Chapter 7 - Data Return

Contents

Introduction to Chapter 7

This chapter is a report on the NIMS data return for the G7 orbit. Due to the low downlink data rates available for Galileo Jupiter Operations and other unforeseen and unpredictable events during the G7 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.

Fifteen NIMS software reloads were inserted into the G7 Encounter sequence to protect against processor halts. During G7 only three NIMS observations were lost due to processor halts. The approach that we are taking to avoid data loss due to processor halts has proven to be very successful.

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

The plots on the pages 3 and 4 show the geometry of the NIMS G7 observations using a north trajectory pole projection. The 'returned' observations are in Bold characters and the 'non-returned' in gray.

The spreadsheets on pages 5 through 8 summarize the 'final' playback model for the 'returned' data.

The text on pages 9 and 10 gives a 'recap' of the G7 playback events which affected which observations were returned.

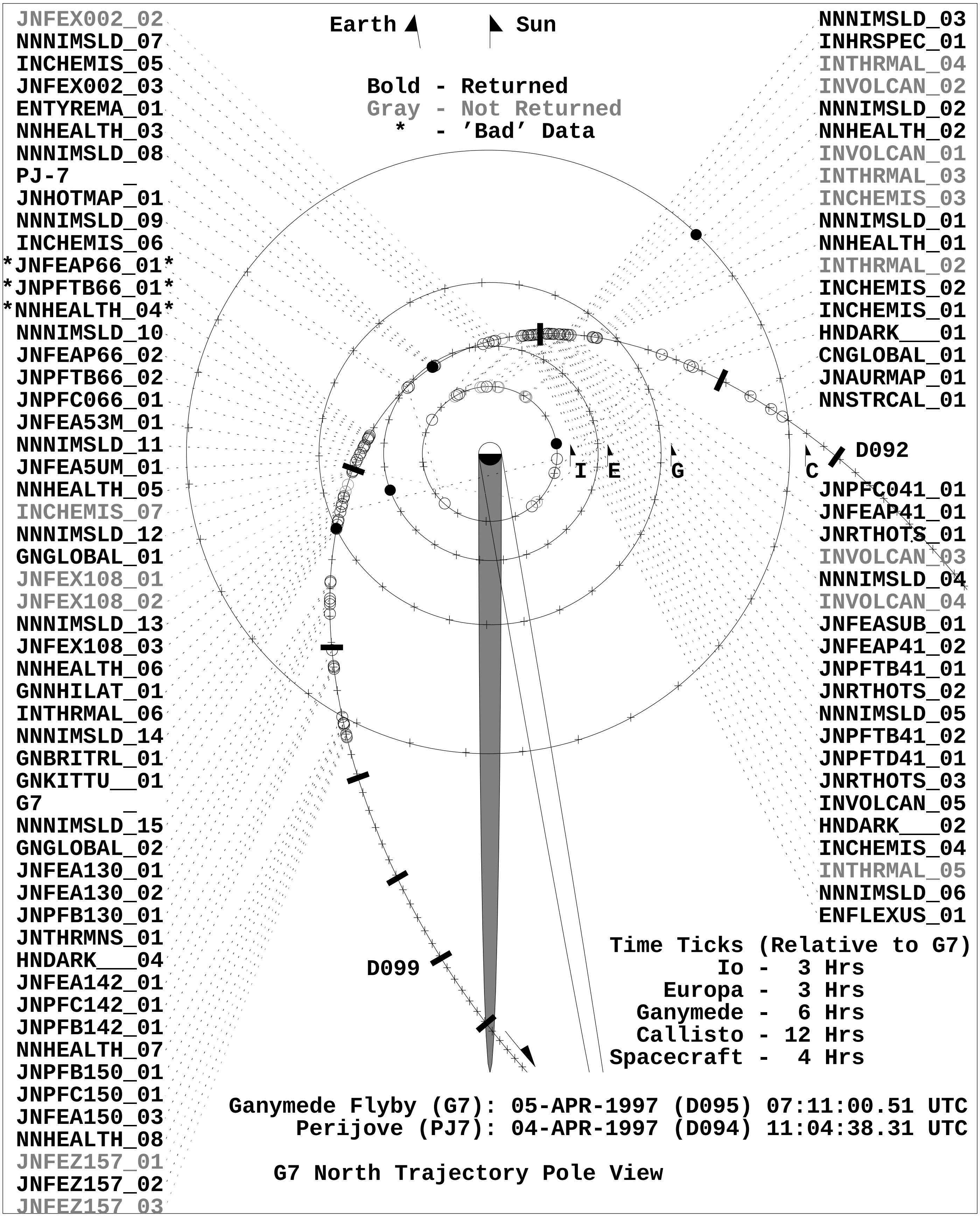
A Timeline of G7 playback events is on pages 11 and 12.

The text on pages 13 through 15 describes the G7 NIMS Anomalies, both Processor Halts and AACS Anomaly.

The text on page 16 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 17 and 18.

