JET PROPULSION LABORATORY **INTEROFFICE MEMORANDUM**

TO: Tim Schofield S & I DFM 95-004 Rev. A

FROM: Donald Meyer October 10, 1995

SUBJECT: MET Experiment Command and Telemetry Definitions

Introduction:

This memo defines the input and output formats for the Mars Pathfinder AIM-resident flight software which is dedicated to the Meteorology (MET) experiment. It does not address the ASI, Atmospheric Structure Instrument (Experiment), which is commanded and produces packets within the context of Entry, Descent, and Landing (EDL) processing.

This memo specifies in detail the format and meaning of the commands' parameter formats as well as the packets' formats. The formats presented represent the as-built flight software, and are expected to be final.

Primary Commands:

- MET Session Execution Command

  This is the sole command for specifying the particulars of a MET data-taking session. This command will be executed as part of the AIM sequencing mechanism. All commands in a sequence will contain a time-tag specifying a mission time at which the command is to be "executed". It is not expected that command execution will be delayed greater than one second due to other spacecraft activities. No provision is made for specifying more than one data-taking session with a single command. Consistency checking is performed on the command parameters received. Commands with errors are not executed.

  This command includes the effects of three secondary commands which therefore do not need to be supplied in the uplink for a MET session. When this command is "executed", the ASI-MET electronics is commanded to power-on, followed immediately by a command for the multiplexer to select the 12 housekeeping parameters (instead of the long-gone AIP parameters). A delay then ensues, as specified by a command parameter, to account for hardware starting transients before data-taking begins.

  Once data-taking begins the data recording for the session is time-continuous since MET data is queued at the specified sampling interval. If there are data dropouts they will be indicated as invalid data in the gap-free time stream.

  In order that command parameters be constant throughout a session, subsequent MET Session Execution commands will not be acted upon until the completion of a data-taking session which might be underway.

  Once the required number of session samples have been captured, the ASI-MET electronics is autonomously commanded to power-off. If required, the secondary

command Set ASI-MET Power State "off" will terminate a session before the specified number of samples is captured.

Session Command Parameters, supplied in the following order:

- Session Duration

  A 32-bit unsigned integer, which is a count of RTIs (125 milliseconds/RTI), specifying the length of the data-taking portion of the session. Maximum value represents 149130 hours. The ASI-MET electronics is autonomously powered-off at the end of the duration.

- Data-taking Delay

  A 16-bit unsigned integer, which is a count of RTIs (125 milliseconds/RTI), specifying the length of time between ASI-MET electronics power-on and when data-taking is to begin. Maximum value represents 8192 seconds, or 2.27 hours. A zero value is valid. No consistency checking is performed.

- Science Averaging Interval

  A 16-bit unsigned integer, which is a count of RTIs (125 milliseconds/RTI), specifying the elapsed time between averaging the samples taken for the 12 "science" measurements. The averaged data is placed in a packet record.

  Maximum value represents 8192 seconds, or 2.27 hours. An averaging interval equal to the sampling interval is permitted, hence yielding point sampled (unaveraged) measurements. An averaging interval equal to the Session Duration is also permitted. An inconsistency is indicated if the Science Averaging Interval is greater than the Session Duration.

- Housekeeping Averaging Interval

  A 16-bit unsigned integer, which is a count of RTIs (125 milliseconds/RTI), specifying the elapsed time between averaging the samples taken for the 12 "housekeeping" measurements. The averaged data is placed in a packet record.

  Maximum value represents 8192 seconds, or 2.27 hours. An averaging interval equal to the sampling interval is permitted, hence yielding point sampled (unaveraged) measurements. An averaging interval equal to the Session Duration is also permitted. An inconsistency is indicated if the Housekeeping Averaging Interval is greater than the Session Duration.

- Sampling Interval

  A 16-bit unsigned integer, which is a count of RTIs (125 milliseconds/RTI), specifying the elapsed time between capturing all 24 measurements, both "science" and "housekeeping", for later averaging. Maximum value represents 8192 seconds, or 2.27 hours. An inconsistency is indicated if the Sampling Interval is greater than either the Science Averaging Interval or the Housekeeping Averaging Interval.

- Wind Sensor Power Mode

  An 8-bit unsigned integer indicating the operating power mode of the wind sensor. The three valid values are:

  0: Low power throughout session.
  1: High power throughout session.
  2: Cyclic low and high power alternating throughout session, starting with high power.

- Wind Sensor High Power Duration

  A 16-bit unsigned integer, which is a count of RTIs (125 milliseconds/RTI), specifying the elapsed time for the wind sensor to be in high power mode before switching to low power mode. High power mode is necessary for meaningful wind measurements. This parameter is used only if Wind Sensor Power Mode specified cyclic operation. Maximum value represents 8192 seconds, or 2.27 hours.

