SAMPEX

Master Data File Description

Version 1.3

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Document Revision History.

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Major modifications:

- Updates for RS and HR sets definitions and contents
- Appendix H - Attitude determination in 1 RPM spin mode
- Appendix I - SAMPEX “Event” table through September 1996
- Appendix J - MDF Generator Versions in Use

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Modifications:

- Update for RS set with 1-second LICA rates (Table 4.2.16)
- Update Statistics record (entries 103 & 104 added)
- Updated Appendices I, J, and K
- Added Appendix L, LICA 1-second rate changes

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Modifications:

- Correct RS table entries for Game 7
- Updated Appendices I, J, and K
- Add Appendix M: DPU patch history

1.0 Using This Document.

1.1 Scope and Intended Audience.

The intended audience for this document is any member of the SAMPEX science team and others interested in studying the SAMPEX mission data. The document will also be useful for programmers developing software to retrieve data from Master Data Files and convert them to scientific and engineering units.

This document describes the SAMPEX Master Data File (MDF), its types (UNIX or VMS), data format (Tennis Standard), contents (set descriptions and point definitions), and the statistics record. This document also presents sample Tennis Standard programming examples in 'C' and FORTRAN for accessing MDF records; however it is not a meant to serve as either a description of the Tennis Standard or a programmer's guide. For a complete description of the Caltech Tennis Data Formatting Standard, hereafter referred to simply as the Tennis Standard, refer to the Space Radiation Laboratory Technical Report No. 92-01 (see appendix A).

1.2 Finding Information Quickly

Refer to the following listings to quickly locate material in this document pertaining to a particular topic.

1.2.1 About Master Data Files in General

1.2.2 HILT Related Topics

§7.0 Rates,
High resolution, HILT
Low resolution, subcom descriptions

1.2.3 LEICA Related Topics

§ 4.2 Set Descriptions,
The EL set - LEICA pulse height analyzed events.
The RS set - LEICA low resolution rates(subcommed).
The HS set - LEICA analog housekeeping.
The DS set - LEICA digital status.

§ 6.0 Pulse height analyzed events,
LEICA

§ 7.0 Rates,
Low resolution, subcom descriptions

1.2.4 MAST Related Topics

§ 4.2 Set Descriptions,
The EM set - MAST pulse height analyzed events.
The RS set - MAST low resolution rates (subcommed).
The HS set - MAST analog housekeeping.
The DS set - MAST digital status.

§ 6.0 Pulse height analyzed events,
MAST

§ 7.0 Rates,
Low resolution, subcom descriptions

1.2.5 PET Related Topics

§ 4.2 Set Descriptions,
The EP set - PET pulse height analyzed events.
The RP set - PET high resolution rates.
The RS set - PET low resolution rates (subcommed).
The HS set - PET analog housekeeping.
The DS set - PET digital status.

§ 6.0 Pulse height analyzed events,
PET

§ 7.0 Rates,
High resolution, PET
Low resolution, subcom descriptions

1.2.6 DPU Related Topics

§ 4.2 Set Descriptions,
The CD set - DPU command error echo.
The SD set - DPU state change.
The PD set - DPU parameter dump.
The MD set - DPU memory dump.
The HS set - DPU analog housekeeping.
The DS set - DPU digital status.

1.2.7 Spacecraft Related Topics

§ 4.2 Set Descriptions,
The AS set - Spacecraft Attitude.
The MF set - Onboard magnetometer.
The PS set - Position, Attitude, and Model Magnetic Field Parameters.
The SB set - Spacecraft battery subsystem monitor.
The SP set - Spacecraft power monitor.
The SR set - Spacecraft reaction wheel monitor.
The ST set - Subsystem temperatures.
The VS set - Spacecraft state vector.

1.2.8 The Tennis Data Formatting Standard

§ 3.0 The Tennis Standard.
§ 4.0 Master Data File Set Descriptions.
Appendix D - Tennis Standard Library Contents.
Appendix E - Set Descriptor File Format.

2.0 Overview of SAMPEX Master Data Files.

2.1 What is a Master Data File ?

A Master Data File (MDF) is a self documenting, formatted file containing SAMPEX mission data for one 24 hour period from 00:00:00 to 23:59:59 UT. These data include the science data from the HILT, LEICA, MAST and PET instruments, engineering data, housekeeping data, and spacecraft position data. MDFs are created under the VAX/VMS operating system and have some but not all file attributes of typical VMS files: there is no end-of-file (EOF) marker in an MDF. The byte order of integers and format for floating point values follows the VAX/VMS specification described in the VAX FORTRAN Language Reference Manual (see appendix A). Consequently, UNIX users may need to perform byte swapping in order to get values into the format native to their platform.

2.2 Master Data File Types

Master Data File Type refers to the operating system compatibility of the medium on which MDFs are distributed. MDFs are distributed on rewritable magneto-optical disks of two types, VMS and foreign (UNIX) compatible. All disks are labeled with a nine character label of the form: *MDFtasnnn* ,

where *t* indicates the file type, V=VMS, F=foreign (UNIX)
a indicates the archive level, G=Gold (permanent), S=Silver (working)
s is a one character site code
nnn is a three digit UMSOC production sequence number

Site specific labels are outlined in table 2.1.

Table 2.1 - Site Specific Labels

Label	Site	File Type	Archive Level
MDFVGU*nnn*	University of Maryland (UMSOC)	VMS	Gold
MDFVSU*nnn*	University of Maryland (UMSOC)	VMS	Silver
MDFVSG*nnn*	University of Colorado / LASP (formerly was sent to: NASA GSFC Code 690)	VMS	Silver
MDFVSM*nnn*	Max Planck Institute	VMS	Silver
MDFVSA*nnn*	The Aerospace Corporation	VMS	Silver
MDFVSN*nnn*	National Space Science Data Center	VMS	Silver
MDFFSL*nnn*	NASA Langley Research Center	UNIX	Silver
MDFFSC*nnn*	California Institute of Technology	UNIX	Silver
MDFFSG*nnn*	NASA Goddard Space Flight Ctr. Code 660	UNIX	Silver

2.2.1 VMS Type

MDFs distributed on VMS type optical disks are compatible with Digital Equipment Corporation's VMS operating system. The distribution medium has a software label, used when mounting the disk, which is identical to the physical label on the disk housing as described in table 2.1. All VMS type disks have a directory named **[MDF]** which contains the names of the individual MDFs. The DCL *DIRECTORY* command will display the list of MDFs. The MDF file naming convention is "MDFyyddd.Hxx" where "yy" is the year, "ddd" is the day of year, and "xx" is the hour of day of the first low resolution rate packet.

2.2.2 UNIX Type

MDFs distributed on foreign type optical disks are compatible with UNIX operating systems. The distribution medium has no software label and no directory structure. The optical disks are divided into 512 byte sectors. Each side of the optical disk contains 576,898 sectors. The first sector on each side is intentionally left blank. This sector is reserved for optional UNIX related header data to be written by the user. The second sector contains an ASCII directory of the remaining sectors on the disk. Each entry of the directory occupies 32 bytes, hence there are 16 entries in the directory. The directory contains the number of MDFs on the optical disk (1 side) and the absolute location, in bytes beginning at sector zero, of each file. Figure 2.1 shows the UNIX compatible disk structure. Each entry format is shown in brackets [ ].

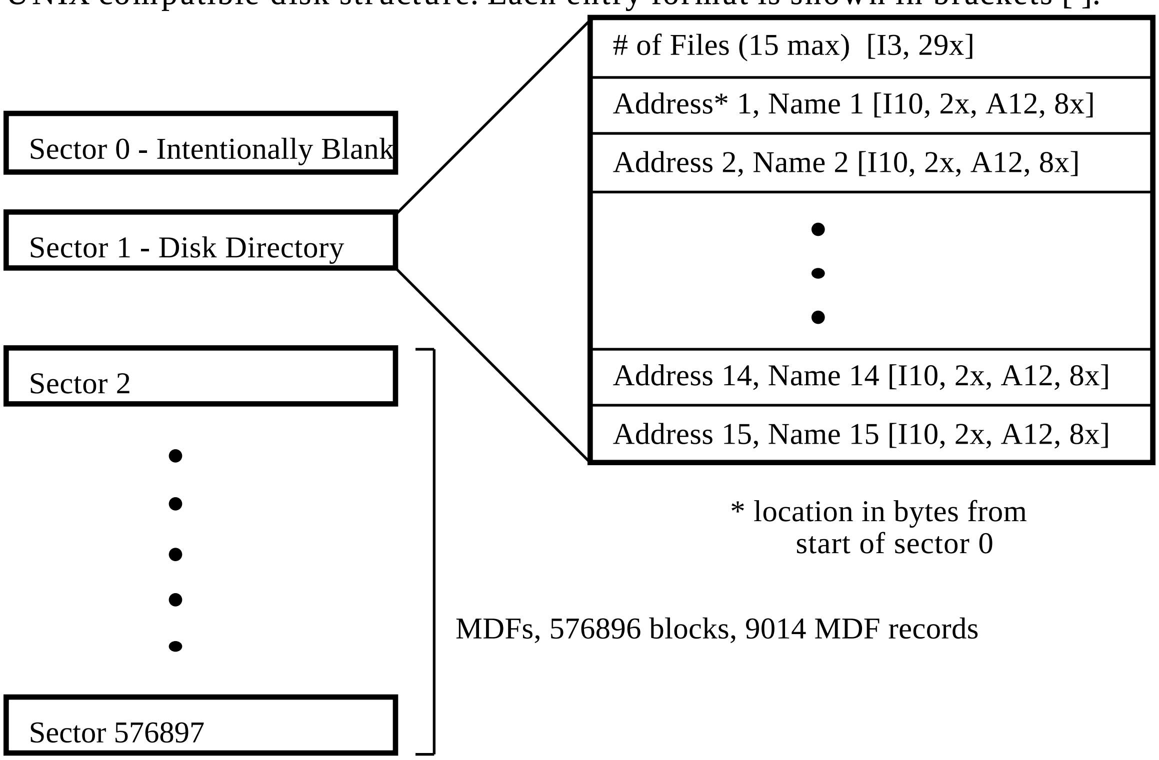


Figure 2.1 - UNIX compatible disk structure.

2.3 Organization of a Master Data File

For the purposes of this document, sectors and blocks may be used interchangeably. MDFs are organized into a collection of records, each of which is 32768 bytes (64 blocks) in length; consequently, all MDFs are some multiple of 64 blocks in length. The first record of each MDF contains the "begin of tourney" marker, "0[", (see Tennis Standard) and the self documenting metadata about the MDF. The second record contains the ASCII set type descriptors which define the set type structures. Refer to appendix E for the format of the set descriptor files. The second record also contains the saved source code files for the main routines of the MDF generator. All subsequent records contain MDF sets packed on 4 byte boundaries.

2.3.1 MDF Bin Timing

Master Data Files are organized into 6-second time bins. The first time bin will have a start time-of-day of between 00 and 05 seconds depending upon the first occurrence of a low resolution rate packet. The packet time stamp is obtained from the first low resolution rate packet. The time, in seconds of day, is determined and extrapolated back in six second steps to the earliest possible time of the same day. This determines the first bin time. Subsequent bin times are some multiple of six seconds later than this time. The last time bin of the day will be less than or equal to 14399 seconds of the day.

As an example, assume the first low resolution rate packet has a packet time stamp of 31017627 (seconds since 00:00:00 01 Jan 92). Divide by 86400 seconds/day to get 359 days, 27 seconds elapsed. This translates to year 1992, day 360, 27 seconds of the day. The corresponding first bin time would be 31017603 (00:00:03); four 6-seconds step backs. All data with packet time stamps or event times of between 31017603 (00:00:03) and 31017608 (00:00:08) will be put into this bin. All data with packet time stamps or event times occurring before this first bin time will be discarded (see **8.3 Discarded Data**). The next 6-second time bin begins at time 31017609 (00:00:09), etc.

Note that in any given six second time bin all sets of the same type will appear together, in increasing time order. However, all sets in the bin are not necessarily in time order since a subsequent group of same-type sets may have members with earlier times. For more information see sections **4.3 Data Sources** and **2.3.2 MDF Set Ordering**.

2.3.2 MDF Set Ordering

Set types do not occur in random order within any bin. The following rules and table 2.2 define the order and frequency in which sets may appear.

1) Each bin begins with a PS set type. The PS set time (game 1, point 1) is identical to the bin time in which it occurs. Each bin contains one and only one PS set. An entire MDF will contain 14400 PS sets, one every six seconds.

2) Following each PS set should be an RS set. RS sets may not be present due to certain spacecraft/instrument conditions. Occasionally more than one RS set will appear in a bin. See section **4.4 Known Limitations and Problems** for more details.

3) For set types which may occur more than once per bin, all sets of the same type will appear together in increasing time order. EH, EL, EM, and EP set types may occur in this way, as may other set types.

4) Other than PS sets, no set type is guaranteed to appear in any given bin.

Set Order	Frequency	Comments
PS	1/bin	Must occur in each bin, see rule #1
RS	1/bin	See rule #2
RP	1 every 8 bins	1 set every 48 seconds (8 bins)
RH	1/bin	See rule #2
EH	variable	See rules #3, #4
EL	variable	See rules #3, #4
EM	variable	See rules #3, #4
EP	variable	See rules #3, #4
MH	variable	See rule #4
MD	variable	See rule #4
CD	variable	See rule #4
SD	variable	See rule #4
PD	variable	See rule #4
HS	1 every 10 bins	1 set every 60 seconds (10 bins)
DS	1 every 10 bins	1 set every 60 seconds (10 bins)
AS	variable	Dependent on rate of spacecraft attitude change
VS	1/day	1 set per day, may occur in any bin (typically early)
ST	1 every 10 bins	1 set every 60 seconds (10 bins)
SP	1 every 10 bins	1 set every 60 seconds (10 bins)
SB	1 every 10 bins	1 set every 60 seconds (10 bins)
SR	1 every 5 bins	1 set every 30 seconds (5 bins)
MF	~1/bin	1 set every ~5 seconds

Table 2.2 - Order of Set Occurrences.

3.0 The Tennis Standard

The Tennis Standard allows the user to perform input and output of data by use of an existing library of 'C' routines and equivalent FORTRAN routines. The Tennis Standard defines the blocking protocol for the data. For a complete description of the Tennis Standard, refer to The Space Radiation Laboratory Technical Report Number 92-01 (see appendix A).

3.1 Reading A Master Data File

MDF users typically will perform only read operations upon an MDF. The following sections describe a subset of the Tennis Standard Library of functions and subroutines which is sufficient to retrieve all data point types found in SAMPEX MDFs. These sections describe the 'C' and FORTRAN equivalent routines of the Tennis Standard library.

3.1.1 FORTRAN Routines

FORTRAN users should pass all arguments by reference in accordance with normal FORTRAN calling conventions. Table 3.1 lists the arguments and their variable types as used in the format lines below.

Argument name	Type
char_count	I*4
game_number	I*4
key	I*2
key_value	I*2
mdf_file_name	A*12 (MDFyyddd.Hxx)
n	I*4
offset	I*4

Table 3.1 - FORTRAN Argument Types

3.1.1.1 F_SET_INFILE

The subroutine F_SET_INFILE opens a channel between the application program and the MDF specified in the argument *mdf_file_name*. It serves the same function as the *OPEN* statement in FORTRAN.

Format: F_SET_INFILE(*mdf_file_name*)

3.1.1.2 F_GET_SET

The integer*2 function F_GET_SET returns an integer*2 value in the variable *key_value* equivalent to the ASCII representation of the set key of the next set type found. Use this function to find the next set of any type.

Format: *key_value* = F_GET_SET( )

3.1.1.3 F_GET_KEY

The integer*2 function F_GET_KEY returns an integer*2 value in the variable *key_value* equivalent to the ASCII representation of the next set of the type specified in the character*2 argument *key*. Use this function to find the next set of a specific type.

Format: *key _value* = F_GET_KEY(*key*)

3.1.1.4 F_GET_GAME

The subroutine F_GET_GAME positions the file to the beginning of the game specified in the argument *game_number*. Use this subroutine to find a specified game within the current set.

Format F_GET_GAME(*game_number*)

3.1.1.5 F_GETBYTE

The byte function F_GETBYTE returns the value of the byte located at the position within the current game specified by the argument *offset* .

Format: *byte* = F_GETBYTE(*offset*)

3.1.1.6 F_GETBYTE_ARY

The subroutine F_GETBYTE_ARY returns *n* bytes located at the position within the current game specified by the argument *offset* to the byte array specified in the argument *byte_array*.

Format: F_GETBYTE_ARY(*offset, byte_array, n*)

3.1.1.7 F_GETWRD

The integer*2 function F_GETWRD returns the value of the word located at the position within the current game specified by the argument *offset* .

Format: *integer*2* = F_GETWRD(*offset*)

3.1.1.8 F_GETWRD_ARY

The subroutine F_GETWRD_ARY returns *n* integer*2 located at the position within the current game specified by the argument *offset* to the integer*2 array specified in the argument *word_array*.

Format: F_GETWRD_ARY(*offset*, *word_array*, *n*)

3.1.1.9 F_GETDBLWRD

The integer*4 function F_GETDBLWRD returns the value of the longword variable located at the position within the current game specified by the argument *offset* .

Format: *integer*4* = F_GETDBLWRD(*offset*)

3.1.1.10 F_GETFLOAT

The real*4 function F_GETFLOAT returns the value of the floating point variable located at the position within the current game specified by the argument *offset* .

Format: *real*4* = F_GETFLOAT(*offset*)

3.1.1.11 F_GETFLOAT_ARY

The subroutine F_GETFLOAT_ARY returns *n* real*4 located at the position within the current game specified by the argument *offset* to the real*4 array specified in the argument *real_array*.

Format: F_GETFLOAT_ARY(*offset*, *real_array*, *n*)

3.1.1.12 F_GETDBLFLOAT

The real*8 function F_GETDBLFLOAT returns the value of the double precision floating point variable located at the position within the current game specified by the argument *offset* .

Format: *real*8* = F_GETDBLFLOAT(*offset*)

3.1.1.13 F_GETSTRING

The integer*2 function F_GETSTRING returns *n* ASCII characters located at the position within the current game specified by the argument *offset* to the argument *char_array* . The function is set to the number of characters read.

Format: *char_count* = F_GETSTRING(*offset*, *n*, *char_array*)

3.1.2 "C" Routines

'C' users should follow ANSI Standard 'C' conventions when using the following routines. Table 3.2 lists the arguments and their variable types as used in the format lines below.

Argument name	Type
key	short
nchar	int
number	int
n	int
offset	int
char_array	array of char
short_array	array of short
float_array	array of float
'string'	character array or pointer to a character array
'inputfile'	character array or pointer to a character array

Table 3.2 - 'C' Argument Types

3.1.2.1 SET_INFILE

The function SET_INFILE opens a channel between the application program and the MDF specified in the argument *inputfile*.

Format: SET_INFILE(*'inputfile')*

3.1.1.2 GET_SET

The *short* function GET_SET returns a pointer to the next set of any type. The short value of the function is equivalent to the ASCII representation of the key of the set encountered. Use this function to find the next set of any type.

Format: GET_SET( )

3.1.1.3 GET_KEY

The *short* function GET_KEY returns a pointer to the next set of the type specified in the argument *key* . Use this function to find the next set of a specified type.

Format: GET_KEY(*key*)

3.1.1.4 GET_GAME

The *char** function GET_GAME returns a pointer to the beginning of the game specified in the argument *number*. Use this subroutine to find a specified game within a set.

Format GET_GAME(*number*)

3.1.1.5 GETBYTE

The *char* function GETBYTE returns the value of the byte located at the position within the current game specified by the argument *offset* .

Format: GETBYTE(*offset*)

3.1.1.6 GETBYTE_ARY

The subroutine GETBYTE_ARY returns a pointer to a *char* array of dimension *n* located at the position within the current game specified by the argument *offset* .

Format: GETBYTE_ARY(*offset*, *char_array*, *n*)

3.1.1.7 GETWRD

The *short* function GETWRD returns a pointer to the *short* located at the position within the current game specified by the argument *offset* .

Format: GETWRD(*offset*)

3.1.1.8 GETWRD_ARY

The subroutine GETWRD_ARY returns a pointer to a *short* array of dimension *n* located at the position within the current game specified by the argument *offset* .

Format: GETWRD_ARY(*offset* ,*short_array*, *n*)

3.1.1.9 GETDBLWRD

The *int* function GETDBLWRD returns a pointer to the *int* located at the position within the current game specified by the argument *offset* .

Format: GETDBLWRD(*offset*)

3.1.1.10 GETFLOAT

The *float* function GETFLOAT returns a pointer to the *float* located at the position within the current game specified by the argument *offset* .

Format: GETFLOAT(*offset*)

3.1.1.11 GETFLOAT_ARY

The subroutine GETFLOAT_ARY returns a pointer to a *float* array of dimension *n* located at the position within the current game specified by the argument *offset* .

Format: GETFLOAT_ARY(*offset, float_array, n*)

3.1.1.12 GETDBLFLOAT

The *double* function GETDBLFLOAT returns a pointer to the *double* variable located at the position within the current game specified by the argument *offset* .

Format: GETDBLFLOAT(*offset*)

3.1.1.13 GETSTRING

The subroutine GETSTRING returns *nchar* ASCII characters located at the position within the current game specified by the argument *offset* to the *char* array or string specified by the pointer *'string'*.

Format: GETSTRING(*offset, 'string', nchar*)

4.0 Master Data File Set Descriptions

A Master Data File (MDF) may contain any of 22 different set types. Each set type contains as its first element a 4 byte set key which indicates the set type to follow. The first 2 bytes contain upper case ASCII characters indicating the set type, the remaining 2 bytes are blanks used to buffer the set key size to 4 bytes. Table 4.1 contains an alphabetical listing of all set keys and set names.

Set Key	Set Name
"AS"	Spacecraft attitude
"CD"	DPU command error echo
"DS"	Digital housekeeping
"EH"	HILT event
"EL"	LEICA event
"EM"	MAST event
"EP"	PET event
"HS"	Analog housekeeping
"MD"	DPU memory dump
"MF"	Onboard magnetometer measurements
"MH"	HILT memory dump
"PD"	DPU parameter dump
"PS"	Position, attitude, and model magnetic field parameters
"RH"	HILT high resolution rates
"RP"	PET high resolution rates
"RS"	Low resolution multiplexed rates
"SB"	Spacecraft battery subsystem monitor
"SD"	DPU state change
"SP"	Spacecraft power monitor
"SR"	Spacecraft reaction wheel temperature monitor
"ST"	Subsystem temperature monitors
"VS"	Spacecraft state vector

Table 4.1 - Set Keys and Set Names

MDFs also contain additional set keys for the Tennis pedigree sets and metasets. These set keys are native to Tennis and a full list may be found in the Tennis Standard. The most important are those for the beginning of tourney metaset, 0[, and end of tourney metaset, 0]. When calling F_GETSET or F_GETKEY (see sections **3.1.1.2** and **3.1.1.3**), one should always test for the presence of the end of tourney key.

4.1 Point Types

Refer to appendix E, Set Descriptor File Format, for the relationship of points to games and games to sets in the following description. The point type designators from column two of tables 4.2 and 4.3 may be substituted for the place holder *typ* in the example given in appendix E. Each set contains one or more games. Each game contains one or more points. A point is a single item of data which may be retrieved from the MDF. A game may contain any of the following basic point types:

Point Type	Designator	Size	Description
Character	A	1 byte	any ASCII character
Byte	B	1 byte	1 byte integer
Short	S	2 bytes	2 byte integer
Integer	I	4 bytes	4 byte integer
Float	F	4 bytes	4 byte floating point
Double float	D	8 bytes	8 byte floating point

Table 4.2 - Basic Point Types

In addition to the basic point types, games may also contain arrays. Arrays are treated as points and retrieved as a single item. A game may contain any of the following array types:

Array Type	Designator	Size	Description
Character	A*n	n bytes	array of n A type points
Byte	B*n	n bytes	array of n B type points
Short	S*n	2n bytes	array of n S type points
Float	F*n	4n bytes	array of n F type points

Table 4.3 Array Point Types

4.2 Set Descriptions

The following set descriptions describe the Tennis Data Formatting Standard game and point structure for each set type. For the following set descriptions, the set key is implied, and the set size includes the 4 bytes contained in the set key. The set descriptions are intended to aid in the retrieval of data, and the comment field is not completely descriptive. For a full description of any given point, refer to the **Data Sources** section of this document to obtain the application ID (APID) from which the data point is obtained and then refer to the SAMPEX Telemetry and Command Handbook (see appendix A) for a complete description of the point.