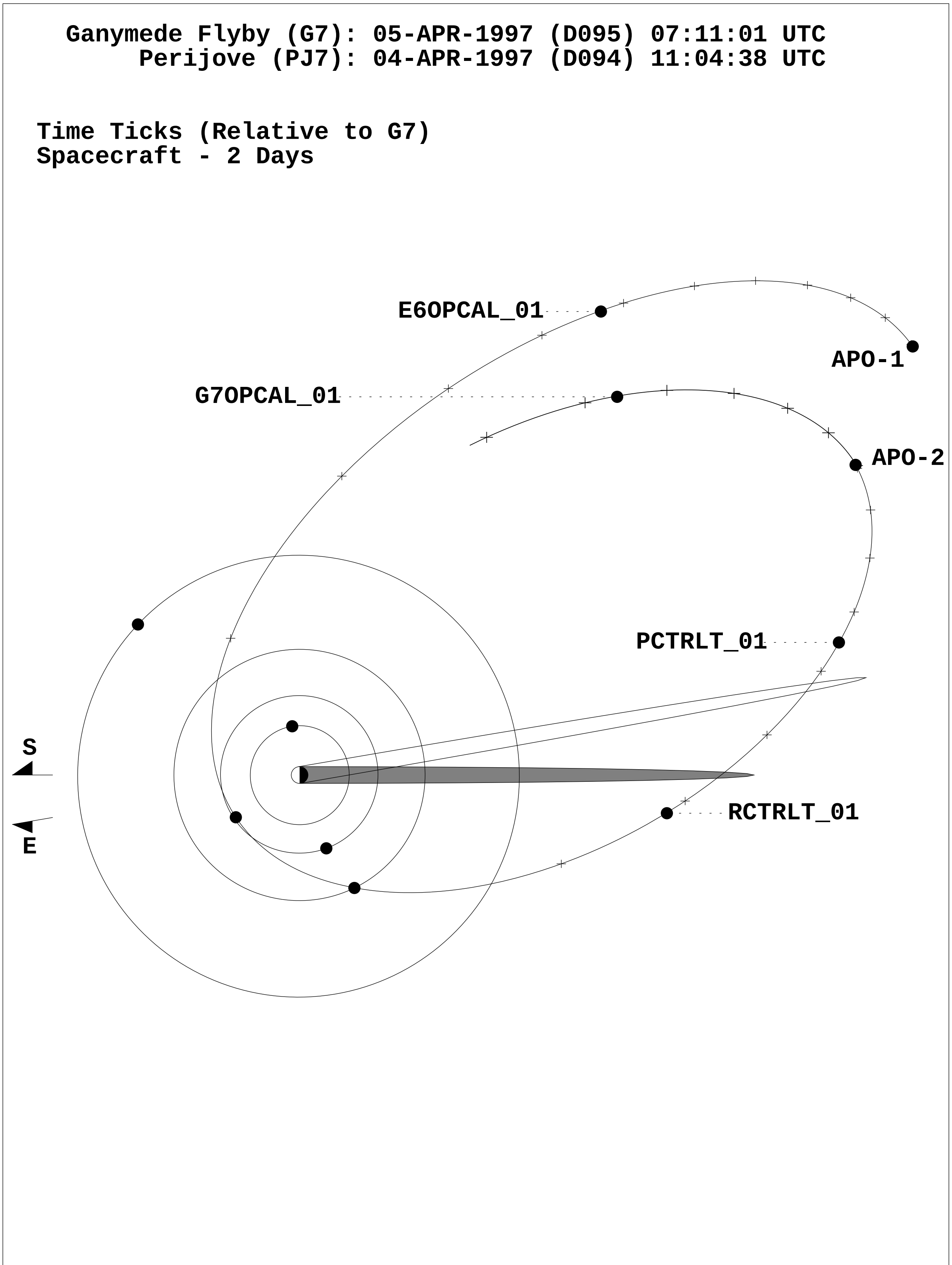
The text on page 19 is a guide to understanding the NIMS MASK.

