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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Author(s):	JF Cusson, Claude Brunet, Patrice Cote, James Lee (CSA)
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1 SCOPE

1.1 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).

1.2 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.

1.3 System Overview

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

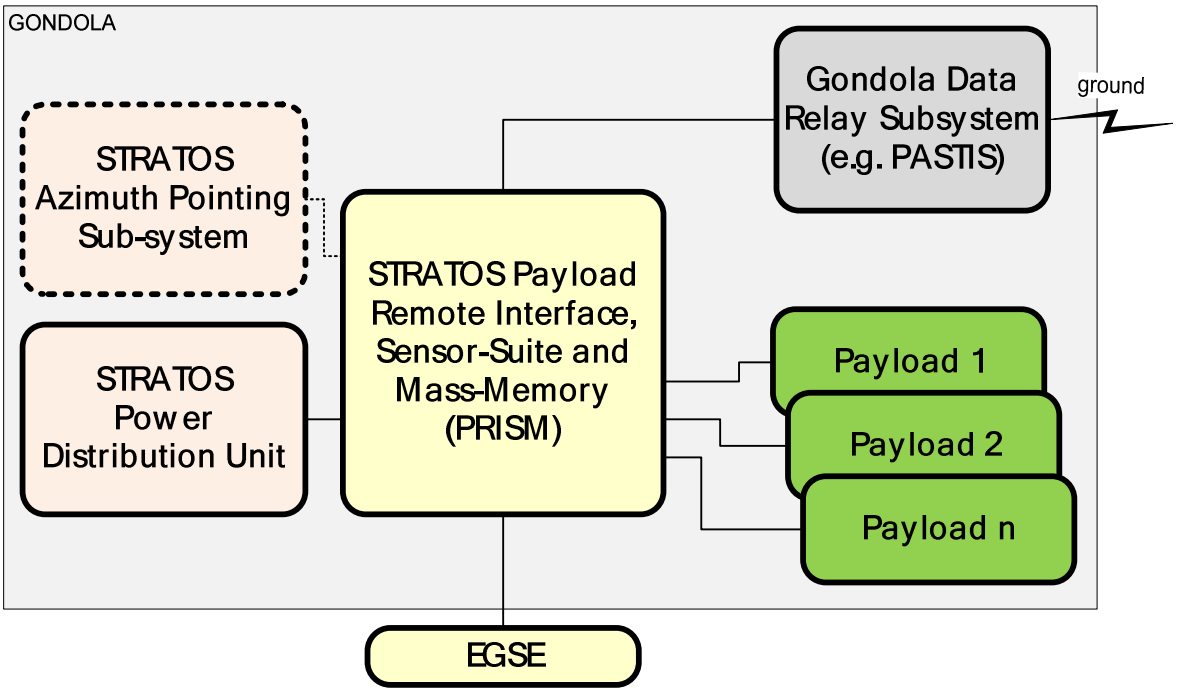

Figure 1: Typical Gondola Setup for PRISM

1.4 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).

1.5 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

1.6 Applicable Documents

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

1.7 Reference Documents

RD No.	Document No.	Document Title	Rev. No.	Date
1.	n/a			
2.				

2 C&DH Software (SWCDH) Telemetry

2.1 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.

2.2 Telemetry Packets Generated by SWCDH

2.2.1 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.

2.2.2 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

2.2.3 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

2.2.4 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`

2.2.5 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.

3 IOCTL Software Telemetry

3.1 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.

3.2 IOCTL Telemetry

3.2.1 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

4 NAV Software Telemetry

4.1 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.

4.2 SWNAV Telemetry

4.2.1 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

4.2.2 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] 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.

[1] Comprehensive reading on the subject available at https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/18_phak_ch16.pdf

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 / Sec^2 `-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/Sec^2 -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.

4.2.3 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	Gondola longitude.+ is East.

	+179.99999	
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)

5 EM Software Telemetry

5.1 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.

5.2 SWEM Telemetry

5.2.1 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

[redacted]		• 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.

5.2.2 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.

5.2.3 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

5.2.4 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 -