In keeping with the Tennis Standard, sets, games and points should obey the following rules for byte alignment. Exceptions are noted in the individual set descriptions.

1) All Sets are a multiple of 4 bytes in length.

2) All Games begin on 4 byte boundaries.

3) All multi-byte points begin on even byte boundaries.

4) All 4 byte and 8 byte points begin on 4 byte boundaries.

5) Single-byte points and byte arrays may begin on any boundary.

In each set description the offset column contains the value used in the subroutine or function call for the variable *offset*. The type column indicates which subroutine or function to employ. See sections **3.1.1 FORTRAN Routines** and **3.1.2 'C' Routines.**

4.2.1 Set: AS - SAMPEX Spacecraft Attitude

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	F	quaternion x-element
2	2	4	F	quaternion y-element
2	3	8	F	quaternion z-element
2	4	12	F	quaternion scalar

set size: 24 bytes
set type: sfl (short fixed length)
game count: 2

4.2.2 Set: CD - DPU Command Error Echo

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
1	2	4	S	sequence counter from APID 42
1	3	6	S	general command count
1	4	8	S	general command error count
1	5	10	B*8	erroneous command data
1	6	18	S	spare, 2 bytes

set size: 24 bytes
set type: sfl (short fixed length)
game count: 1

4.2.3 Set: DS - Digital Instrument Status

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	B	HILT detector status
2	2	1	B	HILT instrument status
2	3	2	S	HILT XILINX status
2	4	4	B	HILT page count
2	5	5	B	Page 1
2	6	6	B	Page 2
2	7	7	B	Page 3
2	8	8	B	Page 4
2	9	9	B	Page 5
2	10	10	B	Page 6
2	11	11	B	Page 7
2	12	12	B	conf. watchdog error count
2	13	13	B	conf. XILINX error count
2	14	14	B	xinit pulse count
2	15	15	B	xpwroff pulse count
2	16	16	S	Valve / HV status
2	17	18	S	spare, 2 bytes
3	1	0	B	LEICA status byte
3	2	1	B	LEICA status byte
3	3	2	B	fixed value (A3H)
3	4	3	B	bit 6 (calibration indicator)
4	1	0	B	MAST status byte (bits 3-7)
4	2	1	B	PET status byte (bits 1-7)
4	3	2	B	LVPS status byte (bits 2-7)
4	4	3	B	spare, 1 byte

continued

Set DS description continued

Game	Point	Offset	Type	Comments
5	1	0	B	DPU status
5	2	1	B	spare, 1 byte
5	3	2	S	seconds until next quota collection
5	4	4	S	HILT running event quota/256
5	5	6	S	LEICA running event quota/256
5	6	8	S	MAST running event quota/256
5	7	10	S	PET running event quota/256
5	8	12	S	HILT high resolution rate quota/256
5	9	14	S	PET high resolution rate quota/256
5	10	16	S	DPU general command count
5	11	18	S	DPU general command error count
5	12	20	S	DPU time command count
5	13	22	S	DPU time command error count
5	14	24	B	DPU software version number
5	15	25	B	DPU count of good RAM pages
5	16	26	B	DPU RAM page 1
5	17	27	B	DPU RAM page 2
5	18	28	B	DPU RAM page 3
5	19	29	B	DPU RAM page 4
5	20	30	B	DPU RAM page 5
5	21	31	B	DPU RAM page 6
5	22	32	B	DPU RAM page 7
5	23	33	B	analog oscillator selected
5	24	34	B*5	MAST command word 1
5	25	39	B*5	MAST command word 2
5	26	44	B*5	MAST command word 3
5	27	49	B*5	MAST command word 4
5	28	54	B*5	MAST command word 5
5	29	59	B*5	MAST command word 6
5	30	64	B*5	PET command word 1
5	31	69	B*5	PET command word 2
5	32	74	B*5	PET command word 3
5	33	79	B	configuration register
5	34	80	S	PROM checksum
5	35	82	S	spare, 2 bytes

set size: 120 bytes
set type: sfl (short fixed length)
game count: 5

4.2.4 Set: EH - HILT PHA Event

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	B*14	single 14 byte HILT event
2	2	14	S	spare, 2 bytes

set size: 24 bytes
set type: sfl (short fixed length)
game count: 2

4.2.5 Set: EL - LEICA PHA Event

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	B*15	single 15 byte LEICA event
2	2	15	B	spare, 1 byte

set size: 24 bytes
set type: sfl (short fixed length)
game count: 2

4.2.6 Set: EM - MAST PHA Event

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
1	2	4	I	MAST sequence number,
2	1	0	B	event offset time
2	2	1	B	spare, 1 byte
2	3	2	B	detector flag
2	4	3	B	event flag
2	5	4	S*14	14 ADC

set size: 44 bytes
set type: sfl (short fixed length)
game count: 2

4.2.7 Set: EP - PET PHA Event

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
1	2	4	I	PET sequence number
2	1	0	B	Event offset time
2	2	1	B	spare, 1 byte
2	3	2	S*4	4 ADC
2	4	10	B	mode flag
2	5	11	B	discriminator flag

set size: 24 bytes
set type: sfl (short fixed length)
game count: 2

4.2.8 Set: HS - Analog Housekeeping

<u>See Appendix C for HS set conversion algorithms</u>

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	B	HILT temp: vent valve
2	2	1	B	HILT temp: main valve
2	3	2	B	HILT temp: pressure regulator, internal
2	4	3	B	HILT temp: analog box, internal
2	5	4	B	HILT temp: sensor internal
2	6	5	B	HILT temp: digital box
2	7	6	B	HILT temp: digital electronics
2	8	7	B	HILT temp: HV converter PC
2	9	8	B	HILT temp: HV converter drift,
2	10	9	B	HILT temp: LV converter 1 analog,
2	11	10	B	HILT temp: LV converter 2 system
2	12	11	B	HILT temp: cover motor
2	13	12	B	HILT: -10 volt monitor
2	14	13	B	HILT: +5 volt monitor
2	15	14	B	HILT: +10 volt monitor
2	16	15	B	HILT: SSD bias
2	17	16	B	HILT: HV monitor (PC)
2	18	17	B	HILT: HV monitor (drift)
2	19	18	B	HILT: pressure monitor # 1
2	20	19	B	HILT: pressure monitor # 2
2	21	20	B	HILT: regulator valve temperature
2	22	21	B	HILT: +13 volt monitor / converter # 2
2	23	22	B	HILT: -13 volt monitor / converter # 2
2	24	23	B	HILT: +10 volt monitor / converter # 2
2	25	24	B	HILT: -10 volt monitor / converter # 2
2	26	25	B	HILT: +5 volt monitor / converter # 2

continued

Set HS description continued

See Appendix C for HS set conversion algorithms

Game	Point	Offset	Type	Comments
3	1	0	B	LEICA: +12 volt monitor
3	2	1	B	LEICA: +6 volt monitor
3	3	2	B	LEICA: +5 volt monitor
3	4	3	B	LEICA: -5 volt monitor
3	5	4	B	LEICA: -6 volt monitor
3	6	5	B	LEICA: -12v volt monitor
3	7	6	B	LEICA: High Voltage monitor # 1
3	8	7	B	LEICA: High Voltage monitor # 2
3	9	8	B	LEICA: temp # 1 (Telescope Foil end)
3	10	9	B	LEICA: temp # 2 (Telescope Detector end)
3	11	10	B	LEICA: temp # 3 (Electronics)
3	12	11	B	LEICA: temp # 4 (TOF board)
3	13	12	B	LEICA: High Voltage control monitor # 1
3	14	13	B	LEICA: High Voltage control monitor # 2
3	15	14	B	LEICA: High Voltage monitor # 1
3	16	15	B	LEICA: High Voltage monitor # 2
4	1	0	B	MAST: matrix (thin) board thermistor
4	2	1	B	MAST: thick board thermistor
4	3	2	B	MAST: M1 thermistor
4	4	3	B	MAST: D2 thermistor (not M3)
4	5	4	B	MAST: D7 thermistor
4	6	5	B	MAST: M1 thermistor
4	7	6	B	MAST: D2 thermistor (not M3)
4	8	7	B	MAST: D7 thermistor
4	9	8	B	PET: P1RT thermistor
4	10	9	B	PET: P8RT thermistor
4	11	10	B	PET: ANART thermistor
4	12	11	B	PET: P1RT thermistor
4	13	12	B	PET: P8RT thermistor
4	14	13	B	PET: ANART thermistor
4	15	14	B	PET: P1RT thermistor
4	16	15	B	PET: P8RT thermistor

continued

Set HS Description continued

See Appendix C for HS set conversion algorithms

Game	Point	Offset	Type	Comments
5	1	0	B	LVPS: +7.5 volt monitor
5	2	1	B	LVPS: +4.7 volt monitor
5	3	2	B	LVPS: -7.5 volt monitor
5	4	3	B	LVPS: -13.5 volt monitor
5	5	4	B	LVPS: -37.0 volt monitor
5	6	5	B	LVPS: ground monitor # 1
5	7	6	B	LVPS: ground monitor # 2
5	8	7	B	LVPS: ground monitor # 3
5	9	8	B	LVPS: ground monitor # 4
5	10	9	B	LVPS: +37.0 volt monitor
5	11	10	B	LVPS: +13.5 volt monitor
5	12	11	B	LVPS: +10.0 volt monitor
5	13	12	B	LVPS: PET monitor
5	14	13	B	LVPS: MAST monitor
5	15	14	B	LVPS: PSA current monitor
5	16	15	B	LVPS: variable load monitor
5	17	16	B	DPU: +5.0 volt monitor
5	18	17	B	DPU: +10.0 volt monitor
5	19	18	B	DPU: -10.0 volt monitor
5	20	19	B	DPU: +2.5 volt monitor
5	21	20	B	DPU: ground monitor
5	22	21	B	Spare, 1 byte

set size: 88 bytes
set type: sfl (short fixed length)
game count: 5

Note: Games 2 and 5 of the HS set type do not comply with the Tennis Standard guidelines for game size. See section **4.4 Known Limitations and Problems**.

4.2.9 Set: MD - DPU Memory Dump

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
1	2	4	S	sequence counter from APID 44
1	3	6	S	spare, 2 bytes
1	4	8	I	memory dump start address
1	5	12	B*256	DPU dump data

set size: 272 bytes
set type: sfl (short fixed length)
game count: 1

4.2.10 Set: MF - Onboard Magnetometer Measurements

<u>See Appendix C for Mfset conversion algorithms</u>

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	S	Body-centered X-axis counts
2	2	2	S	Body-centered Y-axis counts
2	3	4	S	Body-centered Z-axis counts
2	4	6	S	Spare, 2 bytes

set size: 16 bytes
set type: sfl (short fixed length)
game count: 2

4.2.11 Set: MH - HILT Memory Dump

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	A*24	ISO time, [yyyy-mm-ddThh:mm:ssbbbbb]
3	1	0	S	sequence count from APID 43
3	2	2	S	dump mode
3	3	4	S	dump mask
3	4	6	S	memory dump start address
3	5	8	S	eread
3	6	10	S	dump length
3	7	12	B*256	1 page of memory

set size: 300 bytes
set type: sfl (short fixed length)
game count: 3

4.2.12 Set: PD - DPU Parameter Dump

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
1	2	4	S	sequence count from APID 42
1	3	6	B	enable data sources mask
1	4	7	B	LVPS control mask
1	5	8	B	HILT valve/cover control
1	6	9	B	HILT High Voltage enable
1	7	10	S	HILT valve control time-out
1	8	12	S	HILT orbit event allocation
1	9	14	S	LEICA orbit event allocation
1	10	16	S	MAST orbit event allocation
1	11	18	S	PET orbit event allocation
1	12	20	S	HILT high resolution rate allocation
1	13	22	S	PET high resolution rate allocation
1	14	24	B	HILT memory reallocation
1	15	25	B	LEICA memory reallocation
1	16	26	B	MAST memory reallocation
1	17	27	B	PET memory reallocation
1	18	28	B	HILT high resolution reallocation
1	19	29	B	PET high resolution reallocation
1	20	30	B	HILT HE1 1 second quota
1	21	31	B	HILT HE2 1 second quota
1	22	32	B	HILT HZ1 1 second quota
1	23	33	B	HILT HZ2 1 second quota
1	24	34	B	LEICA low+high priority 1 second quota
1	25	35	B	LEICA low priority 1 second quota
1	26	36	B	MAST HIZ 1 second quota
1	27	37	B	MAST PEN 1 second quota
1	28	38	B	MAST Z2 1 second quota
1	29	39	B	MAST Z1 1 second quota
1	30	40	B	MAST HAZ 1 second quota
1	31	41	B	PET 1 second quota
1	32	42	B	HILT high resolution threshold item #
1	33	43	B	enabled interface mask
1	34	44	S	PET high resolution threshold value
1	35	46	S	HILT high resolution threshold value
1	36	48	I	spare, 4 bytes

set size: 56 bytes
set type: sfl (short fixed length)
game count: 1

4.2.13 Set: PS - Position, Attitude, and Model Magnetic Field Parameters

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
1	2	4	I	Orbit #
1	3	8	S	MDF version. #
1	4	10	S	BL_IGRF Version. #
1	5	12	S	MAG_Eph Version. #
1	6	14	S*3	BL_IGRF return status
1	7	20	F	spare, 4 bytes
2	1	0	A*24	ISO time [yyyy-mm-ddThh:mm:ssbbbbb]
3	1	0	F*3	Geographic range, longitude, latitude
3	2	12	F	Geographic altitude
4	1	0	F*3	X,Y,Z coordinates
4	2	12	F*3	VX,VY,VZ velocity
4	3	24	F*9	Direction cosine array
4	4	60	F	Exospheric temperature
4	5	64	F	Drag coefficient
4	6	68	F	Geomagnetic index
4	7	72	S	ACS control mode
4	8	74	F	Inertial dot-product. See note 1.
4	9	78	S	spare, 2 bytes
5	1	0	F*3	Eccentric dipole range, longitude, latitude
5	2	12	F	Local time in ECD
6	1	0	F	L-shell parameter
6	2	4	F	Model field magnitude
6	3	8	F	Local time at magnetic equator
6	4	12	F	Invariant latitude
6	5	16	F	Pitch angle of particle
6	6	20	F	Loss Cone 1
6	7	24	F	Loss Cone 2

continued

Set PS description continued

Game	Point	Offset	Type	Comments
7	1	0	F*3	Magnetic field vector, Cartesian coordinates
7	2	12	F*3	Magnetic field vector, spherical coordinates
7	3	24	F*3	Dipole moment vector
7	4	36	F*3	Dipole moment displacement vector
7	5	48	F	Magnetic declination
7	6	52	F	Magnetic dip angle
7	7	56	F	Algebraic magnetic radial distance
7	8	60	F	Algebraic magnetic latitude
7	9	64	F*3	Geographic alt.,long.,lat. of mirror point
7	10	76	F*4	Field magn. and posn. at magnetic equator
7	11	92	F*4	Field magn. and posn. at north 100 km point
7	12	108	F*4	Field magn. and posn. at south 100 km point
7	13	124	F	spare, 4 bytes
8	1	0	F	nominal vertical cutoff
8	2	4	I	SAA flag
8	3	8	F	spare, 4 bytes
9	1	0	F	zenith angle
9	2	4	F	azimuth angle
9	3	8	F	spare, 4 bytes
9	4	12	F	spare, 4 bytes

set size: 348 bytes
set type: sfl (short fixed length)
game count: 9

Note 1: Alignment error occurs here, see section **4.4 Known Limitations and Problems** .

4.2.14 Set: RH - HILT High Resolution Rates

The RH set contents depend on the DPU software version in use. From launch through August 1996 there have been 4 different versions used. Additional versions may be used at later dates. Section 7.1.1 and Appendix G contain details on the RH set contents and applicable effective dates.

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	B*60	compressed rate*, 60 values
3	1	0	B*60	compressed rate*, 60 values
4	1	0	B*60	compressed rate*, 60 values
5	1	0	B*60	compressed rate*, 60 values
6	1	0	B*60	compressed rate*, 60 values
7	1	0	B*60	compressed rate*, 60 values

* see § 7.1 for rates assigned to each game
* see Appendix B for rate decompression algorithm

set size: 368 bytes
set type: sfl (short fixed length)
game count: 7

4.2.15 Set: RP - PET High Resolution Rates

See §7.1.2 for description of count rate coverage in the RP set.

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	time, seconds since 01JAN92 00:00:00
1	2	4	I	spare, 4 bytes
2	1	0	B*480	compressed P1 rate*, counts in 0.05 second interval

* see Appendix B for rate decompression algorithm

set size: 492 bytes
set type: sfl (short fixed length)
game count: 2

4.2.16 Set: RS - Low Resolution Multiplexed Rates

<u>See Appendix B for RS set rate decompression algorithm</u>

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
1	2	4	S	subcom
1	3	6	S	spare, 2 bytes
2	1	0	S	HILT HE1 rate
2	2	2	S	HILT HE2 rate
2	3	4	S	HILT HZ1 rate
2	4	6	S	HILT HZ2 rate
2	5	8	S	HILT rate, subcom dependent (see §7.2.1)
2	6	10	S	HILT rate, subcom dependent (see §7.2.1)
2	7	12	S	HILT IDLE-HI rate
2	8	14	S	HILT IDLE-LO rate
3	1	0	S	LEICA D4 Singles rate
3	2	2	S	LEICA D3 Singles rate
3	3	4	S	LEICA D2 Singles rate
3	4	6	S	LEICA D1 Singles rate
3	5	8	S	LEICA Triples rate
3	6	10	S	LEICA Doubles rate
3	7	12	S	LEICA Stop Singles rate
3	8	14	S	LEICA Start Singles rate
3	9	16	S	LEICA in-flight calibration count rate
3	10	18	S	LEICA Proton rate
3	11	20	S	LEICA Low Priority rate
3	12	22	S	LEICA High Priority rate

continued

Set RS Description (continued)

Game	Point	Offset	Type	Comments
4	1	0	S	MAST Z1SEC rates
4	2	2	S	MAST ADC OR rates
4	3	4	S	MAST LIVE TIME rates
4	4	6	S	MAST PEN rates
4	5	8	S	MAST Z1 rates
4	6	10	S	MAST Z2 rates
4	7	12	S	MAST HIZR0 rates
4	8	14	S	MAST HIZR1 rates
4	9	16	S	MAST HIZR2 rates
4	10	18	S	MAST HIZR3 rates
4	11	20	S	MAST HIZR4 rates
4	12	22	S	MAST HIZR5 rates
4	13	24	S	MAST HIZR6 rates
4	14	26	S	MAST rates, subcom dependent (see §7.2.1)
4	15	28	S	MAST rates, subcom dependent (see §7.2.1)
4	16	30	S	MAST rates, subcom dependent (see §7.2.1)
4	17	32	S	MAST rates, subcom dependent (see §7.2.1)
4	18	34	S	MAST rates, subcom dependent (see §7.2.1)
5	1	0	S	PET PHI rates
5	2	2	S	PET EHI rates
5	3	4	S	PET PLO rates
5	4	6	S	PET ELO rates
5	5	8	S	PET EWG rates
5	6	10	S	PET LIVE TIME rates
5	7	12	S	PET PEN rates
5	8	14	S	PET RNG rates
5	9	16	S	PET rates, subcom dependent (see §7.2.1)
5	10	18	S	PET rates, subcom dependent (see §7.2.1)
6*	1	0	F	pitch angle at midpoint of RS set
6	2	4	F	zenith angle at midpoint of RS set
6	3	8	F	azimuth angle at midpoint of RS set
6	4	12	F	seconds between quaternions used to interpolate attitude

* see Appendix H; game 6 is present for MDF versions #30 and above

continued

Set RS Description (continued)

Game	Point	Offset	Type	Comments
7**	1	0	S	D4+D3 second #1 **
7	2	2	S	D2+D1 second #1
7	3	4	S	Stop second #1
7	4	6	S	Start second #1
7	5	8	S	Low Pri second #1
7	6	10	S	High Pri second #1
7	7	12	S	D4+D3 second #2
7	8	14	S	D2+D1 second #2
7	9	16	S	Stop second #2
7	10	18	S	Start second #2
7	11	20	S	Low Pri second #2
7	12	22	S	High Pri second #2
7	13	24	S	D4+D3 second #3
7	14	26	S	D2+D1 second #3
7	15	28	S	Stop second #3
7	16	30	S	Start second #3
7	17	32	S	Low Pri second #3
7	18	34	S	High Pri second #3
7	19	36	S	D4+D3 second #4
7	20	38	S	D2+D1 second #4
7	21	40	S	Stop second #4
7	22	42	S	Start second #4
7	23	44	S	Low Pri second #4
7	24	46	S	High Pri second #4
7	25	48	S	D4+D3 second #5
7	26	50	S	D2+D1 second #5
7	27	52	S	Stop second #5
7	28	54	S	Start second #5
7	29	56	S	Low Pri second #5
7	30	58	S	High Pri second #5

Continued

Set RS Description (continued)

Game	Point	Offset	Type	Comments
7	31	60	S	D4+D3 second #6
7	32	62	S	D2+D1 second #6
7	33	64	S	Stop second #6
7	34	68	S	Start second #6
7	35	70	S	Low Pri second #6
7	36	72	S	High Pri second #6

set size: 196 bytes
set type: sfl (short fixed length)
game count: 7

** see Appendix K: game 7 is present for MDF versions #42 and above

4.2.17 Set: SB - SAMPEX Spacecraft Battery Subsystem Monitor

See Appendix C for SB set conversion algorithms

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	B	Battery state of charge
2	2	1	B	Battery under voltage status
2	3	2	B	Safe hold status
2	4	3	B	spare, 1 byte
2	5	4	S	Battery current monitor
2	6	6	S	Shunt current monitor
2	7	8	S	Non-essential bus load current monitor
2	8	10	S	Solar array A current monitor
2	9	12	S	Battery voltage monitor
2	10	14	S	Battery top-of-cell temperature monitor
2	11	16	S	Battery base plate temperature monitor
2	12	18	S	Main bus voltage monitor

set size: 28 bytes
set type: sfl (short fixed length)
game count: 2

4.2.18 Set: SD - DPU State Change

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
1	2	4	S	sequence count
1	3	6	B	DPU state number
1	4	7	B	DPU status
1	5	8	I	spare, 4 bytes

set size: 16 bytes
set type: sfl (short fixed length)
game count: 1

4.2.19 Set: SP - SAMPEX Spacecraft Power Monitor

See Appendix C for SP set conversion algorithms

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	B	HILT acoustic cover power
2	2	1	B	LEICA acoustic cover power
2	3	2	B	HILT pre-regulator power
2	4	3	B	LEICA pre-regulator power
2	5	4	B	MAST/PET bus power
2	6	5	B	operational heater power
2	7	6	B	survival heater power
2	8	7	B	spare, 1 byte
2	9	8	S	PD/PCU signal ground reference
2	10	10	S	spare, 2 bytes

set size: 20 bytes
set type: sfl (short fixed length)
game count: 2

4.2.20 Set: SR - SAMPEX Spacecraft Reaction Wheel Monitor

See Appendix C for SR set conversion algorithms

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	S	Reaction wheel temperature #1
2	2	2	S	Reaction wheel temperature #2

set size: 12 bytes
set type: sfl (short fixed length)
game count: 2

4.2.21 Set: ST - Subsystem Temperature Monitor

See Appendix C for ST set conversion algorithms

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	time, seconds since 01JAN92 00:00:00
2	1	0	B	transmitter power status
2	2	1	B	spare, 1 byte
2	3	2	S	lower S/C radiator plate temperature
2	4	4	S	upper S/C radiator plate temperature
2	5	6	S	instrument/bus separation plate temperature
3	1	0	S	HILT support plate temperature
3	2	2	S	HILT isobutane tank temperature
3	3	4	S	HILT analog electronics temperature
3	4	6	S	HILT sensor base plate temperature
3	5	8	S	HILT acoustic cover temperature
3	6	10	S	spare, 2 bytes
4	1	0	S	LEICA base plate temperature
4	2	2	S	spare, 2 bytes
5	1	0	S	MAST base plate temperature
5	2	2	S	PET base plate temperature
5	3	4	S	MAST/PET low voltage power supply temp.
5	4	6	S	spare, 2 bytes
6	1	0	S	DPU base plate temperature
6	2	2	S	spare, 2 bytes

set size: 44 bytes
set type: sfl (short fixed length)
game count: 6

4.2.22 Set: VS - SAMPEX Spacecraft State Vector

Format:

Game	Point	Offset	Type	Comments
1	1	0	I	SAMPEX time, seconds since 01JAN92 00:00:00
2	1	0	D	ephemeris time
3	1	0	D	previous x position (km)
3	2	8	D	previous y position (km)
3	3	16	D	previous z position (km)
3	4	24	D	previous x velocity (km/s)
3	5	32	D	previous y velocity (km/s)
3	6	40	D	previous z velocity (km/s)
4	1	0	D	current x position (km)
4	2	8	D	current y position (km)
4	3	16	D	current z position (km)
4	4	24	D	current x velocity (km/s)
4	5	32	D	current y velocity (km/s)
4	6	40	D	current z velocity (km/s)
5	1	0	F	exospheric temperature
5	2	4	F	drag coefficient
5	3	8	F	geomagnetic activity index
5	4	12	F	spare, 4 bytes

set size: 128 bytes
set type: sfl (short fixed length)
game count: 5

Notes: The "previous" and "current" state vectors both correspond to the "ephemeris time" and are in GEI coordinates. The "previous state vector" has been propagated (usually for one day) on board until the "ephemeris time". The "current state vector" is a predict from the Flight Dynamics Facility which has been uploaded and is to be used for further orbit propagation. Exospheric temperature, drag coefficient, and geomagnetic activity index are predicted parameters to be used in the orbit propagation routine.

