**Chapter 7 - Data Return**

## Contents

## Introduction to Chapter 7

This chapter is a report on the NIMS data return for the C21 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the C21 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 five autonomous reloads of the NIMS RAM code from CDS during the C21 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.

AACS was in Cruise mode for most of the C21 encounter period. During the 21INHRSPEC01 observation, the scan platform experienced serious pointing problems.

The plots on the pages 3 and 4 show the geometry of the NIMS C21 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' C21 data.

The text on page 7 gives a 'recap' of the C21 playback events which affected which observations were returned.

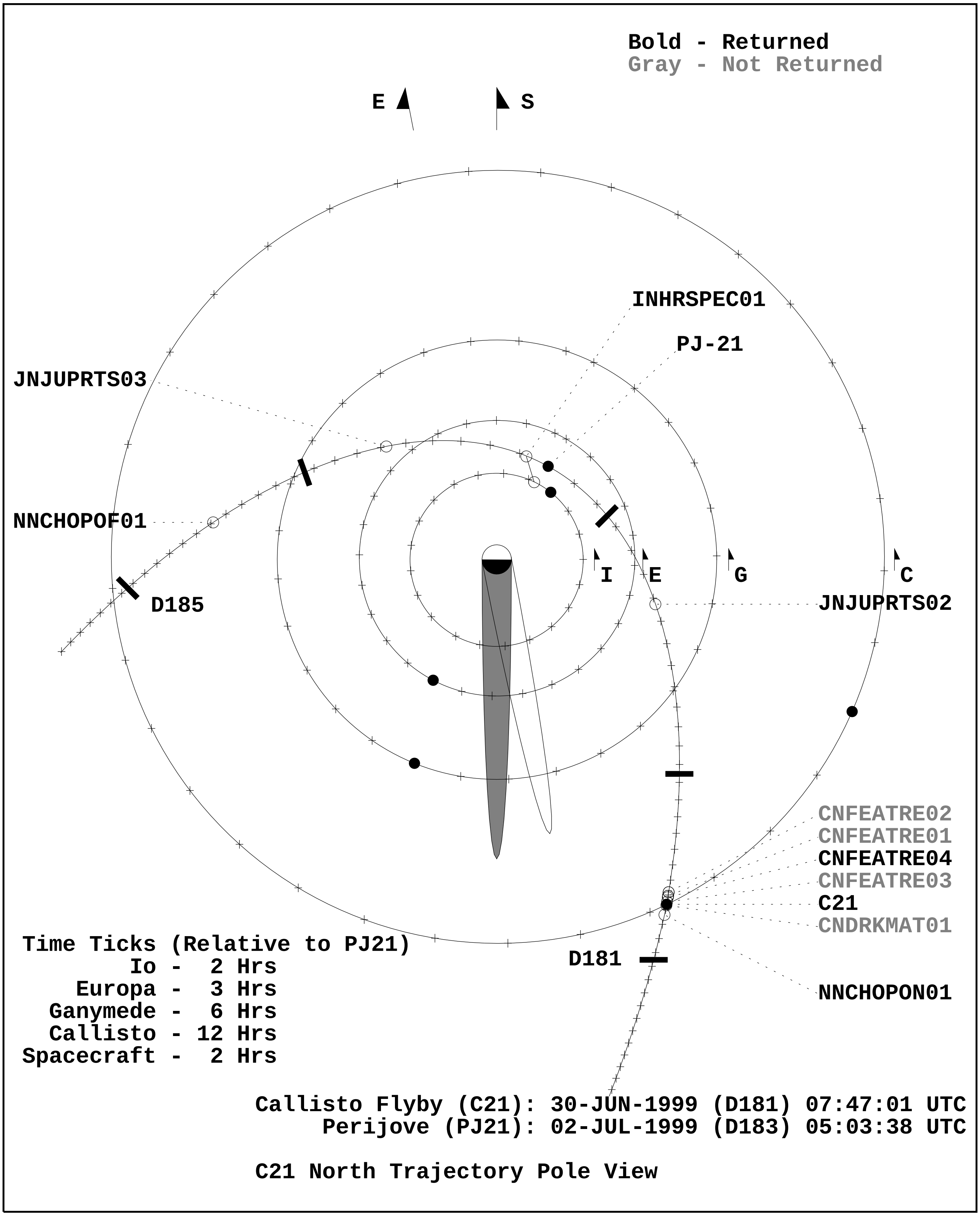
A Timeline of C21 playback events is on pages 7 through 17.

The text on page 18 describes the C21 NIMS and Spacecraft Anomalies.

The text on page 19 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 20 and 21.

The text on page 22 is a guide to understanding the NIMS MASK.

