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| Canadian Space Agency – Space Science and Technology  **Stratos PRISM Telemetry Definition (StratoScience 2018)** | |
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| Project: | PRISM (Payload Remote Interface, Sensors Suite & Mass Memory) |
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# SCOPE

## Introduction

As part of the Engineering Capability Demonstration (ECD) program, the Canadian Space Agency (CSA) is designing and building a flight subsystem supporting science payloads onboard stratospheric balloons, to provide real-time data, such as time, gondola position and orientation, environment etc., as well as offering services like data relay to ground (i.e. forwarding to PASTIS) and mass-memory storage. This sub-system is identified as the Stratos Payload Remote Interface, Sensor Suite and Mass Memory (PRISM).

## Identification

This technical note provides detailed content information related to the telemetry generated by the PRISM sub-system.

*Refer to AD4 (PRISM TMTC Specification) for general format of the PRISM telemetry.*

## System Overview

Figure 1 shows the PRISM as part of a typical setup on a stratospheric balloon gondola.



Figure 1: Typical Gondola Setup for PRISM

## Document Overview

Section 2 defines the format of the C&DH telemetry packets. Section 3 defines the telemetry packets for the I/O Controller, and finally, section 4 and 5 provides the definition of the telemetry packets generated by the NAVEM computer (SWNAV and SWEM software).

## Acronyms

|  |  |
| --- | --- |
| AD | Applicable Documents |
| AHRS | Attitude and Heading Reference System |
| CDH | Command and Data Handling |
| CPU | Central Processing Unit |
| CSA | Canadian Space Agency |
| ECD | Engineering Capability Demonstration |
| EM | Environment Monitoring |
| GPS | Global Positioning System |
| IMU | Inertial Measurement Unit |
| MSL | Mean Sea Level |
| NAV | Navigation |
| NED | North East Down |
| NMEA | National Marine Electronics Association |
| NTP | Network Time Protocol |
| PRISM | Payload Remote Interface, Sensor Suite and Mass Memory Sub-system |
| RD | Reference Document |
| SI | Système International |
| SW | Software |
| TBC | To Be Confirmed |
| TBD | To Be Determined |
| TC | Telecommands |
| TM | Telemetry |
| TMTC | Telemetry and Telecommands |
| UTC | Universal Time Coordinate |
| WGS84 | World Geodetic System of 1984 |

## Applicable Documents

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AD No. | Document No. | Document Title | Rev. No. | Date |
|  | CSA-STRATOS-RD-0005 | Stratos Gondola System Requirements Document | TBD | TBD |
|  | CSA-STRATOS-RD-0004 | Stratos Gondola Equipment General Design and Interfaces Requirements (GDIR) | TBD | TBD |
|  | CSA-STRATOS-RD-0012 | Stratos Gondola Equipment PRISM Sub-System High-Level Requirements Specification | Rel.A | June, 2018 |
|  | **TN2018-02-PRISM** | **PRISM TMTC Interface Specification** | **Init.** | **Jan. 16, 2019** |

## Reference Documents

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RD No. | Document No. | Document Title | Rev. No. | Date |
|  | n/a |  |  |  |
|  |  |  |  |  |

# C&DH Software (SWCDH) Telemetry

## General

The SWCDH process executing on the CDH computer within the PRISM generates the following telemetry packets:

* **SWCDH / EVENT**: Event log data
* **SWCDH / SWCDH\_HKP0**: Housekeeping data
* **SWCDH / CDH\_HW0**: Additional housekeeping data, related to the CPU hardware
* **SWCDH / CDH\_IMG0**: Image data transfer packets

In addition, the SWCDH formats and relays telemetry from the NovAtel GPS receiver GPS01:

* **GPS01 / GGA**: Position data

They are detailed in the following sections.

## Telemetry Packets Generated by SWCDH

### SWCDH / EVENT Telemetry Packet

This telemetry packet is sent by SWCDH whenever there is an event worth reporting.

Format:

**SWCDH**,*m-time*,*ss-time*,**EVENT**,event\_text

Where:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SWCDH / EVENT** | | | | |
| **SRC (“SWCDH”)** | | String | Source of the packet. Set to “SWCDH” | |
| **M\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. | |
| **SS\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Sub-system time, in UTC. Left empty for this packet, as the CDH computer is the baseline for the mission time. | |
| **PKT\_ID (“EVENT”)** | | String | Packet identifier. Fixed string value “EVENT” | |
| **EVENT\_TEXT** | String | | | Text identifying the event, and providing details |

Example (from StratoScience2018 Nimbus-5 flight):

SWCDH,2018-08-25 18:23:47.496,,EVENT,Auto imaging. Index = 1:raspistill -n -vf -hf -w 1920 -h 1080 -q 10 -t 2000 -o /mnt/ssd/swcdh/pictures/1.jpg

In this example, the SWCDH software indicates that it has automatically taken a picture (1.jpg), and provides the command line used.

### SWCDH / SWCDH\_HKP0 (Housekeeping Data) Telemetry Packet

This telemetry packet is sent by SWCDH to ground at a regular rate of 0.1 Hz.

Format:

**SWCDH**,*m-time*,*ss-time*,**SWCDH\_HKP0**,SW\_VER,**0**,isConfigFileRead,isConfigParamErr, isNetworkErr,isFileErr,isImageOverFlow,isImageOverWrite,nbTCRx,nbTCRej,nbTMSent, loopDelay,loopDelayMax,imgFile,isAutoImage,ndxOfNextImgToTake,ndxOfImgBeingSent,nbImages, isTakingLargeOnboardImages,isTakingNAVEM\_images

Where:

|  |  |  |  |
| --- | --- | --- | --- |
| **SWCDH / SWCDH\_HKP0** | | | |
| **SRC (“SWCDH”)** | String | Source of the packet. Set to “SWCDH” | |
| **M\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. | |
| **SS\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Sub-system time, in UTC. Left empty for this packet, as the CDH computer is the baseline for the mission time. | |
| **PKT\_ID (“SWCDH\_HKP0”)** | String | Packet identifier. Fixed string value “SWCDH\_HKP0” | |
| **SW\_VER** | String | | Text identifying the SWCDH software version currently running |
| **EMPTY\_1** | “0” | | Reserved |
| **IS\_CONFIG\_FILE\_READ** | 0/1 | | Specifies whether the software was able to open and read its local configuration file at startup:  0 = **Not successful**: Default configuration parameters will be used.  1 = **Success**: Configuration parameter values in the onboard configuration file will be applied. |
| **IS\_CONFIG\_PARAM\_ERR** | 0/1 | | Specifies whether there was an error while applying at least one configuration parameter value, from reading the onboard configuration file at startup:   * 0 = All parameters could be read successfully and their value applied * 1 = There has been at least one error while reading and applying configuration parameter values, at startup. In this case, default value will be used. |
| **IS\_NETWORK\_ERR** | 0/1 | | * 0 = No network error occurred * 1 = At least one network error occurred, sending UDP telemetry packets to ground. This does not necessarily means that the error is still in effect, and that there is currently something wrong with the system |
| **IS\_FILE\_ERR** | 0/1 | | * 0 = No error writing to telemetry or telecommands onboard log files * 1 = At least one error occurred writing to telecommands or telemetry onboard log files. This would generally indicate that from the time this error is declared, no logs are saved anymore. |
| **IS\_IMAGE\_OVERFLOW** | 0/1 | | * 0 = No overflow of images happened on disk * 1 = Image overflow on disk, i.e. there is not enough disk space left to record images. Depending on the IS\_IMAGE\_OVERWRITE value, the last image will either be lost or will overwrite the oldest image on disk. |
| **IS\_IMAGE\_OVERWRITE** | 0/1 | | * 0 = IMAGE OVERWRITE mode is DISABLED: In the case there would be no more space left on disk, the last image taken will be lost (not recorded) * 1 = IMAGE\_OVERWRITE mode is ENABLED: In the case there would be no more space left on disk, the last image taken will replace the oldest image recorded on disk. |
| **NB\_TC\_RX** | Integer | | Provides the number of telecommands received by the software, since it booted (or the statistics have been reset by a command) |
| **NB\_TC\_REJ** | Integer | | Provides the number of telecommands that were received and rejected by the software (i.e. did not pass the validation steps, and were NOT executed) since the software booted up (or the statistics were reset by a command) |
| **NB\_TM\_SENT** | Integer | | Provides the number of telemetry packets sent to ground by the SWCDH software, since the software booted up (or the statistics were reset by a command) |
| **LOOP\_DELAY** | Milliseconds | | Provides the measure of the time that it took to perform all operations within the last one loop of the SWCDH software, expressed in milli-seconds. Everything being sequential and performed in the main loop, taking an image will cause a very long loop delay. |
| **LOOP\_DELAY\_MAX** | Milliseconds | | Provides the maximum LOOP\_DELAY recorded since the software booted up, or the statistics were reset by a command. |
| **IMG\_FILE** | 0/1 | | * 0 = No image file is currently opened onboard * 1 = An image file is currently opened onboard, indicating there is an image download in progress |
| **IS\_AUTO\_IMAGE** | 0/1 | | * 0 = AUTO IMAGING mode is DISABLED. Images will be taken only on-demand via a tele-command. * 1 = AUTO IMAGING mode is ENABLED. Images will be taken at regular interval by SWCDH. |
| **NDX\_IMG\_TO\_TAKE** | Integer | | Provides the index number of the next image to be taken onboard |
| **NDX\_IMG\_TO\_SEND** | Integer | | Provides the index number of the image currently being downloaded to ground |
| **NB\_IMG** | Integer | | Number of image files currently saved onboard |
| **IS\_LARGE\_IMG** | 0/1 | | The SWCDH software takes small size & low quality images that are downlinked to ground, but can also take large size & high quality images that are only saved on onboard mass memory for later retrieval. This flag indicates if large size images are taken and saved:   * 0 = Large images will NOT be taken * 1 = Large images will be taken and saved onboard |
| **IS\_NAVEM\_IMG** | 0/1 | | The SWCDH executes on the CDH computer. It usually takes images using a locally connected camera. It can also request, via the onboard network, images to be taken from a camera installed on the NAVEM computer. This flag indicates if it does request or not images to be taken from the NAVEM computer:   * 0 = Images taken locally (CDH camera only) * 1 = Images taken locally, but also from the NAVEM camera |

Example (from StratoScience2018 Nimbus-5 flight):

SWCDH,2018-08-26 07:34:34.398,,SWCDH\_HKP0,PRISM C&DH 1.10,0,1,1,0,0,0,0,0,0,257976,444,20770, 0,1,302,301,280,1,1

In this example, the SWCDH software reports the following information:

* It is executing version 1.10
* The next field is not used
* The configuration file has been read successfully at startup
* There was a parameter error while reading the configuration file at startup
* No errors for: Network, file manipulation.
* No overflow of image files
* Image file overwrite mode is OFF
* Number of telecommands received from ground: zero
* Number of telecommands rejected: zero
* 257,976 telemetry packets sent to ground
* Main loop delay: 444 milliseconds
* Main loop maximum delay recorded so far: 20.77 seconds
* Image file is currently closed
* AUTO-imaging is ENABLED
* Index of next image to take = 302
* Index of image being sent to ground = 301
* Number of image files produced = 280
* Producing large image files, saved onboard = ENABLED
* Requesting images to be taken by NAVEM computer = ENABLED

### SWCDH / CDH\_HW0 (Additional Hardware Info) Telemetry Packet

This telemetry packet is sent by SWCDH to ground at a regular rate of 0.1 Hz.

Format:

**SWCDH**,*m-time*,*ss-time*,**CDH\_HW0**,*mem\_total*,*mem\_used*,*mem\_free*,*disk\_total*,*disk\_free*,*disk\_usable*,*cpu\_temp*

Where:

|  |  |  |  |
| --- | --- | --- | --- |
| **SWCDH / SWCDH\_HW0** | | | |
| **SRC (“SWCDH”)** | String | Source of the packet. Set to “SWCDH” | |
| **M\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. | |
| **SS\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Sub-system time, in UTC. Left empty for this packet, as the CDH computer is the baseline for the mission time. | |
| **PKT\_ID (“CDH\_HW0”)** | String | Packet identifier. Fixed string value “CDH\_HW0” | |
| **SW\_VER** | String | | Text identifying the SWCDH software version currently running |
| **MEM\_TOTAL** | megaBytes | | Provides the total on-board memory (RAM) installed on the CDH computer |
| **MEM\_USED** | megaBytes | | Provides the amount of on-board memory (RAM) currently in use, on the CDH computer |
| **MEM\_FREE** | megaBytes | | Provides the amount of on-board memory (RAM) currently free, on the CDH computer |
| **DISK\_TOTAL** | megaBytes | | Not available for StratoScience2018 flight. Reports zero (0). |
| **DISK\_FREE** | megaBytes | | Not available for StratoScience2018 flight. Reports zero (0). |
| **DISK\_USABLE** | megaBytes | | Not available for StratoScience2018 flight. Reports zero (0). |
| **CPU\_TEMP** | xx.xx  Degree C | | Provides the temperature of the CDH computer CPU. |

Example (from StratoScience2018 Nimbus-5 flight):

SWCDH,2018-08-26 04:04:34.847,,CDH\_HW0,862,844,17,0,0,0,42.20

In this example, the SWCDH software reports the following information:

* Onboard memory installed/used/free = 862/844/17 megaBytes
* Disk space = n/a
* CPU temperature = 42.2 C

### SWCDH / CDH\_IMG0 Telemetry Packet

This telemetry packet is sent by SWCDH to ground at high rate (configurable) when transferring an image file to ground. It contains chunks of an image, sent in sequence.