4.3 Data Sources

The sources of data for all set types except set PS are SAMPEX spacecraft packets. Set PS contains data from packets and from calculations performed at the time of MDF generation using the IGRF 1990 Magnetic Field Model (see section **5.1 Models**). Packets are identified by application ID (APID). APID 42 is divided into subcom groups. Sources of data for each set type and the expected frequency of occurrence of each are shown in table 4.4.

Set	Source(s) of Data (APID)	Frequency
AS	11	variable, every 1° attitude change
CD	42 subcom 24	variable
DS	42 subcom 23	60 seconds
EH	42 subcom 0	variable
EL	42 subcom 1	variable
EM	42 subcom 2	variable
EP	42 subcom 3	variable
HS	42 subcom 22	60 seconds
MD	44	variable
MF	24	~5 seconds
MH	43	variable
PD	42 subcom 26	variable
PS	11, 13, Mag Field Model	6 seconds
RH	42 subcom 4	6 seconds
RP	42 subcom 5	48 seconds
RS	42 subcoms 6 through 21	6 seconds
SB	20	~60 seconds
SD	42 subcom 25	variable
SP	19	~60 seconds
SR	21	~30 seconds
ST	18	~50 seconds
VS	13	1/day

Table 4.4 - Sources of Data and Expected Frequency.

4.4 Known Limitations and Problems

Several problems with the MDF have been identified. The following sections describe these problems.

4.4.1 Set RS - Packet Time Stamp Error

RS set times occur every six seconds, thus we expect one in each 6-second time bin. Due to the asynchronous relationship of the spacecraft clock and the DPU clock, there exists the possibility of a one second time jitter in the RS packet time stamp. This may result in two RS sets occurring in a 6-second time bin. The time bin either preceding or following a time bin containing two RS sets will not contain an RS set. No attempt is made to correct this timing error.

4.4.2 Set PS - Byte Alignment Violation

In game 4 of the PS set, point 8 does not begin on a 4 byte boundary. No attempt to fix this alignment problem will be made. Only UNIX users using Tennis will experience a problem reading this point.

4.4.3 Set HS - Game Alignment Violation

Games 2 and 5 of the HS set are not multiples of 4 bytes; however, the entire set is a multiple of 4 bytes (see section **4.2 Set Descriptions**). Since all the points in this set are single byte entries, the entire game can be retrieved into a byte array.

4.4.4 Set PS - ACS Control Mode (Coast)

Game 4, point 7 of the PS set contains the ACS control mode, *ctrl_mode* (see section **5.3**). *Ctrl_mode* can take on four values: 0, 1, 2, and 3. The spacecraft attitude control system (ACS) algorithm produces an APID 11 packets as the spacecraft attitude changes. This packet contains the current control mode of the ACS which is used to update the PS set. When the spacecraft is in full sun and the angle between the unit sun vector and the magnetic field is less than 5 degrees or the spacecraft is in eclipse and this same angle is less than 40 degrees, the ACS control mode takes on the value 3 (coast mode). When the ACS is in coast mode, no APID 11 packets are sent, therefore *ctrl_mode* never assumes the value 3 in the MDF, instead it remains at the value it had prior to the change in ACS control mode for the duration of the coast mode period. Since no APID 11 packets are sent, there will be no AS set types in the MDF during this period.

See Appendix H for other details about attitude determination in coast mode during 1 RPM spinning periods.

5.0 The PS Set

The PS set contains spacecraft position and velocity in inertial coordinates, position in geographic and magnetic coordinates, spacecraft attitude, zenith and azimuth look angles, and model magnetic field parameters. The PS set is *always* the first set in every 6-second MDF bin. The SAMPEX Time Stamp (game 1, point 1) is synonymous with the bin time. Calculated parameters in the PS set correspond to the start time of each bin.

5.1 Models

Game 1, point 4 is the software version number for the subroutine BL_IGRF (author: M. NcNab, Aerospace Corp.) which calculates magnetic field parameters. Game 1, point 5 is the software version number for the magnetic ephemeris library called by BL_IGRF. The IGRF 1990 Model is used. A 3-element return status array, game 1, point 6, indicates the completion status of the call. See table 5.1 for a description of the return status array.

Element	Value	Meaning
[1]	0	Normal processing, no warnings
	1	Processing completed with warnings
	2	Processing did not complete
[2]	1	Input value of IYEAR out of range
	2	Input value of IDAY out of range
	3	Input value of SEC out of range
	4	Altitude (as derived from input XECI) is out of range
	5	Results questionable
	6	Internal error
[3]		Contains quantity relevant to type of error in element [2] (e.g., if [2] = 1, then [3] = IYEAR)

Table 5.1 - BL_IGRF return status array.

5.2 Dynamic Integration Step Size

The integration step size used in the magnetic field model numerical integration routine is dynamically adjustable as a function of the L-shell parameter (game 6, point 1). For L-shell values of 10 or greater the step size is 500. For L-shell values less than 10, the step size is 100. The purpose of this is to achieve good accuracy for $L < 10$ while reducing calculation time for $L \geq 10$ where the model is less accurate.

5.3 Detailed Point Descriptions

Detailed descriptions of the points in the PS set are given in table 5.2 since most are *not* described in the SAMPEX Telemetry and Command Handbook (Appendix A).

Table 5.2 - Detailed PS Set Point Descriptions

Game	Point	Point Name	Description
1	1	SAMPEX Time	Time (seconds since 01Jan92 00:00:00) of current 6-second MDF bin.
1	2	Orbnum	Current orbit number. Launch into orbit 1. Orbit 2 starts at first ascending node through geographic equatorial plane.
1	3	MDF_sw_no	Software version number for MDF Generator.
1	4	BL_IGRF_sw_no	Software version number for routine BL_IGRF
1	5	Mag_Eph_sw_no	Software version number for magnetic ephemeris library.
1	6	Ireturn	BL_IGRF routine return status array (see table 5.1)
2	1	ISOTM	ISO time, Variation A, ISO 8601, Ref. 6. (yyyy-mm-ddThh:mm:ssbbbbb)
3	1	GEO_POS	Geographic position; range (km), longitude (0° to 360°), latitude (-90° to +90°)
3	2	GEO_ALT	Geographic altitude (km).
4	1	GEI_POS	X,Y,Z of spacecraft (km) in Geocentric Equatorial Inertial coordinates (identical to ECI coordinates).
4	2	GEI_VEL	VX,VY,VZ velocities (km/s) in GEI coordinates

continued

PS Set Point Descriptions, continued

Game	Point	Point Name	Description
4	3	Direction Cosine Array	9-element direction cosine array for rotating from GEI coordinates to body fixed coordinates. Z-axis in body fixed is along instrument bore sights. Order of elements is A(1,1), A(2,1), A(3,1), A(1,2), A(2,2), A(3,2), A(1,3), A(2,3), A(3,3).
4	4	Exo_temp	Exospheric temperature (Kelvin) used in orbit propagation code.
4	5	Drag	Drag scaling factor used in orbit propagation; Drag factor = (1+drag)*2.2
4	6	Geomag_index	Geomagnetic activity index used in orbit propagation.
4	7	CTRL_mode	ACS control mode indicator. 0=SUNPOINT 1=MAGCAL 2=ORBIT ROTATION (normal mode) 3=COAST (see section **4.4 Known Limitations and Problems**)
4	8	Idot	Inertial dot product between unit sun vector and unit B-vector.
5	1	ECD_pos	Eccentric Dipole (offset tilted dipole) range (km), longitude (0° to 360°), latitude (-90° to +90°) of spacecraft.
5	2	ECD_LT	Local time in ECD (hr).
6	1	L	L-shell parameter
6	2	Bmag	Model field magnitude (gauss)
6	3	MLT	Local time at magnetic equator (hr) ECD
6	4	Invlat	Invariant latitude (degrees)

continued

PS Set Point Descriptions, continued

Game	Point	Point Name	Description
6	5	Pitch	Pitch angle of particle entering on instrument center line (angle between B and spacecraft minus Z direction) (degrees)
6	6	Losscone1	Loss cone 1/2 angle (degrees) for particles mirroring below 100 km in same hemisphere as spacecraft.
6	7	Losscone2	Loss cone 1/2 angle (degrees) for particles mirroring below 100 km in either hemisphere.
7	1	Bvec_GEI	Magnetic field vector, Cartesian GEI coordinates.
7	2	Bvec_GEO	Magnetic field vector, spherical geographic coordinates (r, theta, phi).
7	3	Dipole_moment	Dipole moment vector. Cartesian geographic coordinates.
7	4	Displacement	Dipole moment displacement vector. Cartesian geographic coordinates.
7	5	Declination	Magnetic declination (degrees).
7	6	Dip	Magnetic dip angle (degrees)
7	7	MagRad	Algebraic magnetic radial distance (km). Note A.
7	8	MagLat	Algebraic magnetic latitude (degrees) Note A.
7	9	Mirror	Geographic altitude (km), longitude (degrees), latitude (degrees) of mirror point.

continued

PS Set Point Descriptions, continued

Game	Point	Point Name	Description
7	10	Equatorial	Magnitude of field (gauss) and GEO altitude (km), longitude (degrees), latitude (degrees) at magnetic equator.
7	11	North100	Magnitude of field (gauss) and GEO altitude (km), longitude (degrees), latitude (degrees) at north 100 km point. Note B.
7	12	South100	Magnitude of field (gauss) and GEO altitude (km), longitude (degrees), latitude (degrees) at south 100 km point. Note B.
8	1	Cutoff	Nominal vertical cutoff (1980) at 20 km altitude at subsatellite location (GV). (Shea and Smart, 1983, Bangalore ICRC, Paper MG10-3).
8	2	SAAF	South Atlantic Anomaly Flag. 0=not in SAA 1=within SAA
9	1	Zenith	Angle (0° to 180°) between zenith and spacecraft z-axis (instrument bore sight).
9	2	Azimuth	Direction of projection of spacecraft z-axis in plane perpendicular to radial direction. 0=east, 90=north, 180=west, 270=south

Table 5.2 - Detailed PS Set Point Descriptions

<u>Note A:</u> Algebraic radius and latitude are computed using the dipole relationship between B, L, and latitude but with values for B and L generated from the IGRF model.

<u>Note B:</u> The 100-km points (a typical altitude for particle loss) are determined numerically, not analytically, so the computed values are step-size dependent. The altitude is included with the longitude and latitude to provide the user with a measure of how close the computed position is to the ideal.

6.0 Pulse Height Analyzed Events

Pulse height analyzed (PHA) events are found in set types EH, EL, EM, EP (see section **4.2 Set Descriptions**). Each set contains one PHA event. Game 1, point 1 of all set types contains the *SAMPEX time*, the time assigned by the DPU to the telemetry packet from which the PHA event set is derived. No PHA set contains the *event time* per se. To determine the *event time*, the time at which the PHA was detected by the instrumentation, do the following:

For **HILT** and **LEICA**, make the substitution:

1) Zero the LSB of hours, and the entire minutes and seconds portion of the *SAMPEX time* (game 1, point 1). (Since the LSB of hours and all minutes and seconds are less than 7200 seconds, divide *SAMPEX time* by 7200 and then multiply again by 7200. Integer math will zero out the proper fields!)

2) Convert the BCD coded time bytes (see sections **6.1 HILT,** and **6.2 LEICA**) to seconds and add to the *SAMPEX time* .

For **MAST** and **PET**, add the offset time byte (see sections **6.3 MAST,** and **6.4 PET**) to the *SAMPEX time* (game 1, point 1).

Descriptions of the contents of game 2 of each pulse height analyzed event set type are presented. Refer to section **4.2 Set Descriptions**.

6.1 HILT

Each EH set contains one 14 byte HILT PHA event in game 2. The contents of these bytes are shown in figure 6.1. An additional spare point exists in game 2.

```
               Byte 0                                  Byte 1
|7  |6  |5  |4  |3  |2  |1  |0  |     |7  |6  |5  |4  |3  |2  |1  |0  |
1444444444444444442444444444444443
                        BCD Time

               Byte 2                                  Byte 3
|7  |6  |5  |4  |3  |2  |1  |0  |     |7  |6  |5  |4  |3  |2  |1  |0  |
1444444444444424444444444443
              Energy, rear proportional counter

               Byte 3                                  Byte 4
|7  |6  |5  |4  |3  |2  |1  |0  |     |7  |6  |5  |4  |3  |2  |1  |0  |
                 1444444444444424444444444443
                          Position, rear proportional counter

               Byte 5                                  Byte 6
|7  |6  |5  |4  |3  |2  |1  |0  |     |7  |6  |5  |4  |3  |2  |1  |0  |
1444444444444424444444444443
              Energy, front proportional counter

               Byte 6                                  Byte 7
|7  |6  |5  |4  |3  |2  |1  |0  |     |7  |6  |5  |4  |3  |2  |1  |0  |
                 1444444444444424444444444443
                          Position, front proportional counter
```

Figure 6.1 - HILT PHA Event

continued

Figure 6.1 - HILT PHA Event, continued

Byte 8

7	6	5	4	3	2	1	0

Byte 9

7	6	5	4	3	2	1	0

1444444444444244444444444443

Energy, ionization chamber (IK)

Byte 9

7	6	5	4	3	2	1	0

Byte 10

7	6	5	4	3	2	1	0

14444444444424444444443

Energy, solid state detector (SSD)

Byte 10

7	6	5	4	3	2	1	0

Byte 11

7	6	5	4	3	2	1	0

14444444444244444444443

Energy, cesium iodide (CsI)

Byte 12

7	6	5	4	3	2	1	0

14444444244444443

Time of Drift (ToD)

Byte 13

7	6	5	4	3	2	1	0

123 123 123 123 123 123 123 123

SSD1 SSD2 SSD3 SSD4 HE1-N HE2-N HZ1-N HZ2-N

Figure 6.1 - HILT PHA Event

6.2 LEICA

Each EL set contains one 15 byte LEICA PHA event in game 2. The contents of these bytes are shown in figure 6.2. An additional spare point exists in game 2.

Byte 0								Byte 1							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

14444444444442444444444443
Energy

Byte 1								Byte 2							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

14444444444442444444444443
Time of Flight (ToF)

Byte 3								Byte 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

14444444444442444444444443
Position 1

Byte 4								Byte 5							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

14444444444442444444444443
Position 2

Byte 6								Byte 7							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

14444444444442444444444443
Position 3

Byte 7								Byte 8							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

14444444444442444444444443
Position 4

Byte 9								Byte 10							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

14444444444442444444444443
Position 5

Figure 6.2 - LEICA PHA Event

continued

Figure 6.2 - LEICA PHA Event, continued

Byte 10 | Byte 11

7	6	5	4	3	2	1	0		7	6	5	4	3	2	1	0

1444444444444424444444444443

Position 6

Byte 12 | Byte 13

7	6	5	4	3	2	1	0		7	6	5	4	3	2	1	0

144444444444444444424444444444444443

BCD Time

Byte 14

7	6	5	4	3	2	1	0

123 123 123 123 123 123 123 123

MS Calena. PRI Calevn. D4 D3 D2 D1

MS = Multistop flag
Calena. = In-flight Calibrator flag
PRI = Priority, 1 = high, 0 = low
Calevn. = Calibrator produced event
D1, D2, D3, D4 = Discriminator which fired

Figure 6.3 shows the HILT/LEICA event time bytes. These BCD coded bytes are substituted into the packet time stamp to determine the event time.

Byte 0 or 12

7	6	5	4	3	2	1	0

123 1444442444443 144444442444444443

Hour 10s of minutes 1s of minutes

Byte 1 or 13

7	6	5	4	3	2	1	0

144444442444444443 144444442444444443

10s of seconds 1s of seconds

Figure 6.3 - BCD Time of Day for HILT and LEICA Events

6.3 MAST

Each EM set contains one MAST PHA event in game 2. The contents of game 2 are shown in figure 6.4.

Point 1

7	6	5	4	3	2	1	0

14444444244444443

Event Time Offset (seconds)

Point 2

7	6	5	4	3	2	1	0

14444444244444443

Spare

Point 3

7	6	5	4	3	2	1	0

1444442444443 123 123 1444442444443

Last Detector Fired G2 G1 Sector Number

Detector Flag

Point 4

7	6	5	4	3	2	1	0

123 123 123 123 123 123 144424443

HIZ PEN Z2 Z1 CAL HAZ unused

Event Flag

Point 5

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	M1X1
																M1XS
																M2Y1
																M2YS
																M3X1
																M3XS
																M4Y1
																M4YS
																D1
																D2
																D3
																D4
																D5
				msb											lsb	D6

14442443 1444444444442444444444443

unused **14 12-Bit ADC VALUES**

Figure 6.4 - MAST PHA Event

6.4 PET

Each EP set contains one PET PHA event in game 2. The contents of game 2 are shown in figure 6.5.

Point 1

7	6	5	4	3	2	1	0

1444444424444444443

Event Time Offset (seconds)

Point 2

7	6	5	4	3	2	1	0

1444444424444444443

Spare

Point 3

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	P1
																P2
																P3
						msb									lsb	P47

14444424444431444444442444444444443

unused **4 10-Bit ADC Values:**

Point 4

7	6	5	4	3	2	1	0

1444442444443 123 1444442444443 123

Buffer Number NMode Sector Number LOZMode

Mode Flag

Point 5

7	6	5	4	3	2	1	0

123 123 123 123 123 123 123 123

P3 P4 P5 P6 P7 P8 AL AH

Discriminator Flag

Figure 6.5 - PET PHA Event

7.0 Rates

All rates as stored in MDF sets are compressed values. See appendix B for rate decompression algorithms.

7.1 High Resolution Rates

The time stamp (game 1, point 1) associated with the RH (HILT) and RP (PET) sets is the time at the *start* of the acquisition interval. Below are the definitions of the individual high resolution rates.

7.1.1 HILT

Each HILT high resolution rate game contains 60 rate blocks, each of which is 1 byte in length. Each byte of a rate block is a rate compressed as described in Appendix B. Rate acquisition intervals vary in length. The first rate block acquisition interval begins at the time stamp associated with the RH set. Subsequent rate blocks correspond to either stated number of millisecond following. Tables 7.1(a) - 7.1(d) show the individual rates. Note that in version 2.3 (Table 7.1(c)) 10 msec of every 100 msec are not accumulated for telemetry. Refer to appendix G to determine exactly when to use each definition.

Set RH, HILT High Resolution Rates - launch configuration	
Game	Rate Description
2	compressed SSD1, 60 rates, 1 every 100 milliseconds
3	compressed SSD2, 60 rates, 1 every 100 milliseconds
4	compressed SSD3, 60 rates, 1 every 100 milliseconds
5	compressed SSD4, 60 rates, 1 every 100 milliseconds
6	compressed PCRE, 60 rates, 1 every 100 milliseconds
7	compressed IK, 60 rates, 1 every 100 milliseconds

Table 7.1(a) - HILT high resolution rates - original version.

Set RH, HILT High Resolution Rates - DPU version 2.2	
Game	Rate Description
2	compressed SSD1, 60 rates, 1 every 20 milliseconds
3	compressed SSD1, 60 rates, 1 every 20 milliseconds
4	compressed SSD1, 60 rates, 1 every 20 milliseconds
5	compressed SSD4, 60 rates, 1 every 100 milliseconds
6	compressed SSD1, 60 rates, 1 every 20 milliseconds
7	compressed SSD1, 60 rates, 1 every 20 milliseconds

Table 7.1(b) - HILT high resolution rates - DPU patch 2.2 version.

Set RH, HILT High Resolution Rates - DPU version 2.3	
Game	Rate Description
2	compressed SSD1, 60 rates, 1st 30 milliseconds
3	compressed PCRE, 60 rates, 1st 30 milliseconds
4	compressed SSD1, 60 rates, 2nd 30 milliseconds
5	compressed PCRE, 60 rates, 2nd 30 milliseconds
6	compressed PCRE, 60 rates, 3rd 30 milliseconds
7	compressed SSD1, 60 rates, 3rd 30 milliseconds

Table 7.1(c) - HILT high resolution rates - DPU patch 2.3 version.

Set RH, HILT High Resolution Rates - DPU version 2.4	
Game	Rate Description
2	compressed sum (SSD1-SSD4), 60 rates, 1st 20 milliseconds
3	compressed sum (SSD1-SSD4), 60 rates, 2nd 20 milliseconds
4	compressed sum (SSD1-SSD4), 60 rates, 3rd 20 milliseconds
5	compressed sum (SSD1-SSD4), 60 rates, 4th 20 milliseconds
6	compressed sum SSD4, 60 rates, 100 milliseconds
7	compressed sum (SSD1-SSD4), 60 rates, 5th 20 milliseconds

Table 7.4(d) - HILT high resolution rates - DPU patch 2.4 version.

7.1.2 PET

PET high resolution rates sets cover a 48 second period with 0.1 second resolution and 50% coverage for the P1 rate. The beginning of the rate accumulation period is the time in game 1, point 1 (packet time stamp assigned by the DPU). PET high resolution rates are only sent if the count during one of the 480 0.05 second intervals is above a threshold set by command to the DPU. See section **4.2.3 Set DS - Digital Instrument Status**. In addition, there is a quota on maximum memory which can be occupied by PET high resolution rates. If this quota is exceeded, no packets will be sent. Table 7.2 shows the PET high resolution rates in game 2 of the RP set.