# NIMS C21 OBSERVATIONS

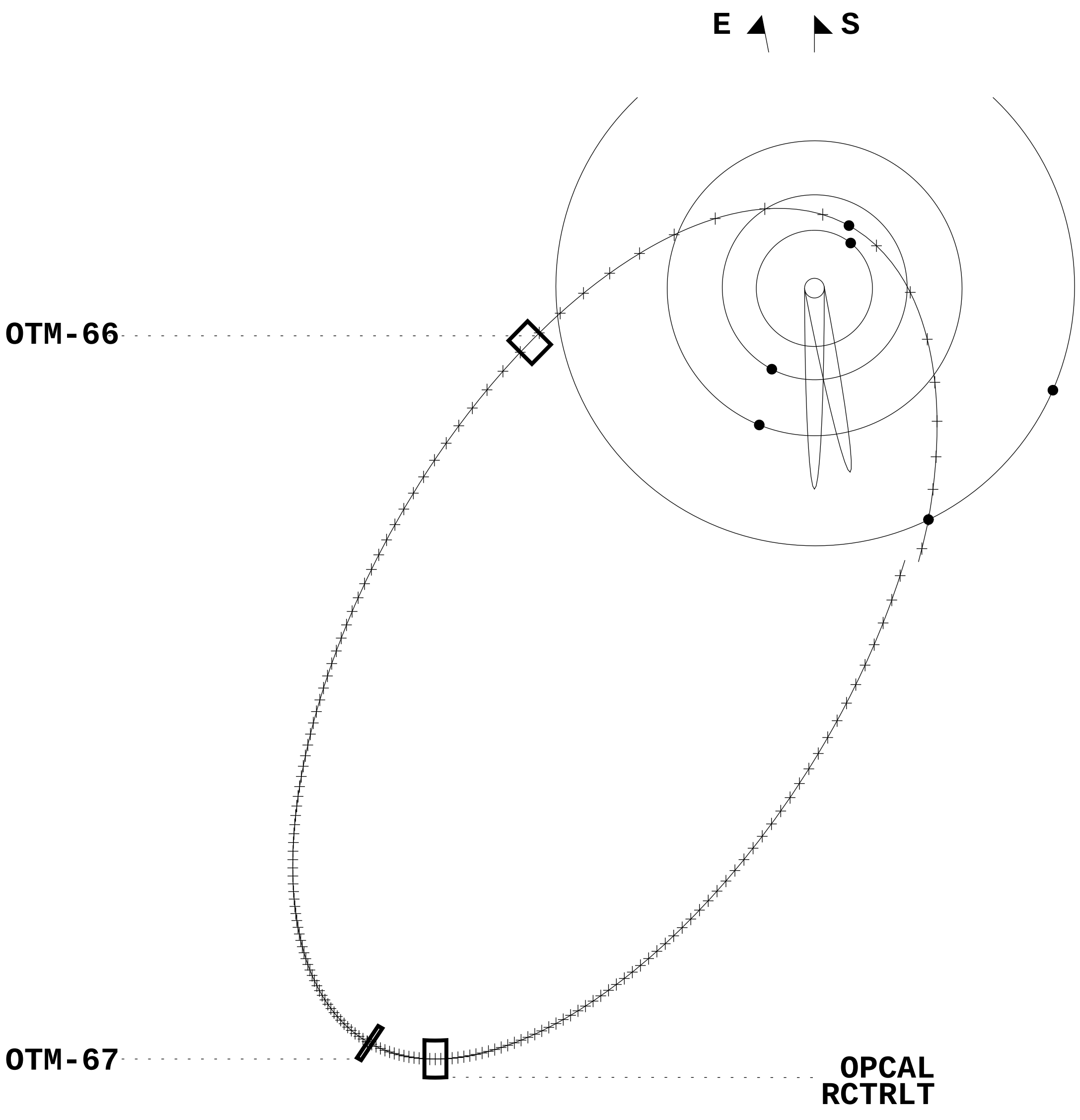



NIMS - FEL - 05/01/00

# NIMS C21 CRUISE CALIBRATIONS

Callisto Flyby (C21): 30-JUN-1999 (D181) 07:47:01 UTC
Perijove (PJ21): 02-JUL-1999 (D183) 05:03:38 UTC
Apojove (AJ21): 22-JUL-1999 (D203) 16:00:00 UTC