Format:

**SWCDH**,*m-time*,ss-*time*,**CDH\_IMG0**,*cam\_id*,*img\_id*,*img\_lat*,*img\_long*,*img\_alt*,*pkt\_ndx*,*img\_data*

Where:

|  |  |  |  |
| --- | --- | --- | --- |
| **SWCDH / CDH\_IMG0** | | | |
| **SRC (“SWCDH”)** | String | Source of the packet. Set to “SWCDH” | |
| **M\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. | |
| **SS\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Sub-system time, in UTC. Left empty for this packet, as the CDH computer is the baseline for the mission time. | |
| **PKT\_ID (“CDH\_IMG0”)** | String | Packet identifier. Fixed string value “CDH\_IMG0” | |
| **CAM\_ID** | 1 | | Camera identifier. Note that for this flight, images from nadir pointing and horizon pointing cameras were sent in alternate sequence, with all images identified as being taken by camera #1. This field will be supported in future flights. |
| **IMG\_ID** | Integer | | An identifier for the image being sent. Will remain constant for all packets containing data this this particular image, and will be unique throughout the flight. Currently, this is a number being incremented after each image (i.e. the first image is “1”). |
| **IMG\_LAT** | Degree\_N  -90.00000 to +90.00000 | | Latitude at which the image was taken. May be provided only on the first or the last image data packet. For StratoScience2018, this information is provided in all image packets, being identical in all packets forming a single image. |
| **IMG\_LONG** | Degree\_E  -180.00000 to +179.99999 | | Longitude at which the image was taken. May be provided only on the first or the last image data packet. For StratoScience2018, this information is provided in all image packets, being identical in all packets forming a single image. |
| **IMG\_ALT** | Meters  -999 to 999999 | | Altitude at which the image was taken. May be provided only on the first or the last image data packet. For StratoScience2018, this information is provided in all image packets, being identical in all packets forming a single image. |
| **PKT\_NDX** | A sequence number, starting at zero.  -1 = END | | Index of the current image data packet. When all data have been transferred, a packet is sent with PKT\_NDX = -1. |
| **IMG\_DATA** | Data in BASE64 format | | Image data, formatted in BASE64. Can be read as a string, as all data in BASE64 are printable characters.NOTE that this field will be left empty in the last packet (the one where PKT\_NDX = -1). |

Example (from StratoScience2018 Nimbus-5 flight, with image chunk data truncated for the purpose of this document):

SWCDH,2018-08-26 05:53:50.541,,CDH\_IMG0,1,254,48.61467,-81.34789,36120,0,/9j/4WQaRAA…wMDAwRCAAwAEAD

In this example, the SWCDH software reports the following information and data:

* Camera/image index = 1/254
* Image was taken at position: latitude=48.61467N, longitude=81.34789W, altitude=36.12km
* Packet index = 0 (i.e. this is the first data chunk sent to ground for image #254)
* Data chunk, to be decoded BASE64 and added to the JPG buffer: /9j/4WQaRAA…etc

### GPS01 / GGA (NovAtel OEM729 GPS Receiver Data) Telemetry Packet

This telemetry packet is sent at a rate of 0.1 Hz by default, as a UDP datagram forwarded to the ground. It contains essential fix data from the NovAtel GPS receiver installed on-board (GPS1), providing 3D location and accuracy data.

Format:

**GPS01**,*m-time*,*ss-time*,**GGA**,**GPGGA**,*time-of-fix*,*latitude*,**N/S**,*longitude*,**E/W**,*fix\_qual*,*nb\_sats*,*hdop*, *alt\_msl*,**M**,*geoid\_sep*,**M**,,**\****chksum*

Where:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **GPS01 / GGA** | | | | |
| **SRC (“GPS01”)** | | String | Source of the packet. Set to **GPS01**. | |
| **M\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. | |
| **SS\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Sub-system time, in UTC. Left empty for this packet (see time-of-fix field for GPS receiver time) | |
| **PKT\_ID (“GGA”)** | | String | Packet identifier. Fixed string value “GGA” | |
| **NMEA\_ID (“GPGGA”)** | String | | | NMEA identifier of the data source on the GPS receiver. Fixed to “GPGGA” |
| **TIME\_OF\_FIX** | hhmmss | | | Time-stamp for location data acquisition, in UTC |
| **LATITUDE** | ddmm.mmmm | | | Latitude of position. Format is:   * dd = degrees (0 to 90). No negative sign, see N\_S field for hemisphere. * mm.mmmm = minutes with fraction   Example: 4822.7502 = 48 degrees, 22.7502 minutes |
| **N\_S** | “N” or “S” | | | Indication of latitude North or South |
| **LONGITUDE** | dddmm.mmmm | | | Longitude of position. Format is:   * ddd = degrees (0 to 180). No negative sign, see E\_W for direction. * mm.mmmm = minutes with fraction   Example: 08241.9860 = 82 degrees, 41.986 minutes |
| **E\_W** | “E” or “W” | | | Indication of longitude East or West |
| **FIX\_QUAL** | “0”, “1” or “2” | | | GPS quality indicator:   * “0” = no fix * “1” = GPS fix * “2” = Differential GPS fix |
| **NB\_SATS** | 00 to 99 | | | Number of satellites in use (not those in view) |
| **HDOP** | x.x | | | Horizontal dilution of position |
| **ALT\_MSL** | x.x | | | Altitude (of antenna) above mean-sea-level. See next field for units, usually specified in meters. Ex: 36381.28 = 36.4 km |
| **ALT\_UNIT** | String | | | Specify the unit of ALT\_MSL value (previous field). Usually “M” for “meters” |
| **GEOID\_SEP** | x.x | | | Geoidal separation (Difference between WGS-84 Earth ellipsoid and mean sea level. A negative number here means that the geoid is below WGS-84 ellipsoid. |
| **GEOID\_SEP\_UNIT** | String | | | Specify the unit of GEOID\_SEP value (previous field). Usually “M” for “meters” |
| **EMPTY\_1** |  | | | This field is left empty. Filled when differential station is used. |
| **CHKSUM** | \*xx | | | Checksum (always with the “\*” prefix) |

Example (from StratoScience2018 Nimbus-5 flight):

GPS01,2018-08-26 08:58:42.461,,GGA,GPGGA,085843.00,4822.7502,N,08241.9860,W,1,09,1.1,36381.28,M,-37.40,M,,\*59

In this example, the gondola is located at latitude 48 deg 22.7502’ North, longitude 82 deg 41.986’ West and at an altitude of more than 36 km. The fix data was acquired at 8h58 UTC.