	Set RP, PET High Resolution Rates, Game 2, Point 1
Byte	Rate Definition
1	P1 counts for 0.1 second interval beginning at time t
2	P1 counts for 0.1 second interval beginning at time t+0.1 seconds
.	.
.	.
479	P1 ounts for 0.1 second interval beginning at time t+478*0.1 seconds
480	P1 ounts for 0.1 second interval beginning at time t+479*0.1 seconds

Table 7.2 - PET High Resolution Rates

7.2 Low Resolution Rates

Low resolution rates are multiplexed and occur every 6 seconds in the RS set type. Refer to section **4.2 Set Descriptions** for the RS set definition. The time stamp (game 1, point 1) associated with the RS set is the time at the *start* of the 6 second acquisition interval. The subcom (game 1, point 2) defines the multiplexed rates.

7.2.1 Subcom Descriptions

Valid subcom values are 6 through 21. Tables 7.3 - 7.5 list the multiplexed rate definitions for the HILT, MAST, and PET rate groups. The LEICA instrument has no multiplexed rates.

RS Set, Game 2, HILT Rates		
Subcom \ Point	5	6
6, 14	SSD1	Strobe
7, 15	SSD2	PCF0
8, 16	SSD3	IK0-AC
9, 17	SSD4	CSI
10, 18	SSD1	PCR0
11, 19	SSD2	NO(PC*SSD)
12, 20	SSD3	Pile-up
13, 21	SSD4	Invalid Array

Table 7.3 - HILT Subcommed Rates

RS Set, Game 4, MAST Rates					
Subcom \ Point	14	15	16	17	18
6	M1XSA	M1X1	D7	Z1R0	Z2R0
7	M1XSB	M1XS	G35L	Z1R1	Z2R1
8	M2YSA	M2Y1	G35H	Z1R2	Z2R2
9	M2YSB	M2YS	G47L	Z1R3	Z2R3
10	M3XSA	M3X1	G47H	Z1R4	Z2R4
11	M3XSB	M3XS	G6L	Z1R5	Z2R5
12	M4YSA	M4Y1	G6H	Z1R6	Z2R6
13	M4YSB	M4YS	HAZ	Z1R0	Z2R0
14	D1A	D1	D5A	Z1R0	Z2R0
15	D1B	D2	D5B	Z1R1	Z2R1
16	D2A	D3	D6A	Z1R2	Z2R2
17	D2B	D4	D6B	Z1R3	Z2R3
18	D3A	D5	M12	Z1R4	Z2R4
19	D3B	D6	M34	Z1R5	Z2R5
20	D4A	G1	L	Z1R6	Z2R6
21	D4B	G2	H	Z1R0	Z2R0

Table 7.4 - MAST Subcommed Rates

RS Set, Game 5, PET Rates		
Subcom \ Point	9	10
6	P1ADC	P4 single
7	ADC OR	P5 single
8	P2ADC	P6 single
9	AL	P7 single
10	P3ADC	P8 single
11	AH	A3L single
12	P47ADC	A3H single
13	HAZ	A4L single
14	P1ADC	A4H single
15	ADC OR	A57L single
16	P2ADC	A57H single
17	AL	A68L single
18	P3ADC	A68H single
19	AH	P1A single
20	P47ADC	P3A single
21	HAZ	P3B single

Table 7.5 - PET Subcommed Rates

8.0 Data Quality

8.1 Boundaries of the MDF Data Set

Master Data Files contain data whose packet time stamp (issued by the DPU) or event time (calculated from the time stamp and event offset) are within the 24 hour period from 00:00:00 to 23:59:59 UT. If the time stamp of the packet is earlier than the time of the first six second time bin, the packet is discarded. See section **8.3 Discarded Data** for a full description of all cases for discarding data. Events whose event times are later than the end of day, causing them to be discarded, are counted for each of the four instruments and reported in the statistics record, see section **9.0 Statistics Record** items 43 through 46. Events whose event times are earlier than the first six second bin time, causing them to be discarded, are counted for MAST and PET, see section **9.0 Statistics Record** items 101 and 102.

8.2 Quality Assurance

All APID 42 packets contain a DPU generated checksum. The MDF generator program calculates the checksum of each APID 42 packet again and compares this new checksum with the original checksum. Any packet with a checksum error must have been corrupted during transmission. These packets are discarded and counted in the statistics record. See section **9.0 Statistics Record**, items 61 and 62.

8.3 Discarded Data

Under certain conditions, data may be discarded. Discarded data is recorded in the statistics record (see **9.0 Statistics Record**). The following sections describe data types which may be discarded.

8.3.1 HILT

If the HILT event time is greater than the packet time stamp of the next HILT event packet (APID 42, subcom 0), the HILT event is discarded. See statistics record item 95.

8.3.2 LEICA

If the BCD coded time bytes of the LEICA event are not valid BCD values, the LEICA event is discarded, and the packet in which it is contained is noted. See statistics record items 73 through 76.

If the LEICA event time is greater than the packet time stamp of the next LEICA event packet (APID 42, subcom 1), the LEICA event is discarded. See statistics record item 96.

If the LEICA event is the first event in the packet and is low priority, the LEICA event is discarded. See statistics record item 99.

8.3.3 MAST

MAST packet time stamps are assigned every 256 seconds. During periods of high data rates, several packets with the same time stamp can be created. MAST event times are determined from the offset (game 2, point 1) and the packet time stamp. It is possible for an event time to be later than the last second of the day if the packet time stamp is within 255 seconds of the end of the day. Under these conditions it is possible for entire packets to contain events all of which are later than the end of day. These packets are discarded. See statistics record item 97.

If the MAST event time (seconds of day) is earlier than the bin time of the first 6-second MDF bin, then the event (EM) is discarded. See statistics record item 101.

8.3.4 PET

PET packet time stamps are assigned every 256 seconds. During periods of high data rates, several packets with the same time stamp can be created. PET event times are determined from the offset (game 2, point 1) and the packet time stamp. It is possible for an event time to be later than the last second of the day if the packet time stamp is within 255 seconds of the end of the day. Under these conditions it is possible for entire packets to contain events all of which are later than the end of day. These packets are discarded. See statistics record item 98.

If the PET event time (seconds of day) is earlier than the bin time of the first 6-second MDF bin, then the event (EP) is discarded. See statistics record item 102.

8.3.5 AS Packets

If the absolute value of any of the quaternion elements of the AS packet (APID 11) are greater than 1.00, the packet is discarded. Typically the values of the bad quaternion elements will be much greater than 1.00 and will disallow determining the inertial dot product. See statistics record item 100.

9.0 The Statistics Record

The statistics record is a formatted ASCII record produced by the MDF generator each time it completes successfully. Each statistics record contains 102 data points and 26 spare points, delimited by commas. The statistics records are written to the file *MDF_STAT.DAT*, which contains at least one record for each MDF produced. To access the statistics records in this file, log onto your account on one of the SAMPEX systems and copy the file from $PROD:[PRODUCTION.MDF.STAT] to your system. Do not attempt to read or write this file while on the SAMPEX system. Table 9.1 defines the contents of the statistics record.

Entry	Name	Format	Description
1	start date	A8	date of first data packet, mm/dd/yy (note 3)
2	start date	A8	date of first data packet, yyyymmdd (note 4)
3	start day	I3	day-of-year of first data packet
4	start dec day	F8.6	decimal day of first data packet
5	start orbit	I8	orbit number of first data packet
6	SAMPEX time	I10	SAMPEX time of first data packet
7	end date	A8	date of last data packet, mm/dd/yy (note 3)
8	end date	A8	date of last data packet, yyyymmdd (note 4)
9	end day	I3	day-of-year of last data packet
10	end dec day	F8.6	decimal day of last data packet
11	end orbit	I8	orbit number of last data packet
12	mdf run len	F8.5	clock time (hrs) to produce MDF
13	mdf start date	A8	start date of MDF run, mm/dd/yy (note 3)
14	mdf start date	A8	start date of MDF run, yyyymmdd (note 4)
15	mdf start time	F8.6	decimal day at start of MDF run
16	received date	A8	date APID 42 data received, mm/dd/yy
17	received date	A8	date APID 42 data received, yyyymmdd
18	node name	A6	system on which MDF was generated
19	mdf version	I5	MDF version number
20	record count	I5	number of Tennis records in this MDF
21	PS count	I8	number of PS sets in MDF
22	VS count	I8	number of VS sets in MDF
23	AS count	I8	number of AS sets in MDF
24	ST count	I8	number of ST sets in MDF
25	SP count	I8	number of SP sets in MDF
26	SB count	I8	number of SB sets in MDF
27	SR count	I8	number of SR sets in MDF
28	HS count	I8	number of HS sets in MDF
29	DS count	I8	number of DS sets in MDF
30	RS count	I8	number of RS sets in MDF

Table 9.1 - Statistics Record, continued

Statistics Record continued

Entry	Name	Format	Description
31	RH count	I8	number of RH sets in MDF
32	MH count	I8	number of MH sets in MDF
33	EH count	I8	number of EH sets in MDF
34	EL count	I8	number of EL sets in MDF
35	EM count	I8	number of EM sets in MDF
36	EP count	I8	number of EP sets in MDF
37	RP count	I8	number of RP sets in MDF
38	PD count	I8	number of PD sets in MDF
39	SD count	I8	number of SD sets in MDF
40	CD count	I8	number of CD sets in MDF
41	MD count	I8	number of MD sets in MDF
42	MF count	I8	number of MF sets in MDF
43	HILT late	I8	HILT events later than 23:59:59
44	LEICA late	I8	LEICA events later than 23:59:59
45	MAST late	I8	MAST events later than 23:59:59
46	PET late	I8	PET events later than 23:59:59
47	other late	I8	all other packets later than 23:59:59
48	HILT packets	I6	HILT event packets in APID 42 (subcom 0)
49	LEICA packets	I6	LEICA event packets in APID 42 (subcom 1)
50	MAST packets	I6	MAST event packets in APID 42 (subcom 2)
51	PET packets	I6	PET event packets in APID 42 (subcom 3)
52	HHRR packets	I6	HILT HRR packets in APID 42 (subcom 4)
53	PHRR packets	I6	PET HRR packets in APID 42 (subcom 5)
54	LRR packets	I6	LRR packets in APID 42 (subcom 6-21)
55	AHKP packets	I6	analog HK packets in APID 42 (subcom 22)
56	digS packets	I6	digital status packets in APID 42 (subcom 23)
57	cmdE packets	I6	DPU cmd error pkts in APID 42 (subcom 24)
58	DPUS packets	I6	DPU state change pkts, APID 42 (subcom 25)
59	DPUP packets	I6	DPU param. dump pkts, APID 42 (subcom 26)
60	A42 total pkts	F8.1	APID 42 total packet count (subcoms 0-26)
61	A42 chk sum	F8.1	APID 42 checksum errors
62	A42%chk sum	F8.1	% APID 42 packets with checksum errors
63	A43 tot pkt	F8.1	APID 43 total packet count
64	A44 tot pkt	F8.1	APID 44 total packet count
65	HILT seq err	I5	HILT sequence error count
66	HILT res	I5	HILT sequence errors resolved
67	LEICA seq err	I5	LEICA sequence error count
68	LEICA res	I5	LEICA sequence errors resolved
69	MAST seq err	I5	MAST sequence error count
70	MAST res	I5	MAST sequence errors resolved

continued

Statistics Record continued

Entry	Name	Format	Description
71	PET seq err	I5	PET sequence error count
72	PET res	I5	PET sequence errors resolved
73	BCD event	F8.1	number of LEICA events with BCD errors
74	% BCD event	F7.3	% of LEICA events with BCD errors
75	BCD packets	F8.1	number of LEICA packets with BCD errors
76	% BCD packets	F7.3	% of LEICA packets with BCD errors
77	APID 11 qac	F8.1	APID 11 number of QAC entries (bad pkts)
78	APID 11 frame	F7.3	APID 11 % pkts from frames with errors
79	APID 13 qac	F8.1	APID 13 number of QAC entries (bad pkts)
80	APID 13 frame	F7.3	APID 13 % pkts from frames with errors
81	APID 18 qac	F8.1	APID 18 number of QAC entries (bad pkts)
82	APID 18 frame	F7.3	APID 18 % pkts from frames with errors
83	APID 19 qac	F8.1	APID 19 number of QAC entries (bad pkts)
84	APID 19 frame	F7.3	APID 19 % pkts from frames with errors
85	APID 20 qac	F8.1	APID 20 number of QAC entries (bad pkts)
86	APID 20 frame	F7.3	APID 20 % pkts from frames with errors
87	APID 21 qac	F8.1	APID 21 number of QAC entries (bad pkts)
88	APID 21 frame	F7.3	APID 21 % pkts from frames with errors
89	APID 24 qac	F8.1	APID 24 number of QAC entries (bad pkts)
90	APID 24 frame	F7.3	APID 24 % pkts from frames with errors
91	APID 24 swap	F8.1	APID 24 number of times packets swapped
92	APID 42 qac	F8.1	APID 42 number of QAC entries (bad pkts)
93	APID 42 frame	F7.3	APID 42 % pkts from frames with errors
94	APID 42 swap	F8.1	APID 42 number of times packets swapped
95	HILT bad time	I5	Number of HILT events with bad times
96	LEICA bad time	I5	Number of LEICA events with bad times
97	MAST pkt dis	I5	Number of MAST packets discarded
98	PET pkt dis	I5	Number of PET packets discarded
99	LEICA dis	I5	Number of LEICA events discarded
100	Bad AS pkt	I5	Number of AS packets discarded
101	Early MAST	I5	Number of early MAST events
102	Early PET	I5	Number of early PET events
103	Packets outside day bound	I5	Number of packets discarded because their time stamp was outside the day being processed
104	PACOR-1 vs -2	I5	Data source was PACOR-1 (via X.25 link) vs. PACOR-2 (via internet)
105-128	Spares	F16.7	Spare items

Table 9.1 - Statistics Record.

Note 3. Dates in the format *yy/mm/dd* are KaleidaGraph compatible.

Note 4. Dates in the format *yyyymmdd* are FOXbase compatible.

Appendices

Appendix A - Reference Documents

The Tennis Data Formatting Standard
SRL Technical Report No. 92-01, March 1992
Space Radiation Laboratory
California Institute of Technology
Pasadena, CA 91125

SAMPEX Mission Telemetry and Command Handbook
GSFC-S-740-90-968, Version 17.0, June 16, 1992
Goddard Space flight Center
Greenbelt, MD

Interface Control Document between PACOR and UMSOC
560-1ICD/0591, September 1991
Information Processing Division
Goddard Space Flight Center
Greenbelt, MD

Telemetry Packet Description for the SAMPEX Data Processing Unit
SAM-1-O-08105 Rev B, April 1991
Space Sciences Laboratory
The Aerospace Corporation
El Segundo, CA 90245

Time Code Formats
CCSDS 301.0-B-2 (Blue Book), Issue 2, April 1990
Consultative Committee for Space Data Systems
Communications and Data Systems Division (Code OS)
National Aeronautics and Space Administration
Washington, DC 20546

VAX FORTRAN Language Reference Manual
AA-D034E-TE, June 1988
Digital Equipment Corp.
Maynard, MA

SAMPEX mission overview

Baker, D. N., G. M. Mason, O. Figueroa, G. Colon, J. G. Watzin, and R. M. Aleman, An Overview of the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) Mission, *IEEE Trans. Geosci. & Remote Sens., 31,* 531, 1993.

HILT instrument description

Klecker, B., D. Hovestadt, M. Scholer, H. Arbinger, M. Ertl, H. Kästle, E. Künneth, P. Laeverenz, E. Seidenschwang, J. B. Blake, N. Katz, and D. J. Mabry, HILT: A Heavy Ion Large Area Proportional Counter Telescope for Solar and Anomalous Cosmic Rays, *IEEE Trans. Geosci. and Remote Sens, 31,* 542, 1993.

LEICA instrument description

Mason, G. M., D. C. Hamilton, P. H. Walpole, K. F. Heuerman, T. L. James, M. H. Lennard, and J. E. Mazur, LEICA: A Low Energy Ion Composition Analyzer for the study of Solar and Magnetospheric Ions, *IEEE Trans. Geosci. and Remote Sens., 31,* 549, 1993.

MAST instrument description

Cook, W. R., A. C. Cummings, J. R. Cummings, T. L. Garrard, B. Kecman, R. A. Mewaldt, R. S. Selesnick, E. C. Stone, and T. T. von Rosenvinge, MAST: A Mass Spectrometer Telescope for Studies of the Isotopic Composition of Solar, Anomalous, and Galactic Cosmic Ray Nuclei, *IEEE Trans. Geosci. and Remote Sens., 31,* 557, 1993b.

PET instrument description

Cook, W. R., A. C. Cummings, J. R. Cummings, T. L. Garrard, B. Kecman, R. A. Mewaldt, R. S. Selesnick, E. C. Stone, D. N. Baker, T. T. von Rosenvinge, J. B. Blake, and L. B. Callis, PET: A Proton/Electron Telescope for Studies of Magnetospheric, Solar, and Galactic Particles, *IEEE Trans. Geosci. and Remote Sens., 31,* 565, 1993a.

DPU description

Mabry, D. J., S. J. Hansel, and J. B. Blake, The SAMPEX data Processing Unit (DPU), *IEEE Trans. Geosci. and Remote Sens., 31,* 572, 1993.

Appendix B - Rate Decompression Algorithms

High Resolution Rates

HILT and PET high resolution rates in sets RH and RP are 16 bit values compressed to 8 bits. To obtain the decompressed value N, extract the exponent (E3 - E0) and the mantissa (M3 - M0) and apply the following algorithm.

If $E < 2$, $N = (E*16)+M$

If $E \geq 2$, $N = (16+M+0.5)*2^{(E-1)}$

8 bit compressed rate

E3	E2	E1	E0	M3	M2	M1	M0

14442443 14424443

exponent (E) mantissa (M)

Figure B.1 - High resolution rates

Low Resolution Rates

Low resolution rates in set RS are 24 bit values compressed to 12 bits. To obtain the decompressed value N, extract the exponent (E4 - E0) and the mantissa (M6 - M0) and apply the following algorithm.

$N = \text{integer}[(128+M)*2^{(E-8)}]$

12 bit compressed rate

E4	E3	E2	E1	E0	M6	M5	M4	M3	M2	M1	M0

1444424443 14444424444443

exponent (E) mantissa (M)

Figure B.2 - Low resolution rates

Appendix C - Analog Conversion Algorithms

Convertible values are listed by set and game. Unless otherwise indicated, analog conversions are polynomial equations of the form:

$$A = C_0 + C_1N + C_2N^2 + \cdots + C_nN^n$$

Coefficients $C_0 \cdots C_n$ are taken from the SAMPEX Mission Telemetry and Command Handbook, "A" is the desired analog value, "N" is the integer value of the point to be converted.

Set HS, Game 2, HILT Analog Housekeeping		
Point	Name	Conversion
1	HILT vent valve temp. (°C)	A=-23.580+(N*0.50870)
2	HILT main valve temp. (°C)	A=-23.580+(N*0.50870)
3	HILT internal pressure reg. temp. (°C)	A=-23.580+(N*0.50870)
4	HILT internal analog box temp. (°C)	A=-23.580+(N*0.50870)
5	HILT internal sensor temp. (°C)	A=-23.580+(N*0.50870)
6	HILT digital box temp.(°C)	A=-23.580+(N*0.50870)
7	HILT digital electronics temp. (°C)	A=-23.580+(N*0.50870)
8	HILT HV converter PC temp. (°C)	A=-23.580+(N*0.50870)
9	HILT HV converter drift temp. (°C)	A=-23.580+(N*0.50870)
10	HILT LV converter 1 analog temp. (°C)	A=-23.580+(N*0.50870)
11	HILT LV converter 2 system temp. (°C)	A=-23.580+(N*0.50870)
12	HILT cover motor temp. (°C)	A=-23.580+(N*0.50870)
13	HILT -10 volt monitor (volts)	A=N*-5.3670e-2
14	HILT +5 volt monitor (volts)	A=N*2.6420e-2

continued

Set HS, Game 2, HILT Analog Housekeeping, continued		
Point	Name	Conversion
15	HILT +10 volt monitor (volts)	A=N*5.1130e-2
16	HILT SSD bias (volts)	A=N*1.4780
17	HILT HV PC monitor (volts)	A=N*4.6900
18	HILT HV drift monitor (volts)	A=N*-11.490
19	HILT pressure monitor # 1 (torr)	A=N*0.45180
20	HILT pressure monitor # 2 (torr)	A=N*4.0210
21	HILT regulator valve temp. (°C)	A=N*2.0740e-2
22	HILT +13 volt monitor converter #2 (volts)	A=N*6.2240e-2
23	HILT -13 volt monitor converter #2 (volts)	A=N*-6.2240e-2
24	HILT +10 volt monitor converter #2 (volts)	A=N*6.2240e-2
25	HILT -10 volt monitor converter #2 (volts)	A=N*-6.2240e-2
26	HILT +5 volt monitor converter #2 (volts)	A=N*2.5930e-2

Set HS, Game 3, LEICA Analog Housekeeping		
Point	Name	Conversion
1	LEICA +12 volt monitor (volts)	A=N*0.13440
2	LEICA +6 volt monitor (volts)	A=N*6.720e-2
3	LEICA +5 volt monitor (volts)	A=N*5.4460e-2
4	LEICA -5 volt monitor (volts)	A=N*-51870e-2
5	LEICA -6 volt monitor (volts)	A=N*-6.2860e-2
6	LEICA -12 volt monitor (volts)	A=N*-0.12570
7	LEICA HV monitor #1 (volts)	A=N*41.494
8	LEICA HV monitor #2 (volts)	A=N*41.494
9	LEICA temperature monitor #1 (°C)	A=-60+(N*0.82990)
10	LEICA temperature monitor #2 (°C)	A=-60+(N*0.82990)
11	LEICA temperature monitor #3 (°C)	A=-60+(N*0.82990)
12	LEICA temperature monitor #4 (°C)	A=-60+(N*0.82990)
13	LEICA HV control monitor #1 (volts)	A=N*4.149e-2
14	LEICA HV control monitor #2 (volts)	A=N*4.149e-2
15	LEICA HV monitor #1 (volts)	A=N*41.494
16	LEICA HV monitor #2 (volts)	A=N*41.494

Set HS, Game 4, MAST/PET Analog Housekeeping		
Point	Name	Conversion
1	MAST matrix board thermistor (°C)	$A=59.321-(N*1.1450)+(N^2*1.3830e-2)-(N^3*1.0370e-4)+(N^4*3.7140e-7)-(N^5*5.0560e-10)$
2	MAST thick board thermistor (°C)	same as point 1
3	MAST M1 thermistor (°C)	same as point 1
4	MAST D2 thermistor (°C)	same as point 1
5	MAST D7 thermistor (°C)	same as point 1
6	MAST M1 thermistor (°C)	same as point 1
7	MAST D2 thermistor (°C)	same as point 1
8	MAST D7 thermistor (°C)	same as point 1
9	PET P1RT thermistor (°C)	same as point 1
10	PET P8RT thermistor (°C)	same as point 1
11	PET ANART thermistor (°C)	same as point 1
12	PET P1RT thermistor (°C)	same as point 1
13	PET P8RT thermistor (°C)	same as point 1
14	PET ANART thermistor (°C)	same as point 1
15	PET P1RT thermistor (°C)	same as point 1
16	PET P8RT thermistor (°C)	same as point 1

Set HS, Game 5, LVPS/DPU Analog Housekeeping		
Point	Name	Conversion
1	LVPS +7.5 volt monitor (volts)	A=N*3.9210e-2
2	LVPS +4.7 volt monitor (volts)	A=N*2.4360e-2
3	LVPS -7.5 volt monitor (volts)	A=-12.881+(N*5.670e-2)
4	LVPS -13.5 volt monitor (volts)	A=-20.880+(N*7.90e-2)
5	LVPS -37.0 volt monitor (volts)	A=-52.849+(N*0.16830)
6	LVPS ground monitor #1 (volts)	A=N*2.0750e-2
7	LVPS ground monitor #2 (volts)	A=N*2.0750e-2
8	LVPS ground monitor #3 (volts)	A=N*2.0750e-2
9	LVPS ground monitor #4 (volts)	A=N*2.0750e-2
10	LVPS +37.0 volt monitor (volts)	A=N*0.19190
1	LVPS +13.5 volt monitor (volts)	A=N*7.0020e-2
12	LVPS +10.5 volt monitor (volts)	A=N*5.1970e-2
13	LVPS PET monitor (amps)	A=N*2.0750e-2
14	LVPS MAST monitor (amps)	A=N*2.0750e-2
15	LVPS PSA current monitor (amps)	A=N*3.00
16	LVPS variable load monitor (amps)	A=N*2.5930e-3
17	DPU VCC monitor (volts)	A=N*2.0750e-2
18	DPU +10 volt monitor (volts)	A=N*6.2250e-2
19	DPU -10 volt monitor (volts)	A=N*-6.2250e-2
20	DPU +2.5 volt monitor (volts)	A=N*2.0750e-2
21	DPU ground monitor (volts)	A=N*2.0750e-2

Set MF, Game 2, On-board magnetometer measurements		
Point	Name	Conversion
1	Body centered x (mgauss)	A=700.0-(N*0.34188)
2	Body centered y (mgauss)	A=700.0-(N*0.34188)
3	Body centered z (mgauss)	A=700.0-(N*0.34188)

Note: Scale is linear from -700 mgauss to 700 mgauss, accurate to four significant digits.