Time Ticks (Relative to C21)
Spacecraft - 6 Hours




C21 North Trajectory Pole View, Perijove to Perijove

# NIMS C21 DATA RETURN

| Activity ID | Observation Title | NIMS Edit TABLE | NIMS PB Table | Mode | Gain | Grating Start | Grating Offset | Record Format | PSID |
|---|---|---|---|---|---|---|---|---|---|
| 21CNFEATRE04 | Callisto Feature Observation | C21CLM243D | C21CLM228D_0 | LM | 4 | 0 | 4 | LPU | DD |
| 21JNJUPRTS02* | Jupiter Real-Time Observation | C21JLM442/MB | R/T | LM | 2 | 0 | 4 | R/T | DF |
| 21INHRSPEC01 | Mapping Io at High Resolution | C21ILM442 | C21ILM15 | LM | 2 | 0 | 4 | MPW | DG |
| 21INHRSPEC02 | Mapping Io at High Resolution | C21ILM442 | C21ILM360 | LM | 2 | 0 | 4 | MPW | DG |
| 21INHRSPEC03 | Mapping Io at High Resolution | C21ILM442 | C21ILM360 | LM | 2 | 0 | 4 | MPW | DG |
| 21INHRSPEC04 | Mapping Io at High Resolution | C21ILM442 | C21ILM15 | LM | 2 | 0 | 4 | MPW | DG |
| 21JNJUPRTS03* | Jupiter Real-Time Observation | C21JLM442/MB | R/T | LM | 2 | 0 | 4 | R/T | DH |
| 21NNRCTRLT01 | NIMS Real-Time RCT Calibration | C21RCT252 | R/T | LM | 1 | 0 | 4 | R/T | |
| 21NNROPCAL01 | NIMS OPCAL | C21OPCAL48 | R/T | LM | 4 | 0 | 4 | R/T | |
| 21INHRSPEC01 | Mapping Io at High Resolution | C21ILM442 | C21ILM360 | LM | 2 | 0 | 4 | MPW | DG |
| 21INHRSPEC02-gf | Mapping Io at High Resolution | C21ILM442 | C21ILM360 | LM | 2 | 0 | 4 | MPW | DG |
| 21INHRSPEC03-gf | Mapping Io at High Resolution | C21ILM442 | C21ILM360 | LM | 2 | 0 | 4 | MPW | DG |
| 21INHRSPEC04 | Mapping Io at High Resolution | C21ILM442 | C21ILM360 | LM | 2 | 0 | 4 | MPW | DG |

# NIMS C21 DATA RETURN

| Activity ID | Mode | Record Format | Record Time (sec) | PB Time (sec) | Selected Bits of Tape sBOT (MBITS) | Tota Bits of Tape BOT (Mbit) | Mode Cycle time (sec) | RT BTG Mbits | Thold | Comp | Total BTG Mbits (w/4% ohead) | Data Reduct. Factor (sBOT/BTG) | Pass |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21CNFEATRE04- | LM | LPU | 600 | 220 | 1.36 | 3.70 | 8.667 | | 0 | 1.97 | 0.611 | 2.22 | 1 |
| 21JNJUPRTS02* | LM | R/T | | | | | 8.667 | 0.160 | 0 | | | | |
| 21INHRSPEC01- | LM | MPW | 3600 | 48 | 0.55 | 41.47 | 8.667 | | 0 | 1.15 | 0.015 | 36.80 | 1 |
| 21INHRSPEC01- | LM | MPW | 3600 | 833 | 9.60 | 41.47 | 8.667 | | 0 | 1.29 | 5.579 | 1.72 | 1 |
| 21INHRSPEC01- | LM | MPW | 3600 | 946 | 10.90 | 41.47 | 8.667 | | 0 | 1.33 | 6.145 | 1.77 | 1 |
| 21INHRSPEC01- | LM | MPW | 3600 | 48 | 0.55 | 41.47 | 8.667 | | 0 | 1.15 | 0.015 | 36.80 | 1 |
| 21JNJUPRTS03* | LM | R/T | | | | | 8.667 | | 0 | | | | |
| 21NNRCTRLT01- | LM | R/T | | | | | 8.667 | 0.080 | | | | | |
| | | | | | | | | | | | | | |
| 21INHRSPEC01- | LM | MPW | 3600 | 599 | 6.90 | 41.47 | 8.667 | | 0 | 1.12 | 4.621 | 1.49 | 2 |
| 21INHRSPEC01- | LM | MPW | 3600 | 30 | 0.35 | 41.47 | 8.667 | | 0 | 1.29 | 0.201 | 1.72 | 2 |
| 21INHRSPEC01- | LM | MPW | 3600 | 149 | 1.72 | 41.47 | 8.667 | | 0 | 1.33 | 0.968 | 1.77 | 2 |
| 21INHRSPEC01- | LM | MPW | 3600 | 807 | 9.30 | 41.47 | 8.667 | | 0 | 1.12 | 6.225 | 1.49 | 2 |
| | | | | | | | | | | | **24.380** | **Total** | |
| | | | | | | | | | | | **23.465** | **Allocation** | |
| | | | | | | | | | | | **0.915** | **Over/Under** | |



5/01/00

## RECAP OF C21 PLAYBACK EVENTS

**C21 featured the highest-resolution NIMS observation of Io of the entire mission to that point. Although NIMS recorded several observations of Callisto during the encounter, the Io observation took precedence, and only a small portion of the recorded Callisto data was returned to Earth.**

**The Io encounter was a success for the spacecraft as a whole, as no spacecraft safing events took place. However, during the long NIMS recording of 21INHRSPEC01, there were several scan platform mis-slews that seriously impacted the data. These were attributed to the high radiation environment in combination with the use of faint stars for scan platform orientation and pointing. The software mis-identified radiation hits as target stars, and commanded a series of scan platform slews to "recover." Although the appearance of the data was initially discouraging, subsequent processing has yielded satisfactory results for some portion of the observation.**