Note: For more details, see the definition of the NMEA GGA sentence, which is standard GPS receiver output data.

# IOCTL Software Telemetry

## General

The IOCTL main process executing on the IOCTL computer within the PRISM generates only one telemetry packets:

* **IOCTL / IOCTRL\_HKP**: Housekeeping and internal voltage monitor data

This packet is detailed in the following section.

## IOCTL Telemetry

### IOCTL / IOCTRL\_HKP – Housekeeping Telemetry Packet

This telemetry packet is sent at a rate of 1Hz by default, as a UDP datagram forwarded to the C&DH. It is targeted toward the ground.

Format:

**GPS01**,*m-time*,*ss-time*,**IOCTRL\_HKP**,*cnt*,*sw-ver*,ups*-out*,dc3v3*-out*,*dc12v-out*,*dc5v-1-out*,dc5v-2-out

Where:

|  |  |  |
| --- | --- | --- |
| **IOCTL / IOCTRL\_HKP** | | |
| **SRC (“IOCTL”)** | String | Source of the packet. Inserted by the C&DH. |
| **M\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. |
| **SS\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Sub-system time, in UTC. In this case, this represents the Rabbit SBC real-time clock. |
| **PKT\_ID (“IOCTRL\_HKP”)** | String | Packet identifier. Fixed string value “IOCTRL\_HKP” |
| **COUNTER** | Unsigned integer | Packet counter, increases by one with each packet sent. Rolls over to 0 at 65535. Note that there is a rollover at 32767, to -32768 due to data representation in a signed integer. |
| **SVER** | Integer | Software version multiplied by 100 |
| **DCUPS\_OUT** | Float  0.0 | n/a. Left at zero for StratoScience2018 flight |
| **DC3V3\_OUT** | Float  x.x | Output voltage of DCDC power converter providing internal 3.3V |
| **DC12V\_OUT** | Float  xx.x | Output voltage of DCDC power converter providing internal 12V |
| **DC5V\_1\_OUT** | Float  x.x | Output voltage of DCDC power converter #1 providing internal 5V |
| **DC5V\_2\_OUT** | Float  x.x | Output voltage of DCDC power converter #2 providing internal 5V |

Example (from StratoScience2018 Nimbus-5 flight):

IOCTL,2018-08-26 06:43:57.837,2018-08-26 06:43:51.000,IOCTRL\_HKP,639,101,0.0,3.3,12.0,5.0,5.0

In this example, the IOCTL software reports the following information:

* Current packet counter = 639
* IOCTL Software version = 1.01
* UPS DC output is not available as expected, indicating 0.0V
* Internal voltages are as expected at 3.3V, 12.0V, 5.0V and 5.0V

# NAV Software Telemetry

## General

The SWNAV process executing on the NAVEM computer within the PRISM generates the following telemetry packets:

* **SWNAV / HKP**: Housekeeping data
* **SWNAV / AHR0**: Attitude and Heading Reference data
* **SWNAV / POS0**: Position data

They are detailed in the following sections.

## SWNAV Telemetry

### SWNAV / HKP (Housekeeping Data) Telemetry Packet

This telemetry packet is sent by SWNAV to ground at a rate of 1Hz by default.

Format:

**SWNAV**,*m-time*,ss-*time*,**HKP**,*SWNAV\_VERSION,MODE,FLT\_PHASE,NB\_CMD\_EXEC,NB\_CMD\_REJECT, LAST\_CMD\_ID\_EXEC,CNT\_LAST\_CMD,LOOP\_MIN\_FREQ,GX5\_STATUS,NOVATEL\_GPS\_STATUS,NAVIO\_GPS\_STATUS,NAVIO\_MPU\_STATUS,NAVIO\_LSM\_STATUS,NAVIO\_BARO\_STATUS,GX5\_EF\_STATUS,GX5\_GPS\_STATUS,LOOP\_AVG\_FREQ,GPS\_SELECT\_MODE,NAVIO\_PRESSURE,NAVIO\_TEMP*

Where:

|  |  |  |
| --- | --- | --- |
| **SWNAV / HKP (House-keeping)** | | |
| **SRC (“SWNAV”)** | String | Source of the packet. Fixed to “SWNAV”. |
| **M\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Mission time |
| **SS\_TIME** | yyyy-mm-dd hh:mm:ss.sss | NAVEN time |
| **PKT\_ID (“HKP”)** | String | Packet identifier. Fixed string value “HKP” |
| **SWNAV\_VERSION** | String | SWNAV software version |
| **MODE** | OPERATE  TEST | SW operating mode (TEST same as OPERATE in flight version) |
| **FLT\_PHASE** | TEST  PRELAUNCH  ASCENT  CEILING  DESCENT  RECOVERY | Flight phase (TEST same as prelaunch in flight version) |
| **NB\_CMD\_EXEC** | Integer | Number of commands executed |
| **NB\_CMD\_REJECT** | Integer | Number of commands rejected |
| **LAST\_CMD\_ID** | String | Last Executed command identifier |
| **CNT\_LAST\_CMD** | Integer | Origin counter of last executed command |
| **LOOP\_MIN\_FREQ** | Float (Hz) | SWNAV main loop ***minimum*** frequency (float) |
| **GX5\_STATUS** | IMU-OK  NOT\_STREAMING  RESETTING  FAILED  INVALID  PAUSED | LORD GX5 (IMU1) Status:   * IMU-OK: IMU operating as expected * Not streaming: no EF data received within 1 sec * Failed: TCP exception * Invalid: EF status bit 6 set - Invalid * Paused: commanded to pause |
| **NOVATEL\_GPS\_STATUS** | FAILED  or  FIX\_QUAL#/# SAT | Status of GPS1 receiver (NovAtel OEM729). If not failed, reports FIX\_QUAL Value / # Satellites |
| **NAVIO\_GPS\_STATUS** | FAILED  or  FIX\_QUAL#/# SAT | Status of the Ublox GPS receiver on Navio2 (GPS2). If not failed, reports FIX\_QUAL Value / # Satellites |
| **NAVIO\_MPU\_STATUS** | FAILED  Or  MPU-OK | Status of Navio2 IMU. Failed if not data within 10 sec |
| **NAVIO\_LSM\_STATUS** | FAILED  Or  LSM-OK | Status of Navio2 second IMU. Failed if not data within 10 sec |
| **NAVIO\_BARO\_STATUS** | FAILED  Or  BARO-OK | Status of Navio2 barometer. Failed if not data within 10 sec |
| **GX5\_EF\_STATUS** | Int | Lord GX5 Estimation filter status:  0x0001 – IMU unavailable  0x0002 – GNSS (GNSS versions only)  0x0008 – Matrix singularity in calculation  0x0010 – Position covariance high warning\*  0x0020 – Velocity covariance high warning\*  0x0040 – Attitude covariance high warning\*  0x0080 – NAN in solution  0x0100 – Gyro bias estimate high warning  0x0200 – Accel bias estimate high warning  0x0400 – Gyro scale factor estimate high warning  0x0800 – Accel scale factor estimate high warning  0x1000 – Mag bias estimate high warning  0x2000 – GNSS antenna offset correction estimate high warning  0x4000 – Hard Iron offset estimate high warning |
| **GX5\_GPS\_STATUS** | FAILED  or  FIX\_QUAL#/# SAT | Status of the GPS receiver within the Lord GX5 IMU.  If not failed, reports FIX\_QUAL Value / # Satellites |
| **LOOP\_AVG\_FREQ** | Float (Hz) | SWNAV Main loop ***average*** frequency (Hz) |
| **GPS\_SELECT\_MODE** | “1/AUTO”  tbd | Provides the current mode for selecting GPS data, i.e. if the main GPS fails are we taking data from another GPS receiver automatically or not? |
| **NAVIO\_PRESSURE** | Float (millibars) | NAVIO2 pressure reading |
| **NAVIO\_TEMP** | Float (Dec C) | NAVIO2 temperature reading |