Set SP, Game 2, S/C power monitor		
Point	Name	Conversion
9	PD/PCU signal ground reference (volts)	A=10.0-(N*4.884e-3)

Set SB, Game 2, Battery monitor		
Point	Name	Conversion
5	Battery current monitor (amps)	A=-20.0+(N*9.76801e-3)
6	Shunt current monitor (amps)	A=5.0-(N*2.442e-3)
7	NEB current monitor (amps)	A=5.0-(N*2.442e-3)
8	Solar Array A current monitor (amps)	A=5.0-(N*2.442e-3)
9	Battery Voltage Monitor (volts)	A=35.220-(N*1.72015e-2)
10	Battery top-of-cell temp. monitor (°C)	A=-66.181+(N*0.25209) -(N^2*5.00065e-4) +(N^3*5.59885e-7) -(N^4*2.97226e-10) +(N^5*6.05992e-14)
11	Battery base plate temp. monitor (°C)	A=-66.181+(N*0.25209) -(N^2*5.00065e-4) +(N^3*5.59885e-7) -(N^4*2.97226e-10) +(N^5*6.05992e-14)
12	Main bus voltage (volts)	A=40.0-(N*1.9536e-2)

Set SR, Game 2, Reaction wheel temperature monitor		
Point	Name	Conversion
1	Reaction wheel Temperature #1 (°C)	A=74.50-(N*6.881e-2)
2	Reaction wheel Temperature #2 (°C)	A=74.50-(N*6.881e-2)

Set ST, Game 2, S/C subsystem temperature monitor		
Point	Name	Conversion
3	Lower S/C radiator plate temp. (°C)	A=-37.229+(N*0.39926) -(N^2*1.10348e-3) +(N^3*1.82231e-6) -(N^4*1.46776e-9) +(N^5*4.54815e-13)
4	Upper S/C radiator plate temp. (°C)	A=-37.229+(N*0.39926) -(N^2*1.10348e-3) +(N^3*1.82231e-6) -(N^4*1.46776e-9) +(N^5*4.54815e-13)
5	Instrument/bus separation plate temp. (°C)	A=-37.229+(N*0.39926) -(N^2*1.10348e-3) +(N^3*1.82231e-6) -(N^4*1.46776e-9) +(N^5*4.54815e-13)

Set ST, Game 3, S/C subsystem temperature monitor		
Point	Name	Conversion
1	HILT support plate (°C)	$A=-37.229+(N*0.39926)$ $-(N^2*1.10348e-3)$ $+(N^3*1.82231e-6)$ $-(N^4*1.46776e-9)$ $+(N^5*4.54815e-13)$
2	HILT isobutane tank (°C)	$A=-37.229+(N*0.39926)$ $-(N^2*1.10348e-3)$ $+(N^3*1.82231e-6)$ $-(N^4*1.46776e-9)$ $+(N^5*4.54815e-13)$
3	HILT analog electronics (°C)	$A=-37.229+(N*0.39926)$ $-(N^2*1.10348e-3)$ $+(N^3*1.82231e-6)$ $-(N^4*1.46776e-9)$ $+(N^5*4.54815e-13)$
4	HILT sensor base (°C)	$A=-37.229+(N*0.39926)$ $-(N^2*1.10348e-3)$ $+(N^3*1.82231e-6)$ $-(N^4*1.46776e-9)$ $+(N^5*4.54815e-13)$
5	HILT acoustic cover (°C)	$A=-37.229+(N*0.39926)$ $-(N^2*1.10348e-3)$ $+(N^3*1.82231e-6)$ $-(N^4*1.46776e-9)$ $+(N^5*4.54815e-13)$

Set ST, Game 4, S/C subsystem temperature monitor		
Point	Name	Conversion
9	LEICA base plate (°C)	A=-37.229+(N*0.39926) -(N^2*1.10348e-3) +(N^3*1.82231e-6) -(N^4*1.46776e-9) +(N^5*4.54815e-13)

Set ST, Game 5, S/C subsystem temperature monitor		
Point	Name	Conversion
1	MAST base plate (°C)	A=-37.229+(N*0.39926) -(N^2*1.10348e-3) +(N^3*1.82231e-6) -(N^4*1.46776e-9) +(N^5*4.54815e-13)
2	PET base plate (°C)	A=-37.229+(N*0.39926) -(N^2*1.10348e-3) +(N^3*1.82231e-6) -(N^4*1.46776e-9) +(N^5*4.54815e-13)
3	MAST/PET low voltage power supply (°C)	A=-37.229+(N*0.39926) -(N^2*1.10348e-3) +(N^3*1.82231e-6) -(N^4*1.46776e-9) +(N^5*4.54815e-13)

Set ST, Game 6, S/C subsystem temperature monitor		
Point	Name	Conversion
1	DPU base plate (°C)	A=-37.229+(N*0.39926) -(N^2*1.10348e-3) +(N^3*1.82231e-6) -(N^4*1.46776e-9) +(N^5*4.54815e-13)

Appendix D - Tennis Standard Library Contents

The Standard Tennis Library containing all the 'C' and FORTRAN routines should include the following modules:

C2TENNIS.C - Contains the 'C' equivalent routines of the "F_" FORTRAN routines.

FINTERNATIVE.C - Contains the FORTRAN callable "F_" routines.

GETSET.C - Retrieves sets from Tennis file.

KEYMAP.C - Initializes the set key table.

PUTSET.C - Puts sets out to Tennis file.

SETPARSE.C - Handles parseing of all keywords in set descriptors.

RMSVAX.C - Allows VMS users to utilize variable length record formatted files instead of stream LF type files.

Each of these modules contains multiple routines.

Appendix E - Set Descriptor File Format

The metadata descriptions of sets contained in the MDF are defined by ASCII set descriptor files. These files are found in the second record of the MDF. These files define the set, its games and the points in each game. In the example below, the hypothetical set "ZZ" is defined. The set contains one game, which in turn contains one point.

BEGIN_GROUP = setdscr;	Indicates start of set descriptor file.
setkey = "ZZ ";	Identifies set by key "ZZ ".
setname = *name_of_set;*	Assigns a set name.
setyp = sfl;	Defines set to be type short, fixed length.
setlen = *n;*	Defines set to be *n* bytes in length.
gamecnt = *m;*	Defines set to contain *m* games.
setext = "*text*";	Text describing set.
BEGIN_GROUP = gamedscr;	Indicates start of game description.
gamename = *name_of_game;*	Assigns a game name.
gamepnt = *l*;	Defines position of game from start of set.
gametxt = "*text*";	Text describing game.
BEGIN_GROUP = pointdscr;	Indicates start of point description.
pointnm = *name_of_point;*	Assigns a point name.
pointpnt = *k*;	Offset of point from start of game.
pointyp = *typ*;	Defines type of point (see table 4.2, 4.3)
pointxt = "*text*";	Text describing point.
END_GROUP = pointdscr;	Indicates end of point description.
END_GROUP = gamedscr;	Indicates end of game description.
END_GROUP = setdscr;	Indicates end of set description.

Appendix F - Acronyms and Abbreviations

Acronyms.

ACS - Attitude control system
ADC - Analog to digital converter
APID - Application ID
BCD - Binary coded decimal
DCL - Digital command language ã Digital Equipment Corp.
DPU - Data processing unit
ECD - Eccentric dipole
EOF - End of file
GEI - Geocentric equatorial inertial
GEO - Geographic
HILT - Heavy ion large telescope
HK - Housekeeping
HRR - High resolution rate
HV - High voltage
IFC - In-flight calibration
IGRF - International Geophysical Reference Field
ISO - International standards organization
LEICA - Low energy ion composition analyzer
LICA - another acronym for LEICA
LRR - Low resolution rate
LSB - Least significant bit
LV - Low voltage
LVPS - Low voltage power supply
MAST - Mass spectrometer telescope
MDF - Master data file
MPL - Missing packet list
MS - Multi-stop
NEB - Non-essential bus
PACOR - Packet processor facility
PET - Proton-electron telescope
PHA - Pulse height analyzed
QAC - Quality and accounting capsule
SAA - South Atlantic anomaly
S/C - Spacecraft
SRL - Space Radiation Laboratory (California Institute of Technology)
SSD - Solid state detector
ToD - Time of day
ToF - Time of flight
UMSOC - University of Maryland Science Operations Center
VMS - Virtual Memory System ã Digital Equipment Corp.

Abbreviations.

alt. - altitude
Calena. - Calibration enable
Calevn. - Calibration event
cmd. - command
conf. - confirmed
dec. - decimal
hr(s) - hour(s)
km. - kilometer
lat. - latitude
len. - length
long. - longitude
magn. - magnitude
param. - parameter
pkt(s) - packets(s)
posn. - position
temp. - temperature

Appendix G - SAMPEX High Res Rate Changes

Below is information relevant to the RH and RS sets, whose contents have been modified during the course of the mission.

In addition, the SAMPEX “event log” (Appendix I) contains events of importance which affect the interpretation of various data contained in the MDF, for example, command states of instruments, etc. A complete listing is contained in the "SAMPEX_EVENT_TABLE.TXT" which is located in the directory:
SAMPX3::$USER:[MASON.SAMPEX.UMSOC]

This table is also available on the SAMPEX WWW page internal memos section (userid: SAMPEX; password: SAMPEXWWW) at URL:
http://lepsam.gsfc.nasa.gov/www/sampex.html

Set RH (see § 7.1.1)

Different versions of the RH set contents for HILT were in use for time intervals shown below. After occasional spacecraft safeholds or other reconfigurations, there were brief intervals when the DPU was operating in the original version.

DPU Version	HRR Contents Reference	Start Date	End Date
original	Table 7.1	launch	3/25/94 19:09:59
Version 2.2	Table 7.2	3/25/94 19:09:59	8/25/94 21:00:34
Version 2.3	Table 7.3	8/25/94 21:00:34	1/31/96 12:35:52
original (2.1)	Table 7.1	1/31/96 12:35:52	8/7/96 17:25
Version 2.4	Table 7.4	8/7/96 17:25	

Appendix H - Attitude determination in 1 RPM spin mode

H.1 Introduction

In its 1 RPM spin mode, SAMPEX attitude gets updated once every 6 seconds, or about every 36 degrees of rotation angle (except in coast mode). In order to more accurately report the attitude and pitch angle in the MDFs for days in the spin mode, the MDF generator was modified as described below.

These changes apply to MDF generator versions 30 and higher.

In order to correlate the rates with the attitude, the S/C attitude is determined, and then the pitch angle at the midpoint of the low resolution rate accumulation interval is calculated. Determining the attitude as close in time to when the low res rates are accumulated improves the correlation with 90 deg. pitch angle in the outer zone and in the anomaly. This information also looks promising for studies of precipitation.

H.2 Non-coast mode times

For times outside of coast mode intervals, the following calculations are done for each RS set:

1. interpolate the S/C attitude at the midpoint of the low resolution rate accumulation interval using the method described by Landis Markley (memo to Doug Hamilton, 4/4/94) and implemented by Mark Looper

2. compute the magnetic field vector in the S/C frame at the midpoint of low res rate accumulation interval using the same IGRF model used to report mag field data in the PS sets (field routine courtesy of Mike McNab)

3. use the attitude and magnetic field to compute the pitch angle

4. report the attitude and pitch angle as a NEW game of the RS set:

```
game = 6
call f_put_game(game)
offset = 0
call f_putfloat(offset,pitch)                     ! pitch angle, real*4
offset = 4
call f_putfloat(offset,zenith)                    ! zenith angle, real*4
offset = 8
call f_putfloat(offset,azimuth)                   ! azimuth angle, real*4
offset = 12
call f_putfloat(offset,time_bet_quaternions)      ! time(sec) between
                                                    quaternions, real*4
```

The last variable in the new game is the time in seconds between the packet times of the two quaternions used to interpolate the attitude. During times when the S/C is in 1 RPM spin mode, a value of >6 seconds in the time between quaternions indicates that the satellite is in coast mode.

H.3 Coast mode

During orbit rate rotation mode, recovering the attitude in coast was difficult since we could not interpolate across a coast mode gap due to the possibility of sudden maneuvers the carried out by the S/C did in order to look at J-perp while maintaining ram avoidance. The 1 RPM spin mode in principle makes it easier to recover the attitude, since we can assume a constant rotation rate and direction through the attitude gap.

When the S/C is determined to be in 1 RPM coast mode, the attitude is calculated as follows:

a) use the most recent attitude update to find the S/C y-axis in the GEI frame (the S/C rotates about the y-axis; this axis is assumed to be stationary in the GEI frame and the rotation rate is constant)
b) in the GEI frame, rotate about the y-axis by an angle (0.1053 rad/sec)*(current RS time + 3 - latest APID-11 time) where the 'latest APID-11 time' is the time of the last quaternions before the coast mode gap
c) apply this rotation to the most recent APID-11 quaternions to get the quaternions at the current RS set time + 3 seconds

Steps 2-4 in §H.2 are followed to find and report the pitch, zenith, & azimuth.

The rate of 0.1053 rad/sec is slightly faster than 1.00 RPM. This rate and the resulting pitch angle fit the LEICA SSD peaks measured during coast modes in the SAA better than 1.00 RPM or the daily averaged rate measured from the APID 11 quaternions.

The time between APID 11 quaternions included in the new RS game 6 indicates which method was used to compute the attitude.

H.4 Changes to RS set descriptor for game 6

The new RS set descriptor has been generated in order to add the new game, #6; the new descriptor is located at:

Directory $PROD:[PRODUCTION.MDF.SETS]SET_RS.;18
27 11-JUL-1996 13:40:03.68 (RWED,RWED,RE,R)

For MDF generator versions ≥ 30, the RS set is 124 bytes, short fixed length, and has a game count of 6.

Addition to RS set descriptor:

```
BEGIN_GROUP = gamedscr;
    gamename = ATTITUDE;
    gamepnt = 108;
    gametext = "Sampex pitch, zenith, & azimuth angles interpolated at
        midpoint of low res rate accumulation interval, last point is time in
        sec between quaternions used to interpolate the attitude";

    BEGIN_GROUP = pointdscr;
        pointnm = pitch;
        pointpnt = 0;
        pointyp = F;
        pointext = "pitch angle at midpoint of RS set";
    END_GROUP = pointdscr;

    BEGIN_GROUP = pointdscr;
        pointnm = zenith;
        pointpnt = 4;
        pointyp = F;
        pointext = "zenith angle at midpoint of RS set";
    END_GROUP = pointdscr;

    BEGIN_GROUP = pointdscr;
        pointnm = azimuth;
        pointpnt = 8;
        pointyp = F;
        pointext = "azimuth angle at midpoint of RS set";
    END_GROUP = pointdscr;

    BEGIN_GROUP = pointdscr;
        pointnm = time between quaternions;
        pointpnt = 12;
        pointyp = F;
        pointext = "sec between quaternions";
```

```
        END_GROUP = pointdscr;
    END_GROUP = gamedscr;
```

Note that the new game is appended to the previous 5 games, it isn't necessary to read the new variables in order to access the low res rates.

Also note that the attitude information in the PS sets is reported as before.

H.5. Example of fortran code that reads new RS game

```
game=6
call f_get_game(game)                    ! game 6
offset=0
pitch = f_getfloat(offset)               ! pitch @ RS midpoint
 offset=4
zenith = f_getfloat(offset)              ! zenith @ RS midpoint
offset=8
 azimuth = f_getfloat(offset)            ! azimuth @ RS midpoint
offset=12
time_bet_quaternions = f_getfloat(offset)
```

Appendix I - SAMPEX "Event" Table

This table contains times of "events" of importance to determining the status of the instrument or spacecraft. Items not included are:

- routine instrument calibrations run on or near the start of each month
- MOST instrument power cycling
- brief turn-ons of HILT for gas pressure checks.

This list is based on examination of command logs through 7/3/94 (day 184), and from inputs from the POCC since that time.

I.1 Spacecraft

Time	Event
08/12/92	NEB off due to DPU reboots
09/19/92	Spacecraft safehold
03/31/93	NEB current noisy due to M/P LVPS instability during 12 hour MAST turnoff
04/07/93	NEB current noisy due to M/P LVPS instability during 12 hour MAST turnoff
9/12/93 11:23:55	Spacecraft clock jump back 2 sec; corrected at 23:48:16
12/15/93	MAST/PET LVPS out of limits
12/22/93	NEB and MAST/PET LVPS noisy all day
2/9/94 01:46:49	Spacecraft clock jumps back 3 sec; corrected at 15:32:06
5/26/94 13:46:28	Spacecraft pointing algorithm modified to point perpendicular to field for B<0.3 gauss, parallel to field at other times subject to pointing and ram avoidance. If a warm restart occurs, will revert to old program until new one loaded and activated.
6/1/94 18:41:01	RPP warm restart, revert to old pointing program
6/2/94 14:52:07	modified pointing algorithm re-activated
8/10/94 15:40:17	RPP warm restart, revert to old pointing program
8/10/94 22:40	modified pointing algorithm re-activated
4/1/95 17:39:30	S/C clock stepback by 5 sec (time approx)
4/1/95 23:38:20 23:41:23 23:43:25:	S/C clock adjusts made to correct 5-sec stepback
4/30/95 12:22:51	RPP warm restart, revert to old pointing program
5/1/95 13:07:01	modified pointing algorithm re-activated
10/24/95 13:41	S/C enters analog safehold, revert to old pointing program
10/26/95 19:55	safehold recovery: MAST & PET command words modified to pre-safehold values
10/27/95 18:26	safehold recovery: modified pointing algorithm re-activated

continued

Spacecraft Event Table, continued

Time	Event
1/1/96 0:00	S/C clock moved back 1 sec to stay in synch with UT
1/30/96 20:05	Memory dwell tables & ACS patch loaded for "spinup"
2/1/96 15:07:12	S/C pointing commanded to 1 RPM mode
2/1/96 19:15	S/C pointing to normal mode (spin down requires ~2 hrs after this command sent)
2/13/96 13:45:32	S/C pointing commanded to 1 RPM mode
2/14/96 19:30	S/C commanded back to normal mode (bad ACS patch)
2/14/96 20:30:50	S/C pointing commanded to 1 RPM mode
2/16/96 18:00:00	S/C commanded back to normal mode
3/5/96 15:25:08	S/C pointing commanded to 1 RPM mode
3/8/96 17:45:00	S/C commanded back to normal mode
5/8/96 13:33:00	S/C pointing commanded to 1 RPM mode
8/19/96 ??:??	S/C commanded to safehold after signal acq. problem
8/22/96 09:53	S/C commanded to ORR (original) pointing mode
8/24/96 03:57	S/C commanded to modified ORR mode
8/26/96 08:53	S/C pointing commanded to 1 RPM mode
11/6/97 23:10:56	S/C commanded to prior spin program (looks towards zenith over poles; perp to B for B<0.3 gauss) for solar flare event study
11/17/97 13:26:20	S/C pointing commanded to 1 RPM mode -- for ACR intercalibration with ACE
12/18/97 13:08:01	S/C commanded to prior spin program (looks towards zenith over poles; perp to B for B<0.3 gauss) (took ~4 hours to achieve new mode)
1/13/98	switchover from GSFC FDF to UMd FDCL daily EPVs
1/14/98 12:45	S/C pointing commanded to 1 RPM mode est 2 hrs to achieve transition (short shadows)
4/21/98 15:08:01	S/C commanded to prior spin program (looks towards zenith over poles; perp to B for B<0.3 gauss) for solar flare event study
4/28/98 16:08:45	S/C pointing commanded to 1 RPM mode; est 2 hrs to achieve transition (short shadows)
5/7/98 14:05:09	S/C commanded to 1 RPO spin program for SEP charge studies, Space Station cutoff support

continued

Spacecraft Event Table, continued

Time	Event
12/05/99 ~14:40	Spacecraft safehold due to watchdog time out
12/09/99 18:30	S/C reconfiguration from safehold completed
12/17/99 20:10	S/C to 1 RPM spin mode in support of L D Balloon
12/25/99 20:20	Spacecraft safehold
12/28/99 23:30	S/C reconfiguration from safehold completed; 1 RPM
2/2/00 20:05	S/C to 1 RPO mode after completion of balloon flight
5/13/00 (134) 03:22:13	S/C clock noticed 4.122 seconds off (spacecraft behind); gradual adjustment back to specifications
5/17/00 (138) 17:05:45	S/C clock readjust back to within limits completed MDF position data not affected by these jumps 6/5

Data losses due to overflow of memory partition in solid state recorder (SSR):

Time Range	Partition	Data Loss
1/9/93 22:06:05 - 22:18:09	ACS	12 min, 4 sec
1/17/93 20:21:56 - 20:31:21	ACS	9 min, 25 sec
3/7/93 14:38:18 - 14:46:04	ACS	7 min, 46 sec
9/29/94 19:21:05 - 20:51:37	ACS	90 min, 32 sec
10/20/94 15:07:53 - 16:08:00	DPU	60 min, 07 sec
10/31/94 15:38:35 - 16:15:37	ACS	37 min, 02 sec
10/5/95 17:55:48 - 18:36:06	ACS	40 min, 18 sec
12/17/95 07:45:36 - 14:38:39	ACS	6 hrs, 53 min, 3 sec
8/18/96 ??:??:??	ACS/DPU due to tracking loss	
8/25/96 10:03:04 - 10:25:45	ACS	22 min 41 sec
10/29/96 13:36:40 - 15:39:29	ACS	2 hrs, 2 min, 49 sec

Other data losses:

Time Range	Partition	Data Loss
12/17/96 18:04 - 12/18/96 01:30	Science	loss of 55% of a blind dump due to Wallops problem
4/27/97 08:47 - 11:16	Science	loss of 82% of a blind dump due to Wallops problem
5/2/97 00:11 - 05:35	Science	loss of 46% of a blind dump due to Wallops problem
6/3/97 19:25 - 21:32	Science	loss of 10% of a blind dump due to Wallops problem
1/15/98 00:24	Science	loss of 14% of a blind dump due to Wallops problem
6/27/98 01:41 - 19:02 (day 178)	Science	loss due to antenna point error at Poker Flats during blind dump
7/21/98 2hr 6 min lost between 10:48-22:33	Science	error at Wallops due to misconfigured equipment
11/17/98 14:30 - 11/18/98 01:00	Science	Instruments off for Leonid Meteor Shower
12/19/98 45% of dump lost	Science	loss due to dropout during blind playback at Wallops
1/17/99 35% of 12-hr dump lost	Science	blind playback at Wallops, reason for loss unknown
1/28/99 10% of 12-hr dump lost	Science	brief dropout during blind pass
3/7/99 53% of 12-hr dump lost	Science	Instr subcom VC2 data loss; 53% of period 98/066/04:59-16:43 due to dropout at Wallops
6/26/99 56% of 12-hr dump lost	Science	VC2 data loss due to drop- out (low elevation Wallops pass)
7/9/99 50% of 12-hr dump lost	Science	low elevation Wallops pass

continued

Time Range	Partition	Data Loss
8/20/99 ~90% of 12-hr dump lost	Science	VC2 data lost from 99/231/18:45 to 99/232/05:41 due to switch error at Wallops
9/15/99 13:19 to 9/16/99 03:20	Science	no tracking due to Hurricane Floyd closedown of Wallops
9/16/99 16:28 to 9/17/99 01:47	Science	no tracking due to Hurricane Floyd closedown of Wallops
10/1/99 16:12 - 10/2/99 01:33	Science	low elevation Wallops pass
11/17/99 16:00 - 11/18/99 16:00	Science	Instruments off for Leonids
11/24/99 03:10-15:33 90% of VC 2 lost	Science	loss of lock at Wallops
1/9/00 20:46 - 1/10/00 02:13 data in VC 2 lost	Science	loss of lock at Wallops
1/27/00 16:53 - 1/28/00 08:43 47% of VC 2 lost	Science	loss of lock at Wallops
2/2/00 18:56 - 2/3/00-02:23 57% of VC 2 lost	Science	loss of lock at Wallops
2/26/00 14:06 - 2/27/00 04:04 loss of unknown % of VC 2	Science	Wallops LEO-T prob
3/17/00 01:47 - 3/17/00 11:51 loss	Science	Wallops equipment prob
4/4/00 22:55:02 - 4/5/00 04:15:05 loss of science data	Science	Wallops equipment prob

I.2 LEICA

note: LEICA individual high voltage spikes, and "noon" turnoffs are NOT included in this list; they are in the data file LEICA_bad_hv.dat on www page.