  The power switching times are with respect to the start of data-taking and may be slightly delayed due to other spacecraft activities. This potential delay is not cumulative. An inconsistency is indicated if the Wind Sensor High Power Duration is less than the Sampling Interval.

- Wind Sensor Low Power Duration

  A 16-bit unsigned integer, which is a count of RTIs (125 milliseconds/RTI), specifying the elapsed time for the wind sensor to be in low power mode before switching to high power mode. This parameter is used only if Wind Sensor Power Mode specifies cyclic operation. Maximum value represents 8192 seconds, or 2.27 hours.

  The power switching times are with respect to the start of data-taking and may be slightly delayed due to other spacecraft activities. This potential delay is not cumulative. An inconsistency is indicated if the Wind Sensor Low Power Duration is less than the Sampling Interval.

- MET Parameter Update Command

This is the sole command for specifying an update to the reference parameters used during a MET data-taking session. There are 24 MET measurements, divided into a 12 item "science" set and a 12 item "housekeeping" set. Each measurement has an associated reference value which is a standard deviation. These values are directly compared to the standard deviation computed for each measurement over a sampling interval, either "science" or "housekeeping".

A baseline set of reference standard deviations is determined in ground testing and is part of the launch flight software. These reference values may be replaced by this command. This command requires 24 parameters, each a 16-bit unsigned integer, which is the value of the updated reference standard deviation in 14 bits as derived from raw digital data. All parameters are required; there is no partial update. These parameters are preserved through a reset.

This command will be executed as part of the AIM sequencing mechanism. All commands in a sequence will contain a time-tag specifying a mission time at which the command is to be "executed". It is not expected that command execution will be delayed greater than one second due to other spacecraft activities.

In order that reference parameters be constant throughout a session, any subsequent MET Parameter Update commands will not be acted upon until the completion of a data-taking session which might be in progress. Parameters are checked to confirm that the high-order two bits are zero, i.e. the parameter is not greater than 14-bits in extent.

Reference Update Command Parameters, supplied in the following order:

- Top Mast Thermocouple Standard Deviation.
- Mid Mast Thermocouple Standard Deviation.
- Bottom Mast Thermocouple Standard Deviation.
- Descent Thermocouple Standard Deviation.
- Pressure Transducer, 6-10 Millibar Range, Standard Deviation.
- Pressure Transducer, 0-12 Millibar Range, Standard Deviation.
- Wind Sensor Segment 1 Standard Deviation.
- Wind Sensor Segment 2 Standard Deviation.
- Wind Sensor Segment 3 Standard Deviation.
- Wind Sensor Segment 4 Standard Deviation.
- Wind Sensor Segment 5 Standard Deviation.
- Wind Sensor Segment 6 Standard Deviation.
- +5 Volt Reference, Motherboard Standard Deviation.
- ±12 Volt Reference Standard Deviation.
- +5 Volt to ADC Standard Deviation.
- -5 Volt to ADC Standard Deviation.
- Sense Voltage, PRT 4 Standard Deviation.
- Mast Base Isothermal Block PRT Standard Deviation.
- Drive Current, PRT 4 Standard Deviation.
- Drive Current, PRT 5 Standard Deviation.
- Wind Sensor Thermocouple Standard Deviation.

- Wind Sensor Current Standard Deviation.
- Pressure Transducer PRT Standard Deviation.
- Circuit Board Temperature Standard Deviation.

**** Note that this ordering is slightly different from that followed by the ASI-MET electronics multiplexer.

- MET Mast Deployment Command

This command commands the energizing of the relay which fires the MET mast deployment pyro. An event message is transmitted to confirm the command actuation. No command parameter is supplied.

Secondary Commands:

These commands may be employed to exercise the ASI-MET electronics at the finest level of control. Each is autonomously accounted for in the MET Session Execution command.

- Set ASI-MET Power State Command

This is the sole command for specifying the power state of the ASI-MET electronics. A parameter value of 0 commands the off state, and a value of 1 commands the on state. Powering off the electronics will terminate any data-taking session in progress.

- Set ASI-MET Multiplexer State Command

This is the sole command for specifying the multiplexer state of the ASI-MET electronics. A parameter value of 0 commands the ASI-MET to produce "housekeeping data" from 12 channels, and a value of 1 commands AIP data-taking on the same 12 channels.

- Set ASI-MET Wind Sensor Power State Command

This is the sole command for specifying the power state of the ASI-MET wind sensor. A parameter value of 0 commands the low power state, and a value of 1 commands the high power state.