NIMS G7 OBSERVATIONS



NIMS - FEL - 11/03/98

NIMS G7 CALIBRATIONS



G7 North Trajectory Pole View, Apoapsis to Apoapsis

NIMS - FEL - 04/26/99

NIMS G7 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format
G7NNSTRCAL01-	NIMS STAR CALIBRATION	G7SXM17	G7SXM17	XM	4	0	4	MPW
G7HNDARK__01-	Dark Observation	G7DRK34	G7DRK32	LM	4	0	4	LPU
G7INCHEMIS01-	MONITORING OF IO'S DAYSIDE	G7ILM244B	G7ILM102B	LM	2	0	4	LPU
G7INHRSPEC01-	MONITORING OF IO'S DAYSIDE	G7ILM442	G7ILM360	LM	2	0	4	MPW
G7JNPFC04101-	Jupiter 22 N Feature Trk 41 deg phase	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNFEAP4101-	Jupiter Ftr and Prtl Trk 41 deg part 1	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNFEASUB01-	Jupiter Campaign Feature sub-spectra	G7JSB253A	G7JSB80A	LM	2	0	4	LPU
G7JNPFTB4101-	Jupiter Partial Ftr. Trk. B 41 deg prt 1	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNPFTB4102-	Jupiter Partial Ftr Trk B 41 deg prt 2	G7JFT68C	G7JFT04B	SM	2	1	4	LPU
G7JNPFTD4101-	Jupiter Partial Ftr Trk D 41 deg prt 1	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7HNDARK_02	Dark Observation	G7DRK34	G7DRK32	LM	2	0	4	LPU
G7ENFLEXUS01-	Europa Global Mosaic Campaign	G7ELM244B	G7ELM228B	LM	3,2,4	0	4	LPU
G7INCHEMIS05-	MONITORING OF IO'S DAYSIDE	G7ILM244B	G7ILM216B	LM	2	0	4	LPU
G7JNFEX00203-	Jupiter Feature Track X 2 deg phase pt 3	G7JFT68A	G7JFT19A	SM	2	1	4	LPU
G7ENTYREMA01-	Europa Tyre Macula Region	G7ELM442	G7ELM360	LM	2	0	4	MPW
G7JNHOTMAP01-	NIMS Jupiter Hotmap Observation	G7JHT238A	G7JHT72A	LM	2	0	4	LPU
G7JNFEAP6601-	Jupiter Ftr and Prtl Trk 66 deg prt 1	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNPFTB6601-	Jupiter Partial Ftr Trk B 66 deg prt 1	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNFEAP6602-	Jupiter Partial Ftr Trk B 66 deg prt 2	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNPFC06601-	Jupiter Partial Ftr Trk C 66 deg	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNFEA5UM01-	Jupiter Feature Track 5 Micron Map 2	G7J5M253B	G7J5M80B	LM	4	0	4	MPW
G7GNGLOBAL01-	GANYMEDE GLOBAL SURFACE MAP	G7GLM244G	G7GLM192G	LM	3	0	4	LPU
G7JNFEX10803-	Jupiter Feature Track 108 deg phse pt 3	G7JFT68C	G7JFT19A	SM	2	1	4	LPU
G7GNNHILAT01-	Ganymede North High Latitude Region Map	G7GLM244H	G7GLM192H	LM	3	0	4	LPU
G7INTHRMAL06-	MONITORING OF IO'S NIGHTSIDE	G7ILMDK244B	G7ILM216B	LM	4	0	4	LPU
G7GNKITTU_01-	Dark Rayed crater KITTU	G7GLM442	G7GLM360	LM	3	0	4	MPW
G7GNGLOBAL02-	GANYMEDE GLOBAL SURFACE MAP	G7GLM442	G7GLM360	LM	3	0	4	MPW
G7JNFEA13001-	Jupiter Feature Track 130 deg phase pt 1	G7JFT68B	G7JFT04B	SM	2	1	4	LPU
G7JNFEA13002-	Jupiter Feature Track 130 deg phase pt 2	G7JFT68B	G7JFT15A	SM	2	1	4	LPU
G7JNPFB13001-	Jupiter Feature Track 130 deg phase	G7JFT68B	G7JFT15A	SM	2	1	4	LPU
G7JNTHRMNS01-	Jupiter Thermal North South Stripe	G7J5M253B	G7J5M80B	LM	4	0	4	LPU
G7HNDARK_04	Dark Observation	G7DRK34	G7DRK32	LM	3	0	4	LPU
G7JNFEA14201-	Jupiter Feature Track 142 deg phase	G7JFT68C	G7JFT04B	SM	2	1	4	LPU
G7JNPFC14201-	Jupiter Ftr Trk C 142 Deg Phase	G7JFT68C	G7JFT04B	SM	2	1	4	LPU
G7JNPFB14201-	Jupiter Ftr Trk B 142 Deg Phase	G7JFT68C	G7JFT04B	SM	2	1	4	LPU
G7JNPFB15001-	Jupiter Feature Track 150 deg phase pt 1	G7JFT68C	G7JFT04B	SM	2	1	4	LPU