Example (from StratoScience2018 Nimbus-5 flight):

SWNAV,2018-08-26 06:09:16.021,2018-08-26 06:09:07.355,HKP,V3\_4,OPERATE,CEILING, 20,0,SELECT\_GPS,78,7.645,IMU-OK,Qual=1 #=10,Qual=0 #=0,MPU-OK,LSM-OK,FAILED,0,Qual 1/# 10,66.690,1/AUTO,0.00,0.00

In this example, the SWNAV software reports the following information and data:

* SWNAV version 3.4 is executing, in OPERATE mode, CEILING flight phase
* 20 telecommands have been received so far, with zero reject. Last was SELECT\_GPS #78
* SWNAV minimum loop frequency recorded = 7.645 hertz
* GX5 IMU1 is OK, sending data
* NovAtel GPS receiver has a fix, using 10 satellites
* Navio2 GPS receiver has no fix, not using any satellite
* Navio2 IMUs are both OK, sending data
* Navio2 barometer sensor has failed
* GX5 IMU status has nothing to report
* GX5 IMU GPS receiver has a fix, using 10 satellites
* SWNAV main loop average frequency performance is 66.69 hertz
* GPS Receiver SELECT MODE is AUTOMATIC
* Navio2 reports no pressure nor temperature data

### SWNAV / AHR0 (Attitude & Heading Reference Data) Telemetry Packet

This telemetry packet is sent by SWNAV to ground at a rate of 1Hz by default.

Format:

**SWNAV**,*m-time*,ss-*time*,**AHR0**,*AHR\_DATA\_SRC*,*TRACK\_ANG*,*TRACK\_ANG\_VALID*,*TRUE\_HEAD*,*TRUE\_HEAD\_VALID*, *VELO\_N*,*VELO\_E*,*VELO\_D*,*VELO\_VALID*,*ROLL*,*PITCH*,ATT\_Q0,ATT\_Q1,ATT\_Q2,ATT\_Q3,*ORIENT\_VALID*, *ANG\_RATE\_X*,*ANG\_RATE\_Y*,*ANG\_RATE\_Z*,*ANG\_RATES\_VALID*, *LINEAR\_ACCEL\_X*,*LINEAR\_ACCEL\_Y*,*LINEAR\_ACCEL\_Z*,*LINEAR\_ACCEL\_VALID*, *GRAV\_VECT\_X*,*GRAV\_VECT\_Y*,*GRAV\_VECT\_Z*,*GRAV\_VECT\_VALID*, SUN\_VECT\_X,SUN\_VECT\_Y,SUN\_VECT\_Z,SUN\_VISIB,SUN\_VECT\_VALID, MOON\_VECT\_X,MOON\_VECT\_Y,MOON\_VECT\_Z,MOON\_VISIB,MOON\_DATA\_VALID, SUN\_AZIM,SUN\_ELEV,GX5\_EF\_STATUS\_FLAGS

Where:

|  |  |  |
| --- | --- | --- |
| **SWNAV / AHR0 (Attitude & Heading Reference)** | | |
| **SRC (“SWNAV”)** | String | Source of the packet. Fixed to “SWNAV”. |
| **M\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Mission time. |
| **SS\_TIME** | yyyy-mm-dd hh:mm:ss.sss | NAVEM computer time. |
| **PKT\_ID (“AHR0”)** | String | Packet identifier. Fixed string value “AHR0” |
| **AHR\_DATA\_SRC** | 16-bit bit mask  0 to 65535 | AHR Data Source. To be interpreted as a 16-bit bit mask. If this value is zero, no source is provided. ***Note that this value will be expressed in decimal notation (and NOT hexadecimal)***. The mask provided here is expressed in hexadecimal for ease of reading.  Bits defined so far:  0x0001=Data provided by primary IMU unit  0x0002=Data provided by backup IMU unit  0x0004=undefined  0x0008=undefined  0x0010=Magnetometer  0x0020=GNSS velocity vector  0x0040=External Heading Update |
| **TRACK\_ANG** | Deg  0 to 359.9 | Track Angle value. Instantaneous direction of movement of the gondola (velocity vector with respect to true north). Defined as the angle between the true north and the gondola NED velocity vector projected onto the local NE plane, measured clockwise.[[1]](#footnote-2) Note that positive direction is clockwise (i.e. 90 degrees represents EAST). See details in appendix. |
| **TRACK\_ANG\_VALID** | 0 (invalid) or  1 (valid) | Corresponding value should be ignored if declared invalid. |
| **TRUE\_HEAD** | Deg  0 to 359.9 | True Heading. Pointing direction of gondola +X axis with respect to true north, specified as the angle between +X of the gondola-fixed reference frame (i.e. mechanical frame) with respect to the +N Axis of NED frame, measured in local NE-plane. THIS IS NOT NECESSARILY THE DIRECTION OF MOVEMENT (see TRACK ANGLE) Expected accuracy = +/- 2 degrees [RD2]. Best accuracy = 0.8 degree (RMS) [RD1] when values are provided by primary IMU.  Note that positive direction is clockwise (i.e. 90 degrees represents EAST).  Note also that in our context, TRUE\_HEADING is identical to the gondola YAW, with proper range mapping. Note, IMU1 YAW has the range from –pi to +pi, however this data is transformed to 0-359.9 degree range.  ***NOTE THAT this value was not reported correctly (i.e. it was significantly diverging from reality) during most of the StratoScience2018 flight*** |
| **TRUE\_HEAD\_VALID** | 0 (invalid) or  1 (valid) | Corresponding value should be ignored if declared invalid. TRUE\_HEADING will be declared INVALID if no heading update is received in 2 seconds. |
| **VELO\_N/E/D** | North/East/Down Meters/Sec  0.00 to 99.99 | Velocity North/East/Down. 3 (comma separated) values provided. Estimated velocity data expressed in the Local-Level Frame. The ground speed North/East velocities are provided, in the addition of the Vertical speed with ***positive value corresponding to descent***)  Best accuracy = +/- 0.1 m/sec (RMS) [RD1] when values are provided by primary IMU. |
| **VELO\_VALID** | 0 (invalid) or  1 (valid) | Corresponding values should be ignored if declared invalid. |
| **ROLL/PITCH** | Deg  -179.99 to 180.00 | 2 (comma separated) values providing the Euler angles representing the ROLL and PITCH orientation of the gondola. Note, gondola attitude is described by Euler angles, representing rotation from NED frame to gondola-fixed coordinate frame (i.e., mechanical build frame), following YAW-PITCH-ROLL attitude sequence. That is, first rotating YAW angle about Z-axis of the NED frame, followed by rotating PITCH angle about the (once-rotated) intermediate Y-axis, finished by rotating ROLL angle about the (twice-rotated) transformed X-axis. The YAW angle is provided as TRUE\_HEADING.  Best accuracy is 0.25 degree when values are provided by primary IMU. |
| **ATT\_Q0** |  | Gondola orientation, expressed as a quaternion. Scalar being the first value (Q0). |
| **ATT\_Q1** |  | “ |
| **ATT\_Q2** |  | “ |
| **ATT\_Q3** |  | “ |
| **ORIENTATION\_VALID** | 0 (invalid) or  1 (valid) | Corresponding values (ROLL/PITCH) should be ignored if declared invalid. |
| **ANG\_RATE\_X/Y/Z** | X/Y/Z Deg/Sec  -99.999 to 99.999 | 3 (comma separated) values provided. Angular rate data expressed in the gondola mechanical frame (with Z axis pointing down). |
| **ANG\_RATES\_VALID** | 0 (invalid) or  1 (valid) | Corresponding values should be ignored if declared invalid. |
| **LINEAR\_ACCEL\_X/Y/Z** | X/Y/Z Meters / Sec2  -99.999 to 99.999 | 3 (comma separated) values provided. Gondola acceleration (***gravity vector removed***) expressed in the gondola mechanical frame (with Z axis pointing down). |
| **LINEAR\_ACCEL\_VALID** | 0 (invalid) or  1 (valid) | Corresponding values should be ignored if declared invalid. |
| **GRAV\_VECT\_X/Y/Z** | X/Y/Z Meters/Sec2  -99.999 to 99.999 | 3 (comma separated) values provided. Estimated gravity vector expressed in the gondola mechanical frame (with Z axis pointing down). |
| **GRAV\_VECT\_VALID** | 0 (invalid) or  1 (valid) | Corresponding value should be ignored if declared invalid. |
| **SUN\_VECT\_X** |  | Normalized vector to the Sun, expressed in the gondola mechanical frame. |
| **SUN\_VECT\_Y** |  |  |
| **SUN\_VECT\_Z** |  |  |
| **SUN\_VISIB** | 0 (not visible)  1 (visible) | Visible = over the horizon as seen from the gondola PRISM |
| **SUN\_VECT\_VALID** | 0 (invalid)  1 (valid) | Corresponding value should be ignored if declared invalid. |
| **MOON\_VECT\_X** |  | Normalized vector to the Moon, expressed in the gondola mechanical frame. NOT SUPPORTED YET. Set at zero. |
| **MOON\_VECT\_Y** |  | NOT SUPPORTED YET. Set at zero. |
| **MOON\_VECT\_Z** |  | NOT SUPPORTED YET. Set at zero. |
| **MOON\_VISIB** |  | An indicator expressing the level of Moon visibility.  NOT SUPPORTED YET. Set at zero. |
| **MOON\_DATA\_VALID** |  | Corresponding value should be ignored if declared invalid. |
| **SUN\_AZIM** | -180.0 – 180.0 | Sun Azimuth angle in degrees in Earth reference frame |
| **SUN\_ELEV** | -180.0 – 180.0 | Sun Elevation angle in degrees in Earth reference frame |
| **GX5\_EF\_STATUS\_FLAGS** | Integer number | GX5 Estimation Filter Status Flags |

Example (from StratoScience2018 Nimbus-5 flight):

SWNAV,2018-08-26 07:17:51.844,2008-08-21 07:17:50.394,AHR0,1,252.374,1,113.891,1,-3.248,-10.222,-0.074,1,-0.327,0.274,0.55,-0.00,-0.00,0.84,1,0.03,0.09,-0.05,1,-0.00,0.00,-0.01,1,-0.05,-0.06,9.70,1,0.09,-0.89,0.44,0,1,0,0,0,0,0,29.92,-26.57,0

In this example, the SWNAV software reports the following information and data:

* Data is provided by the primary IMU unit
* Track angle (direction of movement of the gondola) is reported toward 252.374 degree and is valid
* True heading was reported at 113.891 and valid (note that we cannot trust this value for this flight, as true heading data was declared significantly off from reality)
* Velocity: 3.248 m/s South, 10.222 m/s West & 0.074 m/s Up. Valid
* Roll/Pitch: -0.327 / 0.274 degree
* Gondola orientation quaternion: [0.55, 0, 0, 0.84] valid (including orientation)
* Angular rates X,Y,Z: 0.03, 0.09, -0.05 degree/second, valid
* Linear acceleration X,Y,Z: 0, 0, -0.01 meters/second, valid
* Gravity vector X,Y,Z : -0.05, -0.06, 9.7 meters/second^2, valid
* Normalized vector to the Sun: 0.09, -0.89, 0.44. Sun NOT visible. Data declared VALID, however note that since the true heading is off, the Sun vector will not be correct
* Normalized vector to the Moon: Not supported
* Sun azimuth: 29.92 degrees
* Sun elevation: -26.57 (below horizon)
* GX5 IMU estimation filter status flag: Nothing to report.

### SWNAV / POS0 – Position Data Telemetry Packet

This telemetry packet is sent by SWNAV to ground at a rate of 1Hz by default.