Telemetry Packet Formats:

MET experiment data is returned in normal CCSDS packets. Each is identified by the unique MET Application Process Identifier (APID) of 37. The maximum packet data size of 2176 bytes (17408 bits) is chosen in conformance with the guideline to not have packets exceed two downlink transfer frames. The results of a "standard session" of 5 minutes data-taking, with science averaging interval of 4 seconds, and housekeeping averaging interval of 32 seconds, just fits in a single packet with no margin.

Except for the time value in the packet's Secondary Header, the following discussion relates only to the data portion of a MET packet.

Two packet types are defined for MET data. One serves to echo the parameters supplied in a MET Parameter Update command, as well as supply the spacecraft time at which the update was performed. The other packet type conveys the normal experiment measurement data resulting from a MET Session Execution command.

- REFERENCE UPDATE PACKET

One such packet is produced for every MET Parameter Update command executed. It echos the parameters supplied in the command for ground confirmation. The parameters appear in the packet in the same order as they were uplinked in the command.

The time appearing in the packet's Secondary Header is the mission time at which the update was made. It consists of 4 bytes of whole seconds and one byte of subseconds (2^{-8} seconds per count).

Format:

Byte Size	Byte Offset	Contents
2	0	Packet number of total. Set to 0.
2	2	Total number of packets. Set to 0 to indicate a Reference Update Packet (instead of a Session Packet).
2	4	Echo of first reference parameter, exactly as supplied in the MET Parameter Update command.
...	...	.....
2	50	Echo of 24th reference parameter, exactly as supplied in the MET Parameter Update command.

- SESSION PACKET

One or more such packets are produced for every MET Session Execution command executed. A numbered packet set is produced for every session, with the particulars for the packet, and the session, given in a packet header as the first 38 bytes of each packet's data section. Each packet is intended to be fully self defined, as well as to fit seamlessly into the data stream for the entire session.

Immediately following the packet header there are as many as 85 packet records. Each record supplies the values for a sampling interval. Each record begins with a header halfword, and is followed by 12 words of interval data, either for "science" or for "housekeeping".

The time appearing in each packet's Secondary Header is the spacecraft mission time for the first sample taken for the session, and will so appear for every packet of a session. This time consists of 4 bytes of whole seconds and one byte of subseconds (2^-8 seconds per count).

Each packet's data header contains the first sample time of the packet's first science record and the packet's first sample time of the first housekeeping record. These times update for each packet of the session. For these times there are four bytes of whole seconds, the subseconds portion is fourteen right-justified significant bits in two bytes with resolution of 2^{-14} seconds per count.

Session Packet Header Format:

Byte Size	Offset	Contents
2	0	Packet number of total packets for this session. First packet is numbered 1. Maximum value of 65535.
2	2	Total number of packets for this session. Maximum value of 65535.
2	4	Session Number. Set to 1 on initialization and preserved through reset. Maximum value of 65535.
2	6	Number of Records in packet. Maximum value of 85.
4	8	Seconds portion of spacecraft mission time for the first science sample taken for this packet.
2	12	Subseconds portion of first science sample's time, 2^{-14} seconds per count.
4	14	Seconds portion of spacecraft mission time for the first housekeeping sample taken for this packet.
2	18	Subseconds portion of first housekeeping sample's time, 2^{-14} seconds per count.
4	20	Session Duration. Exactly as supplied in the MET Session Execution command.
2	24	Data Taking Delay. Exactly as specified in the MET Session Execution command.
2	26	Science Averaging Interval. Exactly as specified in the MET Session Execution command.
2	28	Housekeeping Averaging Interval. Exactly as specified in the MET Session Execution command.
2	30	Sampling Interval. Exactly as specified in the MET Session Execution command.
2	32	Wind Sensor Power Mode. Exactly as specified in the MET Session Execution command.
2	34	Wind Sensor High Power Duration. Exactly as specified in the MET Session Execution command.
2	36	Wind Sensor Low Power Duration. Exactly as specified in the MET Session Execution command.