NIMS G7 DATA RETURN

ACTID	Obs. Cost (ticks)	Wave-lengths ret	Record Time (sec)	PB Time (sec)	Sed Bits of Tape sBOT (Mbits)	Total Bits of Tape BOT (Mbit)	Mode cycle time (sec)	Thold	Comp	Total BTG (Mbtg) (4% Ohead)	Data Reduct Factor (sBOT/BTG)	Pass
G7NNSTRCAL01-	35	17	36.67	36.67	0.42	0.42	0.333	0	2.15	0.1811	2.33	1
G7HNDARK__01-	16	32	60.67	60.67	0.37	0.37	8.667	0	2.33	0.0200	18.71	1
G7INCHEMIS01-	33	102	131.33	131.33	0.81	0.81	8.667	2	3.19	0.1008	8.04	1
G7INHRSPEC01-	159	360	178.00	91.33	1.05	2.05	8.667	2	1.72	0.4588	2.29	1,2
G7JNPFC04101-	25	25	100	100	0.62	0.62	2.33	0	1.96	0.1139	5.42	1
G7JNFEAP4101-	72	25	300	300	1.85	1.85	2.33	0	1.88	0.3561	5.20	1
G7JNFEASUB01-	87	80	364	320	1.97	2.25	8.667	0	1.77	0.3471	5.69	1
G7JNPFTB4101-	52	25	213.33	213.3	1.32	1.32	2.33	0	1.63	0.2921	4.50	1
G7JNPFTB4102-	52	4	213.33	213.3	1.32	1.32	2.33	0	1.47	0.0518	25.39	1
G7JNPFTD4101-	52	25	213.33	213.3	1.32	1.32	2.33	0	1.62	0.2939	4.48	1
G7HNDARK__02-	16	32	60.67	60.67	0.37	0.37	8.667	0	1.64	0.0284	13.17	1
G7ENFLEXUS01-	322	228	1366.00	60.67	0.37	8.43	8.667	0	1.52	0.2184	1.71	1
G7INCHEMIS05-	73	216	303.34	242.00	1.49	1.87	8.667	2	1.39	0.9025	1.65	1
G7JNFEX00203-	25	19	100	100	0.62	0.62	2.33	0	1.55	0.1094	5.64	1
G7ENTYREMA01-	867	360	984.00	422.00	4.86	11.34	8.667	0	1.44	2.5319	1.92	1,2
G7JNHOTMAP01-	186	72	786	308	1.90	4.85	8.667	0	1.16	0.4588	4.14	1,2
G7JNFEAP6601-	72	25	300	10	0.06	1.85	2.33	0	1.88	0		1
G7JNPFTB6601-	52	25	213.33	10	0.06	1.32	2.33	0	1.88	0		1
G7JNFEAP6602-	72	25	300	300	1.85	1.85	2.33	0	1.69	0.3962	4.67	1
G7JNPFC06601-	72	25	300	300	1.85	1.85	2.33	0	1.71	0.3915	4.73	1
G7JNFEA5UM01-	322	80	364	300	3.46	4.19	8.667	0	1.31	0.4397	7.86	1
G7GNGLOBAL01-	506	192	2150.67	64.00	0.39	13.27	8.667	0	1.60	0.1843	2.14	1,2
G7JNFEX10803-	25	19	100	100	0.62	0.62	2.33	0	2.15	0.0789	7.82	1
G7GNNHILAT01-	326	192	1382.67	606.00	3.74	8.53	8.667	0	1.80	1.5513	2.41	1,2
G7INTHRMAL06-	45	216	184.67	184.67	1.14	1.14	8.667	0	1.73	0.5533	2.06	1
G7GNKITTU_01-	618	360	700.67	364.00	4.19	8.07	8.667	0	2.05	1.5341	2.73	1,2
G7GNGLOBAL02-	380	360	429.33	429.33	4.95	4.95	8.667	2	2.45	1.5140	3.27	1
G7JNFEA13001-	25	4	100	100	0.62	0.62	2.33	0	1.77	0.0202	30.57	1
G7JNFEA13002-	25	15	100	100	0.62	0.62	2.33	0	2.34	0.0572	10.78	1
G7JNPFB13001-	25	15	100	100	0.62	0.62	2.33	0	2.18	0.0614	10.04	1
G7JNTHRMNS01-	370	80	1570	300	1.85	9.68	8.667	0	1.27	0.4535	4.08	1
G7HNDARK__04-	16	32	60.67	65.00	0.40	0.37	8.667	0	2.46	0.0203	19.76	1
G7JNFEA14201-	25	4	100	100	0.62	0.62	2.33	0	1.79	0.0199	30.92	1
G7JNPFC14201-	25	4	100	100	0.62	0.62	2.33	0	1.69	0.0211	29.19	1
G7JNPFB14201-	25	4	100	100	0.62	0.62	2.33	0	1.46	0.0245	25.22	1
G7JNPFB15001-	25	4	100	100	0.62	0.62	2.33	0	2.00	0.0179	34.55	1