Format:

**SWNAV**,*m-time*,ss-*time*,**POS0**,LAT,LONG,ALT,POS\_VALID,FIX\_TIME,FIX\_QUAL,NSATS,HDOP, GPS\_SRC,SUN\_AZIMUTH,SUN\_ELEVATION

Where:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SWNAV / POS0 (Position)** | | | | |
| **SRC (“SWNAV”)** | | String | Source of the packet. Fixed to “SWNAV”. | |
| **M\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. | |
| **SS\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Sub-system time, in UTC. In this case, this represents the GPS Fix Time.  Source = TPVObject.getTimestamp(), converted from Unix epoch to UTC. | |
| **PKT\_ID (“POS0”)** | | String | Packet identifier. Fixed string value “POS0” | |
| **LAT** | Degree\_N  -90.00000 to +90.00000 | | | Gondola latitude. + is North. Primary: Novatel, 2nd: IMU1 EKF, 3rd: ublox . + is north. |
| **LONG** | Degree\_E  -180.00000 to +179.99999 | | | Gondola longitude.+ is East. |
| **ALT** | Meters  -999 to 999999 | | | Altitude of gondola, above geoid (mean sea level)- WGS84.  Note that negative values are possible. Note: In case of using IMU1, its EKF provides altitude above ellipsoid with accuracy at +/- 5 m (RMS) [RD1]. |
| **POS\_VALID** | 0 = invalid  1 = valid | | | Do not use position data if this flag is set to 0.  Source = Onboard check of LAT, LONG and ALT range. If any of those is determined outside valid range, POS\_VALID will be set to zero. |
| **FIX\_TIME** | HHMMSS  HH=Hours  MM=Minutes  SS=Seconds | | | Time of the GPS fix, as provided by the receiver, in UTC.  ***Note: If SS\_TIME is provided, FIX\_TIME will be left blank as it would be redundant.***  Source = NMEA GGA Fix Time field |
| **FIX\_QUAL** | 0 = invalid  1 = GPS fix  2 = DGPS fix  3 = PPS fix  4 = Real Time Kinematic  5 = Float RTK  6 = Estimated  7 = Manual Input  8 = Simulation | | | Fix quality. As provided by the GPS receiver. |
| **NSATS** | 0-99 | | | Number of satellites being tracked by GPS receiver. |
| **HDOP** | 0.0-99 | | | Horizontal Dilution of Position. An indication of the accuracy of the solution. The lower the number, the better, with 1.0 being ideal. Numbers lower than 1.0 are possible, meaning more satellite data is available than expected, thus an even better solution. |
| **GPS\_SRC** | 0=none/unknown  1=OEM729 NovAtel  2=Navio UBlox  3=Lord GX5 | | | Identifies the GPS receiver that provides the solution. |
| **SUN\_AZIMUTH** | -180.0 – 180.0 | | | Sun Azimuth angle in degrees in Earth reference frame |
| **SUN\_ELEVATION** | -180.0 – 180.0 | | | Sun Elevation angle in degrees in Earth reference frame |

Example (from StratoScience2018 Nimbus-5 flight):

SWNAV,2018-08-26 07:07:40.024,2018-08-26 07:07:38.000,POS0,48.4397,-81.8600,36315,1,,1,8,1.00,1,27.38,-27.32

In this example, the SWNAV software reports the following information and data:

* Gondola position is: Latitude 48.4397 degree North, Longitude 81.86 degree West, Altitude 36.315 km, valid
* Fix time = Not provided (it is inserted in field SS-TIME = 2018-08-26 07:07:38.000)
* Fix quality = 1 (GPS fix)
* Number of satellites used = 8
* Horizontal dilution of position = 1.0 (ideal)
* Source of position info = OEM729 NovAtel GPS receiver (main GPS, GPS1)
* Sun position in the sky = 27.38 degree azimuth, -27.32 elevation (below horizon)

# EM Software Telemetry

## General

The SWEM process executing on the NAVEM computer within the PRISM generates the following telemetry packets:

* **SW\_EM / EVENT**: Event information
* **SW\_EM / REPORT**: Reporting
* **SW\_EM / HK**: Housekeeping data
* **SW\_EM / EM0**: Environment data

They are detailed in the following sections.

## SWEM Telemetry

### SW\_EM / EVENT Telemetry Packet

This telemetry packet is sent by SWEM whenever there is an event worth reporting.

Format:

**SW\_EM**,*m-time*,*ss-time*,**EVENT**,event\_text

Where:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SW\_EM / EVENT** | | | | |
| **SRC (“SW\_EM”)** | | String | Source of the packet. Set to “SW\_EM” | |
| **M\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. | |
| **SS\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Sub-system time (NAVEM computer), in UTC. Note that the format of the time is not as advertised in 2018 telemetry, will be modified for future flights | |
| **PKT\_ID (“EVENT”)** | | String | Packet identifier. Fixed string value “EVENT” | |
| **EVENT\_TEXT** | String | | | Text identifying the event, and providing details. Possible events:   * LOW\_MEMORY: 100 megaBytes or less free memory * CPU\_TEMPERATURE\_WARNING: 80C > CPU temperature > 70C * CPU\_HIGH\_TEMPERATURE: CPU >= 80C * CPU\_HIGH\_UTILISATION: CPU utilization > 90% * SHOCK\_THREAD\_STOP\_BY\_EM: When a certain amount of failed shock sensor (adxl372z) reads occur the SWEM stops the shock read thread * NO\_LOGGING\_AVAILABLE: Error creating log(s) file(s) * LOGGING\_AVAILABLE: NO error creating log(s) file(s) * NO\_TM\_TC\_SUPPORT: Error creating the TC server and HK generator * TM\_TC\_READY: NO error creating TC server and HK generator * NO\_EM0\_SUPPORT: Error creating EM0 generator * EM0\_READY: NO error creating EM0 generator * NO\_SHOCK\_DETECTION\_SUPPORT: Error creating shock detection thread * SHOCK\_DETECTION\_READY: NO error creating shock detection thread * REPORT\_SENSOR\_STATUS: Status for each sensor initialization & I2C link * FLIGHT\_READY: Indicates that SWEM is ready to operate * NOT\_FLIGHT\_READY: Indicates SWEM is not operational |

Example (from StratoScience2018 Nimbus-5 flight):

SW\_EM,2018-08-26 13:32:39.150,2018-08-26 13-32-25,EVENT,LOW\_MEMORY 99.5MB

In this example, the SWEM software reports that there is a low memory condition.

### SW\_EM / REPORT Telemetry Packet

This telemetry packet is sent by SWEM to report initialization status information.

