSPOT02)
6049620	01-144/04:34:00	CDS Bus Reset 02
6049697	01-144/05:51:59	6049619 SCLK reported
6049895	01-144/09:11:59	6049619 SCLK reported
6049946	01-144/10:03:54	NIMS Software Reload (30JNWTOVAL01)

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.