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NIMS G7 DATA RETURN

Activity ID	Observation Title	NIMS Edit Table	NIMS PB Table	Mode	Gain	Grating Start	Grating Offset	Record Format
G7JNPFC15001-	Jupiter Ftr Trk C 150 Deg Phase	G7JFT68C	G7JFT04B	SM	2	1	4	LPU
G7JNFEA15003-	Jupiter Ftr Trk B 150 Deg Phase	G7JFT68C	G7JFT04B	SM	2	1	4	LPU
G7JNFEZ15702-	Jupiter Ftr Trk Z 157 Deg Phase pt 2	G7JFT68C	G7JFT19C	SM	2	1	4	LPU
G7CNGLOBAL01-	Callisto Global Coverage	G7CLM442	G7CLM360	LM	4	0	4	MPW
G7INCHEMIS02-	MONITORING OF IO'S DAYSIDE	G7ILM244B	G7ILM216B	LM	2	0	4	LPU
G7INHRSPEC01-	MONITORING OF IO'S DAYSIDE	G7ILM442	G7ILM360	LM	2	0	4	MPW
G7JNFEAP4102-	Jupiter Ftr and Prtl Trk 41 deg part 2	G7JFT68C	G7JFT04B	SM	2	1	4	LPU
G7INVOLCAN05-	MONITORING OF SELECTED VOLCANIC REGIONS	G7ILM442	G7ILM216B	LM	4	0	4	MPW
G7INCHEMIS04-	MONITORING OF IO'S DAYSIDE	G7ILM244B	G7ILM102B	LM	2	0	4	LPU
G7ENFLEXUS01B-	Europa Global Mosaic Campaign	G7ELM244B	G7ELM228B	LM	3,2,4	0	4	LPU
G7ENFLEXUS01C-	Europa Global Mosaic Campaign	G7ELM244B	G7ELM108	LM	3,2,4	0	4	LPU
G7ENTYREMA01-	Europa Tyre Macula Region	G7ELM442	G7ELM360	LM	2	0	4	MPW
G7JNHOTMAP01-	NIMS Jupiter Hotmap Observation	G7JHT238A	G7JHT72A	LM	2	0	4	LPU
G7JNFEAP6601-	Jupiter Ftr and Prtl Trk 66 deg prt 1	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNPFTB6601-	Jupiter Partial Ftr Trk B 66 deg prt 1	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNPFTB6602-	Jupiter Partial Ftr Trk B 66 deg prt 2	G7JFT68C	G7JFT25A	SM	2	1	4	LPU
G7JNFEA53M01-	Jupiter Campaign Feature 5 and 3 um Map	G7J35160	G7J35083	LM	4	0	4	LPU
G7GNGLOBAL01-	GANYMEDE GLOBAL SURFACE MAP	G7GLM244G	G7GLM192G	LM	3	0	4	LPU
G7GNNHILAT01-	Ganymede North High Latitude Region Map	G7GLM244H	G7GLM192H	LM	3	0	4	LPU
G7GNNHILAT01-	Ganymede North High Latitude Region Map	G7GLM244H	G7GLM192H	LM	3	0	4	LPU
G7GNNHILAT01-	Ganymede North High Latitude Region Map	G7GLM244H	G7GLM192H	LM	3	0	4	LPU
G7GNBRITRL01-	BRIGHT ENDMEMBER FROM TRAIL HEMISPHERE	G7GLM442	G7GLM360	LM	3	0	4	MPW
G7GNKITTU_01-	Dark Rayed crater KITTU	G7GLM442	G7GLM360	LM	3	0	4	MPW
G7JNTHRMNS01-	Jupiter Thermal North South Stripe	G7J5M253B	G7J5M80B	LM	4	0	4	LPU
G7JNTHRMNS01-	Jupiter Thermal North South Stripe	G7J5M253B	G7J5M253B	LM	4	0	4	LPU

NIMS G7 DATA RETURN

ACTID	Obs. Cost (ticks)	Wave- lengths ret	Record Time (sec)	PB Time (sec)	Sed Bits of Tape sBOT (Mbits)	Total Bits of Tape BOT (Mbit)	Mode cycle time (sec)	Thold	Comp	Total BTG (Mbtg) (4% Ohead)	Data Reduct Factor (sBOT/BTG)	Pass
G7JNPFC15001-	25	4	100	100	0.62	0.62	2.33	0	2.07	0.0173	35.76	1
G7JNFEA15003-	25	4	100	100	0.62	0.62	2.33	0	1.62	0.0220	27.98	1
G7JNFEZ15702-	25	19	100	100	0.62	0.62	2.33	0	2.56	0.0663	9.31	1
G7CNGLOBAL01-	254	360	286.67	180.00	2.07	3.30	8.667	2	1.54	1.0098	2.05	2
G7INCHEMIS02-	36	216	144.67	142.00	0.88	0.89	8.667	2	2.39	0.3080	2.84	2
G7INHRSPEC01-	159	360	178.00	95.33	1.10	2.05	8.667	2	1.32	0.6240	1.76	2
G7JNFEAP4102-	72	4	300	300	1.85	1.85	2.33	0	1.51	0.0709	26.08	2
G7INVOLCAN05-	56	216	60.67	60.60	0.70	0.70	8.667	2	1.47	0.2137	3.27	2
G7INCHEMIS04-	71	216	294.67	210.00	1.30	1.82	8.667	2	1.41	0.7721	1.68	2
G7ENFLEXUS01-	322	228	1366.00	41.00	0.25	8.43	8.667	0	1.35	0.1662	1.52	2
G7ENFLEXUS01-	322	108	1366.00	251.00	1.55	8.43	8.667	0	1.27	0.5123	3.02	2
G7ENTYREMA01-	867	360	984.00	398.66	4.59	11.34	8.667	0	1.44	2.3919	1.92	2
G7JNHOTMAP01-	186	72	786	367	2.26	4.85	8.667	0	1.15	0.5514	4.11	2
G7JNFEAP6601-	72	25	300	140	0.86	1.85	2.33	0	1.88	0		2
G7JNPFTB6601-	52	25	213.33	99	0.61	1.32	2.33	0	1.88	0		2
G7JNPFTB6602-	52	25	213.33	213.3	1.32	1.32	2.33	0	1.61	0.2957	4.45	2
G7JNFEA53M01-	201	83	849.338	320	1.97	5.24	8.667	0	1.36	0.4687	4.21	2
G7GNGLOBAL01-	506	192	2150.67	993.60	6.13	13.27	8.667	2	2.04	2.2443	2.73	2
G7GNNHILAT01-	326	192	1382.67	121.00	0.75	8.53	8.667	2	1.91	0.2919	2.56	2
G7GNNHILAT01-	326	192	1382.67	61.00	0.38	8.53	8.667	0	1.83	0.1536	2.45	2
G7GNNHILAT01-	326	192	1382.67	227.00	1.40	8.53	8.667	0	1.83	0.5716	2.45	2
G7GNBRITRL01-	253	360	284.67	284.67	3.28	3.28	8.667	0	1.98	1.2421	2.64	2
G7GNKITTU_01-	618	360	700.67	364.00	4.19	8.07	8.667	0	2.05	1.5341	2.73	2
G7JNTHRMNS01-	370	80	1570	367	2.26	9.68	8.667	0	1.51	0.4666	4.85	1
G7JNTHRMNS01-	370	253	1570	784	4.84	9.68	8.667	0	1.86	2.5593	1.89	1
Total						121.366				30.358		
Allocated										27.620		
Oversubscribed										2.7380		