LEICA Event Table

Time	Event
7/10/92 12:20:56	LEICA first in-calibrate data MCP HV steps 155/155
7/22/92 8:49:12	LEICA out of calibrate until 9/29/92
9/27/92 20:28	LEICA back in calibration at HV steps 165/165
11/16/92	LEICA daily "turn-offs" begin
11/25/92	LEICA daily turn-offs scheduled for 12:00-12:15 GMT
11/10/93 0:30:00	LEICA START MCP bias adjusted up to step 175
12/20/93 23:17	LEICA START MCP bias to step 180
1/21/94 18:46	LEICA proton "slant" disabled
5/4/94 12:17	LEICA START MCP bias to step 185
9/27/94 20:29:23	LEICA START MCP bias to 191; STOP MCP bias to 169
11/11/94 12:15	LEICA START MCP bias to 192; STOP MCP bias unchanged
12/27/94 12:15	LEICA START MCP bias to 193; STOP MCP bias unchanged
2/10/95 12:15	LEICA START MCP bias to 194; STOP MCP bias unchanged
3/27/95 12:18:14	LEICA START MCP bias to 195; STOP MCP bias unchanged
5/11/95 12:15	LEICA START MCP bias to 196; STOP MCP bias unchanged
6/26/95 12:15	LEICA START MCP bias to 197; STOP MCP bias unchanged
8/9/95 12:15	LEICA START MCP bias to 198; STOP MCP bias unchanged
9/22/95 12:18:14	LEICA START MCP bias to 199; STOP MCP bias unchanged
11/7/95 12:15	LEICA START MCP bias to 200; STOP MCP bias unchanged
12/22/95 12:18:14	LEICA START MCP bias to 201; STOP MCP bias unchanged
2/5/96 12:18:14	LEICA START MCP bias to 202; STOP MCP bias unchanged
3/21/96 12:18:14	LEICA START MCP bias to 203; STOP MCP bias unchanged

continued

LEICA Event Table, continued

Time	Event
5/3/96 12:18:14	LEICA START MCP bias to 204; STOP MCP bias unchanged
6/19/96 12:18:14	LEICA START MCP bias to 205; STOP MCP bias unchanged
8/2/96 12:18:14	LEICA START MCP bias to 206; STOP MCP bias unchanged
8/2/96 12:00:00 - 16:58:12	LEICA off due to RTS sequencing error
8/21/96 12:18	LEICA on & HV on after S/C safehold
9/17/96 12:18:14	LEICA START MCP bias to 207; STOP MCP bias unchanged
11/1/96 12:18:14	LEICA START MCP bias to 208; STOP MCP bias unchanged
12/16/96 12:18:14	LEICA START MCP bias to 209; STOP MCP bias unchanged
1/30/97 12:18:14	LEICA START MCP bias to 210; STOP MCP bias unchanged
3/16/97 12:18:14	LEICA START MCP bias to 211; STOP MCP bias unchanged
4/30/97 12:18:14	LEICA START MCP bias to 212; STOP MCP bias unchanged
6/14/97 12:18:14	LEICA START MCP bias to 213; STOP MCP bias unchanged
7/29/97 12:18:14	LEICA START MCP bias to 214; STOP MCP bias unchanged
9/12/97 12:18:14	LEICA START MCP bias to 215; STOP MCP bias unchanged
10/28/97 12:15:10	LEICA START MCP bias to 216; STOP MCP bias unchanged
12/11/97 12:18:14	LEICA START MCP bias to 217; STOP MCP bias unchanged
1/27/98 12:18:14	LEICA START MCP bias to 218; STOP MCP bias 169
3/11/98 12:18:14	LEICA START MCP bias to 219; STOP MCP bias 169
6/23/98 12:15	LEICA START MCP bias to 210 [sic]; STOP MCP bias 169
2/16/99 12:15	LEICA START MCP bias to 215; STOP MCP bias to 172
5/12/99 12:15	LEICA START MCP bias to 216; STOP MCP bias 172
8/10/99 12:15	LEICA START MCP bias to 217; STOP MCP bias 172
11/10/99 12:15	LEICA START MCP bias to 218; STOP MCP bias 172
12/05/99 ~14:40	Spacecraft safehold due to watchdog time out
12/09/99 18:30	S/C reconfiguration from safehold completed

continued

LEICA Event Table, continued

Time	Event
12/25/99 20:20	Spacecraft safehold
12/28/99 23:30	S/C reconfiguration from safehold completed; 1 RPM
02/08/00 12:15	LEICA START MCP bias to 219; STOP MCP bias 172
05/09/00 12:15	LEICA START MCP bias to 220; STOP MCP bias 172

I.3 HILT

HILT Event Table

Time	Event
7/13/92 22:20:54	HILT hi res rate threshold set = 6
8/19/92	HILT door opens; HILT in-calibrate operations begin
10/6/92 18:11:09-	HILT cover cycled
11/1/92 18:12:25	HILT 1-sec quotas changed
11/6/92 20:47:52	HILT flow regulator valve opened
11/12/92 20:17:33	HILT flow regulator valve closed
10/7/92 18:07-	HILT cover cycled
12/23/92 14:49:10-14:51:44	HILT cover cycled
2/3/93 21:54:31-21:57:38	HILT cover cycled
3/11/93 21:34:37-21:37:03	HILT cover cycled
5/24/93 17:24:40-17:29:32	HILT cover cycled
7/3/93 12:56:33-12:59:14	HILT cover cycled
8/11/93 17:29:29	HILT cover closed for meteor shower
8/12/93 03:38:02	HILT cover opened-(took 2-3 hrs to open fully)
10/12/93 20:20:58-20:25:16	HILT cover cycled
12/14/93 11:23:42-11:26:18	HILT cover cycled
2/11/94 03:21:51-	HILT cover cycled
2/21/94 14:10-17:30	HILT gas off for leak test
3/1/94 20:50:42	HILT gas off for conservation
3/11/94 19:12:40	HILT off--turned on briefly every 3 days to check gas
3/25/94 19:03:20-21:29:49	HILT HRR packet changed (DPU patch 2.2) 20 ms for SSD1, 100 ms on HSSD4, (no HSSD2, HSSD3, HPCIK, HPCRE) Threshold: HSSD4 > 6 cts/ 100 ms
4/14/94 18:13:30	HILT cover cycled
5/17/94 13:58:29	HILT gas turned back on; calibrated operation began at ......
6/17/94 18:20:11	HILT SSD voltage & gas regulation disabled
7/19/94 23:58	HILT in calibrate operation begins (gas repressurized, and all detector bias in place)

continued

HILT Event Table, continued

Time	Event
8/25/94 20:08:27-21:00:44	HILT HRR packet changed (DPU patch 2.3) 30 ms for HSSD1, HPCRE (no HSSD2,3,4; HPCIK) Threshold: HPCRE > 6 cts / 30 ms
11/15/94 13:40:02	HILT cover cycled
1/3/95 16:51:55	HILT off--turned on briefly every few days to check gas
1/23/95 20:56:43	HILT in calibrate operation begins (gas repressurized, and all detector bias in place)
2/7/95 15:03:04	HILT cover cycled (open at 15:05:53)
2/9/95 22:17:30	HILT gas off for conservation/ power off on 2/10
3/17/95 12:53:16	HILT in calibrate operation begins (gas repressurized, and all detector bias in place)
3/24/95 07:17:07 - 19:17:31	HILT XILINX anomaly / reset / restart
4/11/95 17:11:28 - 17:14:17	HILT cover cycled
6/23/95 07:25:41 - 07:28:36	HILT cover cycled
7/31/95 21:19:21	HILT HV/gas off for conservation; pwr off 8/1
11/12/95 13:04:36	HILT in calibrate operation begins (gas repressurized, and all detector bias in place)
11/15/95 21:49:29	HILT High Voltages disabled due to pressure regulator temp out of range
2/22/96 14:44:01 - 16:47:02	HILT cover cycled (instr bias off)
3/4/96 18:02:58	HILT switched to high energy mode
4/22/96 13:11:21 - 13:14:13	HILT cover cycled
6/1/96 19:19:06	HILT switched out of high en mode inadvertently
6/2/96 01:16:29	HILT high energy mode resumed
8/2/96 01:01:24 - 01:04:05	HILT cover cycled
8/8/96 12:38	disable HILT sub com word for high res rates (test)
8/9/96 12:48 re-enabled	HILT sub com word
8/22/96 07:28	HILT on in high energy mode after S/C safehold
8/28/96 09:11	HILT HRR subcom disabled EXCEPT for 5 min around Wallops Daily Support pass; subcom to be enabled from AOS - 3 min to AOS + 2 min
9/27/96 17:20:55 - 17:23:44	HILT cover cycled

continued

HILT Event Table, continued

Time	Event
12/6/96 13:00:28 - 13:02:57	HILT cover cycled
2/2/97 02:09:07 - 02:11:56	HILT cover cycled
3/31/97 15:23:33 - 02:26:00	HILT cover cycled
5/29/97 12:33:22 - 12:36:02	HILT cover cycled
8/6/97 22:29:47 - 22:33:00	HILT cover cycled
9/20/97 16:11:32 - 16:14:47	HILT cover cycled
12/5/97 16:00:02 - 16:05:02	HILT cover cycled
1/28/98 18:01:06 - 18:04:28	HILT cover cycled
3/27/98 15:07:22 - 15:09:54	HILT cover cycled
5/28/98 18:09:44 - 18:12:02	HILT cover cycled
7/29/98 14:46:33 - 14:49:52	HILT cover cycled
9/23/98 13:40:15 - 13:43:08	HILT cover cycled
12/2/98 16:32:43 - 16:35:11	HILT cover cycled
1/27/99 20:20:50 - 20:24:06	HILT cover cycled
3/24/99 12:10:08 - 12:13:45	HILT cover cycled
5/19/99 17:34:57 - 17:37:53	HILT cover cycled
7/21/99 21:03:58 - 21:08:48	HILT cover cycled
9/10/99 12:54:56 - 12:57:30	HILT cover cycled
11/10/99 17:44:21 - 17:46:31	HILT cover cycled
12/05/99 ~14:40	Spacecraft safehold due to watchdog time out
12/09/99 18:30	S/C reconfiguration from safehold completed
12/25/99 20:20	Spacecraft safehold
12/28/99 23:30	S/C reconfiguration from safehold completed; 1 RPM
1/11/00 17:26:48 - 17:29:22	HILT cover cycled
3/15/00 (075) 13:25:56 - 13:28:29	HILT cover cycled
5/24/00 (145) 15:42:36 - 15:47:28	HILT cover cycled

I.4 MAST

Note: MAST/PET routine power cyclings are NOT included below

MAST Event Table

Time	Event
7/5/92 11:32:07	MAST initial power on cmd word 2 initially set to FFFEAF5E
08/12/92 09:13	MAST off due to NEB shutdown (DPU reboot problem)
08/13/92 18:36	MAST on after NEB shutdown
09/02/92	MAST/PET power cycles begin
9/25/92 19:26:17	MAST cmd word 2 to FFFEAF7E Removed M4 from event coincidence requirement
11/12/92 20:19:51	Reinstated M4 requirement in event coincidence
5/5/93 02:13:47	Removed M4 from event coincidence requirement
10/02/93	MAST/PET LVPS 7.5 V reached upper yellow limit (7.57 V)
12/15/93	MAST/PET LVPS out of limits
12/19/93 10:45	adjust MAST/PET DPU memory quotas
12/22/93	NEB and MAST/PET LVPS noisy all day
2/8/94	MAST/PET power cycling from noon Tues-non Wed begins
4/1/94 20:56:57	MAST cmd to allow "hazard" events (wrd 1 C03A9FF8)
4/27/94 05:20:25	MAST cmd wrd 2 changed from FF FE AF 7E to FF FE EF 7E Removed M1 from the coincidence eqn for event storage.
5/5/94 04:59:48	MAST cmd wrd 2 changed from FF FE EF 7E to FF FE AF 7E (back to its default state)
5/17/94 02:06:47	MAST cmd wrd 2 changed from FF FE AF 7E to FF FE EF 7E (removes M1 from coincidence equation)
6/19/94 20:19	MAST **D4** is steadily noisy at around 10^4 cts/s after approximately this time
7/19/94 03:50:10	MAST command word 6 changed from 00 0f ff f8 to 00 0d ff f8 (disables the D4 ADC)

continued

MAST Event Table, continued

Time	Event
6/9/95 16:31:21	MAST command word 1 changed from c0 3a 9f f8 to c0 3f 0f f8 (modifies logic for Z2 rate and HIZ equation; enable HAZ event veto)
6/9/95 16:32:16	MAST command word 5 changed from 00 7f 58 68 to 00 6f 58 68 (disable D6L guard discr.)
6/13/95 12:19	MAST command word 1 changed from c0 3f 0f f8 to c0 3f 1f f8 (correct error in HAZ enable in command on 6/9/95 16:31:21)
7/1/95 18:37:42	MAST Command Word 1 Set To Default State (C0 3A 9F F8) out of ATS (after instrument calibrate sequence)
7/2/95 15:38:19	MAST Command Word 1 changed from C0 3A 9F F8 to C0 3F 1F F8
7/20/85 19:10:04	MAST Command Word 5 changed from 00 6f 58 68 to 00 7f 58 68 (enable D6L guard discr.)
10/24/95 13:41	MAST off due to analog safehold
10/26/95 19:55	MAST on and command state configured
8/20/96 ??:??	MAST power on after S/C safehold
8/23/96 02:27:35	MAST command words 1,2 updated after safehold
8/23/96 02:27:35	MAST command word 6 changed from 00 0F FF F8 to 00 0D FF F8 (disables D4 ADC)
9/1/96 07:13:10	MAST CALIBRATE sequence modified so that D4 ADC is also disabled during calibrate mode
11/7/97 14:54:24	MAST command word 6 to be changed from 00 0D FF F8 to 00 0D FF 38 (disables ADCs for M1 detector)
8/14-9/4/98	MAST/PET instrument power cycling near equator suspended for test purposes
9/15/98 13:42	Enable M-1 for 24 hour test
9/16/98 13:50	Disable M-1 after testing it for 24 hrs
9/17/98 13:57	Enable D-4 for 24 hour test per
9/18/98 14:05	Disable D-4 after testing it for 24 hour test
9/21/98 14:28	Attempt to re-enable M1 "permanently" (Mistakenly applied command event to Word2, resulting in garbled data)
9/22/98 02:51	Corrected the change made earlier at 264-14:28z to this word, by changing it to the settings requested by Jay Cummings (02:51z)
9/22/98 02:53	"Permanently" re-enabled M-1
3/25/99 13:54:47	MAST command word 1 (c2) changed from FF FE AF 5E to FF FE EF 5E (remove M-1 trigger requirement to pulse-height-anayze events)

continued

MAST Event Table, continued

Time	Event
12/05/99 ~14:40	Spacecraft safehold due to watchdog time out
12/09/99 18:30	S/C reconfiguration from safehold completed
12/25/99 20:20	Spacecraft safehold
12/28/99 23:30	S/C reconfiguration from safehold completed; 1 RPM
3/1/00 21:51	D7 fails (zero output); D7 and PEN rates = 0 after this time; HIZR6, HIZSUM, Z1R6, and Z2R6 rates all increase due to loss of anti-coincidence condition.

I.5 PET

Note: MAST/PET routine power cyclings are NOT included below

PET Event Table

Time	Event
7/5/92 11:32:07	PET initial power on
7/7/92	Intermittent P3 crosstalk to guard begins
7/7/92 22:47:41	set PET HRR threshold to 6
7/11/92	PET ADC P4-7 fails
7/24/92 21:10:00	PET HRR threshold set to 8
08/12/92 09:13	PET off due to NEB shutdown (DPU reboot problem)
08/13/92 18:36	PET on after NEB shutdown
09/02/92	MAST/PET power cycle
12/2/92 17:28:16	PET command word 2 changed from 04F8FA3E to 04F8FB2E Substitute high guard for low guard anticoincidence
12/19/92 10:45	adjust MAST/PET DPU memory quotas
12/22/92 23:54:02	PET command word 2 changed from 04F8FB2E to 04F8FB7E Remove guard anticoincidence
1/23/93 2:46:27	PET command word 2 changed from 04F8FB7E to 04F8FB2E Reinstate high guard anticoincidence
03/31/93	LVPS noisy during 12 hour MAST turnoff. PET data no good
04/07/93	LVPS noisy during 12 hour MAST turnoff. PET data no good
5/18/93 19:39:26	increase PET HRR memory allocation to allow 100% coverage
7/10/93 21:41:36	set PET HRR threshold to 2
7/12/93 20:27:50	set PET HRR threshold to 1
9/23/93 19:38:22	PET command word 2 changed from 04F8FB2E to 0DF9FB3E Allow all P1 triggers to cause PHA events
10/02/93	MAST/PET LVPS 7.5 V reached upper yellow limit (7.57 V)
10/7/93 09:16:01	Changed PET 1-sec throttle to 10 events/sec
12/15/93	MAST/PET LVPS out of limits
12/22/93	NEB and MAST/PET LVPS noisy all day -PET data bad?

continued

PET Event Table, continued

Time	Event
2/8/94	MAST/PET power cycling from noon Tues-non Wed begins
3/5/94 23:03:12	PET cmd wrd 2 to 04F8FB3E Reinstate requirement for at least 2 detector triggers (No P1 only events)
10/24/95 13:41	PET off due to analog safehold
10/26/95 19:55	PET on and command state configured
8/20/96 ??:??	PET power on after S/C safehold
8/23/96 02:19	PET command words 2 updated after safehold
8/14-9/4/98	MAST/PET instrument power cycling near equator suspended for test purposes
9/21-22/98	see MAST log for garbled data period
1/14/99 22:01	PET cmd word 2 changed from 04 F8 FB 3E to 04 F8 FB 5E. This change allows PHA events in which the guards are triggered to be stored in the RNG buffer.
9/28/99 17:37	PET cmd word 2 changed from 04 f8 fb 5e to 04 f8 fb 68
12/05/99 ~14:40	Spacecraft safehold due to watchdog time out
12/09/99 18:30	S/C reconfiguration from safehold completed
12/25/99 20:20	Spacecraft safehold
12/28/99 23:30	S/C reconfiguration from safehold completed; 1 RPM

I.6 DPU

<u>SEE APPENDIX M FOR MORE DETAILED DESCRIPTION OF DPU PATCHES</u>

(see also list of data loss times above due to SSR overflows)

DPU Event Table

Time	Event
7/4/92 21:22:20	DPU initial power on
08/12/92 09:13	NEB shutdown (DPU reboot problem)
08/13/92 18:36	MAST/PET on after NEB shutdown
2/21/94	New DPU Bootlist to RPP RAM
3/25/94 19:09:59	HILT HRR packet changed to mostly D1 (DPU mod)
8/25/94 21:00:34	HILT HRR packet changed to SSD1 & PCRE
5/31/94 20:18	DPU Time Command Error Count increments from 0 to 1
10/25/95 19:45	DPU reboot during patch load (safehold recovery)
10/26/95 16:50	DPU reconfiguration complete (safehold recovery)
1/31/96 12:35:52	DPU version 2.1 installed; thresh = 1; mostly D1
3/8/96 19:21:16	HILT 1-second quotas reduced from 5 to 1 for both HE1 and HE2
8/7/96 17:25	DPU patch version 2.4 loaded
8/20/96 ??:??	DPU power on (no patches!) after S/C safehold
8/23/96 10:01	DPU patch version 2.4 loaded after safehold
4/22/97 13:42:20	DPU set to version 4.0 (test of 1-s LICA rates in RS) note: rates garbled for ~4 min associated with transition to patch 4.0
4/22/97 22:12:50	DPU set back to version 3.9
10/9/97 17:06:45	DPU set to version 4.0 (1-s LICA rates in RS) note: rates garbled for ~4 min prior to this time associated with transition to new patch
10/9/97 17:06:45	DPU set to version 4.0 (1-s LICA rates in RS) note: rates garbled for ~4 min prior to this time associated with transition to new patch
3/16/98 00:00:00	DPU quotas / reallocations existing values: (units: 256 bytes; realloc every orbit) HILT LICA MAST PET Hilt HRR Pet HRR quota: 1877 3691 2953 1806 540 226 reall: 5 10 12 3 2 0
3/16/98 15:13:31	DPU quotas / reallocations adjusted to increase HRR HILT LICA MAST PET Hilt HRR Pet HRR quota: 1877 2851 2953 1806 1380 226 reall: 5 12 12 3 0 0

continued

DPU Event Table (continued)

Time	Event
12/05/99 ~14:40	Spacecraft safehold due to watchdog time out
12/09/99 18:30	S/C reconfiguration from safehold completed
12/25/99 20:20	Spacecraft safehold
12/28/99 23:30	S/C reconfiguration from safehold completed; 1 RPM

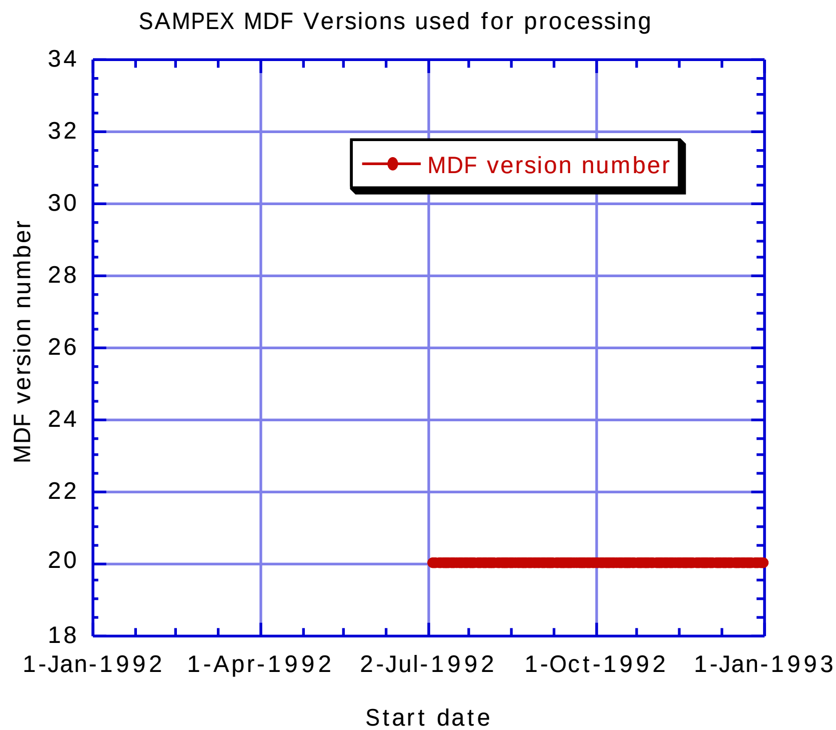
Appendix J - MDF Generator Versions in use through July 2000

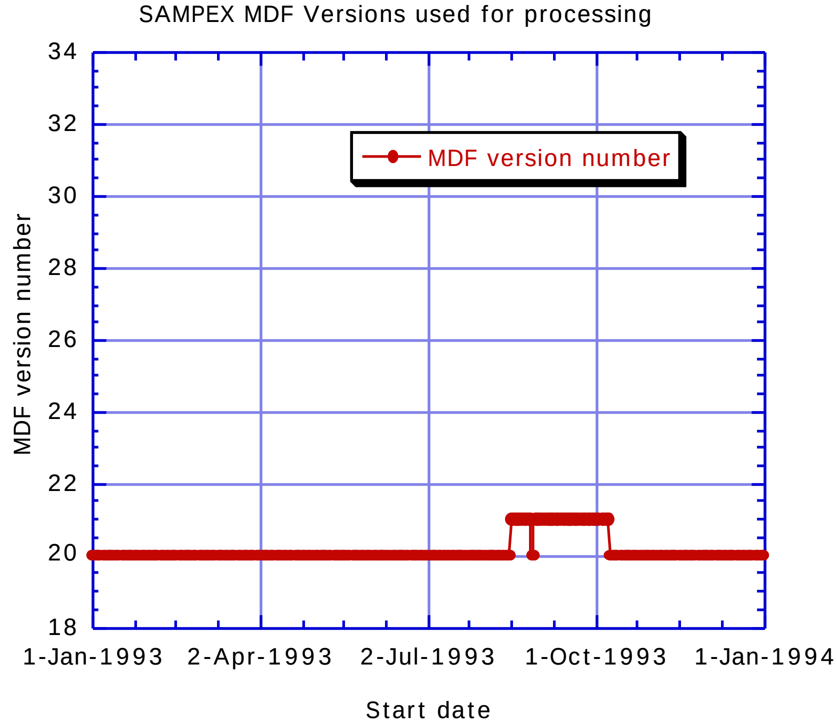
The basic program that creates SAMPEX MDFs (MDF generator) has had a number of modifications during the course of the mission. The version number used for each MDF file is given in the MDF version number in the PS set (see § 4.2.13). On some occasions, data have been retroactively processed when a new version number is created, in others, previously processed data are kept.