**The high scientific value of 21INHRSPEC01 forced new strategies in the observation design and playback. Instrument software reloads were inserted into the mosaic before each of the 4 scans across the target. Uncertainties regarding whether or not the observation had been successfully recorded, and what the actual compression might be, led to the employment of a variety of new tactics during playback, as noted below. Misunderstandings between members of the Science Planning and Operations Team led to some unhappiness on the part of some team members, and lent added interest to the cliff-hanger finish of the playback period. In the end all teams received all of the data that had been commanded for playback, with the exception of the loss of one partial frame of SSI data at the very end.**

**Due to tight schedules projected for 1999, the C21 orbit sequence was first integrated in late 1997. That product was taken "off the shelf" for revisions in March 1999.**

**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.**

### C21 Playback Events Timeline (09-22-97 to 08-10-99)

**09-22-97: (K. Schimmels) C21 Playback tables need to be developed in the next few weeks along with the encounter and cruise products.**

**10-17-97: (J. Gross) The latest merge of the C21 PBT is finally done. We had some modelling problems that cost us more than a day. NIMS allocation is 25.513 Mbits.**

By now I have contacted the teams with any constraint violations I found. Kathy will also be constraint-checking the PBT in the very near future, and may be contacting you with additional items. At this point, we would like to make hand-edits to any problems we find, so that we can archive this product without doing another delivery.

**03-16-99:** (J. Gross) Here's what our pbt delivery schedule will look like:
Fri Mar 19 - 1st SST product released;
includes new telemetry
Mon Mar 22 - PB Coord. sends out updated allocations
Wed Mar 31 - 1st PBT delivery

**03-24-99:** (J. Gross) NIMS allocation - 26.6% - 27.357

**04-08-99:** (J. Gross) NIMS allocation is 26.510
(AACS already taken out)

**06-10-99:** (J. Gross) Unforunately, it appears that our capability has gone down by about 11% (~93 MB down from ~105 MB). I calculated our new capability by taking this new telemetry file and adding to it all the RTSFMT,RTEFMT,OPTRTM,OPTREC, PPB, and RPB PA's from the Final OP product (version C21XQA). This may not exactly match the capability in the official S&CG product, but it's certainly close enough for our purposes.
With this decrease in capability, we are now barely meeting the OPG estimate (a whopping 0.9% increase). Therefore I am unable to satisfy the OPG requirement that any additional capability at S&CG be given off the top to SSI (3.0 MB), NIMS (2.0), and PPR (0.6 MB).
The only margin being held is the usual 4% of the total capability + 2.0 MB of SPOT margin.
NIMS allocation is 23.279.

**06-17-99:** (Special request for C21 Io playback)
The HRSPEC observation in C21 is possibly the most significant observation of Io for NIMS in the entire suite of Galileo missions. NIMS presently plans to invest > 75% of our downlink bits to bring it back.
Since NIMS is deep in the radiation environment it is possible that our instrument will experience radiation hits causing NIMS to record invalid data on the tape. NIMS did not get enough information from the engineering channels to see this as it happens. As an example, if scan 1 of the 4 scans was selected for playback and it turns out to be corrupted, NIMS might receive ~6 Mb of useless data as a result. (We may be able to rule out this worst case after discussions with Tal. We might only receive headers in our packets, costing much less).

There is a simple strategy that would let NIMS preview the data at a low cost and avoid playing back large quantities of garbage. We propose a 3-pass playback plan, initiating playback with the Io HRSPEC01 (or at some convenient location nearby). This first mini-pass would be very short. NIMS would pick up a few seconds of data, with only a few wavelengths, from every 2-3 Rims of the observation. The amount of downlink bits would be well under .5 Mbits. Thereafter playback would continue as in our standard procedure, with 2 passes, starting at the beginning of recording.

The inconvenience to other teams should be minimal, involving replacing pass numbers in singles with numbers 1 digit higher. This might be most efficiently done as a global search and replace on a merged table during your process.

I realize that this is very late in the process. We are all coping with complicated workloads. Still this simple change would insure against possible serious degradation of the science value of the NIMS downlink bits in C21. I hope you will give serious consideration to this change.

06-21-99: (J. Gross) I just talked with Erickson about your 3-pass request, and here's what we've agreed to do:

1) NIMS will be allowed the opportunity for a third pass through INHRSPEC01 for the purpose of gap-filling only.
2) C21 playback will be proceed in the usual first-in, first-out manner.
3) The cost of the slewing from the end of Pass 2 playback to INHRSPEC will be split between NIMS and SPOT. A rough estimate of that cost is 2 MB. Therefore, NIMS should reserve 1.0 MB of their allocation for that cost. The first 1.0 MB of the SPOT margin will also be reserved for that cost.