Format:

**SW\_EM**,*m-time*,*ss-time*,**REPORT**,status\_text

Where:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SW\_EM / REPORT** | | | | |
| **SRC (“SW\_EM”)** | | String | Source of the packet. Set to “SW\_EM” | |
| **M\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Mission time. UTC. | |
| **SS\_TIME** | | yyyy-mm-dd hh:mm:ss.sss | Sub-system time (NAVEM computer), in UTC. Note that the format of the time is not as advertised in 2018 telemetry, will be modified for future flights | |
| **PKT\_ID (“REPORT”)** | | String | Packet identifier. Fixed string value “REPORT” | |
| **STATUS\_TEXT** | String | | | Text providing details on status |

Example (from StratoScience2018 Nimbus-5 flight):

SW\_EM,2018-08-25 18:37:42.043,2018-08-25 18-37-48,REPORT,SENSOR STATUS,I2C Bus = true,BME280 = true,MCP9808 = true,ADXL372Z Self test = true,ADXL372Z = true

In this example, the SWEM software reports the status of various sensors initialization.

### SW\_EM / HK (Housekeeping Data) Telemetry Packet

This telemetry packet is sent by SWEM to ground at a rate of 1Hz by default.

Format:

**SW\_EM**,*m-time*,ss-*time*,**HK**,*SWEM\_VERSION,SWEM\_STATUS,CPU\_USE,CPU\_TEMP,MEM\_FREE,TC\_RX,TC\_REJ, INTERN\_TEMP,EXTERN\_TEMP,EXTERN\_PRESS,RELAT\_HUMID,DERIVED\_ALT,DEW\_POINT*

Where:

|  |  |  |
| --- | --- | --- |
| **SW\_EM / HK (House-keeping)** | | |
| **SRC (“SW\_EM”)** | String | Source of the packet. Fixed to “SW\_EM”. |
| **M\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Mission time |
| **SS\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Sub-system time (NAVEM computer), in UTC. Note that the format of the time is not as advertised in 2018 telemetry, will be modified for future flights |
| **PKT\_ID (“HK”)** | String | Packet identifier. Fixed string value “HK” |
| **SWEM\_VERSION** | String | Version of the SWEM software currently executing |
| **SWEM\_STATUS** | String | Will be set to “EM\_READY” if the software was able to initialize all of the sensors |
| **CPU\_USE** | %  xxx.xx | Percentage of the NAVEM computer CPU currently used |
| **CPU\_TEMP** | Celcius  xx.x | Temperature of the NAVEM computer CPU |
| **MEM\_FREE** | megaBytes | Amount of free memory (RAM) on the NAVEM computer CPU |
| **TC\_RX** | Count | Number of telecommands received by the SWEM |
| **TC\_REJ** | Count | Number of telecommands received but rejected (never executed) by the SWEM |
| **INTERN\_TEMP** | Celcius xx.xx | Temperature sensed inside the PRISM enclosure |
| **EXTERN\_TEMP** | Celcius xx.xx | Temperature sensed outside the PRISM and the gondola enclosure |
| **EXTERN\_PRESS** | hPa  xxxx.xx | Barometric pressure sensed outside the PRISM and the gondola enclosure |
| **RELAT\_HUMID** | %  xxx.xx | Relative humidity reading, sensed outside the PRISM and the gondola enclosure |
| **DERIVED\_ALT** | Meters  xxxxx.xx | Altitude of the gondola, estimated from barometric pressure |
| **DEW\_POINT** | Celsius  xx.xxx | Dew-point of frost-point, calculated from pressure/temperature/relative humidity readings |

Example (from StratoScience2018 Nimbus-5 flight):

SW\_EM,2018-08-26 07:16:24.461,2018-08-26 07-16-23,HK,2.5,EM\_READY,53.99,46.2,308.452,0,0,14.31,-34.70,8.45,2.65,40379.23,-66.90

In this example, the SWEM software reports the following information and data:

* SWEM is executing version 2.5 of the software, and is in the READY state
* The NAVEM computer is running at 53.99 % CPU utilization, and the CPU temperature is 46.2C
* There is 308.452 megaBytes of free memory
* The SWEM has received (and has rejected) zero telecommands
* The SWEM is reporting the following environment data, from querying its sensors:
  + Internal (enclosure) temperature = 14.31C
  + External temperature (outside gondola) = -34.7C
  + External barometric pressure = 8.45 hPa (in the stratosphere)
  + Relative humidity = 2.65%
  + Derived altitude = 40,379.23 meters
  + Calculated dew point = -66.9C

### SW\_EM / EM0 (Environment Data) Telemetry Packet

This telemetry packet is sent by SWEM to ground every 5 seconds by default.

Format:

**SW\_EM**,*m-time*,ss-*time*,**EM0**,*INTERN\_TEMP,EXTERN\_TEMP,RELAT\_HUMID,EXTERN\_PRESS, DEW\_POINT,SHOCK\_X,SHOCK\_Y,SHOCK\_Z*

Where:

|  |  |  |
| --- | --- | --- |
| **SW\_EM / EM0 (Environment Data)** | | |
| **SRC (“SW\_EM”)** | String | Source of the packet. Fixed to “SW\_EM”. |
| **M\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Mission time |
| **SS\_TIME** | yyyy-mm-dd hh:mm:ss.sss | Sub-system time (NAVEM computer), in UTC. Note that the format of the time is not as advertised in 2018 telemetry, will be modified for future flights |
| **PKT\_ID (“EM0”)** | String | Packet identifier. Fixed string value “EM0” |
| **INTERN\_TEMP** | Celcius xx.xx | Temperature sensed inside the PRISM enclosure |
| **EXTERN\_TEMP** | Celcius xx.xx | Temperature sensed outside the PRISM and the gondola enclosure |
| **RELAT\_HUMID** | %  xxx.xx | Relative humidity reading, sensed outside the PRISM and the gondola enclosure |
| **EXTERN\_PRESS** | hPa  xxxx.xx | Barometric pressure sensed outside the PRISM and the gondola enclosure |
| **DEW\_POINT** | Celsius  xx.xxx | Dew-point of frost-point, calculated from pressure/temperature/relative humidity readings |
| **SHOCK\_X** | G | X-axis last peak shock detected in the shock event window |
| **SHOCK\_Y** | G | Y-axis “ |
| **SHOCK\_Z** | G | Z-axis “ |

Example (from StratoScience2018 Nimbus-5 flight):

SW\_EM,2018-08-26 10:37:54.078,2018-08-26 10-37-53,EM0,9.25,-34.75,4.09,8.28,-63.60,0.00,0.00,0.00

In this example, the SWEM software reports the following information and data:

* Internal temperature is 9.25C
* External temperature is -34.75C
* Relative humidity is 4.09%
* External barometric pressure is 8.28 hPa
* Dew point (external) has been calculated at -63.6C
* No shock has been detected

- End of document -

1. Comprehensive reading on the subject available at <https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/18_phak_ch16.pdf> [↑](#footnote-ref-2)