Recap of G7 Playback Events

The G7 encounter was marred by a significant AACS Anomaly. To maintain position and accurate pointing, Galileo uses a star scanner to maintain a celestial-based pointing reference. The celestial-based reference is used to correct for drift in the scan platform gyroes. About 4 hours before G7 perijove on day 94 (4 April 1997), the AACS bright body vector blocked out one of the stars of the star scanner star set. This led to the accumulation of uncompensated drift of the gyroes which affected the accuracy of the pointing for a significant number of NIMS observations. The maximum offset was about 14 mrad in the cone direction for G7GNGLOBAL01, equivalent to 28 NIMS fields of view. As a result approximately 75% of the illuminated portion of the target body shifted outside the limits of the recorded area. The star scanner problem was recognized early on; a fix was devised and implemented, and the anomaly resolved, in less than 20 hours.

About 13 hours after the start of the AACS Anomaly, the NIMS software apparently halted. There is no direct evidence of this halt, but one real time observation (G7NNHEALTH04) failed to appear as scheduled, and playback of two Jupiter observations recorded just after the realtime observation (G7JNFEAP66_01, G7JNPFTB66_01) returned only header packets and some undecodeable bits.

Even with these anomalies, more than 80% of the 75 NIMS G7 observations were recorded exactly as planned, yielding excellent data.

The star scanner anomaly affected 13 NIMS observations during Galileo's outbound passage during G7. There are 4 general categories, based on outcome and action taken:

1. Observations that missed the target entirely:
   G7INCHEMIS06
   G7INCHEMIS07
   G7JNFEX10801

These were deleted from the playback plan.

2. Observations of Jupiter falling on the target body, where the target latitude and longtude are not accurately known:
   G7JNHOTMAP01
   G7JNPFC06601
   G7JNFEA53M01
   G7JNFEA5UM01

These were retained unmodified in the playback plan.

3. Other Jupiter observations falling at or near the limb:
   G7JNFEAP6601
   G7JNFEAP6602
   GJJNPBTB6601
   G7JNPFTB6602

Playback commands to play back small portions of several of these (in order to determine if on-target data is present) were implemented. In addition, the bits allocated for the G7JNFEX10802 observation were shifted to the G7JNFEX10803 observation, which was recorded after the anomaly was fixed.

4. Current best estimates indicate that pointing for G7GNGLOBAL01 drifted such that the mosaic included only about 1/3 of the planned target area. See discussion of playback strategy below.

A number of other modifications to the playback plan were made in order to optimize the data returned. These are listed by target body.

Jupiter: In addition to the information already mentioned above: the wavelengths returned for JNFEAP6602 and JNPFTB6602 were increased from 4 to 25. The observations where only a small strip was returned to look for the limb are JNFEAP6601 and JNPFTB6601.

Io: The complete loss of CHEMIS06 released over 1 Mbit to apply to other observations. Two observations that were not previously in the playback plan were added back: VOLCAN05 and CHEMIS02. Both of these were returned in full with 216 wavelengths. Playback of CHEMIS05 was increased to the full record time (also with 216 wavelengths). Lastly the wavelength coverage for THRMAL06 was increased to 216 wavelengths.

Europa: Since full wavelength coverage was desirable for the ENTYREMA01 observation, it was decided to trim the spatial coverage by 1/5. This allowed the return of 360 rather than 298 wavelengths (Long Map, no detector 3 or 8).

The spatial location of the 1 Rim of pass 1 playback for ENFLEXUS01 was modified following Adriana’s instructions.

Ganymede: GNGLOBAL01 playback originally amounted to 3.2 Mbits of downlink. The pointing problem placed most of the recorded observation on the dark side of the terminator and/or off the body. A small part of each swath was returned in pass 1 to constrain the true extent of the pointing errors, and 0.9 Mb were used for the pass 2 playback of this observation.

The other 2+ Mbits from GNGLOBAL01 were used to change the wavelength selection for GNKITTU_01, GNBRITRL01, and GNGLOBAL02. All of these were returned with 360 wavelengths (up from 192). GNGLOBAL01 and GNHILAT01 were played back with GLM192G.PBK. GNGLOBAL02 had considerable dark sky so thresholding was employed.