06-21-99: Thanks for your consideration of our request for an early preview pass over 21INHRSPEC01. Your counterproposal of a final third pass for gap filling could permit NIMS to assemble a nearly gap-free observations, which is our main objective. Thus we will agree to that, but in the mean time we will work to make the third pass not necessary if at all possible.

Our strategy now will be to play back all of the observation in pass 1, and fill gaps in pass 2.

06-22-99: The C21 encounter begins on 30 June. The playback table that will be uplinked to the spacecraft was delivered Friday.

The Io observation 21INHRSPEC01 is possibly the most significant NIMS Io observation of the entire mission to date. Previously our best spatial resolution was ~120 km / pixel, whereas in this case the resolution is about 60 km / pixel. NIMS should be able to resolve small-scale features features for compositional information to an extent that was previously impossible.

The concensus of team members is that this Io observation takes priority over all of the Callisto observations. Therefore NIMS is making a special effort to obtain the fullest possible spatial and spectral coverage.
21INHRSPEC01 poses a number of problems. Since NIMS is much deeper within the Jovian radiation environment than in prior encounters (aside from J0), there is a significant probability of instrument software crashes due to radiation hits. There is a significant probability that NIMS will see poor data compression ratios due to noise.
Software reloads are included in the sequence prior to each of the 4 15-minute scans across the target. If there is a stoppage due to radiation hits following a reload, data for the balance of that scan will not be recorded correctly.
There are two unpleasant worst case scenarios. Firstly NIMS could return many megabits of garbage, at a low compression ratio. We currently believe this is unlikely based on our experience in E12 when NIMS returned data from 12ENDLINEA01 after an instrument stoppage. In that case a relatively small amount of bad data was returned. The second unpleasant possibility is that lots of fill packets might be generated, during high data downlink rate periods, if very little NIMS data results following a stoppage, AND if AACS data are commanded to enter the downlink stream.
We made a last-minute proposal to the project to permit NIMS a quick preview pass over the data, prior to beginning standard playback. This was not possible due to the necessity of generating and approving a number of real-time commands, requiring the participation of the SST and MCT teams. The project will permit NIMS, at some cost, to make a late, third pass over the data. However, logistically, this may not be feasible since the third pass would most probably begin only a matter of hours after our pass 2 data hit the ground, giving NIMS no time to create new commands for gap fill.
The total downlink allocation for NIMS in this orbit is 23.279 Mbits. With compression estimated at 1.2, 21INHRSPEC01 will require about 22.7 Mbits. At present we are planning to return a portion of 21CNFEATRE04, along with HRSPEC. If compression of the Io data is poor, it will affect our ability to return all of our spatial and/or spectral coverage of Io.
In light of all of the above uncertainties we are adopting a strategy that minimizes all of the risks and gives NIMS time to adapt to conditions. In the first tape pass we are commanding for return all of the central two scans of 21INHRSPEC01 at 360 wavelengths. This is our highest priority data and we will be able to fill gaps in pass 2. We are previewing the polar scans in pass 1, returning a single instrument cycle of data every 3 Rims. If there are software stoppages we will learn the approximate times when they occurred and will not attempt to play the data back in the second pass.

This strategy will let NIMS adapt to either software stoppage problems or compression problems by retaining a significant number of bits for second pass playback. The downside is that we will probably not be able to fill any gaps that occur in the polar scans which will come down in pass 2. (Gaps in our data frequently occur due to DSN hardware and / or weather problems).
If SSI cooperates by playing back lots of Io plumes data after our HRSPEC in pass 2, then it is barely possible that we could make use of the third tape pass for these gap fills.

**06-23-99:** (J. Gross) SPOT has committed to providing NIMS and MWG the opportunity for a third pass, should they need it. I wasn't trying to say that NIMS and MWG will be FORCED to do a third pass.
I'm a bit worried about the second pass thru HRSPEC right now. If you haven't looked at the schedule yet, it's the last thing to hit the ground. There's actually some Pass 2 data in the plan that has "fallen off the end". Now, we know that we invariably run ahead of schedule, but I'm still not sure that it will be enough time for you to have an effective third pass. I'm going to ask Kari to talk to her team about shifting some bits from Pass 1 Io Plumes to Pass 2. I think they'd be willing to do it, it's just something she has to run past them first, so we weren't able to implement in this table. This will help matters, but I'm not sure how much. Keep praying that everybody overcompresses! :)
Also, if they want to do a third pass, NIMS has to be prepared to shoulder about half of the cost of slewing through 2.5 tracks, as I indicated in an earlier email.
I don't see that 1.0 MB of internal margin reflected in this table; NIMS has used up all but ~0.1 MB.