Session Packet Record Format:

Byte Size	Offset	Contents
1	0	Record Header Halfword. Divided into two fields: Most significant bit: Indicates record type: 0: Science Data. 1: Housekeeping Data. The remaining seven bits indicate the number of sample sets which were supplied with an invalid indication, thus accordingly reducing the number of averaged sample sets for the interval. Maximum value of 127; values greater than 127 will be indicated by 127.
2	1	Record First Data Word. This will be either a science or a housekeeping measurement value depending on the most significant bit of the record header. Divided into two fields as follows: Most significant two bits: Indicates the extent to which the standard deviation over the averaging interval for this value differs from its reference standard deviation. 0: Standard deviation for the interval is less than two times the reference standard deviation, or that no valid samples were available during the interval. 1: Standard deviation for the interval is between two and four times the reference standard deviation. 2: Standard deviation for the interval is between four and eight times the reference standard deviation. 3: Standard deviation for the interval is greater than eight times the reference standard deviation. The remaining 14 bits contain the averaged science or housekeeping measurement value over the interval. The averages are obtained on digital data exactly as it is supplied by the instrument / LREU. A zero value indicates that no valid samples were available over the interval.
...	...	.....
2	23	Record Twelfth Data Word.

Session Packet Science Record Contents:

Byte Size	Offset	
1	0	Record Header Halfword.
2	1	Top Mast Thermocouple (Raw Digital).
2	3	Mid Mast Thermocouple (Raw Digital).
2	5	Bottom Mast Thermocouple (Raw Digital).
2	7	Descent Thermocouple (Raw Digital).
2	9	Pressure Transducer, 6-10 Millibar Range (Raw Digital).
2	11	Pressure Transducer, 0-12 Millibar Range (RawDigital).
2	13	Wind Sensor Segment 1 (Raw Digital).
2	15	Wind Sensor Segment 2 (Raw Digital).
2	17	Wind Sensor Segment 3 (Raw Digital).
2	19	Wind Sensor Segment 4 (Raw Digital).
2	21	Wind Sensor Segment 5 (Raw Digital).
2	23	Wind Sensor Segment 6 (Raw Digital).

Session Packet Housekeeping Record Contents:

Byte Size	Offset	
1	0	Record Header Halfword.
2	1	+5 Volt Reference, Motherboard (Raw Digital).
2	3	±12 Volt Reference (Raw Digital).
2	5	+5 Volt to ADC (Raw Digital).
2	7	-5 Volt to ADC (Raw Digital).
2	9	Sense Voltage, PRT 4 (Raw Digital).
2	11	Mast Base Isothermal Block PRT (Raw Digital).
2	13	Drive Current, PRT 4 (Raw Digital).
2	15	Drive Current, PRT 5 (Raw Digital).
2	17	Wind Sensor Thermocouple (Raw Digital).

2	19	Wind Sensor Current (Raw Digital).
2	21	Pressure Transducer PRT (Raw Digital).
2	23	Circuit Board Temperature (Raw Digital).

Engineering, Housekeeping, and Accountability (EH&A) Channels:

The EH&A channels which provide visibility into the workings of the MET experiment flight software are listed here. Channels are not listed which provide, through the ASI-MET hardware manager software, the ASI-MET instrument configuration and individual sensor values.

In the channels which follow, each is a member of the "ASI Group", is "Software Derived", and is an unsigned integer. In the case of a sum, i.e. "ASI_MET_NUM_...", the current value for each is the cumulative value since the last initialization or reset.

GDS Title	Bit Width	Software Name and Description
num_ses_strt	16	ASI_MET_NUM_SESSION_STARTS Number of MET Session Execution commands begun.
num_updates	8	ASI_MET_NUM_UPDATES Number of MET Parameter Update commands begun.
num_mast_dep	8	ASI_MET_NUM_MAST_DEPLOYMENTS Number of MET deploy mast actuations.
last_ses_dur	32	ASI_MET_LAST_SESSION_DURATION Value of parameter "Session Duration" in latest MET Session Execution command.
last_delay	16	ASI_MET_LAST_DELAY Value of parameter "Data-taking Delay" in latest MET Session Execution command.

last_sci_int	16	ASI_MET_LAST_SCIENCE_AVE_INTERVAL Value of parameter "Science Averaging Interval" in latest MET Session Execution command.
last_hkp_int	16	ASI_MET_LAST_HOUSEKEEPING_AVE_INTERVAL Value of parameter "Housekeeping Averaging Interval" in latest MET Session Execution command.
last_smp_int	16	ASI_MET_LAST_SAMPLE_INTERVAL Value of parameter "Sampling Interval" in latest MET Session Execution command.
last_wnd_pwr	8	ASI_MET_LAST_WIND_SENSOR_POWER Value of parameter "Wind Sensor Power Mode" in latest MET Session Execution command.
last_hi_wind	16	ASI_MET_LAST_HIGH_WIND_DURATION Value of parameter "Wind Sensor High Power Duration" in latest MET Session Execution command.
last_lo_wind	16	ASI_MET_LAST_LOW_WIND_DURATION Value of parameter "Wind Sensor Low Power Duration" in latest MET Session Execution command.