Callisto: Only 1 Rim of CNGLOBAL01 (of 5 recorded) was planned to be played back. The wavelength table specified 360 wavelengths (down from 384 with removal of detector 3). The playback start and stop times were modified to return data from the center of the body and to correspond to instrument cycle start times.

<u>G7 Playback Events Timeline</u> (02-24-97 to 05-03-97)

02-24-97: NIMS data downlink bits allocation is 25.5 Megabits. Data requested for playback by science coordinators amounts to about 42 Mbits. Significant reductions in spatial and wavelength coverage are required. The largest cuts are to G7ENFLEXUS01 (>95% of coverage deleted), to G7GNHILAT01 and G7GNGLOBAL01 (substantial cuts in coverage), and to G7GNKITTU_01 (50% reduction in wavelength coverage).

03-11-97: Playback table update. Many Jupiter observation wavelengths were cut; typically, of 68 recorded, 25 were commanded for return in the former plan, and 4 are commanded in the current plan.

03-20-97: Playback table update. Greater sophistication and experience with playback results in dozens of "fine-tuning" changes in the timing of playback commands.

03-26-97: Final pre-uplink update. As E6 ends, hopes for recovery of detector 3 fade. Detector 3 wavelengths are accordingly removed from wavelength edit tables for Io and Europa observations, saving 0.4 Mbits.

03-30-97: G7 Encounter begins.

04-02-97: NIMS recording begins with G7NNSTRCAL01.

04-04-97: Star scanner anomaly begins at approximately 07:00 (GMT). Perijove is reached at 11:04:38 GMT. Probable NIMS software halt at about 20 hours GMT. Software reload number 10 (G7NNNIMSLD_10) is completed at 20:41 GMT.

04-05-97: Star scanner anomaly resolved about 02:46 GMT. Ganymede close approach occurs at 07:11 GMT.

04-10-97: Playback table update providing the first opportunity to adapt to the star scanner anomaly situation. The playback update stategy is discussed in the Playback Recap text.

04-16-97: Playback table update. NIMS compression had been better than predicted. The saved bits are employed to triple the coverage for G7CNGLOBAL01. The Project requests information that will help constrain/describe what occurred during the star scanner anomaly.

04-21-97: Glenn Orton reports that G7JNHOTMAP01 successfully imaged the hot spot targeted, though this appears near the edge of the image. Later, data for G7GNGLOBAL01 shows that the unknown drift in the clock direction (not constrained by other data) was relatively small (about 5 NIMS pixels or 2.5 mrad).

G7 Playback Events Timeline (02-24-97 to 05-03-97)

04-24-97: The Project released 4 Mbits of office margin, of which NIMS received 1.73 Mbits. The new allocation was employed to command for playback G7INCHEMIS04, which had been deleted from the plan in February. Playback of the lower scan of G7ENFLEXUS01 was also added to the plan. Due to saturation at visible wavelengths, a wavelength table without detector 1-8 bands was generated (G7ELM108). Finally, playback for G7GNGLOBAL01 was increased from 0.9 to 2.6 Mbits. Part of this increase was covered by compression savings. The AWG portion of the new allocation was spent in a second attempt to return data from the 66 degree phase observations that were later determined to have been lost due to an instrument software halt.

04-28-97: This early final update was approved in order to make best use of additional office margin bits released by the Project. NIMS and SSI recommended release of 1.6 Mbits of the 3.0 remaining after inefficiency losses. Pigheadedness on the part of the MWG representatives (who insisted on a margin of 2.4 Mbits to protect their remaining 0.2 Mbits of gap-fills) resulted in the release of only 0.6 Mbits, of which NIMS received 0.27. We were able to add only a small portion of the upper scan of G7GNHILAT01 (our highest priority), instead of all of it. As partial consolation we were able to command return of data recorded after the MWG snippets. We specified 80 wavelengths to complete return of the northern portion of G7JNTHRMNS01, and a completely new set of commands to get all 253 bands for the southern hemisphere portion of the observation.

5-03-97: Playback is terminated after running out without incident. In the end MWG's gap fills were never in danger, and we received 100% of the commanded data (an additional 3 Mbits) for G7JNTHRMNS01. For the entire orbit, NIMS data return totaled 30.35 Megabits.

NIMS Anomaly Report - G7 Sequence

Two types of anomalies occurred during the G7 Encounter: The NIMS processor halted once and there was an AACS scan platform anomaly that lasted about 20 hours.

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

Processor Halts

Facts:

0. Between the Start of the G7 Encounter and the single Halt NIMS returned 7 realtime observations and successfully reloaded NIMS from CDS 9 times. The NIMS SCLK engineering channels were continuously monitored for detecting a NIMS processor halt.