**06-28-99:** (M. Segura) I have just been informed that a potential weakness has been discovered in the BURP patch which protects against safing after bus resets. It appears that should a reset occur during a DTURN, one of the possible results would be the loss of the DMS.
This has caused a bit of worry and nail biting here so the project is marching along the path of disabling the patch while we are executing DTURNS in C21. The C21 impact is the lack of protection from safing (loss of data - NIMS is powered off and heaters on in safing event). Unfortunately, the observation to follow the most critical DTURN (at 7.6 Rj or so) is the NIMS Io global map.
We've done every thing possible to protect that observation and it's really unfortunate to be confronted with this development at this late date.

**06-29-99:** C21 encounter begins (day 180 07:00 UTC).

**06-30-99:** Callisto close approach occurs at 07:47:01 UTC.

**06-30-99:** **(J. Erickson) The gyros have performed well during this encounter. The inertial mode observations near Callisto close approach were all performed per plan, and the gyros have now been turned off for the upcoming perijove pass high radiation environment. Perijove will be on 7/1 at 10:49 p.m. PDT.**

**07-02-99:** **Perijove occurs at 05:03:38 UTC.**

**07-02-99:** **(J. Erickson) 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 protect 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 95% of the total recording planned for the encounter.**
**At about 6:10 p.m. PDT on 7/1, the radiation appears to have caused the star scanner to mis-identify stars sufficient to erroneously cause a discrete jump in the spacecraft attitude. The Atitude Control Subsystem then reacted to the sudden jump by assuming the spin bearing assembly was misbehaving and swapped autonomously to the backup SBA. No data was lost as a result of this swap, and the spacecraft continued to record the planned observations.**
**At about 11:30 p.m. PDT on 7/1, the radiation appears to have caused a second fault, this time in the Scan Actuator Subsystem in the Attitude Control Subsystem. This fault occurred just prior to a Near Infrared Mapping Spectrometer observation, and further analysis is required to determine if this observation was interfered with.**
**The bus reset protection software again proved it's value, as a bus reset occurred at about 3:51 a.m. PDT on 7/2. The software handled it as planned, and the sequence continued unaffected.**

**07-02-99:** **(R. Mehlman) Both Jupiter realtime observations are in, and tubes have been generated. No obvious problems, except booms in the first.**
**We know from engineering values that NIMS went to gain state 2 after the Callisto observations, and stayed that way before and after the Io observation. We have a good SCLK value after the Io observation, which preoves that NIMS had not halted during the 4th swath of HRSPEC. However there are no clues to the status of the first three swaths.**

**07-06-99:** **(M. Segura) As most of you have heard, the scan platform safed twice in the C21 encounter - the second incident ~ 10 minutes before our Io observation. During the time period of 183/06:11:11 to 183/07:37:51 (scet) there were a total of four mis-slews detected. The period from 183/07:37:51 to 183/09:04:31 showed another 3 mis-slews - the "trapped" mis-slew was in Jupiter real-time 03.**

I estimate that the majority (5 at most) of the mis-slews will be within the Io observation. There was one SSI mis-slew "trapped". Unfortunately, there won't be much further detail to the affects until the "preview - jailbar data" is returned 2 weeks from now.

**06-07-99:** (NIMS C21 Playback Strategy) The Galileo spacecraft penetrated significantly deeper into the Jovian radiation environment in C21 than was the case for any prior prime mission or extended mission orbit following JOI. We presently have no information concerning whether or not the instrument software crashed during any of the first 3 scans of our most crucial observation 21INHRSPEC01; however we are confident that no crash occurred during the final scan. We presently have no information regarding the noise level and the likely compression ratio for this observation.

The occurrence of an AACS system fault causing temporary spacecraft safing about 10 minutes prior to 21INHRSPEC01 is another source of concern. We expect that the scan platform had time to reposition itself for our observation. Marcia Segura has learned that AACS recorded 5 mis-slews during the period of the observation, of magnitude unknown. There are some possible scenarios with a significant downside. Although it has not happened previously, it is possible that a command to play back NIMS data that was never recorded (due to instrument stoppage) could return large quantities of meaningless data. In a worst case, commands to play back 50% of 21INHRSPEC01 could consume more downlink bits than NIMS has for our total C21 allocation, potentially affecting other teams' ability to return their data. We regard this as a very low probability event. A somewhat more likely scenario would involve compression performance that is up to 20% lower than predicted. In that case we would be unable to return 21INHRSPEC01 completely, but other teams would not be affected.