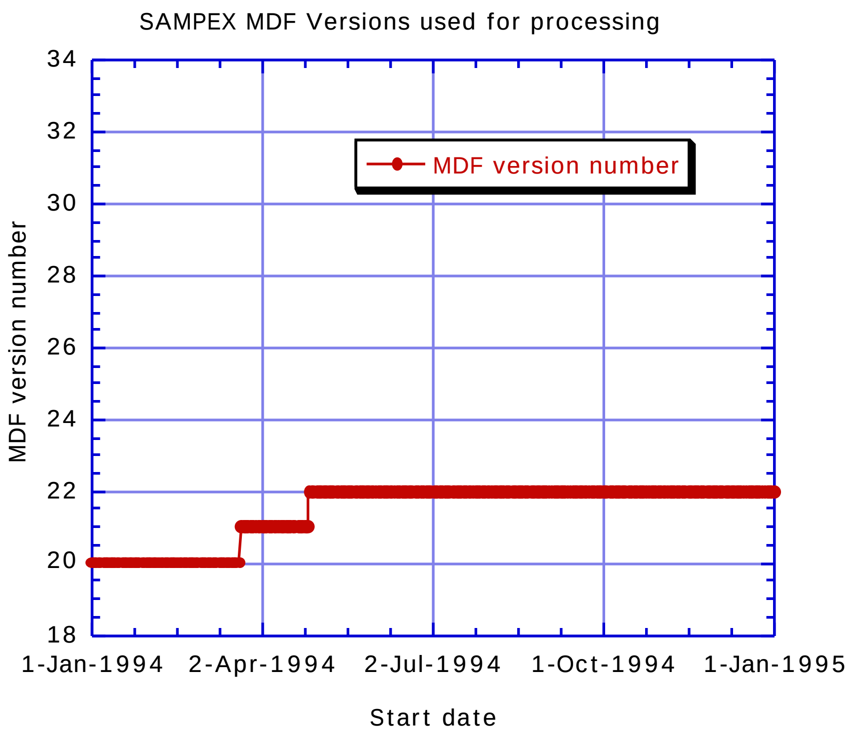
Below are graphs showing the MDF version number used for processing each day of SAMPEX data -- the “start date” in the graphs are the day of data, *not* the date of processing. Following the graphs are descriptions of each of the modifications involved with the different versions. These modification listings begin with MDF generator version #21, since all data processed with prior versions was processed with version 20.

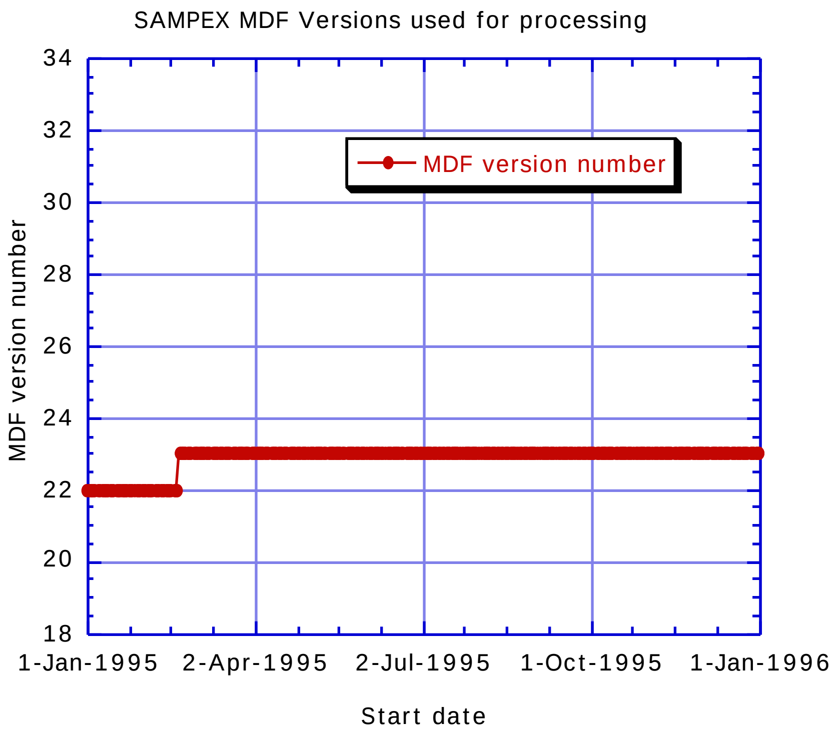
Notes:

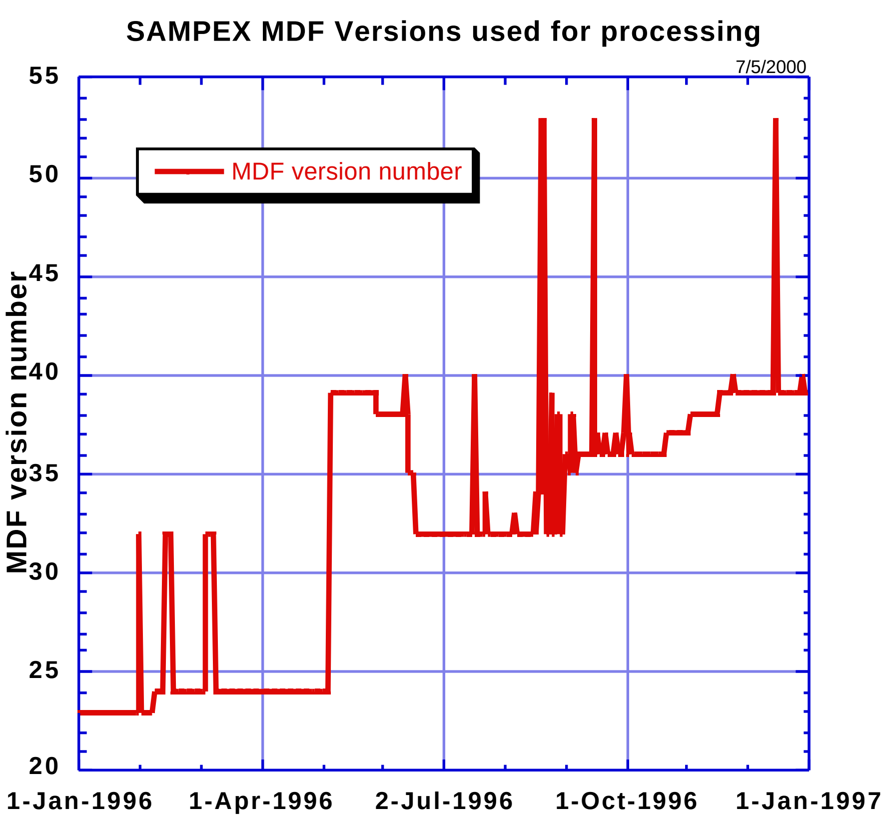
- The large number of modifications in 1996 were the result of introducing the 1 RPM spin mode.
- Isolated MDFs processed with version 53 in 1997, 1998, and 1999 were individual days that had time/orbit stepbacks that required correction (see notes on MDF V53)

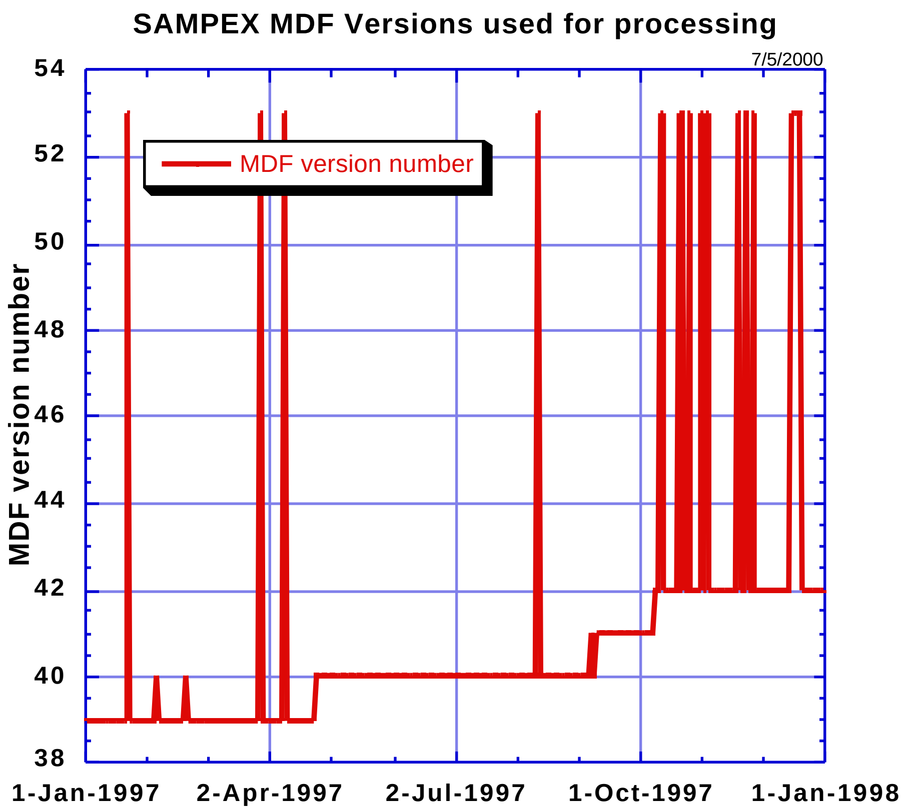


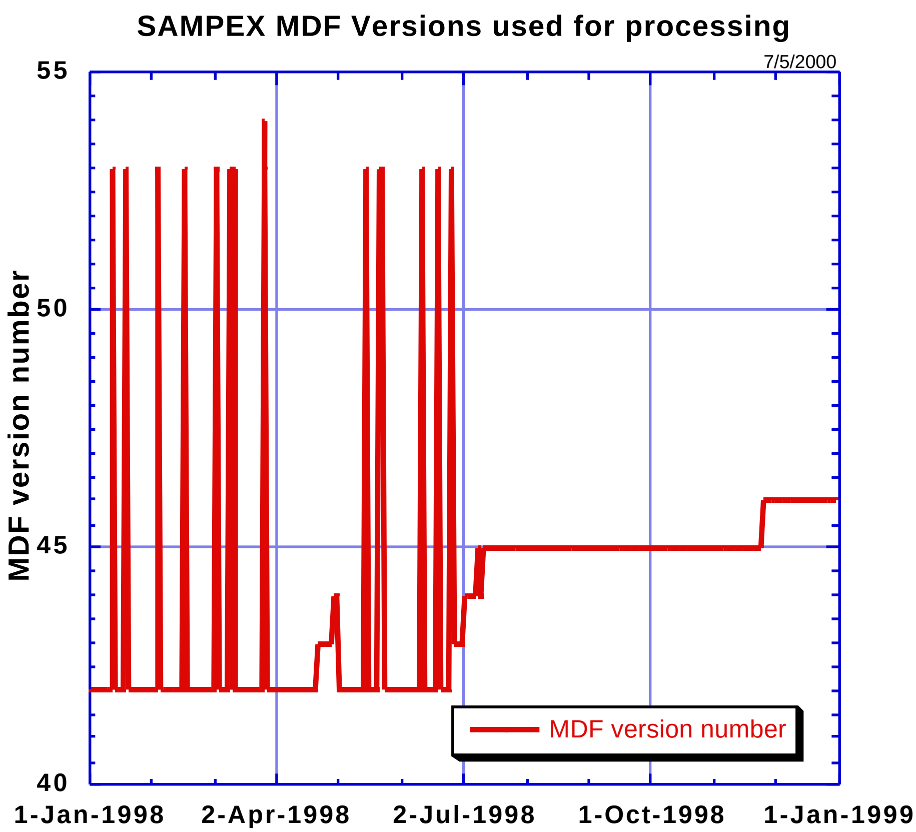

SAMPEX MDF Versions used for processing
MDF version number
MDF version number
34
32
30
28
26
24
22
20
18
1-Jan-1993
2-Apr-1993
2-Jul-1993
1-Oct-1993
1-Jan-1994
Start date

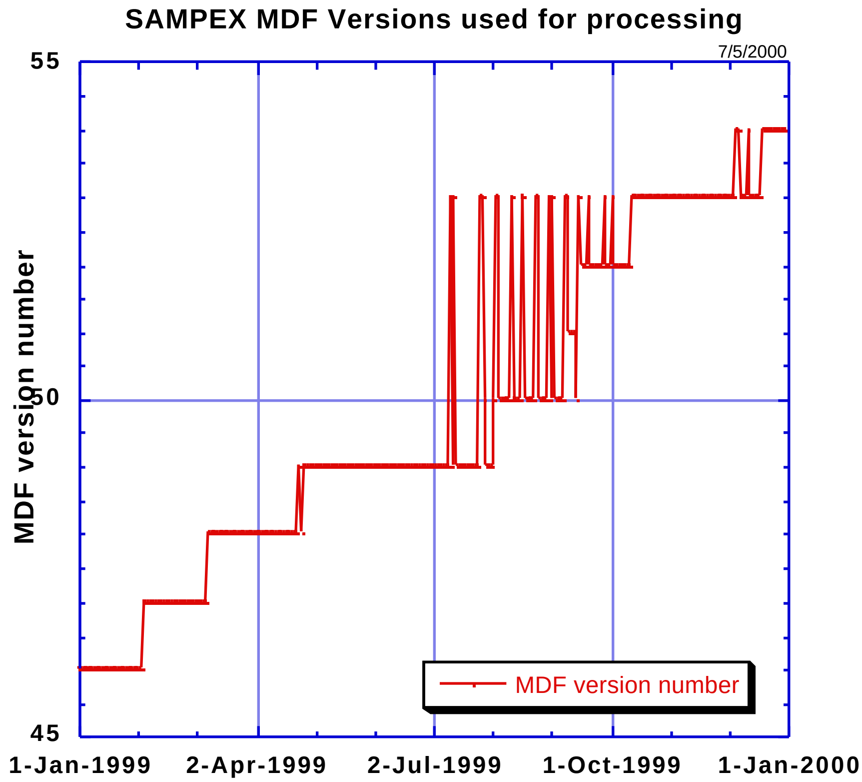

SAMPEX MDF Versions used for processing
MDF version number
MDF version number
34
32
30
28
26
24
22
20
18
1-Jan-1994
2-Apr-1994
2-Jul-1994
1-Oct-1994
1-Jan-1995
Start date

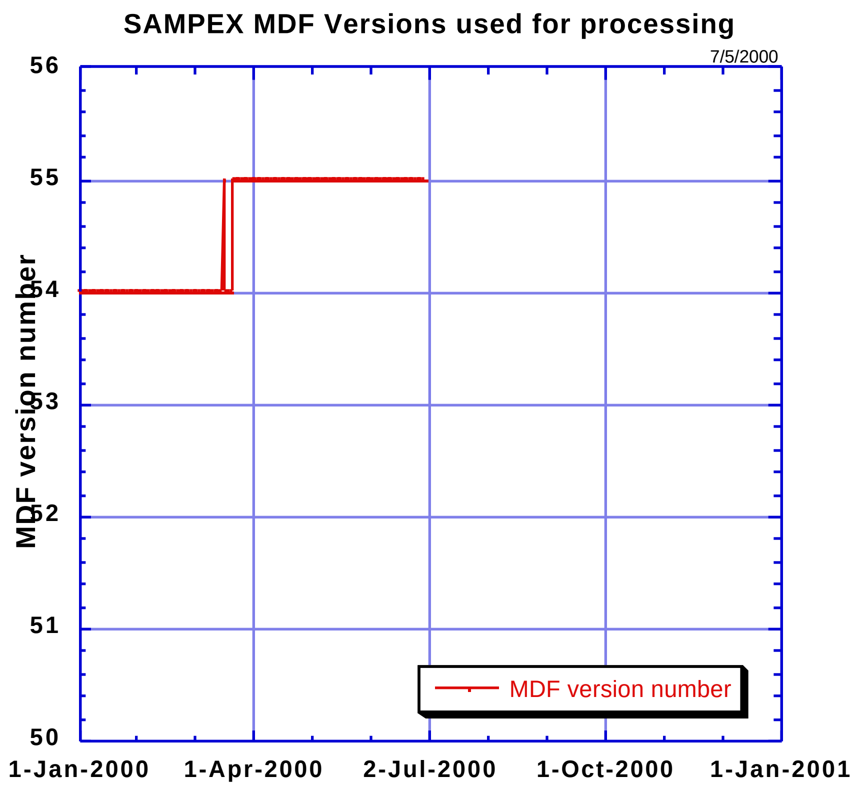

SAMPEX MDF Versions used for processing
MDF version number
MDF version number
34
32
30
28
26
24
22
20
18
1-Jan-1995
2-Apr-1995
2-Jul-1995
1-Oct-1995
1-Jan-1996
Start date


SAMPEX MDF Versions used for processing
7/5/2000
MDF version number
MDF version number
55
50
45
40
35
30
25
20
1-Jan-1996
1-Apr-1996
2-Jul-1996
1-Oct-1996
1-Jan-1997


SAMPEX MDF Versions used for processing
7/5/2000
MDF version number
MDF version number
54
52
50
48
46
44
42
40
38
1-Jan-1997
2-Apr-1997
2-Jul-1997
1-Oct-1997
1-Jan-1998


SAMPEX MDF Versions used for processing
7/5/2000
MDF version number
MDF version number
55
50
45
40
1-Jan-1998
2-Apr-1998
2-Jul-1998
1-Oct-1998
1-Jan-1999





MDF processing shown through 6/30/2000

Appendix K -- Changes to MDF Generator for different Versions

Note: Version number updates are in the file MDF_GEN.for located on the SAMPEX alphastation in the subdirectory of $USER:[WALPOLE.FOR.MDF] that has the highest Vxx number. This Vxx is also the current MDF version number. For example, for the current MDF version this directory is: $USER:[WALPOLE.FOR.MDF.V55]

Version number : 21	Date : 4 April 94	Author : M. Lennard

Modification : Change definition of MD set to accommodate full DPU address (SET_MD.). Change routine PUT_MD_OUT to reflect change.

Version number : 22	Date :26 APRIL 94	Author : M. Lennard

Modification : Change subroutine "PUT_SP_OUT" to contain correct value for HILT preregulator, LEICA preregulator, MAST/PET bus power, HILT acoustic cover, LEICA acoustic cover, survival heater, and operational heater. Change subroutine "PUT_SB_OUT" to contain correct value for Battery state of charge, undervoltage, and safehold. Change subroutine "PUT_ST_OUT" to contain correct value for transmitter power status.

Version number : 23	Date : 2 MAR 95	Author : M. Lennard

Modification : Change subroutine PUT_VS_OUT to pass missing state variables to program for yr='95' day='051'.

Version number : 24	Date : 18 Feb 96	Author : J. Mazur

Modification : Change subroutine PUT_VS_OUT to pass missing state variables to program for yr='96' day='039'. The APID13 packet for 2/8/96 was not generated on the spacecraft, and could not easily be reproduced in its proper format @ UMSOC. We therefore followed the logic used the last time a state vector was missing, and used the data in the extended precision vector from this day to manually pass the state vector data in the routine 'put_vs_out.for'

Version number : 25	Date : 7 Jun 96	Author : J. Mazur

Modification : Patch for APID42 packet with <0 SAMPEX time on 96127: in the routine 'sort_input', make sure that the SAMPEX times are all .ge.0 during the sort for the earliest packet time. The problem was that a negative SAMPEX time for the start time gave erroneous values for start_date,f_start_date,start_day, & start_dec_day in the statistics record. Other than this problem with the statistics record, 96127 ran OK.

Version number : 26	Date : 12 Jun 96	Author : J. Mazur

Modification : /12/96 Patch in proc_input.for: loop through all APID11 packets that are earlier than the current grid time + 5 sec. The previous logic that writes AS sets in proc_input.for would read only the AS packets that are in the current 6-sec PS interval; if there was more than one AS packet before the current grid time, then only one AS set was written. This was a problem during the spin-up test of 96044 - 96047, when the s/c transmitted an AS packet every 2 seconds and this routine did not advance the read of AS packets in sync with the PS sets.

Version number : 27	Date : 26 Jun 96	Author : J. Mazur

Modification : Since the VAX upgrade to 6.0 on 9/8/95, the MDF size as reported in the statistics record has been about 10x too small. This is because of a shift of one character to the right in the dir/lis field. Changed size string (dir_str) pointer in 'get_record_count.for' to point to proper location.

Version number : 28	Date : 15 Jul 96	Author : J. Mazur

Modification : 7/10/96 Add code in put_rs_out.for to write a new game: game #6 has pitch, zenith, & azimuth angles computed at the midpoint of the low res rate accumulation. Interpolates the s/c attitude at the midpoint using the method of Landis Markley (4/4/94 memo to Doug Hamilton) & Mark Looper (communication 6/19/96). New game also has the time interval in sec between quaternions used in the interpolation of attitude. This change more accurately provides the attitude & pitch angle for the times when the s/c is spinning at 1 rpm.

Version number : 29	Date : 18 Jul 96	Author : J. Mazur

Modification : 7/18/96 Fix the part of the code in put_rs_out.for that interpolates the quaternions for the midpoint of the low res rate accumulation. There was a bug that alternated the sign of one quaternion whenever we interpolated within a gap between attitude packets longer than ~6 sec (due to computing the inverse of quat_array(jdum)). This led to oscillatory behavior of the interpolated attitude.