1. A NIMS processor halt was assumed to have occurred somtime between CHEMIS06 and RELOAD10. This halt was inferred from the fact that the realtime observation NNHEALTH04 was never returned and two Jupiter observations (JNFEA06601 and JNPFTB6601) returned empty packets in playback. This combination of facts is consistent with the NIMS processor having halted. Valid NIMS engineering SCLK values were reported just after NIMS reloads 09 and 10 but not during the time that NIMS was halted. A table of the NIMS engineering SCLK values near the time of the Halt follows (Note tat the NIMS engineering SCLK value is normally 2 Rims behind the CDS SCLK Rim when it is reported):

NIMS SCLK	CDS SCLK	CDS SCET	GROUND ERT
03898270	03898272.58	1997-094T14:23:34.442	1997-094T15:49:24.372
03898653	03898655.05	1997-094T20:50:14.428	1997-094T21:36:47.069

2. Three NIMS observations were lost due to this Halt: NNHEALTH04, JNFEA06601 and JNPFB6601.

Timing:

SCLK	Comments
03898256:06	NIMSLD09 software reload completed
03898262:00	Start INCHEMIS06 - not returned - AACS anomaly
03898272.58	Valid 03898270 SCLK Reported
03898616.00	Start JNFEAP6601 - bad data returned
03898626.00	Start JNPFTB6601 - bad data returned
03898632.00	Start NNHEALTH04 - NO R/T data returned
03898645:06	NIMSLD10 software reload completed
03898655.05	Valid 03898653 SCLK Reported

NIMS Anomaly Report - G7 Sequence

Summary:

1. One NIMS processor Halt is inferred to have occurred during the G7 Encounter.

2. Continuous monitoring of the NIMS SCLK channels did not help to identify this Halt. The timing was such that the halt was corrected by a NIMS reload before the NIMS engineering SCLK was picked up by the CDS engineering commutation map.

3. The 15 NIMS software reloads from CDS greatly lessened the potentially disastrous effects of the G7 Halt and protected the NIMS observations during the Encounter.

4. Frequent NIMS realtime observations, both science observations and instrument health monitoring observations, verified that NIMS was functioning normally at various time points throughout the encounter. The fact that one Helath observation was missing helped identify the apparent NIMS processor Halt.

5. The error avoidance measures applied to the G7 Encounter as determined in the analysis of the processor halts that occurred in earlier orbits were shown to be the proper response for dealing with the inevitable occurence of radiation-induced NIMS processor halts.

G7 AACS Anomaly

0. The AACS Bright Body Vector blocked one of the two stars in the AACS Star Scanner star set. This halted the star-based celestial reference, causing drift to accumulate in the scan platform gyro-based pointing.

1. This started near 97-094/07:00. The problem was corrected at 97-095/02:46. During this interval drift error accumulated to a maximum of about 14 mRad just before the problem was corrected. The pointing of the following NIMS observations was affected:

G7NNHEALTH03	G7JNHOTMAP01	G7INCHEMIS06	G7JNFEA96601
G7JNPFTB6601	G7NNHEALTH04	G7JNFEAP6602	G7JNPFTB6602
G7JNPFC06601	G7JNFEA53M01	G7JNFEA5UM01	G7NNHEALTH05
G7INCHEMIS07	G7GNGLOBAL01	G7JNFEX10801	G7JNFEX10802

2. The pointing errors of the NIMS observations during this interval is disussed briefly in the G7 Playback Recap section of this chapter.

3. A more detailed discussion of the AACS Anomally provided by the AACS Team follows:

G7A BRIGHT BODY VECTOR PROBLEM DESCRIPTION

Problem:

The bright body vector loaded to cover Europa on 97-094/07:00 inadvertently blocked out the second star of a two star set. This caused SEQID to fail, eliminating star-based celestial reference.

Without star-based celestial reference, errors in scan platform pointing due to gryo drift accumulated and reached a maximum of 14 mRad in cone before the problem was resolved.

How The Problem Was Solved:

The second star in the set (star 61) was replaced by star 148, which was not in danger of being blocked out by a bright body vector. Star 148 replaced 61 (rather than simply being added to the set) because the two stars were too close to each other to be used simultaneously by SEQID, the FSW algorithm that computes star-based celestial reference.

Why the Problem Occured:

Ground software showed that the clock blockage angle expected by the bright body vector was 2.9 degrees away from the clock pulse of star 61. The star set worked nominally in the testbed, so the set was deemed sufficient.

Why Star 148 Wasn't Used In The Original Set:

The original set consisted of stars 2 and 61. The anomaly resolution set consisted of stars 2 and 148. There were several reasons why the original set was chosen. Firstly, the original set had been used successfully before in flight, whereas the anomaly fix set had never been used. Secondly, star 61 of the original set is brighter than star 148, making it more robust in handling background radiation. Lastly, the original set allowed for a greater amount of S/C attitude uncertainty (1 degree as opposed to .8 degrees for the anomaly fix set).

Why the problem Won't Be repeated:

Analysis has since shown that the FSW timing uncertainty of bright body vectors translates to 2.6 degrees in clock. Star 61 was right on the border of the FSW timing uncertainty, which explains why it worked in the test bed, but dropped out in flight.

Star set generation criteria has since been updated to allow sufficient margin for FSW timing uncertainty. The star set checklist currently requires that there be a minimum of 13 degrees between the end of a bright body vector and the clock pulse of an essential star.

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.