An additional driver for playback strategy is found in the "iffy" performance of the DSN. It is considerably more likely (in comparison with the scenarios above) that there will be gaps in our pass 1 data. This provides a strong incentive to return as much of the data as possible, as soon as possible, so that we may fill the resulting gaps in pass 2. In light of the above uncertainties, however, it would be unadvisable to attempt to return 100% of the data in pass 1. Although a number of alternative strategies were discussed during the past week, in the end we are retaining our original strategy. This is to command for playback the most important 50% of 21INHRSPEC01 in pass 1, while also "previewing" the polar scans by returning small snippets of data at intervals. Should the worst of the worst case scenarios materialize, there is a single option open to NIMS. That option is to terminate playback and re-initiate with the following segment in the existing playback table. This will impact other teams by preventing

them from playing back (in pass 1) the data that accompanies 21INHRSPEC01 in segment 4. Playback will only be terminated if that course will result in lesser impact to the other teams than would be the case if playback were allowed to continue.
Again, the worst case scenario involves unprecedented events. To some extent we have had the same risk throughout the mission; the difference this time lies in the large quantity of downlink bits concentrated in a single observation. Thus we are prepared to deal with the extreme bad-luck case, but we anticipate that playback will follow its normal course, and that no intervention will be required. We will as usual monitor the course of playback closely, and we are requesting a special effort on the part of the query-servers crew to ensure uninterrupted access to the data as it arrives.

**07-14-99:** We have no new information and no additional downlink bits allocation this week so there are no changes to the playback table.
Lucas Kamp has generated plots of the AACS pointing data for the period of 21INHRSPEC01. We only have data spaced at 5 Rim intervals so conclusions are only preliminary; however it appears that the second and third scans of the observation were affected by a significant pointing error and correction. These are the scans that are commanded for playback in pass 1. If we see substantial amounts of dark sky this should improve our data compression and reduce our consumption of downlink bits significantly.
Playback is running ahead of schedule and it now appears that the first data from 21INHRSPEC01 will hit the ground early tomorrow morning (15 July).

**07-21-99:** In this update we made a number of modifications to adapt to conditions. We now have all of our pass 1 21INHRSPEC01 data on the ground, and have implemented commands for the pass 2 portion.
21INHRSPEC01 consists of 4 scans across the body. It appears that severe pointing errors affected all 4 scans. During C21, it is believed that radiation noise affected the star scanner, which was employing relatively faint stars to maintain attitude. The actual causes and effects are not fully known, but what we know now can be encapsulated as follows:
Scan 1: From the snippets received before the first big DSN data gap, it appears NIMS was nearly on target, but possibly pointing too far north. We will continue as planned to bring down the whole scan in pass 2.
Scan 2: This one was more severely affected. Instead of landing on-body, it is even farther mis-pointed to the north of Io. Approximately the last third of it is completely off the body. The earliest portion, affected by a data gap, appears to be in the right position. We are filling this gap at the start, and including 3 more instrument cycles from before the former start time, in hopes that more data near the limb can help constrain the pointing.

Scan 3: Instead of the southern equatorial portion of the body, this saw a portion of the northeastern limb. Instead of scanning across the diameter of the target, it appears that we were "sitting and staring" at this location for a considerable period. The resulting spectra are rather nice and a hot spot is in evidence. There is a 2.5 Rim gap in the data that we are filling in pass 2.
Scan 4: This one apparently executed as planned but there are large departures of the position of the southern limb relative to the predicted position. We returned only snippets in pass 1 and will bring down the entire scan in pass 2. About half a Rim of playback time was added to the end of the scan to ensure we will get all of the longitudes, and will have sufficient data for fitting the limb. Compression for 21INHRSPEC01 is running a little better than predicted (1.3 versus 1.2), and the compression savings permitted NIMS to enter our gap fills and extensions as noted above, with a little left over. This will go to complete playback of the top scan of 21CNFEATRE04 in pass 3. If slewing inefficiency turns out to be less than expected, there may be a release of margin bits next week, which might be employed for more Callisto, or for cost of slewing to do more gap fills on 21INHRSPEC01 in pass 3.

**07-21-99:** (J. Gross) After much analysis, the bad news is that there will be no margin release. The good news is, no one has to cut! From now thru Terminate Playback, there are 36.3 MB of capability. During that time, we have 36.04 MB of (MB data selected + teams' unused MB + worst-case inefficient slewing). So, despite what PBT Editor thinks, it looks like we should be able to finish (which is a good thing!)

**07-28-99:** No modifications to the playback table were made in today's delivery. No margin was released due to results of modeling with the Mirage/Playback Table Editor program, which continue to show large amounts of "slewing inefficiency" (downlink fill packets generated while the tape recorder slews over recorded data not selected for playback).
NIMS is not planning to make use of the 3 pass option for 21INHRSPEC gap-filling due to the high cost to NIMS of doing so (1 Mbit subtracted from our allocation, for slewing inefficiency). We do have .2 Mbits of Callisto data selected at the start of pass 3.
We have approximately 10 Mbits of data selected for pass 2 playback of 21INHRSPEC01, including the upper and lower scans, and gap fill for the others. Compression for these is estimated to be the same as we saw for the middle two scans (1.3).