Version number : 30	Date : 29 Jul 96	Author : J. Mazur

Modification : 7/29/96 Calculate the quaternions in coast mode for the case of 1 rpm spinning assuming a constant rotation direction & rate of 0.1053 rad/sec (rate determined by matching pitch angle boundary conditions on either side of a coast mode gap and fitting the # peaks of LICA SSDs while coasting through the SAA).

Version number : 31	Date : 7 Aug 96	Author : J. Mazur

Modifications : 8/7/96 In put_rs_out, add a check for when the RS packet midpoint is later than the last AS packet time. This case caused an int overflow in the search for quaternions that bracket the low res rate accumulation midpoint, and prevented the MDFs for 96168, 96169,... from completing the last few seconds. In such cases we just use the last 2 quaternions to do the interpolation.

In sort_input.for, fixed problem with the line that checked if the current APID42 SAMPEX time was less than the first_data_time. This line went over the limit of # char/line, so the compiler set the first_data_time to an uninitialized variable whose value was 0. Problem with 96171 to 96173 start times = 0.

Version number : 32	Date : 8 Aug 96	Author : J. Mazur

Modifications : 8/8/96 In put_as_out.for, revise the logic that checks for bad quaternions. The program was checking that each quaternion component was <1.1, but the actual constraint is that sqrt(q1^2 + q2^2 + q3^2 + q4^2)=1.0 When it comes across a bad quaternion, it writes a message to the screen and increments the bad_as_pkt counter by one. In put_rs_out, look for quaternions that don't satisfy the magnitude constraint. If one of the pair that we're going to use for interpolating the attitude fails the test, then look to previous quaternion pairs until we find a pair that is OK. Program was bombing on 96175 @ 141313745 due to quaternion components that were >10^15.

In get_sampex_time, handle case of 96180 where some packet's time stamp caused an i*4 sampex_time overflow error. Put a test in for ts_days > 24820 (68 years) and return a zero sampex_time if true.

Version number : 33	Date : 12 Sep 96	Author : J. Mazur

Modifications :

9/12/96 In pbl.for:

1. At all points where an error forces the pbl routine to 'fortran stop', also write the error message to screen; before wrote only to diagnostics file.

2. Instead of stopping at a time step-back during the call to integrate the trajectory, reinitialize the integration with the first state vector & integrate up to the current time. Routine was stopping because of the higher probability of time step-backs once we began calling pbl at the midpoint of every low res rate accumulation.

In put_rs_out.for:

1. Pass the 'q_time' of the interpolated quaternion to pbl (q_time is the pb5 time of the quaternion). pbl checks for quaternions within 20 min of present time, & was writing too many warning messages to its diagnostics file.

2. Fix bug in check for magnitude of quaternions: make sure the magnitude is 1.00 +/- 0.01 (tolerance was too big before).

In put_vs_out.for:

Pass missing state vector variables to program for yr='96' day='232' and '233'. We did not receive a state vector for 96232 due to safehold status.

Version number : 34	Date : 17 Sep 96	Author : J. Mazur

Modifications : 9/16/96 In put_rs_out.for: Check if the start of day falls within a coast mode gap; if so, don't interpolate for game #6 of the RS set. Just write the same pitch, zenith, & azimuth that are written in the PS set. Note that these attitude data are incorrect, but to recover the attitude in this case cannot be done without knowledge of the prior day's data.

Version number : 35	Date : 2 Oct 96	Author : J. Mazur

Check if the current RS packet time + 3 equals the first quaternion packet time. If it does, then skip the code that searches for quaternions that bracket the current RS time +3. The previous logic resulted in a call to AS_time_array with index = 0, which had not been written to, and subsequent int overflows.

Version number : 36	Date : 10 Oct 96	Author : J. Mazur

In put_rs_out.for: Revise logic for when the day begins while in coast mode: check for grid times that are before the time of the first attitude packet (was requiring that the time difference be 6 sec before).

Version number : 37	Date : 25 Oct 96	Author : J. Mazur

In check_qac.for: Skip the qac check & the read of the missing packets list for apid11 files (quaternions). An unknown problem in the PACOR processing for days during the spin mode in late 1996 (e.g. 96242, 96261, 96265, 96270, & 96275) led to the qac listing all the apid11 packets as missing. Such a large list of missing packets crashed mdf_gen in the check_qac routine. Rather than trap the resulting overflow & read errors, we elect to skip the qac check for apid11, since we later check for good quaternions in put_as_out & put_rs_out. Note that apid11 will no longer have any bad or missing packets statistics in the mdf log file, & the apid11 qac statistics in the stat record will be zero.

Version number : 38	Date : 7 Nov 96	Author : J. Mazur

In init_state.for: Add the state vectors for days 96241 & 96248 here; they were never transmitted from PACOR. Change logic so missing state vectors are read from this routine instead of from 'put_vs_out.for' (not sure why that worked before).

In check_input.for:

1. Add an EOF trap when first reading the first packets of the level zero files to check for APID consistency. Program crashed on 96241 & 96248 where state vector files existed but were empty.

2. Set the EOF marker (file_ref(i,2) to be 1 (i.e. no EOF) for all level zero files at the start of the check of APID consistency. Set the marker to be 0 (i.e. reached an EOF) if we get an EOF on any file other than apid11 or apid42. This will allow the program to continue to execute if any data other than the quaternions or the science data are missing. Note that this causes the qac & mpl checking as well as the writing of the set to be skipped for any such missing file, since file_ref is passed in common to check_qac & to proc_input.

In check_qac.for: Skip the qac & mpl check of any file with file_ref(i,2) = 0 (i.e. pointer is at EOF). The EOF marker is set in check_input & will be 0 for any empty level zero file other than quaternions & science data.

Version number : 39	Date : 21 Nov 96	Author : J. Mazur

In get_ieee_r8.for:
Added a trap for floating overflow in math library with a call to 'errset'. An overflow caused 96238 to bomb at 10:01:50. The calling routine was put_as_out.for, converting an inertial dot product that had expn = 1381. The error handler writes a message to the screen & continues execution making the result = 0.00.

In get_ieee_r4.for:
Added a trap for floating overflow in math library with a call to 'errset', identical to the addition to get_ieee_r8.for.

These floating point error traps will trap up to 64 violations & are local to these 2 subroutines.

Version number : 40	Date : 30 Apr 97	Author : P. Walpole

For 97-037 the start_date in the stat_record.dat file was incorrect. Problem believed to be bad sampex_time in early packets. Solution was:

SORT_INPUT: Using new subroutine YRDOY2EPOCH, initialize start_date to the first second of the DOY and YR of the data being processed. Make sure all packets have dates falling on this same DOY. Packets that do not are counted in WRONG_DAY_42 but not sorted.

MDF_ICL_COMM: Add START_OF_DAY and WRONG_DAY_42 to common

STAT_RECORD: Write out WRONG_DAY_42 as item 103 in the MDF_STAT.DAT records, replacing one of the spares.

YRDOY2EPOCH: new subroutine, passes sampex time of first second of DOY and YR back as START_OF_DAY

MAKE_MDF.COM: modified to add YRDOY2EPOCH

Unused variables and unitialized variables were causing numerous warning messages. These were fixed in the following subroutines:

CHECK_INPUT
CHECK_KBD
CHECK_QAC
CHK_HILT_SEQ
CHK_LEICA_SEQ
GENERATE_MDF
GET_ISO_TIME
PROC_INPUT
PUT_HS_OUT
PUT_RS_OUT

Version number : 41	Date : 12 Sep 97	Author : P. Walpole

Modifications : A problem with massive numbers of time step-backs on day 224 forced us to modify PBL to save the current state each time before calling INTEGRATE. A check is made when a time step-back occurs to see if the calling time is also less than the time of the saved state. If so we restore the state from the starting point as before and re-integrate the entire day. If not, however, we restore from the saved state and only reintegrate from there - typically only a few seconds- at a considerable savings in computation time. File changed: PBL

In addition, a new item was added to the statistics record: DATA_SOURCE. This is set to 1 if the data being processed came from the X.25 line (as determined by the value of the second item in PKT_BUF). It is set to 2 if the data came from the Sun Station. Integers are used rather than text to be more useful to Kaleidagraph.

Files Changed: INIT_STATE: detect data source and set logical PACOR2
MDF_ICL_COMM: add logical PACOR2
STAT_RECORD: set DATA_SOURCE based

Version number : 42	Date : 13 Oct 97	Author : P. Walpole and J. Mazur

Modifications : On day 97182 a patch was sent to the DPU to generate LICA one-second rates and put them in unused bytes at the end of the lo-res rate packets. To accommodate these new rates, PUT_RS_OUT was changed to read, decompress and store these rates - storage as a 7th game at the end of each RS set. Appropriate changes were also made in the set descriptor file.

Version number : 43	Date : 2 Jul 98	Author : P. Walpole

Modifications : Several people have noticed discontinuities in the S/C state vector on several days. These discontinuities are associated with time step-backs in calling PBL. PBL is called by both PS and RS sets and the time step-backs seem to be in the RS sets. Time stepback problems were thought to have been solved in the revisions made in ver 41 above (PBL ver 18) but it seems the revisions in PBL ver 18 introduced a new bug in the processo f fixing an old one. This version of MDF_GEN takes two approaches:

- 1. Fix bug in PBL (change to PBL 19)
- 2. Modify SORT_INPUT to discard RS sets with time step-backs and count the discards. The count appears as item 105 in the statistics record.

In addition, INIT_STATE was modified to explicitly change values of exo_temp and geomag for days 98113-98120 inclusive. The original vectors for these days used wrong values for these variables, and uploaded them to the S/C. This resulted in wrong durations for the orbits on these days. Modules changed were: MDF_ICL_COMM, STAT_RECORD, SORT_INPUT PBL, PBLLIB, INIT_STATE, Stat Record Header (on GMM Mac).

Version number : 44	Date : 15 Jul 98	Author : P. Walpole

Modifications : We have discovered that the S/C vector had problems with incorrect exo_temp and geomag (= Tc and Kp) on different days from the definitive EPVs and that therefore the fix in ver 43 of INIT_STATE did not include the correct days. The fix was not needed , but harmless, for days 98113-98115. The fix was needed but not applied for days 98121 and 98122. In this version of MDF_GEN, INIT_STATE has been modified to 'fix' days 98113-98122 inclusive, setting Tc=677 and Kp=3.01 for each day, but leaving other paramteters untouched.

Version number : 45	Date : 29 Jul 98	Author : P. Walpole

Modifications : We have found unexpected variations in the orbit period that were not being caught by PBL. PBL is therefore changed to fail whenever the orbit period exceeds the expected period by ~12 seconds. (Old test was error had to exceed 1200 seconds.)

Version number : 46	Date : 02 Dec 98	Author : P. Walpole

Modifications : Modified INIT_STATE to use supplied values for initial state (from Definitive EPV) instead of APID 13 for day 98-330 for which APID 13 data is missing. Also modified, PUT_VS_OUT setting STATE(1-13) for day 98330 to EPV values.

Version number : 47	Date : 04 Feb 99	Author : P. Walpole

Modifications : NONE (except the version number and this note) In late Jn 99 the $prod disk got corrupted during an attempted shift to VMS ver 7.1. Backups were unreadable. This new version of the program was built to ensure that we are working with an uncorrupted version of the program.

Version number : 48	Date : 05 May 99	Author : P. Walpole

Modifications :

- 1.Moved to SAMPEX [DEC ALPHASTATION], changed order of commons
- 2.changed location of 'magnetic' data from $x25:[level_0.x25data] to $prod:[level_0_data]

Version number : 49	Date : 17 May 99	Author : P. Walpole

Modifications : Bring SAMPEX version up to date with modifications v48 and v49 from SAMPX3 [DECSTATION] version of code.

Modifications are as follows (Copied from SAMPX3 version notes):

v48:

- Modified INIT_STATE to use supplied values for initial state (from Definitive EPV) instead of APID 13 for day 99/068-083 for which APID 13 data is suspect because of antenna problems at Wallops.
- Also modified, PUT_VS_OUT setting STATE(1-13) to EPV values

v49:

- Changed size of qac_err and qac_rep in check_qac to agree with get_qac_stats.
- Changed stat_record so that after 1 Jan 99, pacor2 = false is interpreted as data source = DPS instead of PACOR1.
- Changed INIT_STATE notes describing variable pacor2

These changes were made by copying INIT_STATE, PUT_PS_OUT, CHECK_QAC, and STAT_RECORD over from SAMPX3 and re-compiling .

Also accumulated the following changes:

20 May 99
MDF_GEN:

- if cmd_mode = auto then read mode as well as loop. This allows us to do batch mode from disk or optical.
- Changes also made in FIND_INPUT, CHECK_INPUT

29 Jun 99

- changes made in ADD_STATE_VECTOR,EXCHANGE_DATE,FIND_INPUT, GET_ISO_TIME,INIT_STATE,RUN_TIME_STATS,SORT_INPUT, YRDOY2EPOCH and PB5 (in PBL) to fix Y2K problems.
- Routines compiled, pb5 replaced in pbllib and mdf_gen.exe generated.

Version number : 50	Date : 03 aug 99	Author : P. Walpole

- 1. First new version on Alpha-station
- 2. added diagnostic to put_rs_out when quat not normalized

Version number : 51	Date : 10 sep 99	Author : P. Walpole

Modifications :

1. Change data source to DPS as of 20 sep 99

Version number : 52	Date : 22 sep 99	Author : P. Walpole

Modifications :

- 1. Edit Init_state and Put_VS_Out to include vector data for day 99259 for which APID13 data is missing due to hurricane Floyd

Version number : 53	Date : 19/20 oct 99	Author : P. Walpole

Modifications :

- 1. Edit Init_state and Put_VS_Out to include vector data for day 99286 for which APID13 data is missing due to bad data from Poker Flats
- 2. Introduce version 20 of PBL. This version fixes a problem introduced back in ver 18 of PBL (ver 41 of MDF_GEN 12 sep 97) and not caught in the fix of Ver 43. In dealing with small time stepbacks PBL was supposed to step back to the previous vector, correct the value of "delt" and call integrate. It was performing the first of these tasks but neglecting the last two. This has been fixed.
- 3. Change version number
- 4. Change GET_IEEE_R4 and _R8 to conform to FOR90
- 5. Compile in FORTRAN 90
- 6. Change the read format for variable "DOY" in GET_PROC_DATE.for from A5 to A3. DOY is declared as character*3 but the A5 format worked ok in FOR77. Now that we have switched to FOR90/95 it no longer works.

22 nov 99

- 1. fixed format statement 400 in CHK_HILT_SEQ which caused a crash on day 317. The format statement exceeded the 132 character buffer limit and caused a crash when invoked. Day 317 must have been the first time this warning message was ever generated - there is missing data on the day and the warning is of "BCD error" in the HILT data.

No change in version for this fix.

Version number : 54	Date : 20 dec 99	Author : P. Walpole

Modifications :

- 1. Edit Init_state and Put_VS_Out to include vector data for day 99340 for which APID13 data is missing due to S/C safe hold
- 2. Change version number

Version number : 55	Date : 23 Mar 00	Author : P. Walpole

Modifications :

- 1. Edit TENNIS_PREP to write out mdf filename to mdf.list
- 2. Modify MDF_GEN to call Sri Kanekal's program to generate the GDDF from the MFD listed in MDF.LIST
- 3. Change version number

Appendix L - LICA rates at 1-second resolution

K.1 Introduction

The LICA instrument sends its singles rates to the SAMPEX DPU every second, where they are accumulated and reported as 6-second sums in the low resolution rate packets. In order to extract more information from these rates, DPU patch 4.0 (implemented on 10/9/97) appended the individual 1-second readouts for selected LICA rates to the existing low resolution rate packets, increasing their size from 90 to 144 bytes. This improved the time resolution of LICA by a factor of 6, and allowed more detailed studies of the pitch angle distributions of trapped and precipitating ions.

MDF generator versions 42 and above include the LICA 1-second rates in an additional game of the RS set: game #7.

K.2 Changes to RS set descriptor for game 7

The LICA 1-second rates are appended to the existing RS sets as specified in a revised set descriptor:

Directory $PROD:[PRODUCTION.MDF.SETS]
SET_RS.;19 43 13-OCT-1997 14:35:49.64 (RWED,RWED,RE,R)

For MDF generator versions >=42, the RS set is 196 bytes of short-fixed length words and has 7 games.

The following is a partial listing of the addition to the RS descriptor. The 36 new points are the 6 LICA rates read out 6 successive times:

D4+D3	readout # 1 + (n-1)*6
D2+D1	readout # 2 + (n-1)*6
Stop	readout # 3 + (n-1)*6
Start	readout # 4 + (n-1)*6
Low Pri	readout # 5 + (n-1)*6
High Pri	readout # 6 + (n-1)*6

where n is an index that labels the individual 1-second intervals that make up this low resolution rate packet: n=1, 2, 3, 4, 5, 6.

```
BEGIN_GROUP = setdscr;
        setkey = "RS ";
        setname = LRRates;
        setext = "Subcommed low time resolution (6 sec) Sampex
                instrument rates";
```

```
        BEGIN_GROUP = gamedscr;
                gamename = LICAONESEC;
                gamepnt = 124;
                gametext = "LICA rates sampled at 1Hz: D4+D3, D2+D1, Stop,
Start,
Low Pri, High Pri; 12-bit compressed";

        BEGIN_GROUP = pointdscr;
                pointnm = LICA D4+D3 at 1Hz sampling sec 1;
                pointpnt = 0;
                pointyp = s;
                pointext = "LICA D4+D3 at 1Hz sampling sec 1";
        END_GROUP = pointdscr;

        BEGIN_GROUP = pointdscr;
                pointnm = LICA D2+D1 at 1Hz sampling sec 1;
                pointpnt = 2;
                pointyp = s;
                pointext = "LICA D2+D1 at 1Hz sampling sec 1";
        END_GROUP = pointdscr;

        BEGIN_GROUP = pointdscr;
                pointnm = LICA Stop at 1Hz sampling sec 1;
                pointpnt = 4;
                pointyp = s;
                pointext = "LICA Stop at 1Hz sampling sec 1";
        END_GROUP = pointdscr;

        BEGIN_GROUP = pointdscr;
                pointnm = LICA Start at 1Hz sampling sec 1;
                pointpnt = 6;
                pointyp = s;
                pointext = "LICA Start at 1Hz sampling sec 1";
        END_GROUP = pointdscr;

        BEGIN_GROUP = pointdscr;
                pointnm = LICA Low pri at 1Hz sampling sec 1;
                pointpnt = 8;
                pointyp = s;
                pointext = "LICA Low pri at 1Hz sampling sec 1";
        END_GROUP = pointdscr;

        BEGIN_GROUP = pointdscr;
                pointnm = LICA Hi pri at 1Hz sampling sec 1;
                pointpnt = 10;
                pointyp = s;
```

```
        pointext = "LICA Hi pri at 1Hz sampling sec 1";
    END_GROUP = pointdscr;
```

...repeated for seconds #2, 3, 4, 5, & 6.

K.3 Fortran code for writing & reading RS game # 7

For writing to the MDF:

```
      game = 7
      call f_put_game(game)
      i = 1
      offset = 0
      do while (i.le.36)
          call f_putwrd(offset, onesec_rate(i) ) ! lica one-sec rates
          offset = offset + 2
          i = i + 1
      end do
```

For reading from the MDF:

```
      game=7
      call f_get_game(game)          ! beginning of game 7
      i=1                            ! index into rate array
      offset=0
      do while(i.le.36)              ! points 1..36
       rate_i2=f_getwrd(offset)      ! point is integer*2
       lica_onesec_rates_i4(i) =
     *          decompress(rate_i2)
      offset=offset+2
      i=i+1                          ! next point
      enddo
```

Appendix M - DPU Patch History

M.1 Patch versions & reasons for patch

SEE APPENDIX I.6 FOR TIMES WHEN DPU PATCHES IN USE

Patch Version	Reason for Patch
1.1	Fix LEICA analog housekeeping sampling.
1.2	Modify Xmit-Events routines so that event packets are properly disposed of when the sensor's interface is enabled but its ENABDATA event setting has not been enabled.
1.3	Modify code so that sensor interfaces are forced disabled (and quiet) whenever the ENABINTS commands turns that interface off.
1.4	Modify HILT/XILINX verification code to take double buffering of the XILINX status readout into account.
1.5	Generate proper S2E-2 in PET controlword.
1.6	Fix MAST/PET event flush operation for case where packets are not full.
1.7	Fix CY flag problem in Compress30 routine.
HILT High Energy Mode (for later)	Inhibit enabling of the HILT high voltages regardless of tank pressure condition. This patch will be used late in the mission.
1.8a	Correct DPU history output timetag.
1.8b	Modify control table to use 5v scale for HILT Regulation Valve monitor
Ignore CTT Time Pulse (if needed)	Modify DPU code to use CTT serial time cmd as time fiducial instead of 1 Hz pulse. Will be used only in CTT anomaly.
1.9	Put correct HILT HKs into history packet.
2.0	Would have performed LEICA HV safing; this patch was never implemented.

2.1	Disable autodoubling of HILT 1 sec quotas.
2.2	Modify HILT high-resolution rate packets to give 20 msec resolution on SSD1 by eliminating readout of SSD2, SSD3, IK, PCRE.
2.3	Supercedes patch 2.2; modify HILT high-res rate packets to give 30 msecs coverage on SSD1 and PCRE only. Results in 10 msec blind region if 3 samples of each are reported.
2.4	Supercedes patchs 2.2,2.3; modify HILT hi-res rate packets to give 20 msecs coverage on sum of SSD1-SSD4 and 100 msec coverage on SSD4
-	New contents = '06030000' disables counting of the HILT subcom value at 3.
-	New contents = '3A9C0247' enables counting of the HILT subcom.
4	Appends 1 second rates for LEICA rates (D4+D3), (D2+D1), STOP, START, LOWPRI, and HIPRI data to the end of existing low-res rate packet. Six sets (9 bytes ea.) are appended to the old packet; values are compressed as other rates.

M. 2 Patch versions & memory modifications

Patch Version	Old Memory Modified	Routine Modified	New Memory Modified
1.1	38B2	SendLCmd	none
1.2	342D-342E	XmitHEvents	none
	3996-3997	XmitLEvents	
	40A0-40A1	XmitMEvents	
	474B-474C	XmitPEvents	
1.3	217C-2183	DMAHGo	5100-511F
	21A9-21B0	DMALGo	
	21D6-21DD	DMAMGo	
	2213-221A	DMAPGo	
	1AD0-1AD2	SetInterfaces	
1.4	25DA-25DC	CheckPulses	5200-5150
	25FC-25FF	CheckPulses	
	33B1-33B4	StartHDMA	
1.5	425F-4269	BldPCntrlWrd	none
1.6	3DF4-3DF6	MProcessor	5160-5167
	452F-4531	PProcessor	5170-5177
1.7	20D5-20E4	Compress30	5180-5184
HILT High Energy Mode (for later)	24AB-24AD	CheckHV	none
1.8a	5040-5042	UpdHistRates	5190-519F
1.8b	04C0	AnalogCntrl	none
Ignore CTT Time Pulse (if needed)	0923-0924	ExecDPUCmd	none
	092B-0932	ExecDPUCmd	
	4994-499F	SECInt	
1.9	4DFF-4E00	UpdHISTHK	none
2.0	-	-	none
2.1	1426	OrbitMonitor	none
2.2	1B4E-1B53	TimeInt	51A0-51F7

	2F19-2F3C	ProcHHiRes	
	3E7B-3E7D	MPStrobes	
2.3	1B4E-1B53	TimeInt	51A0-51FF
	2F19-2F3C	ProcHHiRes	
	3E7B-3E7D	MPStrobes	
2.4	1B4E-1B53	TimeInt	51A0-51FA
	2F19-2F3C	ProcHHiRes	
	3E7B-3E7D	MPStrobes	
-	30C4-30C7	SendHCmd	none
-	30C4-30C7	SendHCmd	none
4	76FC - 76FF	LowRatPktSCPtr	A500 - A70F
	1142 - 1144	MakRateHdr	
	3648 - 364A	LProcessor	