**08-03-99:** (J. Gross) I've checked the bested data and looked at what we have left in the plan, and I'm unable to release any margin bits. Here's the picture:

```
  18.177 -> capability 'til Terminate (from start of 4th
            scan of INHRSPEC01)
 -14.558 -> data still to be played back from current PBT
  -1.660 -> unused team BTG
  -2.030 -> worst-case estimate of remaining inefficiency
```

**08-04-99:** Today's is the final update for the C21 playback table. We made only one change to the existing table. We deleted our commands to play back additional Callisto data from 21CNFEATRE04. We needed to do this because our 21INHRSPEC01 data from the top and bottom scans across the body is coming down with lower compression than was the case for the two central scans returned earlier.
As this is written we are nearing the end of the 4th scan. So far compression has been quite variable, with the first half of the 4th scan averaging 1.18, versus predicted compression of 1.3. This will result in an increase in the downlink bits requirement for this scan of about 0.6 Mbits. Fortunately, according to the Playback Coordinator, we have returned significantly less data to date than predicted. Our bit savings, together with the .22 Mbits we are cutting out of the plan, should cover the expected overage on the balance of the 4th scan.
The mis-slews of the scan platform during 21INHRSPEC01 have had the effect of making accurate compressions prediction nearly impossible. The erratic scan platform motion, caused by radiation hits producing star misidentifications by the star scanner, moves our boresight on and off the target, in unpredictable ways. As a result we cannot be sure about the compression for the remainder of 21INHRSPEC01, even though we have more than 80% of the observation on the ground, and we have a few snippets of data (obtained earlier) from the 4th scan.
On the positive side, some portions of 21INHRSPEC01 are quite interesting. The noise level is lower than one would expect based on Galileo's close proximity to Jupiter (~7.2 Rj).

**C21 Playback Events Timeline (09-22-97 to 08-10-99)**

**08-04-99:** (J. Gross) As of Wednesday afternoon, we are in the middle of playing back the 4th scan of NIMS Io High-Res Spectra. Playback is on schedule and is 85% complete. To date we have received 77.61 MB and have 1.30 MB of gaps. Playback terminates on Tuesday, August 10 at approximately 3:27 AM PDT.

Major Changes to This Week's PBT
--------------------------------

1. SSI used up internal margin by adding cutout windows in Io Color and Io Albedo.
2. MWG used up internal margin by adding gap-fill and selecting 7.5 new RIMs of Perijove Crossing data.
3. NIMS deleted Pass 3 Callisto feature data to account for undercompression of Io High-Res Spectra.
4. One additional segment (Segment 13) was added to accomodate increased number of Pass 3 SINGLEs.

Outstanding Issues
------------------

The only remaining issue is that the schedule appears not to finish. In fact, none of Segment 13 is on the schedule! However - we have 13.711 MB of capability left, we have 11.235 MB of data selected, and a worst-case inefficiency of 1.52 MB. 13.711-11.235-1.52 = 0.956, meaning we should be able to get almost 1.0 MB or more into Segment 13, so we're really OK.

**08-10-99:** Playback terminates at 10:27 UTC.

## NIMS Anomaly Report - C21 Sequence

There were no NIMS processor halts detected during the C21 Encounter. Detectors 3 and 8 are still not functioning and are expected to be lost for the rest of the mission.

The scan platform experienced severe pointing problems during NIMS' highest resolution observation (to date) of Io. The erratic pointing during this observation was attributed to operating in cruise mode, high radiation and a poor choice of stars for the star scanner's star set.

### Processor Halts

There were no NIMS processor halts in C21.

The high priority observation 21INHRSPEC01 was protected from halts by placing software reloads between each of the four swaths across the disk, as well as at the beginning of the observation. No data in this 1 hour twenty minute record were lost due to halts, even though the observation took place about 1 hour after perijove.

### Scan Platform Anomaly

AACS operated in Cruise mode during the C21 encounter, except for the Callisto flyby period, in response to errors in the gyro rates. Scan platform pointing in cruise mode is maintined using the star scanner. During the NIMS observation 21INHRSPEC01, scan platform pointing was very erratic. The pointing became so bad that the last three of the four swaths across Io's disk could not be reconstructed.

The erratic pointing was attributed to mis-identification of stars by the star scanner due to the high radiation environment. When a star is mis-identified by the star scanner, the scan platform is perceived to be pointed in the wrong place and is commanded to move a percentage of the error towards the new 'correct' location. A poor choice of dim stars for the star scanner's star set made it easy for radiation spikes to be confused with the true stars.

Because of poor pointing, the 21INHRSPEC01 mosaic was only partially recoverable. The pointing for the first swath across the northern hemisphere of Io had a large component of wobble at multiple periods. This swath was recoverable by fitting periodicities in the location of Io's limb in the NIMS footprint and identification of Io hotspots. The beginning of the second swath started at a spot on Io different from that planned. The scan stayed on Io for about half of the scan, but then went out of control and off of Io's disk. The third swath started at a spot near Io's limb inconsistent with the planned mosaic. It did not scan across Io but seemed to hover about one spot on Io's limb. The fourth swath did manage to scan across the disk, but the location of Io's limb in the NIMS footprint showed that the pointing was very wild, jumping in unknown directions. Thus it was not possible to reconstruct the last three swaths across Io.

## 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.